Topics in Biodiversity and Conservation

Ghulam Hassan Dar
Anzar A. Khuroo *Editors*

# Biodiversity of the Himalaya: Jammu and Kashmir State

Springer

# Topics in Biodiversity and Conservation

Volume 18

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ISSN 1875-1288 ISSN 1875-1296 (electronic)
Topics in Biodiversity and Conservation
ISBN 978-981-32-9173-7 ISBN 978-981-32-9174-4 (eBook)
https://doi.org/10.1007/978-981-32-9174-4



This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

# Foreword

*Jammu and Kashmir: Resurrecting the Paradise for Sustaining Biodiversity*

Global environmental challenges need to be addressed everywhere but perhaps more so in the Himalaya than anywhere in the world. The Himalaya is a biodiversity hotspot, source of Asia's eight largest rivers, and the "third pole"— with the amount of ice stored in the glaciers being only next to the two poles. The natural assets of the Himalaya sustain approximately one fifth of the humanity.

Within the Himalaya, the State of Jammu and Kashmir occupies a special position, once called a paradise on Earth because of its spectacular beauty and cultural and natural endowment. This westernmost State of the Indian Himalaya contains approximately one half of biodiversity found in the Indian part of this great mountain chain. Jammu and Kashmir is also a source of major rivers, fed by glaciers in the high mountains, for the provinces of Punjab in both Pakistan and India that constitute the breadbaskets of both the countries.

This remarkable book by Ghulam Hassan Dar and Anzar A. Khuroo provides a comprehensive account of the biodiversity of the State. Rich in information about floral and faunal diversity, the book emphasizes the need for further exploration in vast areas that have not been explored. Threats to biodiversity are the subject of a couple of chapters. Another set of chapters outlines the steps needed to conserve biodiversity.

Humanity is facing a first rate crisis in stemming the loss of biodiversity and the services it provides to support human endeavors. Jammu and Kashmir faces a particular challenge in conserving its natural heritage. The region is beset with political conflict with both India and Pakistan caught in a bitter struggle over rival claims to the State. Sound governance is a prerequisite for conserving biodiversity, but good governance requires cooperation and collaboration among stakeholders. With violence almost a daily occurrence, biodiversity takes a back stage.

Perhaps, the book can garner support to conserve the incredible biodiversity and beauty of the State. A desire to combat environmental challenges that pose a greater threat to human security than political ones can usher a new era of peace for the people and the biodiversity around them, regaining a paradise lost a generation or two ago.

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# Preface

Since the earliest humans settled there, it has been obvious that the State of Jammu and Kashmir (J&K) is incredibly rich in different kinds of plants and animals, an endowment that has come to be known as biodiversity. This richness was surely one reason for the Mughal emperor Jahangir's calling Kashmir a "paradise on Earth," a factual depiction of its biological wonders among other very special features of structure and environment. In modern times, we have come to ask about quantitative assessment of this biological richness of the State as a whole. A good deal of scientific work on biodiversity has been conducted in J&K State over the years, but no adequate summary of rich information contained in the hundreds of papers and books dealing with the subject has yet been offered. To do just that is what this book is for.

Collectively, biodiversity has become a widespread and fundamentally important human concern. Just after the concept was developed, some 50 years ago, it became generally known that the humans are wholly dependent on the living world and that the elements that make it up, species, are disappearing at a speed unprecedented for tens of millions of years. It has come to be known that the more comprehensive the knowledge of local biodiversity, the better strategies a country or region can develop for its socioeconomic development.

The flora and fauna of J&K State have been studied by many workers for over two centuries, with the numerous results scattered widely in such publications as journals, books, checklists, newsletters, conference and workshop proceedings, and miscellaneous reports. Many of these are out of print or rare and difficult to obtain, making the task of summarizing the information they contain all the more difficult. Difficulties of this sort encountered in the course of our taxonomic studies provided the impetus for our attempt to bring it together in a single, convenient, and authentic source of information on what is known about the J&K State's biota. This turned out to be a much larger job than we had first envisioned and has taken some years to bring to completion.

The opportunity to attempt this major task presented itself when Prof. G. H. Dar (senior editor) was selected for the Mahatma Gandhi Chair on Ecology and Environment at Baba Ghulam Shah Badshah University, Rajouri (J&K), in 2012. It was here that he undertook the preparation of this book on the biodiversity of J&K State as one of the Chair's intents. To provide an accurate impression of the biodiversity of the whole (pre-partition/pre-1947) J&K State, it was decided early on to include areas of the State beyond its current political borders. Also, to provide perspective in which to view our local biodiversity, the book was decided to begin with general chapters dealing with the world, national, and Himalayan biodiversity. In the context of these broad chapters, it was framed to have chapters dealing with details of floristic and faunal diversity of the State. Accordingly, relevant chapters dealing with various aspects of biodiversity and treatments of individual taxonomic groups were identified to be contributed by selected experts in those areas from our region and abroad. We provided a format to these experts and requested that they complete their chapters within a specific time frame. Since experts residing in Pakistan-administered parts of the State either could not be contacted or did not respond, their potential contributions could not be included. Almost all of the other experts whom we did contact agreed to contribute chapters to this work, but unfortunately it did not prove possible for some of them to do so timely.

During the course of this prolonged process, Prof. Dar's tenure as holder of the Mahatma Gandhi Chair came to an end, and for a time the work on this volume was suspended. Ultimately, it became possible to resume the effort at the University of Kashmir, with Dr Anzar A. Khuroo as the co-editor. Once this had been accomplished, pending chapters were reassigned and those received screened for appropriateness to be included in this volume. The selected chapters were edited, revised one or more times, appraised further in 2017–2018, and then prepared for publication.

The main aims of this book are to acquire, collate, and document all the available taxonomic information about the rich biota of the J&K State and to assess its richness and the degree to which it is unique to our area. Starting with a general overview of biodiversity at the global and national levels, we have dealt in detail with the ecosystems of the region, the genetic diversity of some select taxa, and the species diversity in algae, fungi, lichens, plants, and animals, as well as in some individual taxa, known there. Then the overall threats to biodiversity of the State are considered, followed by presentation of the effectiveness of conservation efforts made here. To cover all these aspects, we have organized the book into 42 chapters arranged in seven parts.

Part I comprises a general introduction to biodiversity and its usefulness, our aims in this treatment, and a summary of all the chapters that follow. Part II reviews the biodiversity of the world, of India, and of the Himalaya regionally. The four chapters of Part III sequentially present a vivid overview of J&K State, a general account on its vegetation, and descriptions of its forest and aquatic ecosystems. Part IV includes three chapters devoted to the genetic diversity of a few select groups of plants and animals. Part V, the largest part, deals in 14 chapters with the diversity of plants, algae, and fungi. The first seven of these (Chaps. 13, 14, 15, 16, 17, 18, and 19) review what is known of local diversity in algae, fungi, lichens, bryophytes, pteridophytes, gymnosperms, and angiosperms. Some important features of the angiosperms of the State are emphasized and presented in the following seven (Chaps. 20, 21, 22, 23, 24, 25, and 26) chapters; these deal, respectively, with aquatic macrophytes, medicinal and aromatic plants, woody plants, Asteraceae, Leguminosae, poisonous plants, and the flora of Ladakh. The ten chapters of Part VI (Chaps. 27, 28, 29, 30, 31, 32, 33, 34, 35, and 36) are devoted to the faunal diversity: ants, butterflies, flies, the insects that attack medicinal and aromatic plants, moths, bark beetles, fishes, amphibians and reptiles, birds, and wild mammals. Part VII (Chaps. 37, 38, 39, 40, 41, and 42) deals with threats that do lead to or might result in the extinction of plants or animals in this Himalayan region and the conservation strategies to deal with such threats. The first two of these chapters deal, respectively, with threatened plants and threatened animals, the third with the impact of urbanization on biodiversity, the fourth with the impact of climate change on vegetation, the fifth with current conservation practices and the challenges they confront, and the final chapter with the legal framework that affects, positively or negatively, biodiversity conservation.

In summary, this book provides a snapshot of all the available information concerning the biodiversity of J&K State. As such, it allows us to understand such matters as the collective species richness for the State better than ever before, with some more intensively studied groups of plants and animals the best known. It provides guidance to which groups are most poorly known taxonomically. We recommend the construction of an electronic catalog (ECAT) of the State's biodiversity, starting with the information reviewed here.

Using the information we have reviewed will allow improved conservation strategies to be devised and implemented in the State. Our organization of local biological information has the potential to become an important element in the biodiversity, conservation, and management (BCM) scheme of the National Mission on Himalayan Studies (NMHS), which is implemented by the Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India. It will also provide helpful information to the Himalayan Biodiversity and Climate Change Knowledge Network (HBCC-KN).

We ardently hope that this book will be of value to all those who, directly or indirectly, have to deal not only with local biodiversity but also with Indian biodiversity in general and also for the whole Himalayan region and even to the attainment of a comprehensive global picture of our biological endowment. Its prospective users include students, teachers, researchers, academics, naturalists, taxonomists, ecologists, environmentalists, conservationists, resource managers, planners, government agencies, NGOs, biodiversity boards and alliances, foresters, and the public at large. For this reason, we consider that our efforts may have a very broad impact and we hope that they will be useful generally.

Srinagar, Jammu and Kashmir, India

Ghulam Hassan Dar
Anzar A. Khuroo

# Acknowledgments

The editors are thankful to all the contributing authors (totaling 87), for their valued contributions to this book. Special thanks are due to the book series editor of *Topics in Biodiversity and Conservation* (Springer Nature) Prof. David L. Hawksworth for his useful comments and kind suggestions about the book. We applaud Dr. Kamaljit Singh Bawa, Distinguished Professor, Department of Biology, University of Massachusetts, Boston, USA, for writing a heartening foreword to the book and Prof. Peter H. Raven, President Emeritus, Missouri Botanical Garden, USA, for his encouragement all along this work. Prof. S.I. Ali, University of Karachi, Pakistan, is greatly thanked for his help with some literature. Thankfulness is due to Prof. Talat Ahmad, Vice Chancellor, University of Kashmir, for providing working facilities to the editors during the final phase of this work. We are grateful to Prof. Irshad Ahmad Hamal and Prof. Javeid Musarrat, ex- and present Vice Chancellors of BGSB University, Rajouri (J&K), for their encouragement. Prof. Zafar Ahmad Reshi, Dean Research, University of Kashmir, and Prof. B.A. Wafai, former Director of the Centre for Biodiversity Studies (CBS), BGSB University, provided some fruitful suggestions and help, for which we cheer them. Prof. Dar is thankful to the Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India, New Delhi, for sponsoring the Mahatma Gandhi Chair on Ecology and Environment which he held at BGSB University, Rajouri, from 2012 to 2015, during which period work on this book was initiated, and to the staff associated with CBS for their help during the initial phase of this project. Dr. Anzar acknowledges the support from various sponsoring agencies, SAC-ISRO, Ahmedabad, and MoEF&CC and SERB-DST, New Delhi, which has helped in undertaking biodiversity surveys across the state over the last decade. The help received in one way or the other from Mr. Akhter Husain Malik, other staff members, and research scholars at the Centre for Biodiversity and Taxonomy, University of Kashmir, is fittingly acknowledged. Prof. Dar also thanks his sons (Dr Tanvir-Ul-Hassan and Sameer-Ul-Hassan), daughter (Dr Rubiya) for their help in computerization and designing of illustrations, and his wife (Zareena) for her forbearance during the long course of this work. Dr. Anzar thanks his parents, wife (Mohsina), and kids (Adeena, Sufwan, and Mansha) for allowing him to use precious home and holiday time on this work, which was otherwise their share. The editors thank M/S Springer Nature and their diligent team, especially John Ram Kumar, Mamta Kapila, Raman Shukla, and last, but not the least, Keerthiga Kaliaperumal for undertaking the arduous job of processing, proofing and printing this huge volume. Lastly, no work can ever claim to be complete and error free, and same is true for this work too. Therefore we request potential readers to share their precious inputs and valuable feedback with the Editors.

# Contents

# Editors and Contributors

## About the Editors

**Professor Ghulam Hassan Dar,** an eminent plant taxonomist, is widely known for his significant research contributions to the biodiversity of Kashmir Himalaya. In more than 40 years of teaching and research career, Prof. Dar has to his credit 200 research publications (including 10 books) and supervised 27 Ph.D. and M.Phil. students. A Fellow of Indian Association for Angiosperm Taxonomy and awardee of its Prof. Y. D. Tiagi Gold Medal, he has also been a recipient of International Fellowship of the Danish Academy of Sciences, Denmark. He has successfully completed several extramural research projects and attended numerous national and international conferences. In pursuit of research and academic collaboration, he has visited many foreign countries. He has held the positions of Head Department of Botany at University of Kashmir, Srinagar, Director CBS, Dean School of Biological Sciences, and prestigious Mahatma Gandhi Chair on Ecology and Environment at BGSB University, Rajouri, India.

**Dr. Anzar A. Khuroo** is currently working as a Senior Assistant Professor at the Centre for Biodiversity and Taxonomy, Department of Botany, University of Kashmir, Srinagar, Jammu and Kashmir (J&K), India. His main areas of research interest include taxonomy, ecology, and biodiversity. He has to his credit about 100 publications in reputed scientific journals and completed and/or ongoing extra-mural research projects. He is a recipient of Young Scientist Award by the Department of Science and Technology, J&K Government and a visiting scientist fellowship from the Institute of Botany, Chinese Academy of Sciences, Beijing, by the Indian National Science Academy. He has served as Country Editor (India) for IUCN-led *Global Register of Introduced and Invasive Species*, and is presently serving as Associate Editor for the journal *Conservation Science* and Section Editor (Botany) for *Checklist*. He has decade-long teaching experience at postgraduation level and also coordinates Massive Online Open Course on Plant Systematics, hosted by Consortium for Educational Communication, University Grants Commission, India.

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# Part I
# General Introduction

# Chapter 1
# An Introduction to Biodiversity of the Himalaya: Jammu and Kashmir State

**Ghulam Hassan Dar and Anzar A. Khuroo**

**Abstract** The chapter provides a brief introduction about the emergence of biodiversity concept and highlights its vital value as the very basis of sustenance of life on Earth on one hand and its continuous alarming loss on the other, thereby underlining the need for its documentation, conservation, and sustainable use at the global, national, and local levels. India, being a globally recognized megabiodiversity country, harbors about 12% of world's biota, though forming only 2.2% of its land area. The Indian Himalayan Region (IHR), with only ca. 13% of the Indian landmass, contains about half of its known species, most of which are endemic to the country. The Jammu and Kashmir (J&K) State, representing the major portion of the IHR, comprises of three mutually distinct biotic provinces (Jammu, Kashmir, and Ladakh), each showing equally diverse topography and habitat diversity which support a rich repository of biodiversity. The knowledge on biodiversity of this State, however, is scattered in a plethora of scientific literature published over the last two centuries, which is mostly fragmentary, inaccessible, and often outdated. This necessitated their collation, expert scrutiny, updated documentation, and consolidation under a single cover in the present book. The present introductory chapter provides a synthesis of the contents of the book, with a lucid synopsis of each of the 42 chapters contained in it, as well as summarized figures of the current status of biodiversity in various taxonomic groups of J&K State.

**Keywords** Biodiversity · Documentation · Conservation · Himalaya · Jammu and Kashmir State

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_1

## 1.1 Introduction

We are living in an era of Anthropocene, where unprecedented loss of biodiversity is recognized as one of the major global environmental concerns confronting humanity (Corlett 2015; Mehraj et al. 2018). This growing global concern is well-reflected in the United Nations Sustainable Development Goal (SDG) 15: “protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.” In fact, in the month of May 2019, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) released Global Assessment Report on Biodiversity and Ecosystem Services, which was first such global synthesis on the issue of biodiversity since the Millennium Ecosystem Assessment in 2005. With contributions from 400 leading international experts from 50 different countries, the IPBES Report examined the causes of biodiversity loss, the impacts on general public, policy options available, and likely future pathways and scenarios. The Report aims to provide a holistic understanding of where the world stands in relation to key international goals, including the Sustainable Development Goals, the Aichi Biodiversity Targets, and the Paris Agreement on climate change (IPBES 2019).

In recent times, mountains across the world are receiving increasing attention from researchers, natural resource managers, and policy-makers. In terms of global biodiversity, mountains support 25% of the known terrestrial biodiversity (Wester et al. 2019). The Himalaya, one of the majestic marvels of mountain chains in the world, is a global biodiversity hotspot (Zachos and Habel 2011). With rising risks of climate change and rampant land use transformations across the Himalaya (Hamid et al. 2018), the rich repository of biodiversity in this mountainous region is becoming increasingly threatened. In this regard, the Target 15.4 of SDG 15 assumes immediate relevance: “by 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development.” The Himalayan chain of mountains is spread over eight Asian countries from Afghanistan in the west to Myanmar in the east and comprises of several sub-regions with their unique topography, biodiversity, history, communities, and culture. The Jammu and Kashmir (J&K) State, situated in the north-western extremity of the Himalaya, is well-known for its breathtaking natural landscapes and bounty of biodiversity. The present book, first of its kind, presents a comprehensive synthesis of all the existing knowledge about the biodiversity of J&K State; and this introductory chapter provides a concise summary of each of the 42 chapters contained within the book.

## 1.2 What Is Biodiversity?

The term “biodiversity” was first coined in late 1987 (Wilson 1988) as contraction of the phrase “biological diversity” proposed about 15 years earlier (Raven this volume), though some components of the concept have been known since very early times in the history of science. Biodiversity refers to the variety and variability of living organisms and of the ecological complexes in which they occur (Dar and Farooq 1997; Dar et al. 2002). One of its early and simple definitions is that of Wilcox (1984), according to which biological diversity is “the variety of life forms in a given region, the ecological roles they perform and the genetic diversity they contain.” A more detailed and wider definition is that adopted in the United Nations Conference on Environment and Development at Rio de Janeiro in 1992 and given in Article 2 of the Convention on Biological Diversity (CBD) in 1993 (Glowka et al. 1994), which reads as “‘Biological Diversity’ means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems.” This definition explicitly recognizes three major ascending levels of biodiversity: genetic, species, and ecosystem diversity. In practice, however, biodiversity is usually described in terms of species because of relatively recent emergence of the concepts of genetic and ecosystem diversity and complexities involved in their scientific characterization. In terms of spatial scale, biodiversity is also described as *alpha*, *beta*, and *gamma* diversity, with respect to diversity within a particular site, between two such sites, and among all the sites within a habitat/region/landscape, respectively.

Biodiversity is a fast-evolving science with the increasingly robust databases, analytical tools, and climate change models having led to substantial progress in understanding biodiversity distribution and rates of change (Dirzo and Loreau 2005). As of now, “biodiversity science is progressing in leaps and bounds, empowered by the sharing of large amounts of data” (William et al. 2018). Notwithstanding this, the fundamental question, “how many species does our planet have,” which as per May (2010) would be one of the first questions asked even by aliens if they happen to visit here, has been daunting the scientists for having no certain answer. This highlights a dire need of knowing how many species are there on Earth and our hitherto limited progress with this basic issue (Erwin 1991; May 1992; Storks 1993; Gaston and Blackburn 2000; May 2010; Mora et al. 2011).

## 1.3 Why Biodiversity Is Important?

The biodiversity, hallmark of the planet Earth, is the current biological buzzword. Biodiversity is a blanket term embodying a multifaceted concept covering the entire range of diversity in all the life forms from microorganisms through fungi, plants to animals and at all levels from the genes, individuals, populations, species, communities, and ecosystems.

It is a global natural resource of immense value, providing all the biological resources and social and spiritual benefits, besides being of vital use in the present-day biomimicry. It is equally a profitable investment, having great prospects in both public and private sectors, as well as in industries and MNCs; it is indeed pivotal in achieving United Nations sustainable development goals (see Stone et al. 1997; Dar et al. 2002). At least 40% of the world's economy and 80% of the needs of the poor are said to be derived from biological resources (CBD).

In addition to direct-use values, biodiversity provides the ecosystem services – the processes which are unquantifiable economically but form the very basis of life-supporting systems, thus being crucial to the sustenance of human life. As an example, the global economic value of pollination services performed by insects has been valued at $217 billion per year (Gallai et al. 2009).The latest Global Environment Outlook (GEO-6) has a message that "the health of the planet and its people depend absolutely on biodiversity" (Davies and Stoett 2018).

## 1.4 Loss of Biodiversity and Need for Its Documentation

Notwithstanding its indispensability for the existence and continuation of life on Earth, biodiversity is being lost at an alarmingly increasing rate, largely due to unprecedented anthropogenic activities. Currently, the rate of species extinction is believed to have exceeded 1000 times than the background extinction rate in geological past (Wilson 1992, Raven 1994, Dar and Farooq 1997). Realizing the severity of global biodiversity crisis, countries across the world have become seriously concerned about their fast dwindling biodiversity and are striving to devise ways and means for its sustainable use and conservation. This necessitates comprehensive knowledge about biodiversity at the world, national, and regional levels, which among other things includes up-to-date scientific documentation, distribution, utilization, and determination of threat status in all the groups of biota, from the microbial to the largest life forms (Heywood 1995). Responding to this requirement, different countries of the world have arrived at different advancement levels of biodiversity studies. Majority of the developed countries have completed the documentation of biodiversity and compiled Red Lists for plants and animals; however, most of the developing countries, which harbor the maximum proportion of global biodiversity, still lag in completing the documentation of their biota.

In the summary of recently released IPBES report, the most comprehensive ever completed assessment of its kind, around one million animal and plant species are reported to be as threatened with extinction, many within decades (IPBES 2019).

## 1.5 Status of Biodiversity in India and Its Himalayan Region

India, with only 2.20% of the world's land area, contributes ca.12% of the global biota and is, thus, recognized as one of the mega-biodiverse countries. Ranked 12$^{th}$ in the world in terms of total number of catalogued species [1,50,170 species (49,003 plants + fungi (Singh and Dash 2018) + 1,01,167 animals (Venkataraman et al. this volume) out of 1,244,360 in the world (Mora et al. 2011)], India is part of two of the major bio-realms, three biomes and all the major ecosystems of the world (Dar et al. 2002). The Indian Himalayan Region (IHR), constituting only about 13% of the Indian landmass, harbors about half of its known biodiversity, most of which is endemic to the country. Notwithstanding this strikingly rich biota, the IHR is such a vast and heterogeneous landscape in its physiography, topography, climate, altitude, and culture (Bawa and Kadur, 2013), that it has not so far been possible to document its overall biodiversity, especially in microorganisms and lower groups of plants and animals.

## 1.6 Status of Biodiversity in Jammu and Kashmir State

The Indian Himalayan State of Jammu and Kashmir, spreading over three biogeographic zones, Trans-Himalayan zone of Ladakh, Northwest Himalaya of Kashmir, and Western Himalaya of Jammu (Rodgers et al. 2002), is a vast biological paradise. Bestowed with a bewitching habitat diversity from the plains of Jammu (<300 m), through mountain-girdled Kashmir (1600–4250 m), cold desert of Ladakh (>3000 m), to the summit of Nanga Parbat (8126 m) and the K2 (8611 m), the undivided State has a correspondingly rich biota and has been aptly called as a "biomass State" (Khoshoo 1997). Being such an abode of biodiversity, complete documentation of the biota of this State assumes urgent priority. Ahmedullah (1997) attempted a profile of the biodiversity of Jammu and Kashmir, but it is too preliminary and grossly incomplete, giving a sketchy account based on some selected publications on angiosperms and higher animals. Dar et al. (2002) provided a synthesis of information available till then on the floristic and faunal groups in only one of the provinces (i.e., Kashmir Valley) of the State. The focus in the book has been to put together the information available on species richness of plants and animals, major uses they are put to, threats they face, and steps taken for their conservation. Notwithstanding this work and some other publications, a complete and consolidated account of the biodiversity of Jammu and Kashmir State is still lacking. Many of the publications on various aspects of its biodiversity are still preliminary, fragmented, scattered in scientific literature, or unavailable due to inaccessible sources.

## 1.7 Aims, Process, and Coverage of the Present Book

Existence of yawning knowledge gaps prompted us to undertake work on the present book for achieving an inclusive, up-to-date, and consolidated synthesis of all known biodiversity of Jammu and Kashmir State and present it under a single cover. Known experts working on various aspects of biodiversity at the international, national, and State levels were identified and requested to write chapter(s) of their specialized group of organisms as per a format set for this book and within a defined time frame. While some of them responded on time, some others delayed their chapters considerably, while a few backed out at the eleventh hour, necessitating us to contact other experts for writing the leftover chapters (see also preface).

The book provides the readers an introductory, wide-ranging perspective of biodiversity at the global level, followed by summarized accounts of biodiversity of India and the Himalaya, so as to allow them to grasp and analyze with ease detailed information presented on various biotic groups of the Jammu and Kashmir State. To accommodate this huge information, there are 42 chapters in the book, which are arranged under 7 parts.

Part I comprises of single chapter (current chapter) that deals with introduction to documentation of biodiversity of J&K State (Dar and Khuroo this volume). After a brief account of biodiversity (its definition, importance, loss, and need for documentation), it provides an overview of the known biodiversity at the global and Indian levels, followed by its updated status in J&K State. It is emphasized that India, with only 2.20% of world's land area, has ca. 12% of its biota, making it a mega-biodiverse country and that Himalaya, with only 18% Indian landmass, harbors ca. half its known species of biota to make it a global biodiversity hotspot. J&K is a vast State, with tremendous habitat heterogeneity, resulting in a correspondingly rich biodiversity. Up-to-date documentation of this biodiversity under a single cover is the urgent task that has been undertaken in the present book in 42 chapters arranged under 7 parts. This chapter concisely summarizes the results of all the chapters included in the present volume.

Part II presents a general account of biodiversity in the world, India, and the Himalaya under four (2–5) chapters. Chapter 2, while providing an overview of global biodiversity, highlights that most of the 12 million eukaryotic species that share this planet, together with numerous prokaryotes, are still unknown (Raven this volume). It states that, despite complete dependence of humans on other organisms for making life possible on Earth, our current consumption patterns are so high that we are on the threshold of one of the most devastating extinction events that have ever occurred. It further warns that the humans have embarked on a very dangerous experiment which must be stopped both locally and globally before it becomes too late. Lastly, the chapter emphasizes that Jammu and Kashmir State is home to one of the richest and the most diverse assemblies of biodiversity found in the South Asia and calls for an urgent research attention toward an internationally based effort to save as much of these riches as possible. Chapter 3 provides an updated synthesis of the floristic diversity of India (Singh this volume). It states that out of 49,003 species of plants (including viruses, bacteria, fungi and lichens) occurring in India, angiosperms comprise ca. 18,532 species, representing ca. 10% of all known flowering plants of the world, and that about 4300 (23.20%) species of angiosperms are endemic to the country. The largest angiosperm family in the number of species is Leguminosae (1421 spp.), followed by Poaceae (1291 spp.), Orchidaceae (1251 spp.), Asteraceae (1120 spp.), and Rubiaceae (679 spp.). The largest genus is *Impatiens* (279 spp.), followed by *Carex* (160 spp.), *Pedicularis* (145 spp.), *Bulbophyllum*, and *Primula* (135 spp. each). The chapter briefly reviews vegetation pattern in the country, together with species richness in various taxonomic groups of land plants, algae, fungi, and lichens, as well as phytogeographical analysis of the Indian flora. Chapter 4 summarizes the current knowledge about the faunal diversity in India – its various ecosystems and species richness (Venkataraman et al. this volume). It states that, out of 15,66,353 animal species in the world, 1,01,167 species are known from India. Thus India, with only 2.20% of the world's land area, accounts for 6.45% of its recorded faunal species. The chapter highlights that the faunal inventory in India, however, is detailed mostly in the case of commercially important higher animal groups, but very preliminary with respect to minor phyla or microbial organisms. In terms of spatial coverage, probably only two-thirds of the total area of India has so far been covered, and the remote islands and other such far-flung areas remain still unexplored. The chapter concludes that the actual faunal diversity in India could be several times more than what is known today. Chapter 5 discusses the floristic diversity and distribution of land plants in the Indian Himalayan Region (IHR) (Singh and Pusalkar this volume). It states that angiosperms in the region are represented by 8700 taxa, gymnosperms by 51 taxa, pteridophytes by 766 taxa, and bryophytes by 1955 taxa. Orchidaceae with ca. 1036 taxa and *Rhododendron* with 121 taxa are the largest family and genus, respectively, with both showing their maximum species richness in the Eastern Himalaya. Ranunculaceae, Brassicaceae, Rosaceae, Asteraceae, and Orchidaceae are said to have more than 75% of their Indian taxa represented in the IHR. The chapter estimates ca. 12% of the Himalayan angiosperms are endemics, while an equal number of taxa are currently falling under various threatened categories. Among non-flowering plants, Ephedraceae, Dryopteridaceae, and Pottiaceae are the most species-rich families of gymnosperms, pteridophytes, and bryophytes, whereas *Ephedra*, *Thelypteris*, and *Plagiochila* are the most diverse genera of these taxonomic groups, respectively. Eight taxa of the Himalayan gymnosperms, 25 of pteridophytes, and 308 of bryophytes are endemic to India, majority of which are restricted to the IHR. The chapter concludes by providing an overview of the topography and vegetation of the region, its curious and sacred elements, and conservation needs.

Part III presents a general account of biodiversity of Jammu and Kashmir (J&K) State under four (6–9) chapters. Chapter 6 provides a general introduction to the J&K State (Romshoo et al. this volume). Besides brief overview about location, geography, and geology, the chapter states that the altitude in J&K State ranges from 220 m to 8611 m (amsl), rising from the foothills of Shivalik in the south to Karakoram in the north. On the basis of climate, the State is divided into three divisions: subtropical Jammu in the south, temperate Kashmir in the middle, and cold desert of Ladakh in the east. The State has 22 administrative districts, 10 each in Jammu and Kashmir provinces and 2 in Ladakh. The (presently Indian-administered) State is spread over an area of 1,01,386 km$^2$, with the Kashmir region occupying 15.73%, Jammu 25.93%, and the Ladakh region 58.33%. Geologically, the State depicts rocks of all ages, from the Archean to the recent alluvium, whereas hydrologically, it boasts of numerous freshwater lakes, wetlands, and glaciers (the largest glacier being the Siachen in Ladakh), which sustains three major rivers – Indus, Jhelum, and Chenab. The chapter also provides brief account on population, culture, economy, and biogeography of the State, besides highlighting the disasters it is vulnerable to. Chapter 7 describes general vegetation of J&K State (Vir Jee this volume). The chapter states that Kashmir has experienced major geo-climatic perturbations in the recent geological past. Even though only a few of the Pleistocene taxa (conifers, birches, barberries, alders, figs, cherries, horse chestnuts, etc.) thrive in Kashmir today, majority of them have emigrated toward more suitable habitats in the outer Shivalik ranges in Jammu. The extant vegetation of the State manifests a remarkable degree of differentiation: while as vegetation of Kashmir reveals a typical blend of temperate, sub-alpine, and alpine elements, no such stratification is discernible in Ladakh, where cold desert vegetation type occurs. In Jammu, the predominantly subtropical vegetation reflects peculiarities within the plains, kandi, and foothill types, though an admixture of some temperate elements renders a transitional touch to the prevailing vegetation along Rajouri-Poonch and Doda-Kishtwar ranges. It is emphasized that an adaptive evolutionary potential with reference to the varied environmental conditions is depicted by the vegetation along the wide altitudinal gradient in the State. The alien plant invasions and biotic stress are reported as having considerably increased in the recent past. Chapter 8 makes available a concise review of the forest ecosystems of J&K State (Haq et al. this volume). The chapter provides an account of various attempts made on classification of diverse forest types occurring in the State. It is supplemented with precious information on species composition and structure of each forest type. The various threats currently faced by the forests of the State have been discussed and conservation measures suggested. Chapter 9 provides an overview of the diversity of aquatic ecosystems in the State, with a bird's-eye view of their biodiversity status (Shah et al. this volume). The diverse forms of aquatic ecosystems (lakes, wetlands, rivers, streams) represent an integral part of State's natural landscape and render a range of life-supporting economic goods and ecosystem services to its people. The lakes and wetlands occur from valley lands to high altitudes and harbor a rich diversity of macrophytes, phytoplankton, zooplankton, and macro-fauna. Over the years, however, the aquatic ecosystems in the State have been under severe anthropogenic pressures, deteriorating significantly their ecological status. The major threats to these ecosystems are also highlighted and some management models discussed.

Part IV deals with genetic diversity of some plant and animal groups of J&K State under three (10–12) chapters. Chapter 10 describes genetic diversity in apple, apricot, and almond, the three important rosaceous fruits of J&K State (Wani et al. this volume-a). Apple, ranking first in terms of area and production in the State, is represented by more than 190 cultivars. Some of the widely grown cultivars include

Red Delicious, Royal Delicious, Shimla Delicious, Kullu Delicious, Mollies Delicious, American Trel, Maharaji, Razakwari, and Kesri. Due to the monoculture of Delicious apples, however, many cultivars, such as Ambri, Kashur Farash, and Shireen Dahan are at the verge of extinction. The Ladakh region and some parts of Kashmir host a rich apricot germplasm, which include Afgani, Raktse-Karpo, Halman, Australian Sweet, and Charmagz. Another important stone fruit in the State, particularly Kashmir, is almond. Three types of almond, sweet hard-shelled, bitter hard-shelled, and paper-shelled, are cultivated in J&K; and some common cultivars grown include Shalimar, Makdoom, Waris, Non Pareil, and Kagzi. Due to high economic returns in apple, cultivation of other rosaceous fruits in Kashmir has not received due attention. As a result, genetic diversity of traditional land races of such fruits has greatly eroded. Chapter 11 documents the existing agro-biodiversity of J&K State with particular reference to the major cereal crops, namely, maize, wheat, barley, and rice (Zeerak this volume). The chapter lists varieties of these cereal crops, including traditional farmer's varieties, land races, released varieties, and State-related varieties. It is pointed out that the well-adapted indigenous cultivars of these crops are now increasingly being threatened due to their rapid replacement by the modern high-yielding varieties. As such, scientific management for conservation of these invaluable genetic resources is urgently required in this State. Chapter 12 describes genetic diversity in pond snail (*Lymnaea acuminata* – Pulmonata: Lymnaeidae) from the Jammu region of J&K State (Tripathi and Sharma this volume). Pond snail is a generalist species with a wide Palaearctic distribution and grows in relatively unstable habitats with large fluctuations in temperature and water level and occasional desiccation. The results, based on morphometric and RAPD analysis, have revealed that the shape of shells in subtropical populations is highly differentiated from those in intermediate and temperate populations. The RAPD analysis showed close linkage between the populations of subtropical, intermediate, and temperate habitats with a limited genetic variation. It is concluded that populations in various habitats may share a common ancestor and that the difference in their shell morphology may be due to phenotypic plasticity.

Part V covers 14 (13–26) chapters, dealing with floristic diversity of J&K State. Chapter 13 documents the algal diversity of J&K State (Kaloo and Amin this volume). Because of abundance of lakes and wetlands, the State possesses a rich diversity of freshwater algae. A total of 1065 taxa of algae are reported from the State as a whole. Based on species richness, Bacillariophyceae (299 species, 56 varieties, and 8 forma) are the largest class, followed by Chlorophyceae (240 species, 39 varieties, and 8 forma), Cyanophyceae (216 species, 5 varieties, and 3 forma), Desmidiaceae (102 species, 22 varieties, and 2 forma), Euglenophyceae (44 species and 2 varieties), Chrysophyceae (5 species), Dinophyceae (4 species), Xanthophyceae (4 species and 1 form), Charophyceae (2 species and 1 variety), Rhodophyceae, and Cryptophyceae (1 species each). Chapter 14 documents the fungal diversity of J&K State. A total of 548 species of fungi are reported from the State (Wani et al. this volume). These include 268 and 280 species of micro- and macro-fungi, respectively. *Basidiomycetes* with 182 species are the dominant group, followed by *Ascomycetes* with 25 species. Among *Basidiomycetes*, in terms of species richness, the largest families are *Russulaceae* (with 29 species), *Cortinariaceae*, and *Boletaceae* (17 species each), *Coprinaceae* (12 species), and *Trichlomataceae* (11 species), whereas the largest genus is *Russula* (with 21 species), followed by *Amanita* (11 species). In *Ascomycetes*, the largest family is *Morchellaceae* (with 7 species), followed by *Helvellaceae* (6 species) and *Pyronemataceae* (5 species), whereas the larger genera are *Morchella* and *Helvella* (with 5 species each). The chapter emphasizes that till now only preliminary studies on fungal diversity in the State have been conducted, thus necessitating urgent research attention. Chapter 15 deals with lichen diversity in J&K State (Khare et al. this volume). From the State, 424 species of lichens are reported, which belong to 126 genera in 38 families, and represent ˃18% of total lichen species so far known from India. *Parmeliaceae* is the largest family with 73 species, followed by *Lecanoraceae* (53 species), *Physciaceae* (48 species), and *Teloschistaceae* (36 species). *Buellia*, *Caloplaca*, *Cladonia*, *Lecanora*, *Parmotrema*, *Phaeophyscia*, *Physcia*, *Peltigera*, and *Ramalina* are the most common genera in the State, while more than 30 genera show restricted distribution. Lichens in the State display diverse growth forms, being represented by 178 species of crustose, 159 foliose, 32 squamulose, 28 fruticose, 23 dimorphic, and 4 leprose. Likewise, the corticolous species dominate with 240 species, followed by 163 saxicolous, 46 terricolous, 21 muscicolous, and a single folicolous species. It is emphasized that extensive exploration in poorly explored and unexplored districts of the State will add to the number of lichen taxa reported herein. Chapter 16 presents an updated checklist of the bryophytes of J&K State (Ismail et al. this volume). The bryoflora of the State comprises of 420 species belonging to 158 genera in 56 families. Mosses comprise of 328 species and liverworts 91 species, but only single species of hornworts, *Phaeoceros laevis*, has been recorded from district Rajouri of the Jammu province. Three larger families in mosses are Pottiaceae (with 66 species), Bryaceae (35 species), and Brachytheciaceae (32 species), whereas three larger moss genera are *Brachythecium* (with 24 species), *Orthotrichum* (17 species), and *Bryum* (13 species). Three larger families in liverworts are Aytoniaceae (with 15 species), Porellaceae (11 species), and Marchantiaceae (9 species), whereas three larger liverwort genera are *Porella* (with 11 species), *Marchantia* (7 species), and *Plagiochila* (7 species). Chapter 17 provides an updated account of the pteridophytic flora of J&K State (Kumar et al. this volume). A total of 200 species of pteridophytes, belonging to 44 genera under 19 families, are reported from the State; these include 189 taxa of ferns and 11 of fern allies. Among ferns, the largest family is Dryopteridaceae (with 43 taxa), followed by Pteridaceae (41 taxa), Woodsiaceae (33 taxa), Aspleniaceae (22 taxa), Thelypteridaceae (17 taxa), and Polypodiaceae (13 taxa). The largest family among fern allies is Selaginellaceae (with 6 taxa). Twenty-nine doubtful reports published by earlier workers are also appended. All the taxa are provided with brief ecological notes and distribution in the State. Chapter 18 unveils the diversity of gymnosperms in J&K State (Dar and Dar this volume). A total of 41 species, 20 growing in wild and 21 under cultivation, are reported from the State; these species belong to 18 genera in 10 families. Conifers are the largest group comprising 31 species in 13 genera, with family Cupressaceae having the largest number of species (16) in 4 genera. *Juniperus* is the largest genus (with 8 species: 6 wild +2 cultivated), followed by *Ephedra* (6 species: all wild). While the majority, i.e., 31 species, are trees, the remaining 10 species show shrub/sub-shrub habit. In all, 28 species are reported from the Kashmir region, 26 from Jammu, and only 10 species from the Ladakh region. The chapter also gives an overall glimpse of composition, association, and distribution of wild gymnosperm species in different forest ranges of the State.

Chapter 19 presents a comprehensive checklist of angiosperms, the largest plant group in J&K State (Dar and Khuroo this volume-b). A total of 5056 taxa, comprising of 4778 species plus 278 subspecies/varieties, belonging to 1, 306 genera in 180 families are recorded from the State. Asteraceae, with 613 species plus 50 subspecies/varieties in 130 genera, is the largest family, followed by Poaceae, Fabaceae, Brassicaceae, and Rosaceae. The larger genera in the flora include *Taraxacum* (with 83 species, mostly apomicts), followed by *Carex*, *Potentilla*, *Astragalus*, *Artemisia*, *Saussurea*, etc. It is emphasized that 5056 taxa of angiosperms recorded from the State constitute 27.28% of all the angiosperm species in India and 58.11% of the angiosperm flora of the Indian Himalayan Region. Furthermore, many families and genera in the State contain 50% or more of their total species occurring in India. These results reveal that J&K is a mega-biodiversity State of India, rich in endemics, arboreal, aquatic, medicinal, and crop plants. A good proportion of the flora, however, comprises exotic weeds, some of which have become invasive.

Chapter 20 provides an updated checklist of aquatic macrophytes of J&K State (Ganie et al. this volume-a). In total, 191 species of aquatic macrophytes are recorded from the State. These species include both aquatic and semi-aquatic plants and belong to 80 genera in 37 families; 22 families belonging to dicotyledons, 12 to monocotyledons, and 3 to pteridophytes. These aquatic plants include different growth forms: submerged, emergent, floating, free-floating, floating/emergent, emergent/submerged, and floating/submerged, which together comprise 92 species; the remaining 99 species are emergent and semi-aquatic. Most of the aquatic macrophyte plants (160 spp.) occur in the Kashmir region, followed by Jammu (94 spp.) and Ladakh (44 spp.). Chapter 21 presents diversity in medicinal and aromatic flora (MAPs) of the Kashmir Himalaya (Ganie et al. this volume-b). A total of 833 plant species, belonging to 378 genera in 112 families, are reported being used as MAPs. Of these, 749 (89.91%) species belong to dicotyledons, 66 (7.92%) to monocotyledons, and 10 (1.20%) to gymnosperms, while 8 (0.96%) species belong to pteridophytes. Asteraceae have the largest number of 126 MAP species. In all, 709 (85.14%) species are herbs, 59 (7.06%) shrubs, 31 (3.71%) sub-shrubs, and 34 (3.60%) trees. Most of these species (818) inhabit terrestrial habitats, 10 species are aquatic, while some are parasitic herbs. These plants are used, either as whole plant or its parts, to treat more than 50 types of diseases in humans and livestock. Some of the plants are used to treat more than one disease; likewise more than one medicinal plant may be used to treat a particular disease. Information on altitudinal distribution of MAPs and on anthropogenic threats to them is also appended. Chapter 22 provides an annotated inventory of the arboreal flora of J&K State, including both native and exotic species (Malik et al. this volume). It is asserted that, as a surrogate of biota in a region, arboreal flora is extremely useful for rapid assessment and monitoring of biodiversity. A total of 768 woody species belonging to 362 genera in 106 families are documented. These include 382 species which exclusively grow in wild, 323 species cultivated for different purposes, and 63 species both cultivated and growing as wild. The trees, shrubs, sub-shrubs, and woody climbers are represented by 291, 364, 39, and 74 species, respectively. The three regions – Jammu, Kashmir, and Ladakh – contribute 561, 384, and 92 species, respectively, to the total arboreal flora of this Himalayan State. Chapter 23 gives an account of Asteraceae in Jammu and Kashmir Himalaya (Bhellum this volume). Asteraceae is the largest plant family in the J&K State. The article reports a total of 554 asteraceous species, belonging to 133 genera in 12 tribes, from Jammu & Kashmir regions of the State. These species constitute nearly 50% of all known species of Asteraceae from India and 11% of the entire angiosperm flora of the State. The constituent taxa are fairly distributed across different climatic zones – subtropical, temperate, and alpine. Cichorieae is the largest tribe, followed by Cardueae and Inulaeae. The five larger genera are *Taraxacum*, *Artemisia*, *Saussurea*, *Erigeron*, and *Lactuca*. Several of the species are endemic to this Himalayan region, while many others are exotic. Information on economic importance of some taxa is also appended. Chapter 24 provides a systematic checklist of Leguminosae in J&K State (Sanjappa and Ambarish this volume). The family is represented in this State by 399 species belonging to 106 genera in 36 tribes under 3 commonly recognized subfamilies: Caesalpinioideae (33 species in 11 genera under 4 tribes), Mimosoideae (28 species in 9 genera under 4 tribes), and Papilionoideae (338 species in 86 genera under 28 tribes). Papilionoideae is the largest subfamily, accounting for 84% of all legume species of the State; and *Astragalus* is the largest genus with 55 species. Among Caesalpinioideae, *Senna* is the largest genus with 11 species, while in Mimosoideae, *Acacia* is the largest genus with 12 species. It is reported that three legume species from the State, viz., *Hedysarum astragaloides*, *H. cashmirianum*, and *H. microcalyx*, are included in the Red Data Book of Indian Plants, while 12 species are listed in the IUCN Red List. Chapter 25 gives a checklist of poisonous plants of the Kashmir Himalaya. The checklist, based on thorough exploration of the region and extensive literature review, reports 152 species of poisonous plants from this region (Ahmad et al. this volume-a).These species belong to 127 genera in 59 families. It is reported that several traditional naturopaths were consulted to obtain information about toxic effects and medicinal uses of these plants. Chapter 26 provides an annotated inventory of the angiosperm flora of Ladakh (Shukla and Srivastava this volume). Based on about 20,000 plant specimens collected since 1975, the inventory lists 1085 species of angiosperms from the Ladakh region, which belong to 370 genera in 74 families. Poaceae is the largest family with 184 species, followed by Asteraceae with 122 species and Fabaceae and Brassicaceae with 77 species each. *Astragalus* is the largest genus with 35 species, followed by *Carex* with 28 species and *Poa* with 27 species. Herbs account for 1010 species, shrubs 48 species, trees 13 species, and under-shrubs 11 species, whereas climbers and twiners have 2 and 1 species, respectively. It is emphasized that the Ladakh flora is unique, having been generally influenced by altitude, climate, soil, and drainage.

Part VI covers ten (27–36) chapters, dealing with faunal species diversity of J&K State. Chapter 27 documents ants (Hymenoptera: Formicidae) of J&K State (Wachkoo et al. this volume-a). The inventory – first ever comprehensive overview of ants in the State – is based on relevant scientific literature and museum collections, combined with data obtained from the field surveys during last one decade. The inventory records 198 ant taxa (species and subspecies), representing 54 genera and 7 subfamilies. It is emphasized that much research effort is required to explore and document the unknown ant diversity in this Himalayan region. Chapter 28 deals with biodiversity of butterflies (Lepidoptera: Rhopalocera) of J&K State (Qureshi this volume). A total of 408 species are listed for the State, which account for about 27% of the India's butterfly fauna. These species belong to 129 genera in 25 subfamilies and 5 families. Ladakh region harbors most of these species (317), followed by Kashmir (274 species) and Jammu (192 species). Nymphalidae is the largest family in terms of number of species (166), followed by Papilionidae (81), Lycaenidae (80), Pieridae (50), and Hesperiidae (31 species). In total, 150 species are common to all 3 regions of the State; while 17, 50, and 116 species occur exclusively in Jammu, Kashmir, and Ladakh, respectively. Thirty-eight from the State's butterfly species are reported as included in the Wildlife (Protection) Act of India (1972). The article is hoped to offer a baseline for undertaking further research and devising conservation strategies for biodiversity fauna of this Himalayan State. Chapter 29 presents inventory of select Brachycera families (Diptera) in J&K State (Wachkoo et al. this volume). These families include Bombyliidae (bee flies), Conopidae (thick-headed flies), Dryomyzidae (dryomyzid flies), Megamerinidae (megamerinid flies), Stratiomyidae (soldier flies), Syrphidae (hover flies), and Ulidiidae (picture-winged flies). Altogether, 107 species have been reported from the State. Family Syrphidae is the most diverse with 88 species distributed over 33 genera, followed by Bombyliidae with 7 species in 6 genera. Among other families, Conopidae is represented by six species in four genera, Stratiomyidae by three species in three genera, whereas Dryomyzidae, Megamerinidae and Ulidiidae have a single species each. The article is hoped to provide impetus for further research on this important insect group in the State. Chapter 30 deals with diversity of insects infesting medicinal and aromatic plants in the Kashmir Valley (Razak and Ahmad this volume). In total, 91 insect species, including 1 new species, under 36 families are identified as inflicting damage to various parts of medicinal and aromatic plants. In addition, 27 species of insect parasitoids, including 5 new species, and 11 species of insect predators are reported to control these phytophagous insects. In all, 14 species are reported for the first time from Kashmir and 12 species for the first time from India, while 2 species are first reported from the Indian sub-continent. A total of 65 plant species in 35 families are recorded as hosts to these insects; these include 25 new host-plant records and 51 new insect-host plant associations. Out of these 65 host plant records, 13 plant species (18.8%) are reported as threatened (Kaul 1997). Chapter 31 provides a taxonomic overview of moth (Lepidoptera) fauna of J&K State (Dar et al. this volume). Based on review of scientific literature, museum collections and data generated from the field surveys since 2002, the list of moths from J&K State is provided which includes 461 species belonging to 23 families classified under 12 superfamilies. Noctuoidea (with 283 spp.) is the most diverse superfamily, Erebidae (with 152 spp.) is the most diverse family, whereas *Cyana* (with 16 spp.) is the richest genus. Jammu is the most moth-speciose region with 392 species, followed by Kashmir (with 332 spp.) and Ladakh region (with 136 spp.). Some of the species are reported to act as pests, causing considerable damage to major crops. It is hoped that the present study will provide baseline data and facilitate further research on this important group of insects in this Himalayan region.

Chapter 32 deals with bark beetle (Coleoptera: Curculionidae: Scolytinae) fauna of J&K State (Buhroo et al. this volume). Taxonomic diagnosis, distribution, and host plant aspects of 12 species of bark beetles belonging to 5 genera under 4 tribes are recorded from different areas of the State. The bark beetles being considered as the most damaging pests in forest ecosystems, the chapter provides baseline data for undertaking advanced systematic studies on them and devising strategies for their effective management and control in this Himalayan region. The article emphasizes that, in view of these beetles being serious forest pests, thorough surveys and in-depth research studies need to be undertaken in this State for their overall inventory to facilitate their proper check and control.

Chapter 33 deals with diverse fish fauna supported by variety of aquatic systems in J&K State (Bhat et al. this volume-a). A total of 120 species of fishes are recorded from the J&K State. Among these, 105 species occur in the Jammu region, 23 in Kashmir, while 15 species inhabit the Ladakh region. In all, eight species are common across the three provinces of the State. High species richness in the Jammu region is attributed to the presence of warm water fishes, while their low number in Ladakh is probably due to its high altitude, cool climatic conditions during winter, and high water turbidity during summer. Over the years, species composition, distribution, and abundance of fishes in this State have witnessed significant changes. This has resulted in the dominance of exotic fishes in various aquatic ecosystems and many indigenous species, known to contribute substantially to capture fishery in the past, have either disappeared or restricted to isolated aquatic habitats. Chapter 34 provides an annotated list of amphibians and reptiles of J&K State (Sahi and Koul this volume). A total of 17 species of amphibians and 63 species of reptiles are documented from J&K State. The amphibian species belong to ten genera under four families, with Ranidae being the largest family with eight species in six genera. The reptilian species are grouped into 44 genera under 14 families. Colubridae (Ophidia) is the largest family with 20 species in 13 genera. Whereas most of the amphibian species are reported to occur from the Zanskar range in the Greater Himalaya, the reptiles mostly occur along the Shivalik range in the Lesser Himalaya. The article emphasizes that, in view of incomplete survey and collection of herpetofauna in the State, further explorations and detailed systematic research will add to the list of amphibians and reptiles presented herein. Chapter 35 dwells on avi-faunal diversity in J&K State (Suhail et al. this volume). The checklist provided here contains a total of 555 species of birds, belonging to 76 families in 20 orders, recorded from the State. Of these, 32 species are reported to be threatened under various IUCN "threat" categories and 9 species as endemic to the Western Himalaya. Jammu region supports the largest number (381) species, followed by Kashmir (299 spp.) and Ladakh region (291 spp.). The chapter provides precious information on distribution of all the bird species and their status (whether resident, passage migrant, summer visitor, winter visitor) in all the three provinces of the State. It is emphasized to immediately focus on threatened birds of the State to evolve concrete measures for their conservation. Chapter 36 presents an overview of the diversity and conservation status of wild mammalian fauna of J&K State (Ahmad et al. this volume-b). In all, the State possesses 112 species of mammals, including 34 threatened species placed under various IUCN "threatened" categories. Owing to the heterogeneity of habitats, wide range in altitude, and varied climatic conditions, the State is home to a distinctive mammalian fauna, including many species which are endemic to this region. Some recommendations for effective management and conservation of wild mammals of the State are also listed in the article.

Part VII covers six (37–42) chapters, dealing with threat and conservation aspects of biodiversity of J&K State. Chapter 37 presents an updated synthesis of threatened flora of J&K State (Hamid et al. this volume). Based on various threat assessment studies, a total of 429 species of seed plants, belonging to 256 genera in 87 families, are listed as threatened in the State. Among all the species assessed, 24 species are critically endangered, 88 endangered, 75 vulnerable, 3 near threatened, and 32 least concern as per the currently recognized IUCN threat assessment categories. In addition, several species are noticed where threat categorization is needed, while in several others, which are previously reported but not collected recently, their presence/probable extirpation from this region needs to be ascertained. Current knowledge gaps are highlighted, and future road map for globally standardized framework for threat assessment of flora of the State has been outlined to help implement targeted conservation strategies based on scientific facts. Chapter 38 deals with threatened fauna of J&K State (Bhat et al. this volume-b). In it are documented 71 threatened and near-threatened faunal species from the State. These include 33 species of birds, 26 of mammals, 5 each of reptiles and fishes, and 2 species of amphibians. Among the birds 3 species are critically endangered (CR), 4 endangered (EN), 11 vulnerable (VU), and 15 near threatened (NT); among mammals 1 species is CR and 5 are EN, 8 VU, and 12 NT; among reptiles 2 species are EN and 2 VU, and 1 is NT; among amphibian 1 species is EN and 1 VU, while among fishes 1 species is CR, 1 EN, and 1 VU and 2 are NT. Overall, the number of CR, EN, and VU species is 5, 13, and 23, respectively, whereas 30 species are NT. The inclusion of majority of these species in CITES appendices and various schedules of the Wildlife Protection Act of India, 1972 (amended in 2006), is said to emphasize their threat extent in this Himalayan State. The major threats to fauna of the State are given as loss, degradation, and fragmentation of habitat, poaching, livestock grazing, over-exploitation, and human-wildlife conflict. The chapter also highlights the knowledge gaps about threat status of various faunal groups in the State and the appropriate steps required to be taken in the immediate future. Chapter 39 dwells on the impact of urbanization on biodiversity in J&K State (Reshi et al. this volume). Urbanization, a global phenomenon with many social, economic, and ecological consequences, is posing serious challenges to the maintenance of biodiversity in J&K State. In Kashmir, urban population has increased from 18.41% in 1951 to 31.6% in 2011. The number of urban centers has increased from 01 in 1901 to 46 in 2011, with Srinagar attracting most of the rural population. The major consequence of urbanization has been the land use/land cover change, associated with impacts on biodiversity which include homogenization of biota, local species extirpation, and promotion of invasion by alien species. Furthermore, urbanization has resulted in extensive homogenization of habitats, a serious ecological concern. Uneven and unprecedented urbanization is severely damaging the fragile ecosystems of the Kashmir Himalaya, with serious consequences for their sustenance. Chapter 40 deals with the impact of contemporary climate change on vegetation in the Kashmir Himalaya (Rashid and Romshoo this volume).The current vegetation distribution is mapped using remote sensing data supported with extensive ground validation. Statistically, significant trends across the years are shown and the future model projections of vegetation made under the changing climate in the region. It is predicted that grasslands and tropical deciduous forests shall altogether vanish from the region ending this century, which will be replaced by the savannah, temperate evergreen broadleaf forest, boreal evergreen forest, and the mixed forest types. Furthermore, a substantial area under permanent snow and ice may vanish by the end of this century, which shall have severe impact on the streamflows, agriculture productivity, and biodiversity, thus adversely affecting the livelihoods and food security in the region. Chapter 41 reviews the current status and future prospects of conservation of biodiversity in J&K State (Khuroo et al. this volume). The conservation of wildlife and forests in the State has an illustrious legacy, tracing back to the erstwhile *Maharaja's* rule. Presently, under in situ conservation approach, about 15.6% of total geographic area of the State is demarcated under the protected area network (PAN); this comprises 5 national parks, 14 wildlife sanctuaries, 37 conservation reserves, and 4 Ramsar sites. Under the ex situ conservation approach, several botanical gardens, zoos, and aquaria have been established over the years. Besides, concerted efforts are in place to conserve the flagship species, such as Hangul (*Cervus elaphus hanglu*), markhor (*Capra falconeri*), and snow leopard (*Panthera uncia*). A set of legislative measures are in place to ensure proper implementation of conservation programs in the State. Notwithstanding all these conservation measures in the recent past, the State has still to surmount daunting challenges of mainstreaming the conservation of biodiversity in public policy-making and prioritizing it for effective environmental management and sustainable development of this Himalayan region. Chapter 42 reviews the existing biodiversity laws and their flaws in J&K State (Dar this volume). After the Stockholm Conference in June 1972, many federally enacted laws for protection of the environment have either a direct application in the State or have been applied with its concurrence. Today, a wide variety of laws, old and new, State and Central, operate in Jammu & Kashmir. The Biological Diversity Act, 2002, a comprehensive law governing biodiversity issues in India, is also applicable to the State. The article calls for adoption of a holistic approach, wherein biodiversity concerns are integrated into the existing statutes and rules. In addition, strengthening of the Environmental Impact Assessment (EIA) system and the legal action infrastructure, including locus standi, right to information of citizens, and other such issues are vital for the efficacy of laws related to biodiversity.

## 1.8 Importance and Use of the Present Book

The book covers one of the most comprehensive and updated syntheses ever available on biodiversity of the Jammu and Kashmir State (Table 1.1). It embodies a goldmine of baseline data on the various aspects of biodiversity in the form of unified synthesis of varied information that, till now, was fragmented, widely scattered, and mostly inaccessible to the intending users. The knowledge base contained in the book represents an authoritative inventory/documentation of the remarkably rich biodiversity of this State and would form the foundation for bio-auditing (assessing current status of knowledge about the bioresources and identify the knowledge gaps) and help in prioritization and designing of conservation strategies to facilitate long-term bio-security and sustainable use of biodiversity in this Himalayan region. The book would be a valuable addition to the biodiversity literature available at the international, national, and regional levels. Given the breadth of topics covered under the banner of biodiversity in this book, it can serve as model for documentation of biodiversity in other regions of world. The book will be surely of immense value to all those who, directly or indirectly, have to deal with biodiversity, including students, teachers, researchers, academics, naturalists, taxonomists, ecologists, environmentalists, conservationists, resource managers, planners, government agencies, NGOs, Biodiversity Boards and Alliances, foresters, and the general public at large.

## 1.9 Concluding Remarks

Most of the inaccessible mountainous terrain and remote areas of the J&K State are still incompletely or little explored, thus making it difficult/impossible to arrive at complete documentation of its biodiversity. In addition, a major part of the erstwhile State (pre-partitioned/pre-1947) is presently under the administration of Pakistan and China, which is not accessible to workers on Indian side of the State. In view of these constraints, it can be construed that there is a lot of further scope and need to fill gaps in our knowledge of overall biodiversity of the State before having a final word on complete inventory of diversity of organisms that inhabit this bioresource-rich region (Table 1.1).

The extent of species in "viruses," archaea, and bacteria in prokaryotes (kingdom Monera) is not at all known in J&K State, although bacteria are often estimated as the largest biotic group on Earth (numbering as many as 1.6 million distinct microbes, Louca et al. 2019), and each of these is almost certainly associated with at least one virus (Kuhn et al. 2019). Among the four kingdoms of eukaryotes, Protista are reported to have 128 species of protozoans in this region (Dar et al. 2002), just 3.6% of 3510 species from India. Fungi, as elsewhere in the world and India, are not represented to the extent expected in such a vast and varied State; lichens seen almost everywhere, are not that much reflected in their collections/

**Table 1.1** Current status of biodiversity in Jammu and Kashmir State compared with that of the Indian Himalayan Region (IHR) and India

| Taxonomic group | Number of species | | | % age in | | Remarks |
|---|---|---|---|---|---|---|
| | J&K State | IHR[a] | India[2] | IHR | India | |
| Viruses/ bacteria – **Monera** | – | – | 1196 | – | – | Only 1196 spp. are reported from India (Singh and Dash 2018); number of spp. from J&K State and IHR is not known! |
| Protozoa –**Protista** | 128 | 372 | 3510 | 34.40 | 3.64 | 128 spp. of free-living protozoans from Kashmir Himalaya are cited in Dar et al. 2002. Total number of spp. from the State is not known! |
| **Fungi** | | | | | | |
| Fungi | 548 | 7080 | 15,223 | 7.74 | 3.60 | Little-studied kingdom in J&K State. Overall fungal diversity of the state needs to be authentically documented |
| Lichens | 424 | 1197 | 2528 | 35.42 | 16.77 | Not well known. Several districts in the state still poorly explored or unexplored for lichens |
| **Plantae** | | | | | | |
| Algae | 1065 | 1355 | 7396 | 78.59 | 14.39 | Work on algae in the state is still preliminary; many taxa reported without vouchers need to be checked! |
| Bryophytes | 420 | 1955 | 2754 | 21.48 | 15.25 | Liverworts ± well known; mosses are ubiquitous, but not widely collected |
| Pteridophytes | 200 | 766 | 1293 | 26.10 | 15.46 | Ferns are frequent here and need to be explored more, along with their allies |
| Gymnosperms | 41 | 51 | 81 | 80.39 | 50.61 | Well known; but *Ephedra* and *Juniperus* need to be studied in detail |
| Angiosperms | 5056 | 8700 | 18,532 | 58.11 | 27.28 | Largest group of plants. Well known; but many pockets still poorly explored or unexplored for angiosperms; also, several complex genera need revision |
| **Animalia** | | | | | | |
| **Invertebrates** | | | | | | |
| Platyhelminthes | – | 250 | 1738 | – | – | 250 spp. from the whole IHR (Chandra et al. 2018); number of spp. from J&K State not known! |
| Rotifera | 121 | 129 | 466 | 93.79 | 25.96 | 121 rotifer spp. cited from Kashmir in Dar et al. (2002) seems too high as compared to 129 spp. from the entire IHR |
| Nematoda | – | 744 | 2914 | – | – | Number of spp. from J&K State is not known! |
| Annelida | 22 | 178 | 1024 | 12.35 | 2.14 | Exact number of spp. from the State not known. Dar et al. (2002) report 14 spp. of leeches +4 spp. each of earthworms and aquatic oligochaetes |

| | | | | | | |
|---|---|---|---|---|---|---|
| Arthropoda | 1315 | 26,392 | 75,528 | 4.98 | 1.74 | 1315 spp. comprise insects belonging to ants (Hymenoptera) 198 spp. + flies (Diptera) 107 + moths (Lepidoptera) 461+ bark beetles (Coleoptera) 12 + butterflies (Lepidoptera) 408 + insects (Hexapoda) 129 species. The largest phylum of animals, but the least known among all biotic groups here. Much effort and expertise is required to document vast unknown diversity in this phylum in J&K State |
| Mollusca | 27 | 422 | 5189 | 6.39 | 0.52 | 27 (13 land +14 aquatic) mollusk spp. cited in Dar et al. (2002) seem too less from J&K State in this second largest phylum of invertebrate animals |
| **Vertebrates** | | | | | | |
| Fishes | 120 | 316 | 3364 | 37.97 | 3.57 | Much literature is available on this group, but not all of fish reports from the state are in agreement |
| Amphibians | 17 | 80 | 407 | 21.25 | 4.18 | Least represented biotic group in the state in terms of number of known species. Further state-wide explorations needed |
| Reptiles | 63 | 200 | 584 | 31.50 | 10.79 | Scary animal group, required to be explored and studied further to reveal true status |
| Birds | 555 | 940 | 1340 | 59.04 | 41.42 | Well known; the species from the state form ca. 60% of those in IHR and nearly half of those in India. Further taxonomic research on birds needed |
| Mammals (wild) | 112 | 280 | 427 | 40.00 | 26.23 | Well known; but exploratory surveys needed for more collection and to update status of keystone and flagship mammals |

[a]Numbers for Plantae and Fungi in IHR are after Singh and Pusalkar (this volume), [2]while those in India are after Singh and Dash (2018). Numbers for Protozoa and invertebrates in IHR and India and for vertebrates in IHR are after Chandra et al. (2018), while those for vertebrates in India are after Venkataraman et al. (this volume)

number. In Plantae, the second highest representation of algae seems to be due to its being based on literature that needs authentication by taxonomic experts. Mosses among bryophytes, growing almost everywhere from low valleys to mountain summits, have great scope for further collection and addition; the same is almost true of ferns in pteridophytes. Gymnosperms contain many cultivated species, some of which are presently represented by a few growing trees only (two species perhaps by one each only); among wild gymnosperms, *Ephedra* and *Juniperus* need further collecting and taxonomic attention. Angiosperms are the largest and the well-known group of plants, yet further extensive taxonomic studies/explorations in the State usually add to their number; many flowering-plant genera are also complex and merit monographic studies to reveal their true taxonomic delimitations. Among angiosperms, up to 1000 species are presently reported as being medicinal and aromatic, most of which are over-exploited and rendered threatened. This major plant group includes a good proportion of endemics, together with a large number of alien weedy plants, as well as a rich representation of woody and aquatic and marshland plants. Among Animalia, invertebrates, the largest assemblage of animal phyla comprising ca. 91,000 known species in India, are the least known in J&K State; especially too little is known about the largest phylum Arthropoda, more so of its extremely numerous insects and allies (class Insecta). Vertebrates, the most conspicuous animals, are not too large in number of species. Much has been published on fish-fauna of the State, but without agreeing on their number of species; there is need for a valid taxonomic treatment. The herpeto-fauna does not comprise too many species; more exploratory surveys throughout the State will help know their exact status. Higher vertebrates – Aves and Mammalia – are well-known in their species richness, primarily because of having been cared for their vivid attractiveness as "wild life" and "game animals." Nonetheless, enough scope exists for further efforts to fill the existing knowledge gaps in bird as well as mammal diversity in the State (including domesticated taxa). Many of the higher animals are rare, some facing life threat.

At the organizational level too, reasonable information is available about species diversity, less so on ecosystem diversity, and the least on genetic diversity. Degradation of forest ecosystems and homogenization of agro-ecosystems leading to ever-increasing loss of domesticated germplasm are areas that need to be addressed. This is the apt time to generate awareness among the local population about rich bioresources of the State and their value in regional development, as also about consequences of their excessive exploitation and climate change and other impending threats to them, if we would like to sustain and conserve biodiversity for the future generations.

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# Part II
# Biodiversity: Global and Indian Perspectives

# Chapter 2
# Biodiversity: A Global Perspective

**Peter H. Raven**

**Abstract** Perhaps 12 million species of eukaryotic organisms share this planet with us, together with many more kinds of bacteria and their relatives. Most of these remain unknown to us. We depend completely on other organisms for the conditions that make possible our life on Earth and supply so many of our needs. However, our rapidly growing numbers and consumption patterns are so high that we are causing one of the most devastating extinction events that have ever occurred. We are clearly running a very dangerous experiment that we must strive to deflect both locally and globally before it becomes too late. Jammu and Kashmir, located in the northwestern Himalaya, is broadly defined as home to one of the richest and most diverse assemblies of biodiversity found in South Asia. An internationally based effort to save as much of these riches as possible, therefore, merits urgent research attention.

**Keywords** Biodiversity · Conservation · Jammu and Kashmir State · South Asia

## 2.1 Introduction

It is difficult to believe that the term "biodiversity," now in such wide use, was invented only in the late 1987 (Wilson 1988), as a shortened version of "biological diversity," a term that had come into widespread use after it was proposed for general use by Thomas Lovejoy about 15 years earlier. Whereas "biological diversity" was used to refer to all the species of living organisms on Earth, "biodiversity" became too popular with a wider meaning. Biodiversity came to be defined as variability among all the living organisms on Earth, all of the communities and ecosystems in which they occur, and all of their genetic and phenotypic diversity as well. The term, therefore, became almost synonymous with "the living world" or "life on Earth," the two terms that were in wide use much earlier.

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_2

## 2.2 Brief History of Biodiversity

In order to give a general idea of biodiversity, we must begin with an account of its dimensions and how it came to be. Our planet, Earth, was formed approximately 4.57 billion years ago. Within 800 million years, as the surface temperatures of Earth cooled to the extent where life could exist, we find the first traces of life preserved as fossils. It is difficult to date precisely the time of life's origin because very old rocks tend to have been digested and redigested as Earth's mantle evolved. At any rate, we do have tangible evidence of the existence of life at least 3.8 billion years ago. All the early organisms were what we consider prokaryotes, or bacteria. The structure of their cells is simple, and, among other distinguishing characteristics, they lack a distinct, membrane-bound nucleus and most other organelles. It is uncertain whether the earliest prokaryotes originated here on Earth or they were transported somehow from another planet and thus of extraterrestrial origin. In any case, the results were the same.

Among the groups of early bacteria evolved one-celled *Cyanobacteria*, or blue-green algae, for which we have fossils up to about 3.5 billion years old. *Cyanobacteria* are especially important in the history of origin of life because in the early members of this group evolved the critically important biochemical process called photosynthesis. When it first appeared, photosynthesis was anoxic, i.e., not producing oxygen. About 500 million years later, photosynthesis evolved into the process what we know at present, one that combines carbon dioxide with water, sunlight being a catalyst, to form carbohydrates and oxygen. The carbohydrates nourish the cells within which they are produced, and the oxygen is released as a gas into the atmosphere. Before the evolution of oxygen-producing photosynthesis, Earth had a reducing atmosphere, containing large amounts of hydrogen, but millions of years of photosynthesis by huge masses of early *Cyanobacteria* floating in the surface of the seas and emitting oxygen as a by-product of photosynthesis gradually converted the atmosphere to an oxidizing one. As it does now, oxygen increased to about a fifth of the atmosphere's total volume. Earlier on, when the atmosphere contained much lower amounts of oxygen, ultraviolet rays from the sun bombarded Earth's surface; and these rays were highly destructive to biological molecules. But once sufficient oxygen had accumulated in the atmosphere, most of the ultraviolet radiation was blocked by a stratospheric ozone layer that formed in equilibrium with the oxygen [oxygen has two atoms joined by chemical bonds, ozone three]. Presumably the protection afforded by this layer would have been a key factor in allowing various groups of organisms, which earlier had been exclusively aquatic, to move onto the land. At any event, almost all of the petroleum and natural gas that we consume in vast amounts as sources of the energy originated as the result of the accumulation of masses of trillions of dead cells of *Cyanobacteria* sinking to the bottom of ancient seas and being chemically altered through the ages.

More than 1.5 billion years ago appeared the first complex cells of eukaryotes, organisms that have within their relatively large cells a membrane-bound nucleus, mitochondria, and if they are photosynthetic, chloroplasts. Special mention should be made of viruses, which are basically segments of DNA or RNA, parts of the genetic apparatus of cells that form templates for the replicating themselves within the cells of other organisms. Viruses may or may not be considered organisms. It is likely that all of them originated from eukaryotic or prokaryotic organisms, which in that case must have evolved before viruses came into existence.

At any rate, all of the plants, animals, and fungi, as well as many kinds of single-celled organisms, including protozoa and single-celled algae, are eukaryotes, in that their cells, which are relatively large, share a basic ground plan that is much more complex than the ground plan of prokaryotic bacterial cells. Perhaps for the first 600 million years of their history, 1.5–0.9 billion years ago, all the eukaryotic organisms were single-celled. These highly diverse organisms, however, included the ancestors of animals, plants, and fungi, as well as many other groups that still exist today. About 900 million years ago, organisms evolved that were multicellular, each individual consisting of more than a single cell. Multicellularity seems to have been the critical evolutionary step in allowing organisms to live outside of the water.

The colonization of land by living organisms began about 540 million years ago. The different groups of multicellular organisms were able to protect themselves better in a dry, variable, terrestrial environment than single-celled ones, with shells, cuticles, layers of flesh, trunks, branches, and leaves within which water could be stored and circulated. Before about 440 million years ago, invertebrates dominated the land, with four-legged land animals comparable to amphibians evolving from early fishes somewhat later. Over the course of the next 30 million years or so, most of the groups that dominate our terrestrial world today, including the precursors of amphibians, reptiles, mammals, and early relatives of insects, appeared in terrestrial habitats, with the earliest land plants diversifying at about the same time.

During the Mesozoic Era (250 million to about 65 million years ago) forests first came into existence, with dinosaurs, mammals, reptiles, birds, and seed plants evolving progressively over this long period of time. Gymnosperms (naked-seeded land plants such as pines, yews, and ginkgo) evolved first, competing with other groups of early land plants, but by the end of the era, flowering plants (angiosperms), which are the dominant land plants of the present, replaced them and diversified into the communities that we see today. At the end of the Mesozoic Era, it is believed that a giant meteorite collided off with Earth, the end of what is now the Yucatán Peninsula in southeastern Mexico. As a result of this massive collision, an opaque cloud of dust was formed, blocking much of the sunlight that normally reaches Earth and stalling the process of photosynthesis. This eventually led to the extinction of about two-thirds of the existing species that occurred on land before the collision. During the earlier history of life on Earth, several major, widely spaced extinction events had taken place, but the effects of the one at the end of the Mesozoic Era are particularly important, since the living world that we know today gradually formed from the surviving organisms in that Era.

Subsequently, in the Cenozoic Era (65 million to about three million years ago), plants, mammals, reptiles, insects, and all groups of organisms that are dominant in today's world diversified and evolved into the numerous species that make up the ecosystems that support all life on Earth, including humans. Some 15 million years ago, global climates began to diverge more sharply into ones that were warmer near the Equator and others that were cooler in Polar regions. Consequently, deserts and other relatively dry habitats expanded and formed important regions for the evolution of biodiversity. Communities and ecosystems like the ones we have today were formed in areas with conditions comparable to the ones in which they occur today. Finally, the expanding and retreating ice ages of the Pleistocene Era over the past three million years have resulted in the further differentiation of or survival of the habitats in which organisms have survived or evolved into the contemporary patterns with which we are currently familiar.

Hominids, humans, and their direct ancestors evolved from African apes some 6–seven million years ago, with the first human beings appearing about two million years ago, in Africa. A dominant species of our genus, *Homo erectus*, migrated from Africa to Eurasia some 1.9 million years ago, surviving in Asia until about 250,000 years ago, after having disappeared earlier in Africa. *Homo sapiens*, the species to which we belong, also evolved in Africa, migrating into Eurasia at least 200,000 years ago. The entire history of human and humanlike animals occupies what may seem an amazingly short span of Earth's history, two million years out of a total of the 4.54 billion years that our planet has existed! During most of their history, human populations existed as scattered bands of some 30 to 50 people, faring for themselves and rarely coming into contact with other groups of people. Dogs were domesticated more than 19,000 years ago, aiding in hunting and guarding encampments from marauding animals, but crop agriculture was not developed until about 12,000 years ago, possibly in Turkey. At the time when plants were first domesticated, the whole population of humans on all six inhabited continents is estimated at about one million. Even though our ancestors had developed the use of fire and evidently used it to improve hunting conditions before that time, they did not have a steady source of food to see them through unfavorable seasons. With the invention of agriculture, however, the human population began to grow rapidly, reaching one billion for the first time in the early 1800s, two billion about 1930, and exploding to more than 7.6 billion today, with leveling off not projected until we have reached more than 10.6 billion people by the end of the twenty-first century. We shall consider the compound effects of our huge population on biodiversity below, after providing estimates of the biodiversity that we have now and discussing briefly our dependence on it.

## 2.3 How Much Biodiversity Exists, and How Much of It Have We Discovered?

The number of existing six to seven million species of insects and other arthropods (Raven and Yeates 2007) suggests that a reasonable estimate of the number of species of eukaryotes would be at least 12 million. The organisms found in many habitats, such as the canopy biota of tropical forests, are not yet well enough known to make reliable estimates of their ultimate numbers possible, a major problem being that a majority of species in such habitats are very rare, often represented in samples by a single individual. As a result of this relationship and the extreme difficulty in sampling such a fauna adequately, it is by no means sure that we have approached an adequate estimate of the number of species globally yet. We have so far described and named some two million species of eukaryotic organisms, the great majority of them very poorly known. Taking the degree of knowledge of different habitats into account, it can reasonably be assumed that for tropical rain forests, there are likely to be at least 20 times as many species living in a given area, say in New Guinea, than have yet been discovered.

In contrast to the situation for eukaryotes, there is no reasonable way to estimate total numbers of prokaryotic species (bacteria and archaea), regardless of how they are defined. Using acceptable criteria of genetic difference, it has been found that 30 g of soil contains over 500,000 species, which, given differences between samples taken in different habitats, might lead one to estimate a world total in the range of one billion species (Dykhuizen 1998; see also Curtis et al. 2002), a calculation that cannot be evaluated with our present level of knowledge. For the Indian subcontinent, the occurrence of about 20,000 species of vascular plants, at least 10% endemic, suggests that there may be on the order of 2,50,000 species of eukaryotic organisms in the subcontinent, only about half of which have been recorded within national boundaries to date. The need for extensive biological inventory within the region to prepare properly for a sustainable future is obvious. Within the boundaries of Jammu and Kashmir, perhaps more than 50,000 eukaryotic species may occur, marking the state as a very rich and important center of biodiversity and one that, as the chapters in this volume demonstrate, forms both the eastern limits of distribution for a number of species and at the same time the western limit for others – a genuine crossroads.

## 2.4 Our Relationships with Biodiversity

Although various means have been used to calculate the value of biodiversity for human beings, we can easily conclude that the value is in fact infinite – without biodiversity, we would not exist. All of our food is derived from plants, directly or indirectly; two-thirds of the people in the world depend on plants as a source of medicine, with approximately half of all prescription drugs having had a biological origin; ecosystem services, such as the control of erosion, protection of soils, moderating the runoff of water following storms, providing pollination services, or controlling pests; and very clearly the beauty that biodiversity adds to our lives – all of these points illustrate how fully we depend on biodiversity for our very existence in more ways that we normally recognize.

In addition, we need the genetic diversity of all organisms to help modify crops and other products and to realize the full potential of nature to satisfy our requirements sustainably. For crops, the need to produce enough food to nourish the estimated one billion people who are chronically malnourished now, and to take care of the several billion more, mostly poor, people who are predicted to join our ranks during the next several decades, will require every ounce of ingenuity that we can muster. It is a mere 50 years since molecular biology grew into a science capable of providing rich insights into the nature and functioning of life, and our ability to use it to produce the necessary crops, medicines, and other products for the future depends greatly on our ability to keep what we have.

We must never allow ourselves to forget that our ancestors evolved into a world that functioned because of living organisms and the ways in which they had evolved to interact with one another. We live because we manipulate biodiversity, for better or for worse, and in doing so we have created serious problems for ourselves that only the very best efforts we can put forth will alleviate. Whatever our reasons for failure to act may be, they will cumulatively subject our descendants to conditions far worse than any we are experiencing now.

A fine, detailed analysis of our common predicament is presented by the Global Footprint Network (http://www.footprintnetwork.org). In general terms, we are estimated to be using about 174% of the sustainable capacity of the Earth on a continuing basis, up from an estimated 70% in 1970. With global population of 7.6 billion people, about 800 million are malnourished and perhaps 100,000 on the verge of starvation at any given time. A majority of the people on Earth earns less than $2 per day, and about half of us lack adequate supplies of at least one essential nutrient. Staggeringly difficult is the point that if the Earth were 1.74 times larger than it is now, we would be living sustainably here, but we would be no better off than we are now with respect to hunger, starvation, or poverty; and even then, as the population continues to grow at the rate of 230,000 people a day toward an estimated 10.6 billion people, the situation would rapidly go downhill at current levels of consumption and using available technologies. Therefore, we must change.

The human population of South Asia is on a trajectory that will lead it to double from its present level of approximately 1.89 billion to 2.4 billion by mid-century (Population Reference Bureau, 2017 World Population Data Sheet). Thus the density of people per square kilometer, already high by world standards, will by nearly a third during these 32 years, and the pressure on all systems, human or biological, will intensify accordingly, making it ever more difficult to alleviate poverty, improve the efficiency of productive systems, and conserve biodiversity. In one of the fastest-growing parts of the world, we can only imagine the difficulty in supplying people with what they need.

## 2.5 Biodiversity Loss

Four major factors, all driven by the intensity of human activities, contribute to the extinction of species. These are habitat loss, global climate change, invasive species, and overharvesting from nature. We shall discuss each of these in turn.

The first and most obvious factor is habitat loss, which can result from overgrazing, deforestation, urbanization, construction of many kinds, and the expansion of agriculture. All of these human-driven activities expand in relation to the numbers of people living in a given area, the level of consumption per individual, and the kinds of technology that are used regionally. Perhaps three-quarters of all the biodiversity in South Asia occurs in its northern mountainous regions, with Jammu and Kashmir State being one of the richest biodiversity regions. In these mountains the biological communities are especially fragile in the face of overgrazing, susceptible to erosion and flooding, and generally at high risk from almost any kind of disturbance.

A second major factor threatening the integrity of life on Earth is the global climate change that has come into focus in relation to its highly destructive impact on biodiversity over the course of the past few decades. This fast-moving process has had and will continue to have a massive impact on the species that inhabit the mountains of the world, including Jammu and Kashmir. Biological communities at high elevations are at the greatest risk in a warming world because as the world warms, the habitats in which they occur will progressively be lost. Because of the nature of mountain habitats and the species that live in them, those species often cannot simply move to higher latitudes as conditions change, so that they are likely to become extirpated locally. If they are endemic to a particular mountain range, as plants and animals of montane habitats often are, they are very much at risk of extinction. It is clear that for these reasons many species will be lost both in Jammu and Kashmir and from other mountain regions of South Asia as well. In the worst-case scenario, the whole habitats are likely to disappear during the course of this century, all depending on our common progress toward mitigating the global production of greenhouse gases. No matter what we manage to do in this respect, both the degree of change and the biological losses will be massive. An additional negative effect of great importance for human beings in the Himalaya will be the loss of glaciers and persistent snow banks, which eventually will have a major effect on the water supply for the region as a whole and on the capacity for producing hydropower.

A third major factor leading to extinction is the introduction and spread of invasive plants, pests, and pathogens, which can often outcompete native species directly or by making it impossible for them to reproduce. The spread and wider dispersal of the invasive alien species have been over the past few decades greatly accelerated by global trade and by the ever-increasing amount of travel throughout the world. Against a background of habitat destruction and climate change, the spread of invasive species is proceeding ever more rapidly and is hastening the loss of genetic diversity, of species, and of ecosystems around the world.

The widespread practice of harvesting plants, fungi, and animals from nature for food or medicine also contributes to hastening the extinction of species whose survival might already be precarious for other reasons. Some of the favorite plants and animals used for food, medicine, or other purposes already have become scarce, and they can be pushed to local extirpation or even extinction for this reason. Particular examples from threatened flora and fauna in Jammu and Kashmir are discussed in some of the individual chapters of this volume.

With the world human population growing so rapidly, our levels of consumption rising even faster, and the continued use of many harmful kinds of technology unabated, it is not surprising that we have already reached levels of extinction higher than at any time for the past 65 million years, since the end of the Cretaceous Period, when about two-thirds of all species on land became extinct in a short period of time (Pimm and Raven 2000; Dirzo and Raven 2003; Pimm et al. 2006). Thus, over the past 65 million years, judged from the record of fossils of animals with hard shells that are preserved fairly continuously through time, the rate of biological extinction appears to have been about one species per million per year. Such a calculation of course depends on extrapolating the calculated rate of extinction in groups such as vertebrate animals and mollusks to others, and it is by no means certain that the extrapolation is sound. It does, however, allow us to make the best estimate possible at this time.

Moving toward the present, we can see that this calculated rate increased by some two orders of magnitude in the 500 years since the production of printed works in Europe where extinction events for certain groups were carefully recorded. For the past half century, we are observing extinction (again based on extrapolation for well-recorded groups of organisms) at the rate of thousands of species per year. Considering the factors involved in extinction, of which we have highlighted the major ones above, it seems virtually certain that the overall extinction rate may accelerate to tens of thousands of species per year during this century and that we may lose half of all biological species in the near future without knowing that most of them ever existed. That would be an incredible tragedy and one for which we would be wholly responsible.

## 2.6 Conservation of Biodiversity

We are living in the most challenging decades for conservation that have existed during the span of human existence. Depending on what we do in the immediate future, the world could experience the loss of diversity at a magnitude that it has not experienced for 65 million years. Our efforts during the twenty-first century will determine the amount of biodiversity that will exist in the twenty-second century and beyond. To counter the major driving forces leading to species extinction, we will have to reach and maintain a level population and find ways to hold our individual consumption within the limits that the world can afford sustainably. We will also have to develop an array of new technologies that are less destructive to the productivity of our planet than the ones we are using so widely now. Global climate change, for example, cannot be abated without the adoption of new technologies, and until greenhouse gas emission is limited to the extent possible, it will continue to be ever more destructive to biodiversity.

The more rapidly we destroy biodiversity, the fewer opportunities for building sustainability will exist in the future. As part of our dilemma, we must remember that the genetic variability within species is of fundamental importance in the ongoing process of evolution and adaptation. We are losing individual populations much more rapidly than we are losing species, and both trends will lead inexorably to the impoverishment of the human future. On the other side of biodiversity complexity, the relationships between species in ecosystems that make possible the ecosystem services on which we depend are equally important. Within ecosystems, the loss of individual species, especially those considered keystone species – the ones that are especially important elements in the structure of their communities – has important consequences for the integrity and proper functioning of the ecosystem as a whole.

In order to conserve organisms, their communities, and their genetic diversity efficiently, we need as much knowledge as we can obtain. Biological inventories of all nations and all regions within those nations are critically important, and should be maintained on an ongoing basis, using advanced geospatial techniques and determining correlations between the ranges of species and other factors. Probably three-quarters of the eukaryotic species that occur in Jammu and Kashmir, and perhaps an even higher proportion for South Asia generally, are yet to be discovered. A major effort, involving international collaboration, would be necessary to increase the current level of knowledge substantially while most of the species still exist. Toward this effort, some outstanding contributions are described in this volume, and those who are pursuing them should be congratulated for the strength and successful nature of their efforts.

Given sufficient knowledge, the most efficient way of preserving biodiversity is setting aside natural areas as reserves. For some time, however, conservationists have realized that the idea of setting aside large, pristine areas ("game parks") will be increasingly difficult in anything but the richest countries. Since those countries are rich largely on the basis of importing goods and thus reducing the sustainability of others, the whole traditional system will need to be managed in a very flexible way if global conservation is the objective. For this reason, the idea of natural areas inhabited by people who derive economic return and sustenance from them while being encouraged by policies and subsidies to preserve much of the fabric of the ecosystems where they live has become increasingly favored by those who face the realities of conservation in most of the world (Sodhi et al. 2013). Given the realities of global climate change, we certainly should include as much topographic relief within areas kept relatively natural so that there will be enough opportunities for the internal migration of organisms, including human beings, as the climate shifts and consequently the survival of more species and genetic diversity than would be possible otherwise.

We now turn to the conservation of individual kinds of organism in ex situ conditions – out of their natural ranges. Zoos and botanical gardens are the most familiar examples of such situations, but diverse kinds of culture facilities can be used effectively for the preservation of fungi and microorganisms, including prokaryotic ones (bacteria and archaea). For animals, preservation in captivity can be relatively expensive, considering the necessity of maintaining a sufficient amount of genetic diversity to maintain the genetic integrity of the species. For plants, small samples can be grown in botanical gardens, but when only a few individuals constitute the sample of a given species, the normal case, genetic diversity cannot be maintained properly. Moreover, if the sample of a given species is one of a series of species of that genus, which is often the case, any seeds set in the garden may be of hybrid origin and thus not a proper representative of either parent. Samples of adequate size can be grown in areas adjacent to the display garden, but such areas are often not available or large enough for a few species only. For the traditional model of building a healthy population of a species in a garden and then transplanting some of the individuals back in their natural habitats or similar ones when they may survive without human intervention, global warming makes the likelihood of success much undependable than one might think. Despite this problem, it is highly desirable to continue transplanting individuals in presumably suitable habitats to learn the principles of how to carry out such species recovery and reintroductions. The knowledge gained will be necessary to manipulate effectively the distribution of species in whatever circumstances may occur in the future.

In the face of these difficulties, however, botanists increasingly are turning as a conservation strategy to seed banks, where seeds are stored at low temperatures and tested periodically for viability, as the preferred method for ex situ preservation. As much genetic diversity as desired can be preserved in such samples, and since the seeds remain viable for long periods, seed banks do seem to be an effective means of conserving plants.

## 2.7 Regional Conservation Recommendations

To the extent possible, biotic inventories should be conducted locally and regionally. The samples should be organized in museums and the information associated with them organized according to geospatial framework so that they can readily be understood. Although the difficulties of working in many areas are evident, organizing what is available and working in areas where such studies are feasible will add up to useful results whatever the problems may be. To achieve reasonable success in this effort, massive international collaboration will be absolutely necessary. There will never be enough specialists living in any given country or region to deal with all of the groups of organisms that occur there, and most of the historical collections from South Asia are housed elsewhere.

Natural and seminatural areas should be preserved to the extent that this can be accomplished. As the population density increases, it will become increasingly obvious that this can be done successfully only if the people living in and near the areas perceive clear benefits from maintaining them, at least to some extent, in their present form and not degrading them further. Trans-boundary parks and protected areas, or those that run along waterways, should be considered when they make good biological and socioeconomic sense.

Botanical gardens and zoos should be supported for educational and recreational purposes and for conservation as well. For plants, every effort should be made to collect seed samples according to scientific principles and preserve them either within the region or in an international facility such as the Millennium Seed Bank of the Royal Botanic Gardens, Kew, with complete access as desired and exclusive access if necessary politically.

The sustainable management can be achieved only by dealing with the major factors of human population, level of consumption, and the deployment of technology will be necessary for the long-term security of the human population as well as the biodiversity of the region. That biodiversity will serve importantly in improving the human condition if it is preserved. If it is lost, much will be lost both locally and for the world. Making people generally aware of these relationships, and especially educating the children who will be responsible for them in the future, will be of key importance for the realization of the human aspirations and hopes that are so important for the quality of life for us all.

## 2.8 Concluding Remarks

Within the Indian subcontinent, the Jammu and Kashmir State forms an important region in the entire Himalaya; the latter is so rich in biodiversity that it is rightly recognized as a global biodiversity hotspot. The State, like the Western Ghats (another biodiversity hotspot in India), has more species restricted, i.e., endemics, than any other part of the region, and they are both quite heavily disturbed already. Special efforts to conserve the biodiversity that occurs in the region are highly desirable in terms of that richness and its importance for preserving human civilization at a reasonable level in the future. With widespread poverty in the region; a gross national income of about US $6000, only a third of the world average; and the population growing by 50% over the next 32 years, this is going to be a very difficult task to say the least. But the regional biodiversity will never again be as rich as it is now, and we must come together and find ways to act. I hope that all of the notable contributions by experts from diverse disciplines in this volume will help to show the way and that working together we can create the best possible future for our children and grandchildren. There will never be a better time to try to accomplish this highly desirable goal.

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# Chapter 3
# Floristic Diversity of India: An Overview

**Paramjit Singh**

**Abstract** The present chapter gives a synthesis of the floristic diversity of India, dwelling briefly on its ecosystem diversity, vegetation pattern, species richness in various taxonomic groups traditionally dealt with as plants (angiosperms, gymnosperms, pteridophytes, bryophytes, algae, fungi and lichens), endemism and primitive angiosperms and phytogeographical analysis of the flora. It is estimated that out of 49,003 species of plants forming the evident vegetal cover, angiosperms comprise ca. 18,532 species, representing ca. 10% of all known flowering plants of the world. The largest angiosperm family in the number of species is Leguminosae (with 1421 spp.), followed by Poaceae (1291spp.), Orchidaceae (1251 spp.), Asteraceae (1120 spp.) and Rubiaceae (679 spp.). The largest genus is *Impatiens* (with 279 spp.), followed by *Carex* (160 spp.), *Pedicularis* (145 spp.), *Bulbophyllum* and *Primula* (135 spp. each). Existing estimate pertaining to the political boundaries of present-day India is that about 4300 (23.20%) of 18,532 flowering plant species are endemic to this country.

**Keywords** Floristic diversity · Phytogeography · Endemism · Primitive angiosperms · India

## 3.1 Introduction

India, with over 7500-km-long coastline and about 15,000-km-long land frontier, is the seventh largest country in the world and second largest in Asia. Lying in the tropical belt with a total area of about 329 million hectares, it represents 2.2% of the total world landmass. A great variety of climatic and altitudinal variations, coupled with varied ecological habitats, have contributed immensely to the rich floristic diversity of this country. Its physiographic diversity has produced all possible types

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_3

and extremities of climatic conditions suitable for supporting varied types of ecosystems. It demonstrates both extremes, from almost rainless areas in Rajasthan to the world's rainiest areas in the Northeast India; from tropical, hot and humid to coldest arctic climate; and from vast riverine plains and delta of the mighty Ganga and Brahmaputra to high mountains of the Himalaya. The altitude varies from the sea level to the highest mountain ranges of the world. The habitat types vary from the humid tropical Western Ghats to the hot deserts of Rajasthan and from cold deserts of Ladakh and icy mountains of the Himalaya to the long, warm coastline stretch of the Peninsular India.

India is noteworthy for its biodiversity. With 2.2% of world's land area having 11.4% of flowering plants, India is recognized as one of the megadiversity countries of the world. It is a part of the global biodiversity hotspots. Hotspots generally refer to the areas rich in general diversity, high degree of endemism and higher incidence of rare and endangered species. All the global hotspots are based on two main criteria: species endemism and degree of threat. To qualify as a hotspot, an area must contain at least 1500 or 0.5% of the world's plant species as endemic (Myers 1990). Based on this concept, 34 global biodiversity hotspots with areas of high biological diversity and high endemism, but with severe anthropogenic threat, have been identified. All the present global biodiversity hotspots have a minimum of 1500 endemic vascular plant species each.

India shares 4 of the 34 global biodiversity hotspots: (1) Indo-Burma covering part of Assam, Mizoram, Manipur, Nagaland, Meghalaya, Tripura and Andaman Islands; (2) Himalaya covering Jammu and Kashmir, Himachal Pradesh, Uttarakhand, northern part of West Bengal (Darjeeling), Sikkim, hills of Assam and Arunachal Pradesh; (3) Western Ghats falling within the states of Tamil Nadu, Kerala, Karnataka, Goa, Maharashtra and Gujarat; and (4) the Sundaland covering the Nicobar Islands (Myers et al. 2000; Mittermeier et al. 2004). These regions show high degree of endemism and higher incidence of rare and threatened plant species. The rich biodiversity of the country is highly influenced by different floral elements from three major biogreographic realms, namely, the Indo-Malayan (the richest in the world), the Indo-Arctic (Eurasia) and the Afrotropical.

Several workers have attempted division of the world's flora into phytogeographical regions based on comparative studies. The first attempt towards this was that of the Danish botanist J. F. Schouw in 1823. He divided world's flora into 25 kingdoms, with several provinces in each. Subsequently Engler (1882, 1924), Diels (1918), Good (1947, 1974), Turrill (1953, 1959) and some others have presented several classifications. The most recent one is that of Takhtajan (1986). He, based on climatic parameters, geographic position, evolutionary history and taxonomic affinities, divided the world's flora into the following six kingdoms: (1) Holarctic Kingdom (Holarctics) containing North America, Europe, North Asia and Arctic regions; (2) Paleotropical (Paleotropics) containing Africa, Indo-Malaysia and Polynesian regions; (3) Neotropical (Neotropics) containing Tropical, Central and South America; (4) Cape (Capensis) containing southernmost end of Africa only; (5) Australian (Australia) containing Australia and Tasmania; and (6) Holantarctic Kingdom (Holantarctics) containing New Zealand, Antarctica and the southernmost

**Table 3.1** Major phytogeographical divisions of world with regions and provinces recognized in India (Takhtajan 1986)

| Kingdoms | Subkingdoms | Regions | Provinces | Areas coming under |
|---|---|---|---|---|
| *Holarctic* | Boreal | Eastern Asiatic | Eastern Himalayan Province | Darjeeling, Sikkim and Arunachal Pradesh, including Bhutan and parts of Tibet |
| | | | Khasi-Manipur Province | Meghalaya, Manipur, Nagaland, Mizoram and Tripura |
| | Tethyan | Irano-Turanian | Western Himalayan Province | NW Himalaya, including Kashmir, Himachal Pradesh and Garhwal Himalaya, extending to N. Pakistan and Afghanistan |
| *Paleotropical* | Indo-Malesian | Indian | Malabar Province | West Coast and Western Ghats |
| | | | Deccan Province | Deccan Plateau, south of Vindhya Hills, Eastern Ghats and Coromandel Coast |
| | | | Upper Gangetic Province | From Aravalli Hills and Yamuna river eastward to Kosi river and northwards to Siwalik Hills and south to Vindhya ills |
| | | Indo-Chinese Region | Andaman Province | Andaman group of islands alone |
| | | Malesian Region | Sumatran Province | Nicobar group of islands extending to Sumatra |

end of South America. These kingdoms have been further divided into subkingdoms, regions and provinces. India depicts well-defined phytogeographical regions. The classification of Takhtajan (1986) provided a list of key elements and endemics in each of the regions and provinces and their significant affinities. The territory of India fits into the classification as shown in Table 3.1.

The extreme diversity of the habitats has resulted in such luxuriance and variety of flora that all types of forests, ranging from scrub forests to the tropical evergreen rainforests and coastal mangrove to the temperate and alpine vegetation, occur in the country. A significant feature of the Indian flora is the confluence of species from the regions such as Malaya, Tibet, China, Japan, Europe and even from widely separated continents of America, Africa and Australia. Notwithstanding this, about 23.20% of the Indian flowering plants are endemic to the country. The high endemism of plants in India is due to its geographical position, physiography and geological history. The high mountains in the north preventing migration northwards; the separation of the southern region by large water mass of the Arabian Sea, Bay of Bengal and the Indian Ocean; the extremely arid conditions in the western parts blocking westward migration of species from the middle and eastern regions; and the humid tropical conditions of Western Ghats and Northeastern India, all together have resulted in the evolution and speciation of several endemic elements, as in the case of oceanic islands. The occurrence of many endemics, on the other hand, is suggestive of India having been a centre of isolation, speciation, extinction and adaptive evolution of biota. Distribution of endemic species, their concentration and the level in biological hierarchy are very important aspects in judging the phytogeographical affinities and demarcations.

The present chapter gives a synthesis of the floristic diversity of India, dwelling briefly on its ecosystem diversity, vegetation pattern, species richness in various taxonomic groups traditionally dealt with as plants (angiosperms, gymnosperms, pteridophytes, bryophytes, algae, fungi, lichens) and phytogeographical analysis of the flora.

## 3.2 Materials and Methods

Based on literature survey, field experience of the last 38 years and herbarium records available in the major Indian and foreign herbaria, an attempt has been made here to give a brief glimpse of the plant diversity in India based on current state of knowledge. The numerical data given is indicative and ever changing and is not claimed to be a final figure but only an estimated picture of the overall floristic diversity as known through literature available till now.

## 3.3 Results and Discussion

### *3.3.1 Ecosystem Diversity*

The vast geographical area, with its diverse climatic conditions and topography, has led to almost all types of ecosystems in India. Its ecosystems range from the tropical wetlands and mangroves to alpine wetlands, riverine plain forests to moist evergreen rainforests and alpine grasslands to high-rising mountains. Each of these ecozones has further biotypes, characterized by unique floristic composition. These communities are highly influenced by the elements from adjacent phytogeographical regions, such as tropical Indo-China, temperate East Asia, the Palaearctic region and the Deccan Plateau. The riverine plain forest ecosystems along the foothill valleys of Brahmaputra, Lohit, Subansiri and tropical rainforests of Western Ghats and Andaman and Nicobar Islands are among the tallest in the world. Characteristic species in the highly productive grasslands of riverine plain ecosystems include *Saccharum spontaneum*, *Aristida adscensionis*, *Arundo donax*, *Imperata cylindrica* and species of *Andropogon* and *Phragmites*.

The cold deserts of Ladakh region in Jammu and Kashmir, Lahaul-Spiti and Kinnaur in Himachal Pradesh, Nelang valley, Mana and Niti valley in Uttarakhand and Trans-Himalayan zone in Sikkim are some of the most unique ecosystems worthy to mention. Extending from 4500 to 6000 m in altitude, these comprise Trans-Himalayan rain-shadow zone of the Western Himalaya characterized by extremely low temperature (up to −45 °C) and low rainfall. The climate is hot in the daytime and extremely cold during night, coupled with excessive dryness. The vegetation of the region is very scanty and highly specialized, with plants exhibiting a number of ecological, morphological and physiological adaptations to help them counteract the impact of harsh climate. The dominant species found in these deserts include *Thylacospermum caespitosum*, *Acantholimon lycopodioides*, *Echinops cornigerus*, *Lindelofia anchusoides*, *Tanacetum tibeticum*, *Nepeta floccosa*, *Arnebia guttata*, *Lancea tibetica*, *Lepidium apetalum*, *Elaeagnus angustifolia*, *Potentilla anserina*, *Sedum ewersii*, *Saxifraga sibirica*, *Waldheimia tomentosa*, *Dianthus anatolicus*, *Oxytropis lapponica*, *Potentilla multifida*, *Plantago minima*, *Sedum tibeticum*, *Arabis tibetica*, *Corydalis crassifolia*, etc. The most noticeable adaptive characters of the vegetation of this region are cushion-forming or bushy habit, diminutive or miniature size and protective layer of hairs. The plants with cushion-forming habit are *Acantholimon lycopodioides*, *Thylacospermum caespitosum*, *Arenaria bryophylla* and species of *Astragalus*, *Androsace*, *Draba*, *Sedum* and *Saxifraga*; those with bushy habit are *Caragana pygmaea*, *Ephedra gerardiana*, *Hippophae rhamnoides*, *Myricaria prostrata* and *Lonicera hispida*; those with diminutive or miniature size are *Pleurogyne brachyanthera*, *Gentiana thomsonii*, *Taraxacum bicolor*, *Astragalus heydei*, *Corydalis crassissima*, *Thermopsis inflata* and *Dracocephalum heterophyllum*; while plants with a dense layer of protective covering of hairs are *Astragalus munroi*, *Saussurea gossypiphora* and *Soroseris glomerata*.

The plants of Llonakh Valley in Sikkim Himalaya are of rare kind, forming a unique alpine community. The species occurring in this high-altitude region are predominantly of Tibetan affinity. Ranunculaceae are moderately represented. Among the few shrubby plants of higher regions are the species of *Berberis*, which persist far into the upper Llonakh Valley, where they are much dwarfed and generally prostrate. *Corydalis* is well represented and rich in species. Brassicaceae are well represented by species of *Draba. Lychnis*, *Stellaria* and *Arenaria* (Caryophyllaceae) are strongly represented in species and abundance, while the tufted arenarias form one of the most characteristic features of Llonakh. Legumes are moderately represented by species of *Astragalus* and *Oxytropis.* Rosaceae are a conspicuous feature of the vegetation, with many species of *Potentilla*, *Sibbaldia*, *Spiraea* and *Cotoneaster. Saxifraga* is another dominant genus in the upper reaches. Apiaceae are represented by prostrate *Cortia*, *Pleurospermum* and *Trachydium* on open wind-swept areas of Llonakh. With the exception of *Galium*, Rubiaceae are absent from the higher altitudes. Asteraceae are well distributed with abundance of species of *Saussurea* in the valley, *Anaphalis* and *Artemisia* being common towards the dry Tibetan region. *Pedicularis* is another dominant genus in this valley; bright colour of its species is a conspicuous feature of sparse Llonakh vegetation. Prostrate species of *Salix* are prevalent right up to the melting snow. Sparing species of *Habenaria* and *Cypripedium* represent the Orchidaceae. Juncaceae, Cyperaceae and Poaceae are less prevalent. Species of *Ephedra* and dwarf junipers ascend to over 5000 m altitude. The dominant genera in the area are *Saxifraga* (34 spp.), *Pedicularis* (31 spp.), *Primula* (24 spp.), *Saussurea* (21 spp.), *Potentilla* (17 spp.), *Corydalis* (16 spp.), *Rhododendron* (15 spp.) and *Arenaria* (14 spp.) (Smith and Cave 1911).

### 3.3.2 *Vegetation Pattern*

The varied climatic and altitudinal conditions, coupled with diverse ecological habitats, have immensely contributed to the development of rich vegetation and wide-ranging flora of India. Forests are important components of land cover and a climatic expression of biodiversity in terms of spatial coverage. Based on parameters, such as habitat conditions, altitude, community structure and floral composition, all possible types of forests and other vegetation are found in India; these include tropical, subtropical, temperate and alpine forests, humid evergreen rainforests, semi-deciduous and deciduous forests, scrub jungles, hot dry-arid zones, cold dry-arid zones, coastal mangroves, submerged seaweeds and seagrasses, salt marshes, swamps, sand-dune formations, freshwater and saline aquatic vegetation.

The total forest cover in India is about 692,027 km$^2$ (21.05%) of its geographical area. In terms of density classes, the area covered by very dense forests is 83,471 km$^2$ (2.54%), moderate dense forests is 320,736 km$^2$ (9.76%) and that of open forests is 287,820 km$^2$ (8.75%) (FSI 2011). The state of Mizoram has the maximum forest cover (90.68%), followed by Arunachal Pradesh (80.50%) and Nagaland (80.33%). The forest cover of Andaman and Nicobar Islands is 81.23% of their geographical area, while in Sikkim, it is 47.34%.

Broad vegetation types in India can be summarized under each phytogeographical region which is unique in its composition and characterized by typical elements which are significant to that region. General composition and the area covered by different vegetation types, following Champion and Seth (1968), are given in Table 3.2.

### 3.3.3 *Species Diversity*

Status of species richness in various taxonomic groups traditionally considered as plants, as documented from India by Singh and Dash (2018), is provided in Table 3.3.

#### 3.3.3.1 Angiosperms

It is estimated that out of 49,003 species of plants forming the evident vegetal cover in India, angiosperms comprise ca. 18,532 species, representing ca. 10% of the world's known flowering plant species (Singh and Dash 2018). Out of 416 recognized plant families (Brummit 1992, APG 2016), 257 families, with more than 4000 genera, are represented in the Indian flora. Ten largest families with respect to number of species are given in Table 3.4, whereas ten largest genera with respect to number of species are given in Table 3.5.

**Table 3.2** Different types of vegetation in India with their composition and area covered

| S. no. | Vegetation type | General composition | Approx. area (km$^2$) | % age of forest cover |
|---|---|---|---|---|
| 1 | Tropical wet evergreen forests | Dense tall forests, entirely evergreen or nearly so | 15,886 | 2.29 |
| 2 | Tropical semi-evergreen forests | Dominants include deciduous species but evergreens predominant | 95,422 | 13.79 |
| 3 | Tropical moist deciduous forests | Dominants mainly deciduous but sub-dominants and lower story largely evergreen, top canopy even and dense but 25 m high | 1,35,833 | 19.73 |
| 4 | Littoral and swampy forests | Mainly evergreens of varying density and height but always associated predominantly with wetness | 4774 | 0.69 |
| 5 | Tropical dry deciduous forests | Entirely deciduous or nearly so, top canopy uneven, rarely over 25 m high | 2,98,727 | 41.87 |
| 6 | Tropical thorny/ scrub forests | Deciduous with low thorny trees and xerophytes predominant, top canopy more or less broken, less than 10 m high | 15,569 | 2.25 |
| 7 | Tropical dry evergreen forests | Hard-leaved evergreen trees predominate, with some deciduous emergents, often dense but usually under 20 m high | 899 | 0.13 |
| 8 | Subtropical broad-leaved hill forests | Broad-leaved, largely evergreen high forests | 18,613 | 2.69 |
| 9 | Subtropical pine forests | Pine associated, predominates | 18,199 | 2.63 |
| 10 | Subtropical dry evergreen forests | Low xerophytic forests and scrubs | 207 | 0.03 |
| 11 | Montane wet temperate forests | Evergreen, without coniferous species | 4774 | 0.69 |
| 12 | Himalayan wet/ moist temperate forests | Evergreen forests, mainly sclerophyllous oak and coniferous species | 28,509 | 4.12 |
| 13 | Himalayan dry temperate forests | Coniferous forests, with sparse xerophytic undergrowth | 5812 | 0.84 |
| 14 | Subalpine forests | Stunted deciduous or evergreen forests, usually close formation with or without conifers | 17,645 | 2.55 |
| 15 | Moist alpine forests | Low but often dense scrub of evergreen species | | |
| 16 | Dry alpine forests | Xerophytic scrub in open formation, mostly deciduous in nature | | |

Some other species-rich genera are *Syzygium* (Myrtaceae), *Saxifraga* (Saxifragaceae), *Piper* (Piperaceae), *Taraxacum* (Asteraceae), *Astragalus* (Fabaceae), *Saussurea* (Asteraceae) and *Citrus* (Rutaceae). Bamboos and hedychiums also exhibit remarkable diversity in this country. Some families of flowering plants are represented in India by just one species each; these include Turneraceae,

**Table 3.3** Number of species of major groups of plants, algae, fungi and microorganisms reported from India

| Taxonomic group | Number of species in India | Percentage of Indian flora |
|---|---|---|
| Viruses/bacteria | 1196 | 2.44 |
| Algae | 7396 | 15.09 |
| Fungi | 15,223 | 31.07 |
| Lichens | 2528 | 5.16 |
| Bryophytes | 2754 | 5.62 |
| Pteridophytes | 1293 | 2.64 |
| Gymnosperms | 81 | 0.17 |
| Angiosperms | 18,532 | 37.81 |
| Total | **49,003** | **100** |

**Table 3.4** Ten largest families of angiosperms in the Indian flora

| S. no. | Name of family | Number of species | Number of genera |
|---|---|---|---|
| 1. | Leguminosae | 1421 | 179 |
| 2.. | Poaceae | 1291 | 263 |
| 3. | Orchidaceae | 1251 | 185 |
| 4. | Asteraceae | 1120 | 167 |
| 5. | Rubiaceae | 679 | 113 |
| 6. | Cyperaceae | 580 | 38 |
| 7. | Rosaceae | 532 | 40 |
| 8. | Euphorbiaceae | 530 | 84 |
| 9. | Acanthaceae | 510 | 92 |
| 10. | Lamiaceae | 475 | 72 |

**Table 3.5** Ten largest genera of angiosperms in Indian flora

| S. no. | Name of genus | Family belonging to | Number of species |
|---|---|---|---|
| 1. | *Impatiens* | Balsaminaceae | 279 |
| 2. | *Carex* | Cyperaceae | 160 |
| 3. | *Pedicularis* | Scrophulariaceae | 145 |
| 4. | *Bulbophyllum* | Orchidaceae | 135 |
| 5. | *Primula* | Primulaceae | 135 |
| 6. | *Polygonum* s.l. | Polygonaceae | 134 |
| 7. | *Ficus* | Moraceae | 132 |
| 8. | *Rhododendron* | Ericaceae | 129 |
| 9. | *Dendrobium* | Orchidaceae | 114 |
| 10. | *Crotalaria* | Leguminosae | 105 |

Illiciaceae, Ruppiaceae, Tetracentraceae, etc. About 15% species are trees, which include some of the highly valued timbre species of the world, belonging to families Meliaceae, Verbenaceae, Dipterocarpaceae, Fabaceae, Lauraceae, Euphorbiaceae, Annonaceae, Moraceae, etc.

Some of the species of *Arenaria*, *Thylacospermum*, *Acantholimon*, *Saussurea*, etc., growing in cold deserts, are highly adaptive for their survival. There are several botanical curiosities, such as *Nepenthes khasiana*, *Sapria himalayana*, *Mitrastemon yamamotoi*, *Balanophora dioica*, *Boschiniackia himalaica*, *Aeginetia indica* and species of *Utricularia*, *Drosera*, *Pinguicula*, *Galeola*, *Epipogium*, *Monotropa*, etc. The insectivorous plant families are represented by Lentibulariaceae (with 36 spp.), Droseraceae (3 spp.) and Nepenthaceae (1 sp.). The parasitic plant species are prominent in Orobanchaceae (54 spp.), Loranthaceae (46 spp.), Cuscutaceae (12 spp.), Santalaceae (10 spp.), Balanophoraceae (6 spp.) and Rafflesiaceae (1 sp.).

The Indian flora also shows rich diversity in aquatic flowering plants. Some important families of aquatic plants are Podostemaceae (with 24 spp.); Hydrocharitaceae and Pontederiaceae (13 spp. each); Alismataceae (8 spp.); Najadaceae and Nymphaeaceae (7 spp. each); Aponogetonaceae and Potamogetonaceae (6 spp. each); Typhaceae (4 spp.); Ceratophyllaceae, Callitrichaceae and Salviniaceae (3 spp. each); Barclayaceae, Cabombaceae and Trapaceae (2 spp. each); and Azollaceae, Butomaceae, Nelumbonaceae, Ruppiaceae and Zannichelliaceae (1 sp. each). The species of the families Podostemaceae and Tristichaceae grow on underwater rocks in fast-flowing streams.

- **Diversity in Some Larger and Economically Important Families**
  - **Poaceae:** The family is represented in India by 1291 species in 263 genera. These species are distributed over 6 subfamilies and 25 tribes. About 105 genera of the Indian grasses are represented by one species each only. The genus *Poa* has the maximum (55) species. Other genera with 25 or more species are *Ischaemum* (46 spp.), *Dimeria* (35 spp.), *Panicum* (34 spp.), *Isachne* (30 spp.), *Eragrostis* (30 spp.), *Festuca* (27 spp.), *Stipa* and *Digitaria* (25 spp. each). The maximum species diversity of grasses is found in the Peninsular India, with more than 50% of the Indian total. In this region, Tamil Nadu alone has ca. 460 species of grasses. The Northeast India is another grass-rich area, with about 480 species.
  - **Orchidaceae:** The family exhibits enormous species diversity in India, mostly in tropical and subtropical forests. According to present estimate, ca. 1251 species, belonging to 185 genera, are recorded from the country. *Bulbophyllum* shows the maximum diversity, being represented by 135 species. It is followed by *Dendrobium* (114 spp.), *Habenaria* (71 spp.), *Eria* (54 spp.), *Oberonia* (52 spp.), *Liparis* (43 spp.), *Coelogyne* (38 spp.), *Eulophia* (29 spp.), *Peristylus* (27 spp.), *Cymbidium* (25 spp.) and *Calanthe* (25 spp.).
  - Region-wise, the Eastern Himalaya has 870 orchid species distributed over 159 genera, while the Western Himalaya has only 288 species in 75 genera. The Peninsular India contains 379 species belonging to 89 genera. A total of 115 species, belonging to 53 genera, are recorded from Andaman and Nicobar

Islands. About 18 genera of Indian orchids are identified as monotypic; these include *Arundina*, *Acrochaene*, *Aenhenrya*, *Anthogonium*, *Bulleya*, *Cephalantheropsis*, *Dickasonia*, *Eriodes*, *Herpysma*, *Hygrochilus*, *India*, *Jejosephia*, *Neogyna*, *Ornithochilus*, *Risleya* and *Stereosandra*.

- **Fabaceae (Leguminosae):** Leguminosae is the third largest family of flowering plants in the world, with over 19,400 species in 730 genera and 41 tribes (Polhill and Raven 1981), while it is the largest family in India, with 1421 species in 179 genera (Sanjappa 1991; Dash and Prasad personal communication). The family is divided into three subfamilies – *Papilionoideae (Faboideae)*, *Mimosoideae* and *Caesalpinioideae*. Of the three subfamilies in India, *Mimosoideae* comprises ca. 173 species in 23 genera, distributed mainly in the Peninsular region, Western Ghats and Northeast India, apart from a few species cultivated in gardens; *Caesalpinioideae* comprises 175 species in 35 genera, restricted up to the temperate regions; while *Papilionoideae* is represented by 894 species in 140 genera, distributed in various phytogeographical zones from tropical to alpine regions (Sanjappa 2001). From the commercial point of view, the family is next to Orchidaceae and Poaceae.
- **Asteraceae:** Asteraceae is the fourth largest flowering plant family in India. Hajra et al. in their detailed, revised taxonomic account of the family in India, recorded 892 species, 37 subspecies, 123 varieties and 13 forma in 177 genera, 12 tribes and 17 subtribes, whereas as per recent estimates, the family is represented by 1120 species and 167 genera in India (Dash and Prasad personal communication). The maximum (600) species occur in the Western Himalaya, followed by the Eastern Himalaya (including Northeast region) with over 350 species, Western Ghats with ca. 300 species and Andaman and Nicobar Islands with just 25 species. It is interesting to note that 60 out of 61 species of *Saussurea* are confined to the Himalayan region, while all the Indian species in *Tanacetum*, *Taraxacum* and *Waldheimia* are also confined to the Himalaya. Of all the genera in India, 80 genera are represented by a single species each; out of these, 19 genera are monotypic (Mabberley 2008).
- **Rubiaceae:** Mostly woody, this family is distributed predominantly in the tropical and subtropical regions. In India, it is represented by 679 species spread over 113 genera, 28 tribes and 4 subfamilies. Various economically important genera of this family include *Coffea* (Coffee), *Cinchona* (Quinine), *Rubia* (Madder), *Cephaelis* (Ipecac), etc. *Hedyotis* with 68 species is the largest genus, followed by *Ophiorhiza* (47 spp.) and *Psychotria* (44 spp.).

- **Endemism and Primitive Angiosperms**

Present estimate pertaining to the political boundaries of present-day India is that about 4300 (23.20%) of 18,532 flowering plant species are endemic to this country (Singh et al. 2015). Perhaps it would be necessary to revise these figures once revision of the entire flora of India in the present series is completed. Western Ghats has the maximum number (2116) of endemic taxa. Eastern Himalaya, consisting of Sikkim, hills of Darjeeling and Kalimpong and Jalpaiguri districts of West Bengal and Arunachal Pradesh, together contribute 466 endemic taxa, followed by the Northeast region with 395 taxa. Andaman and Nicobar Islands have 278 endemic taxa, and the Indian desert has only one endemic plant species (Singh et al. 2015). The flora of Indian region has no endemic family, while the number of endemic genera is a topic of debate among botanists {Sarkar 1995 (142 genera); Nayar 1980, 1996 (147 genera); Ahmedullah 2000 (140 genera); Mitra and Mukherjee 2007 (121 genera); Irwin and Narasimhan 2011 (47 genera); and Singh et al. 2015 (58 genera)}. All these accounts considered the respective genera as endemic based on then available information on range of their distribution.

The northeastern region of India, Eastern Himalaya and Assam have quite a large number of primitive plants, of which many species do not occur in other parts of the country (Dash and Singh 2018). The presence of many primitive species and their close allies in this region lend support to Takhtajan's view of its being the 'cradle of flowering plants' and an important centre of speciation. The genera of primitive flowering plants that are abundant in this region are *Annona*, *Alphonsea*, *Artabotrys*, *Desmos*, *Fissistigma*, *Gonithalamus*, *Milliusa*, *Uvaria*, *Knema*, *Myristica*, *Actinodaphne*, *Alseodaphne*, *Beilschmiedia*, *Cinnamomum*, *Cryptocarya*, *Lindera*, *Litsea*, etc. (see also Table 3.6).

#### 3.3.3.2 Gymnosperms

Gymnosperms, the most primitive type of seed plants, are represented in India by 81 species and 8 varieties and about 26 species of exotics which have been introduced into various Indian gardens, belonging to 46 genera in 12 families. Pinaceae (with 42 taxa in 7 genera) is the largest family, followed by Cupressaceae (with 28 taxa in 11 genera), Ephedraceae (with 12 taxa in 1 genus) and Gnetaceae (with 10 taxa in 1 genus). The dominant genera are *Ephedra*, *Pinus*, *Juniperus* and *Gnetum. Abies spectabilis*, *Cupressus torulosa*, *Taxus wallichiana*, *Pinus wallichiana* and *P. roxburghii* are widely distributed in the Himalaya; *Cedrus deodara*, *Picea smithiana* and *Abies pindrow* are being confined to Western Himalaya; while *Abies densa* and *Larix griffithiana* are restricted to the Eastern Himalaya. Many species, such as *Pinus gerardiana* (WH), *P. kesiya* (EH), *P. merkusii* (EH), *P. bhutanica* (EH) and *Cephalotaxus manii* (EH), have very restricted and localized distribution in their respective Himalayan zones. *Amentotaxus assamica* and *Pinus wallichiana* var. *parva* are endemic to Arunachal Pradesh, while *Cycas beddomei*, *C. sphaerica*, *Gnetum contractum* and *G. latifolium* var. *macrocarpum* are endemic to Andhra Pradesh (Cuddapah district), Orissa (Puri & Angul), Kerala and Tamil Nadu (Nilgiri) and Andaman and Nicobar Islands, respectively.

Most species of *Gnetum* are woody climbers/lianas and, along with species of *Cycas*, are mostly confined to the Northeast India, Eastern and Western Ghats and Andaman Islands. *Juniperus* species mostly grow near timberline. *Abies spectabilis* has been found growing at an altitude of 5350 m in Kashmir, probably the highest limit for any tree species. *Pinus gerardiana* (seeds) and *Gnetum gnemon* (leaves and

**Table 3.6** Primitive flowering plants occurring in India

| Name of species | Family | Distribution |
|---|---|---|
| *Alnus nepalensis* | Betulaceae | Himalaya (India), China |
| *Altingia excelsa* | Hammamelidaceae | E. Himalaya (India), S. China, Indo-China, Java |
| *Aspidocarya uvifera* | Menispermaceae | E. Himalaya (India), SE Asia |
| *Betula alnoides* | Betulaceae | E. Himalaya (India), SE Asia |
| *Chloranthus brachystachi* | Chloronthaceae | E. Himalaya (India), China, Japan |
| *Decaisnea insignis* | Lardizabalaceae | E. Himalaya (India), W. China |
| *Distylium indicum* | Hammamelidaceae | E. Himalaya (India), China, Taiwan, Korea, Japan |
| *Euptelea pleiosperma* | Eupteleaceae | E. Himalaya (India), Indo-China, Japan |
| *Exbucklandia populnea* | Hamamelidaceae | E. Himalaya (India), Sumatra |
| *Haematocarpus validus* | Menispermaceae | E. Himalaya (India), Myanmar, W. Malaysia, New Guinea |
| *Holboellia latifolia* | Lardizabalaceae | E. Himalaya (India), China |
| *Houttuynia cordata* | Houttuyniaceae | E. Himalaya (India), China, Japan, Thailand, Taiwan |
| *Illicium cambodianum* | Illiciaceae | E. Himalaya (India), China |
| *I. griffithii* | Illiciaceae | E. Himalaya (India), China |
| *I. simonsii* | Illiciaceae | E. Himalaya (India), China |
| *Magnolia griffithii* | Magnoliaceae | E. Himalaya (India), Myanmar |
| *M. gustavii* | Magnoliaceae | E. Himalaya (India), Myanmar |
| *M. hodgsonii* | Magnoliaceae | E. Himalaya (India), Myanmar |
| *M. pealiana* | Magnoliaceae | E. Himalaya (India), Myanmar |
| *M. pterocarpa* | Magnoliaceae | E. Himalaya (India), Myanmar |
| *Manglietia insignis* | Magnoliaceae | E. Himalaya (India), S. China, Indo-China, Java |
| *Myrica esculenta* | Myricaceae | W. and E. Himalaya (India), China, Korea, Japan |
| *Parvatia brunoniacea* | Lardizabalaceae | Himalaya (India), SW China, |
| *Pycnarrhena pleniflora* | ,, | E. Himalaya (India), NW Australia |
| *Stauntionia elliptica* | Lardizabalaceae | E. Himalaya (India), SW China, Taiwan, Vietnam, Korea |
| *Stauntonia brunoniana* | Lardizabalaceae | E. Himalaya (India), SW China, Taiwan, Vietnam, Korea |
| *Tetracentron sinense* | Tetracentraceae | E. Himalaya (India), SW China, Myanmar |

Source: Takhtajan (1969)

strobili) have edible value, while *Ephedra* spp. (yielding ephedrine) and *Taxus wallichiana* (yielding taxol) are known for their medicinal value.

#### 3.3.3.3 Pteridophytes

Pteridophytes (ferns and fern allies) are represented by over 1293 taxa under 204 genera in all climatic zones of the country. They grow in a variety of habitats and range from epiphytes (e.g. species of *Arthomeris*, *Belvisia*, *Microsorium*, *Lycopodium*, *Polypodium*, *Oleandra*, *Drynaria*, *Asplenium*, *Lepisorus*, *Vittaria*, etc.) and terrestrials (e.g. species of *Cyathea*, *Alsophila*, *Angiopteris*, *Osmunda*, *Equisetum*, *Lycopodium*, *Pteris*, *Pteridium*, *Polystichum*, *Athyrium*, etc.) to aquatics (e.g. species of *Marsilea*, *Azolla* and *Salvinia*). Though pteridophytes in general prefer shady and moist places, a few species (e.g. *Woodsia elongata* and *Actmopteris radiata*) survive in dry places. *Acrostichum speciosum* and *A. aurexum* grow in mangrove forests; *Lygodium flexuosum* and *Microsorium normale* are climbers; while some species of *Vittaria*, *Lepisorus* and *Asplenium* prefer tree tops. Tree ferns, such as *Cyathea spinulosa* and *C. gigantea*, adorn the tropical forests.

Northeast India, including Eastern Himalaya, is the richest region, harbouring 2nd/third of the known pteridophytes from India, i.e. ca. 845 taxa under 179 genera. This is followed by South India, including Eastern and Western Ghats, with 345 taxa under 117 genera, and North India, including Western Himalaya, with 340 taxa under 101 genera. Polypodiaceae (with ca. 150 spp.), Dryopteridaceae (129 spp.), Athyriaceae (101 spp.), Thelypteridaceae (88 spp.), Aspleniaceae (70 spp.) and Aspediaceae (50 spp.) are the largest families. Similarly, *Selaginella* and *Pteris* (with ca. 62 spp. each), *Dryopteris* (53 spp.), *Asplenium* and *Polystichum* (with 45 spp. each) are the largest genera in Indian pteridophytic flora. Some species of *Diplazium*, *Dryopteris* and *Marsilea* are edible. Similarly, *Adiantum capillus-veneris*, *Selaginella bryopteris* and species *of Lycopodium*, *Polystichum* and *Marsilea* are well-known for high medicinal properties. Contrary to richness and diversity of Indian pteridophytes, endemism in them is very low; only 68 species of pteridophytes are being recognized as endemic to India (Singh et al. 2015).

#### 3.3.3.4 Bryophytes

- **Mosses**

Mosses (Musci) constitute the major component of bryophytes, being represented in India by ca. 1909 species, occurring mostly in the hot and moist climates of the Himalaya (ca. 1420 species in 318 genera) and Western Ghats (684 species in 41 genera). Eastern Himalaya has the maximum (1030) species, followed by Western Himalaya (751 spp.) and Western Ghats (684 spp.). Pottiaceae (with ca. 190 spp.), Bryaceae (150 spp.) and Dycranaceae (146 spp.) are the largest families, whereas *Fissidens* (with ca. 67 spp.), *Bryum* (59 spp.), *Campylopus* (41 spp.) and *Brachythecium* (39 spp.) are the largest genera of Indian mosses. Species of *Fissidens*, *Stereophyllum*, *Ditrichwn*, etc. are common at lower altitudes, while those species belonging to *Brachymenium*, *Philonotis*, *Campylopus*, *Pogonatum*, *Thuidium*, *Mnium*, etc. dominate in between 1500 and 3500 m altitudes. Another interesting aspect of Indian mosses is the occurrence of species of *Sphagnum*, *Calliergon*, *Pleuridium*, etc. above 5000 m, indicating their adaptability to such cool conditions where other plants cannot survive.

- **Liverworts**

Indian liverworts (Hepaticae) comprise ca. 845 species spread over 140 genera. Vast areas in the Himalaya and Peninsular India, with abundant precipitation and high humidity, are richer in liverworts as compared to the large plains stretching over greater part of the country. The Eastern Himalaya, with ca. 548 species, is the richest region, followed by Western Ghats (with ca. 280 spp.) and Western Himalaya (235 spp.). The rest of the country accounts for only ca. 135 species. Lejeuneaceae (with ca. 155 spp.), Plagiochilaceae (119 spp.) and Jungermanniaceae (76 spp.) are the largest families, whereas *Plagiochila* (with ca. 114 spp.), *Frullania* (54 spp.) and *Jungermannia* (38 spp.) are among the largest genera in India. The rich representation in certain genera, such as *Cyathodium* with 9 species out of the 12 known and *Notothylus* with 8 species out of the 18 known and presence of some phylogenetically significant genera such as *Fossombronia* and *Sewardiella*, together with the discovery of some fossil liverworts (e.g. *Hepaticites pantii*), are all indicative of a diversified and unique liverwort flora of India.

### 3.3.3.5 Algae

Algae are a highly diversified group of plants standing near the lowest rung of the ladder of evolution of life, with enormous economic implications, not only as primary producers and pollution indicators but also as a source of several natural products, biofertilizers and fine chemicals. They occur in a wide range of habitats, mostly in freshwater ecosystems like lakes, ponds, rivers, wetlands, etc. and in marine water systems like salt marshes, etc.

As of now, 7396 species of algae are reported from India, making 15.09% of overall flora of the country. Most of the taxa are contributed by Chlorophyceae (328 genera, 2592 species, 817 varieties, 336 forma), followed by Cyanophyceae (90 genera, 939 species, 207 varieties, 86 forma), Euglenophyceae (21 genera, 384 species, 117 varieties, 15 forma), Chrysophyceae (25 genera, 82 species, 9 varieties, 2 forma) and Xanthophyceae (25 genera, 66 species, 3 varieties, 2 forma) (Gupta 2012a, b). The freshwater algae, dominated by Chlorophyceae (green algae), Bacillariophyceae (diatoms) and Cyanophyceae (blue-green algae/Cyanobacteria), represent the major components of Indian algae. The genera *Spirogyra*, *Nitella*, *Volvox*, *Anacystis*, *Zygnema*, *Mougeotia*, etc. are dominant and well known. Over 70 species of the Indian stonewort belong to genera *Chara*, *Tolypella*, *Nitellopsis*, etc. *Oscillatoria*, *Lyngbya* and *Phormidium* are the dominant genera of blue-green algae, whereas species of *Nostoc* and *Anabaena* are common in the rice fields.

The marine algae (seaweeds), known for their varied colours, are an attractive group of plants found growing on the ocean floors and the long stretches of Indian sea coasts. A total of ca. 856 seaweed species are reported from the Indian coasts; out of these ca. 50% belong to Rhodophyceae (red algae), 25% to Chlorophyceae (green algae), 22% to Phaeophyceae (brown algae) and 3% to Cyanophyceae (blue-green algae). The Gujarat coast, the island stretches in Gulf of Mannar and Andaman and Nicobar group of islands are of special interest and excel other areas in the abundance and variety of marine algae. In India, over 45 species of marine algae are useful mainly as sources of agar-agar (species of *Gelidium*, *Gelidiella* and *Gracilaria*) and algin (species *of Sargassum*, *Turbinaria*, *Dictyota*, *Padina*, etc.). Some species are also useful as food (species of *Ulva*, *Enteromorpha*, *Turbinaria*, *Gracilaria* and *Porphyrd*), as fodder (species of *Dictyota*, *Padina*, *Sargassum*, etc.) and as manure (all seaweeds in coastal areas).

#### 3.3.3.6 Fungi

Fungi, a group of heterotrophic organisms subsisting as parasites or as saprophytes on other organisms or their residues, span the world and are as numerous and varied as flowering plants. They range from microscopic organisms to huge solid bodies and from rusts, smuts and mildews which damage growing crops to yeasts used in the preparation of food and drink and yield products ranging from life-savers like penicillin to killers such as ergot.

As per the present state of our knowledge, about 15,223 species of fungi are recorded from India under 117 orders, 378 families and 2660 genera (Singh and Dash 2018; Kanad Das personal communication). Out of the total number known from India, ca. 3500 species are endemic. Deuteromycota (fungi imperfecti), together with Ascomycota and Basidiomycota, account for more than 88% of the Indian mycoflora. Deuteromycota alone represent ca. 40%, followed by Ascomycota (25%) and Basidiomycota (23%). Interestingly, out of 2660 genera of Indian fungi, 1197 (46%) have only one species each, while 1275 (48%) genera have 2 to 10 species each as presented in Table 3.7.

Dominant genera with respect to number of species in various groups of fungi recorded from India are shown in Table 3.8.

A fascinating group of fungi is aphyllophoraceous fungi. These constitute a cosmopolitan group, fruiting mostly on dead woods and wood products. Sufficient substrata provided both by angiosperm and coniferous tree species, coupled with a great diversity of ecological habitats, furnish conducive conditions for the growth of these fungi in the Himalayan forests from tropical to alpine zones, viz. in Western Himalaya (Jammu and Kashmir, Himachal Pradesh and Garhwal and Kumaon regions of Uttarakhand), Eastern Himalaya (Arunachal Pradesh, Assam and Meghalaya) and Sikkim Himalaya (Sikkim and Darjeeling district of West Bengal). Due to greater diversity in woody tree species and more precipitation, east Himalayan forests have richer aphyllophoraceous mycoflora than the western sector (Sharma 2012).

A total of 681 aphyllophoraceous fungal taxa (676 species +5 varieties), belonging to 188 genera in 26 families, have been recorded from India. Polyporaceae is the largest family (with 213 spp. in 68 genera), followed by Corticiaceae (138 spp. in 48 genera) and Hymenochaetaceae (96 spp. in 9 genera). Out of the total genera, ca. 60 (37%) have only one species each, 114 (60%) have 2–9 species each, while 12 (3%) genera have 10 or more species each. *Phellinus* with about 52 species is the

**Table 3.7** Number of genera and species reported in major groups (taxa) of fungi from India

| Phyla | Families | Genera | Species |
|---|---|---|---|
| Ascomycota | 182 | 1835 | 9607 |
| | Mycosphaerellaceae | 71 | 1643 |
| | Meliolaceae | 10 | 811 |
| | Erysiphaceae | 35 | 380 |
| | Botryosphaeriaceae | 23 | 285 |
| Basidiomycota | 128 | 639 | 3775 |
| | Pucciniaceae | 20 | 450 |
| | Ustilaginaceae | 14 | 200 |
| | Russulaceae | 2 | 200 |
| | Polyporaceae | 44 | 170 |
| | Hymenochaetaceae | 19 | 150 |
| Chytridiomycota | 11 | 30 | 208 |
| | Synchytriaceae | 3 | 60 |
| | Physodermataceae | 1 | 50 |
| Glomeromycota | 4 | 9 | 50 |
| | Glomeraceae | 5 | 30 |
| | Gigasporaceae | 2 | 12 |
| Zygomycota | 21 | 46 | 210 |
| | Mucoraceae | 7 | 70 |
| | Cunninghamellaceae | 3 | 15 |
| Chromista (Chytridiomycetes, Hypochytri-diomycetes, Oomycetes) | 16 | 48 | 250 |
| | Saprolegniaceae | 14 | 80 |
| | Peronosporaceae | 10 | 100 |
| Protozoan fungal analogues (Acrasiomycetes, Myxogastria, Plasmodio-phorida) | 16 | 53 | 400 |
| | Physaraceae | 8 | 90 |
| | Didymiaceae | 7 | 85 |

largest and widely distributed genus in the Himalaya, followed by *Ramaria* (26 spp.), *Trametes* (19 spp.), *Tomentella* (18 spp.), *Inonotus* (17 spp.), *Hyphodontia* (14 spp.), *Polyporus* (13 spp.) and *Phlebia* (12 spp.).

#### 3.3.3.7 Lichens

Lichens, with 2528 species under 74 families (Singh and Sinha 2010; Singh and Dash 2018), constitute an interesting component of the Indian flora, occurring on various substrata in tropical, subtropical, temperate and alpine regions. About 508 (22.2%) species are endemic, mostly crustose-form neo-endemics described mostly from the Western Ghats and Andaman and Nicobar Islands. Analysis of species diversity at the family level indicates that foliose Parmeliaceae are the most diverse with 345 species, being widely distributed in subtropical, temperate and alpine

**Table 3.8** Species-rich genera in different groups of fungi recorded from India

| S. no. | Name of the group | Dominant genera (with approx. number of species) in India |
|---|---|---|
| 11 | Myxomycetes (true slime moulds) | *Physarum* (60), *Didymium* (34), *Diderma* (35), *Arcyria* (19) |
| 22 | Chyt. Hypochyt. and Oomycetes (fungi with motile cells) | *Synchytrium* (72), *Physoderma* (45), *Peronospora* (35), *Phytophthora* (24), *Pythium* (54), *Albugo* (18) |
| 33 | Zygomycetes (bread moulds) | *Mucor* (56), *Rhizopus* (19), *Mortierella* (15), *Syncephalis* (23), *Conidiobolus* (18) |
| 44 | Ascomycetes (sac fungi) | *Meliola* (469), *Phyllachora* (149), *Chaetomium* (91), *Xylaria* (96), *Hypoxylon* (57), *Leptosphaeria* (63), *Asterina* (95) |
| 45 | Ustilaginales (smuts) | *Ustilago* (69), *Sphacelotheca* (44), *Sorosporium* (39), *Tilletia* (58). |
| 46 | Uredinales (rusts) | *Puccinia* (303), *Aecidium* (102) *Uromyces* (99), *Uredo* (82) |
| 77 | Agaricales (mushrooms) | *Marasmius* (55), *Russula* (116), *Lactarius* (75) |
| 88 | Aphyllophorales(woodrotting fungi) | *Phellinus* (54), *Tomentella* (19), *Trametes* (18), *Inonotus* (17) |
| 99 | Gasteromycetes (stomach fungi) | *Lycoperdon* (29), Scleroderma (17) |
| 110 | Fungi imperfecti | *Cercospora* (707), *Phyllosticta* (280), *Aspergillus* (121), *Phome* (125), *Alternaria* (91) |

regions. It is followed by crustose Graphidaceae with 269 species, mostly distributed in tropical and subtropical regions. The other dominant families are Thelotremataceae (with 130 spp.), Pyrenulaceae (116 spp.), Caliciaceae (103 spp.), Lecanoraceae (98 spp.), Physciaceae (97 spp.), Trypetheliaceae (78 spp.), Teloschistaceae (75 spp.) and Collemataceae (67 spp.). Similarly, at the generic level, *Graphis* shows the maximum diversity, being represented by 111 species in tropical and subtropical regions, followed by *Pyrenula* with 84 species, also distributed in tropical regions of the country. The other dominant genera in India are *Pyrenula* (with 84 spp.), *Lecanora* (83 spp.), *Caloplaca* (65 spp.), *Porina* and *Usnea* (60 spp. each), *Cladonia* (58 spp.), *Parmotrema* (51 spp.), *Pertusaria* (50 spp.) and *Thelotrema* (44 spp.).

## 3.4 Phytogeographical Analysis

Any review of the phytogeography of the Indian subcontinent should be in the context of its historical geomorphology. Three factors, (i) the ancient Gondwanaland with which it formed a part, (ii) the grand northward migration of the Indian plate after breaking away from the Gondwanaland of Southern Hemisphere and its collision with the Asian mainland of Northern Hemisphere – the Eurasian continent – resulting in the rise of the mighty Himalaya and (iii) the Great Ice Age which caused southward migration of several northern floristic elements and the subsequent

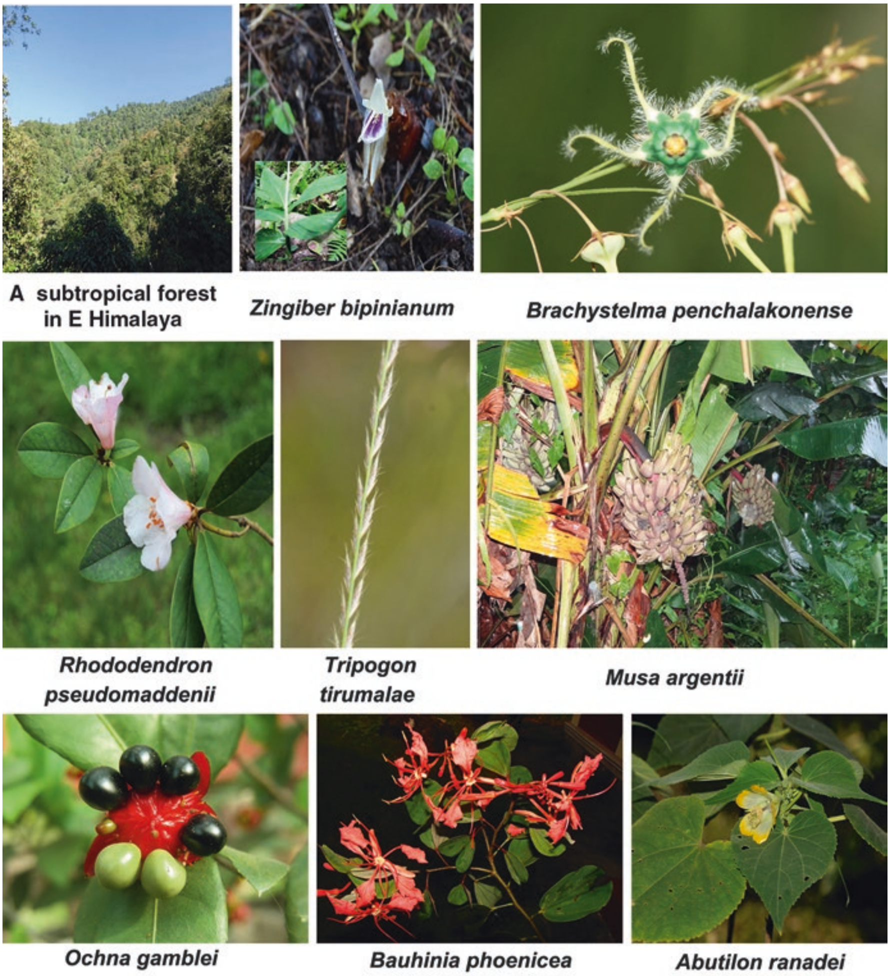


**Plate 3.1** Pictorial representation of flowering plant diversity of India

northward migration of southern floristic elements during the retreat of ice, have all influenced the formation of the present flora of this region (Plates 3.1 and 3.2).

The study of phytogeography in India can be traced back to Clarke (1898) who published a paper on the sub-subareas of the then British India where he expertly analysed the flora of the Indian subcontinent, including Sri Lanka, Myanmar and Malayan Peninsula. Hooker (1904), in his sketch of the flora of British India, modified Clarke's work and presented a new classification for the Indian subcontinent, taking into consideration the migration of plants from Siberia, China and Tibet in the north, Malaysia in the south and Africa and Europe in the west. Chatterjee (1940, 1962), taking this view and relying mostly on the herbarium materials available to him, made an elaborate analysis of the flora of the Indian subcontinent

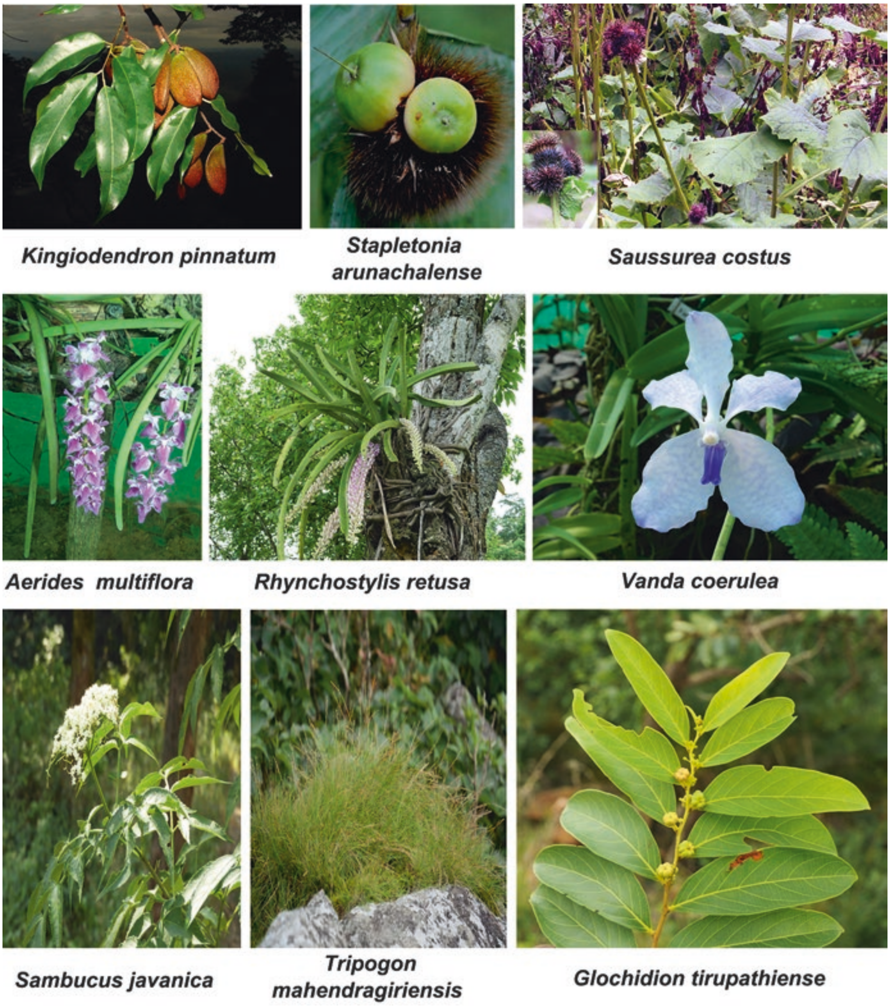


**Plate 3.2** Glimpses of flowering plant diversity of India

including Pakistan, Nepal, Bhutan, Bangladesh, Myanmar and Sri Lanka. He based his conclusions on the percentage of endemics as an indication of the distinctiveness of the flora and also the natural barriers of the lofty Himalaya and the Indian Ocean separating the subcontinent from all other regions.

Based on an analysis of distribution patterns, vegetation of India has been divided into various forest types by Champion and Seth (1968) and Sagareiya (1969). Several other researchers have attempted to provide useful data for different phytogeographical regions of India (Arora 1960, 1964; Rao 1974; Rau 1974, Subramanyam and Nayar 1974; Thothathri et al. 1975; Balakrishnan 1977, 1988; Jain and Sastry

1978; Nair et al. 1980; Hajra 1982; Jain 1982; Hajra and Shukla 1982; Nair and Daniel 1986; Hajra and Rao 1990; Rao and Murti 1990).

Phytogeographical zones indicate a unique set of geophysical and hydro-climatic conditions, as well as distinct geological origins, ranging from the Trans-Himalaya to the islands. They also represent unique floral elements, of which floras of high mountains of Himalaya, Gangetic plains and islands show some extreme ranges of distribution. Rodgers and Panwar (1990) and Rodgers et al. (2000) have divided India into 10 biogeographic zones and 24 biotic provinces; Gadgil and Meher-Homji (1990) distinguished 16 phytogeographical zones in India, while Balakrishnan (1996) differentiated 11 physiographic regions within the Indian territory. A comparison of the two best known classifications of biogeographic zones of India after Rodgers et al. (2000) and Balakrishnan (1996) is given in Table 3.9.

### *3.4.1 Phytogeographical Affinities of Flora*

India is considered as the confluence point of three biogeographic realms, viz. the Afrotropical, the Indo-Malayan and the Palaearctic (Takhtajan 1986). Survey of literature and study of several floristic works on Indian flora have revealed very interesting phytogeographical affinities. The flora of Northwest Himalaya has many elements of the Mediterranean, West Asian and Central Asian regions. Similarly, one finds certain elements common between the floras of Western India and the eastern parts of Africa. The flora of southern Western Ghats has several elements common with Sri Lanka and even with distant Australia. The flora of Northeast India has considerable admixture of floristic elements from Tibet, China, Japan, Indo-China, Myanmar, Thailand and Malaysia. The flora of Andaman Islands shows close affinity to that of Myanmar, Indo-China, Thailand and Malaysia. Similarly, the floristic affinity of Nicobar Islands leans towards the eastern and southern territories of Malaysia and Indonesia, in particular to Sumatra and Java.

It is, thus, certain that there has been continuous migration, in both ways, of floristic elements from all the surrounding regions and also from the distant lands. These migratory elements got mixed up with the indigenous plants of India, resulting in its present-day complexly diverse flora. Analysis of the Indian flora vis-à-vis those of the adjacent phytogeographical regions shows that many species reported from this country may be a result of comparatively recent migration along the Himalayan mountain chain from China. But disjunct taxa, such as *Codonopsis tubulosa*, *Clethra racemosa*, *Aspidopterys indica*, *Archidendron* spp., *Elaeocarpus aristatus*, *E. rugosus* and *Schima wallichii*, may reflect processes of contraction and isolation of formerly widespread taxa.

Various interpretations are available to explain the affinities of the flora of India. Hooker included most of the northeastern mountainous regions of India under the province Burma, where he separated the subprovince northern Burma, encompassing eastern parts of Arunachal Pradesh to Yunnan, continuous with the mountainous regions of Nagaland, Mizoram and Manipur. Mani (1974) considered the flora of

**Table 3.9** Comparison of phytogeographical regions of India as recognized by Rodgers et al. (2000) and Balakrishnan (1996)

| After Rodgers et al. (2000) | | | | After Balakrishnan (1996) |
|---|---|---|---|---|
| Biogeographic zones | Provinces | States covering | %age of total land area | Phytogeographical regions |
| Trans-Himalaya | Ladakh mountains | Parts of Jammu and Kashmir | 3.3 | Western Himalaya (1) |
| | Tibetan Plateau | Upper ridges of Himachal Pradesh | 2.3 | |
| Himalaya | Northwest Himalaya | Himachal Pradesh, Uttarakhand | 1.6 | |
| | Central Himalaya | Sikkim | 0.2 | Eastern Himalaya (3) |
| | Eastern Himalaya | Arunachal Pradesh | 2.5 | |
| Desert | Thar | Rajasthan | 5.4 | Arid zone (6) |
| | Khacha | Gujarat | 1.1 | |
| Semiarid | Punjab Plains | Punjab, Haryana and Rajasthan | 3.7 | |
| | Guajrat and Rajputana | Rajasthan, Gujarat and parts of Madhya Pradesh | 12.9 | |
| Western Ghats | Malabar Plains | Maharashtra, Karnataka and Kerala | 2.0 | Northern Western Ghats and West Coast (7) |
| | Western Ghat mountains | Maharashtra, Karnataka and Kerala | 2.0 | Southern Western Ghats and West Coast (8) |
| Deccan Peninsula | Central Highlands | Madhya Pradesh | 7.3 | Central India (5) |
| | Chota Nagpur | Jharkhand, Chhattisgarh and Western Odisha | 5.4 | |
| | Eastern Highlands | Southern Odisha and Northern Andhra Pradesh | 6.3 | Eastern Ghats and Coromandel Coast (10) |
| | Central Plateau | Maharashtra, Andhra Pradesh and Parts of Karnataka | 12.5 | Deccan (9) |
| | Deccan south | Andhra Pradesh, Karnataka and Tamil Nadu | 10.4 | |
| Gangetic Plains | Upper gangetic plain | Uttar Pradehsh | 6.3 | Gangetic Plain (2) |
| | Lower gangetic plain | Bihar and West Bengal | 4.5 | |
| Coasts | West coast | Coastal region of Gujrat | 0.6 | Arid zone (6) |

(continued)

**Table 3.9** (continued)

| After Rodgers et al. (2000) | | | | After Balakrishnan (1996) |
|---|---|---|---|---|
| Biogeographic zones | Provinces | States covering | %age of total land area | Phytogeographical regions |
| | East coast | Coast of West Bengal, Odisha, Andhra Pradesh and Tamil Nadu | 1.9 | Eastern Ghats and Coromandel Coast (10) |
| | Lakshadweep | Lakshadweep | <0.1 | Northern Western Ghats and West Coast (7) |
| Northeast | Brahmaputra valley | Assam | 2.0 | Assam (4) |
| | Northeast hills | Manipur, Meghalaya, Tripura, Nagaland, Mizoram | 3.2 | |
| Islands | Andamans | Andamans | 0.2 | Andaman and Nicobar Islands (11) |
| | Nicobars | Nicobars | 0.1 | |

Arunachal Pradesh to be young, derived from the Asiatic (Yunnan-Burma) tertiary flora and, therefore, should be under the Indo-Chinese amphitheatre. According to Burkill (1925) and Sahni (1969), the flora of Northeastern India is an intermingling of Chinese, Malayan and Himalayan elements. Biogeographically, Assam and north Myanmar represent a high transition zone of Asiatic and Indian Peninsular elements. This forms a gateway for Indo-Malayan elements to Peninsular India or Western Ghats or vice versa. The affinities of Indian flora with those of other phytogeographical regions of the world are dealt with under the following headings:

- **Afro-Perso-Arabian/Western Elements**

Indian strand vegetation is a mixture of Afro-Perso-Arabian/Western and Indo-Malayan/Eastern elements, which are derived from the Indo-Pacific, bordering Indian Ocean and W. Pacific Ocean. Much of the terrestrial estuarine flora distributed in the estuarine and tidal mangrove zones of Coromandel Coast is derived chiefly from Malaysian and Polynesian islands. The eastern elements, whose distribution range extends to Myanmar, Malay Peninsula, Australia and Polynesia, are represented by plants such as *Allmania nodiflora*, *Bauhinia anguina*, *Calophyllum inophyllum*, *Calotropis gigantea*, *Cordia subcordata*, *Clerodendrum inerme*, *Cyperus penduncultatus*, *Ipomoea macrantha*, *I. pes-caprae*, *Heritiera littoralis*, *Morinda citrifolia*, *Oldenlandia diffusa*, *Pemphis acidula*, *Scaevola plumieri*, *S. taccada*, *Scyphiphora hydrophyllacea*, *Spinifex littoreus* and *Xyris indica*. Many of these plants extend up to Southwestern Indian Peninsula from Malaysian Islands through Malacca, Tenasserim, Sunderbans and Coromandel Coast. Certain endemic elements are noticeable in the Coromandel Coast, which may extend to Sri Lanka. *Eulophia epidendraea*, *Heterostemma tanjorense*, *Oldenlandia shuteri* and *Sesamum prostratum* are the plants strictly of the Coromandel Coast. The disjunct occurrence of *Psilostachys sericea* from Gujarat and Maharashtra and at Nellore in

Coromandel Coast is of considerable interest. The strand flora of Sri Lanka is well represented along the southern shores of Tamil Nadu, including the islands in the Gulf of Mannar.

- **Indo-African Elements**

Meher-Homji (1965, 1973*)* analysed the floral elements of the dry regions of India and recognized 'tropical and North African-Indian Desert' elements in the north contiguous to the desert of Thar, extending into Rajasthan, Punjab, parts of Uttar Pradesh and north Gujarat. He recognized two series of vegetation from the desert region, i) *Calligonum polygonoides* series as dominant species in Thar and ii) *Salvadora oleoides-Prosopis cineraria* series in western Rajasthan and Kutch. Members of both the series are well represented in the Indus Plain, Saharo-Sindian, Sudano-Rajasthanian, Tropical Indo-African and Mediterranean regions.

The Sudan and SW Arabian elements in the semiarid zone situated in the south included the Deccan Plateau and parts of Coimbatore, Ramanathapuram and Tirunelveli districts of Tamil Nadu. *Calophyllum inophyllum*, *Cordia subcordata*, *Launaea coromandelica*, *Suriana maritima*, *Ximenia Americana*, etc. are some of the examples of this type of elements.

- **SE Asian-Malaysian Elements**

These elements dominate the warm broad-leaved and subtropical forests but gradually decline westwards. A number of taxa, such as *Acrocarpus fraxinifolius*, *Actinidia callosa*, *Alcimandra cathcartii*, *Baccaurea ramiflora*, *Bauhinia purpurea*, *Bischofia javanica*, *Calamus* spp., *Careya arborea*, *Crateva religiosa*, *Debregeasia longifolia*, *Dendrocnide sinuata*, *Dipterocarpa* spp., *Duabanga grandiflora*, *Engelhardia spicata*, *Eria paniculata*, *Exbucklandia populnea*, *Garuga pinnata*, *Hedychium coccineum*, *Hodgsonia macrocarpa*, *Lithocarpus elegans*, *Macrosolen cochinchinensis*, *Maesa* spp., *Mangifera indica*, *Meliosma simplicifolia*, *Michclia champaca*, *Mucuna nigricans*, *Musa balbisiana*, *Oroxylum indicum*, *Plectocomia* spp., *Podocarpus nerrifolius*, *Procris crenata*, *Rhaphidophora decursiva*, *Solanum anguivii*, *Spondias pinnata*, *Talauma hudgsonii*, *Tetrameles nudiflora*, *Toona surenis*, *Trevesia palmala*, *Vernonia volkameriifolia*, etc., are the typical species; all occurring in S. Myanmar and the Malaysian Peninsula, many range to Indo-China and a smaller number to the Malaysian Islands and Indonesia.

Melville (1973) stated that the landmasses surrounding the Indian Ocean were formerly parts of the Gondwana continent during the Palaeozoic and Mesozoic times. Takhtajan (1986) classified Andaman Islands as a province under Indo-Chinese Region and Nicobar Islands under Malaysian Region, both distinct from the Indian region, indicating the affinities exemplified by the flora of these islands. An analysis of the flora of different islands shows very interesting features. The Andaman group of islands has more species common with the Northeast India, Myanmar, Thailand and Malaysia, while the Nicobar group has more species common with Indonesia in the south and Malaysia in the east. It is estimated that Andaman and Nicobar Islands possess about 700 species mostly related to the flora of Malaysia and Sumatra (Renovize 1979).

The disjunct distribution of various plant species found in Andaman and Nicobar Islands makes them all the more interesting. *Pterocarpus dalbergioides* and the various species of *Dipterocarpus*, which form the pride of the Andaman forests (except Little Andaman Island), are curiously absent from the Nicobar group. Moreover, *Pometia pinnata*, *Scyphiphora hydrophyllacea*, *Pemphis acldula*, *Ancistrocladus tectorius*, *Crypteronia paniculata*, *Tetrameles nudiflora* and *Pandanus andamanensium*, which are common in Andaman group, are totally absent in Nicobar group. Many of the plants of Andaman Islands extend in distribution to north towards Thailand, Myanmar, Bangladesh and Northeast India. Some obscure orchids of Northeast India, such as *Ascocentrum ampullaceum* and *Porpax meirax*, find place on 700 m high saddle peak of N. Andaman. *Coelogyne trinervia*, *C. thailandica*, *Thunia alba* and *Hopea helferi* also share their distribution with the northern landmasses.

- **Himalayan-Chinese-Japanese Elements**

These are the temperate and subtropical ancient biota with rich biodiversity and high endemism, mainly represented by the members of Fagaceae, Theaceae and Ericaceae. These are the typical elements restricted to the Himalayan-Chinese-Japanese area and do not occur elsewhere or extend to other parts of Asia or the world. Close links between temperate floras of the Himalaya and Sino-Japanese have long been recognized. The distribution pattern of these elements depends on its limit of extension and the range of overlapping with adjacent geographic regions. Based on the range of distribution, both east- and westward, the following four main patterns of distribution within the Himalayan-Chinese-Japanese phytogeographical element are found in India.

- **Taxa distributed from NW Himalaya to China**

*Acer oblongum*, *Allium prattii*, *Alnus nepalensis*, *Anemone rupicola*, *Arisaema tortuosum*, *Astilbe rivularis*, *Berchemia floribunda*, *Carpinus vimine*, *Circaeaster* sp., *Clematis montana*, *Coriaria nepalensis*, *Cotoneaster microphyllus*, *Cremanthodium* spp., *Cyananthus lobatus*, *Desmodium elegans*, *Deutzia compacta*, *Elsholtzia fruticosa*, *Fragaria nubicola*, *Galeola lindleyana*, *Gaultheria trichophylla*, *Hedera nepalensis*, *Holboellia latifolia*, *Hydrangea anomala*, *Ilex dipyrena*, *Juniperus recurva*, *J. squamata*, *Leptocodon gracilis*, *Leycesteria formosa*, *Myrsine semiserrata*, *Nardostachys grandiflora*, *Paris polyphylla*, *Photinia integrifolia*, *Piptanthus nepalensis*, *Pleione praecox*, *Podophyllum hexandrum*, *Prunus cerasioides*, *Pyrus pashia*, *Quercus semecarpifolia*, *Rhus succedanea*, *Ribes takare*, *Rosa sericea*, *Rubus calycinus*, *Saurauia napaulensis*, *Schefflera elata*, *Spiraea bella*, *Streptopus simplex*, *Trollius pumilus*, etc.

- **Pan-Himalayan taxa distributed from NW Himalaya to Arunachal Pradesh but absent from China and Japan**

*Arisaema intermedium, Astragalus chlorostachys, Clematis tortuosa, Cortia depressa, Dalbergia sericea, Delphinium brunonianum, Dodecadenia* sp., *Gypsophila cerastioides, Jasminum nepalense, Mahonia nepaulensis, Meliosma* *simplicifolia, Pandanus nepalensis, Parnassia nubicola, Picrorhiza* sp., *Pinus roxburghii, P. wallichiana, Potentilla fulgens, Rhus wallichii, Rosa macrophylla, Rubus nepalensis, R. paniculatus, Schisandra grandiflora, Sorbus cuspidata, S. foliolosa, S. microphylla, Tsuga dumosa*, etc.

- **Taxa distributed from Eastern Himalaya to China but absent from W. Himalaya and Japan**

*Aeschynanthus bracteatus*, *Allium sikkimensis*, *Aspidocarya indica*, *Betula alnoides*, *Callicarpa rubella*, *Campylandra aurantiaca*, *Cardamine griffithii*, *Cassiope selaginoides*, *Chrysosplenium griffithii*, *Cinnamomum obtusifolium*, *Coelogyne corymbosa*, *Crawfurdia* sp., *Decaisnea sp.*, *Diapensia himalaica*, *Diplarche* sp., *Entada pursaetha* subsp. *sinohimalensis*, *Gentiana stylophora*, *Helwingia himalaica*, *Ilex fragilis*, *Itea macrophylla*, *Leycesteria gracilis*, *Litsea cubeba*, *Litsea kingii*, *Loxostigma griffithii*, *Magnolia campbellii*, *Meconopsis napaulensis*, *Michelia doltsopa*, *Millettia pachycarpa*, *Morina nepalensis*, *Neillia rubiflora*, *Panax pseudo-ginseng*, *Phlomis rotata*, *Populus rotundifolia*, *Potentilla griffithii*, *Primula geraniifolia*, *P. sikkimensis*, *Rhododendron edgeworthii*, *R. maddenii*, *R. neriiflorum*, *Ribes luridum*, *Rubus sumatranus*, *Smilax ferox*, etc.

- **Taxa restricted to Eastern Himalaya**

These are the plant species in the higher elevation forests, including conifers, such as spruce (*Picea*), fir (*Abies*) and larch (*Larix*), as well as deciduous broadleaved taxa such as birch (*Betula*), alder (*Alnus*), willow (*Salix*) and numerous alpine forbs such as species of *Potentilla* and *Pedicularis*. The other species are *Abies densa*, *Agapetes sikkimensis*, *Alcimandra cathcartii*, *Aristolochia griffithii*, *Astragalus stipulates*, *Butea buteiformis*, *Capparis sikkimensis*, *Dipsacus atratus*, *Geum macrosepalum*, *Larix griffithii*, *Liparis perpusilla*, *Pleione scopulorum*, *Meconopsis villosa*, *Rhododendron grande*, *R. galucophyllum*, *R. wallichii*, *R. lanatum*, *R. lindleyi*, etc. Apart from this, other species such as *Fragaria indica*, *Houttuynia cordata*, *Hovenia* sp., *Hypoxis aurea*, *Luzula plumose, Monotropastrum humile, Quercus glauca, Rhus javanica, Streptolirion volubile* and *Symplocos paniculata* are distributed from NW Himalaya (Kashmir and W Nepal) to Japan; and the taxa which are distributed from E. Himalaya to Japan but absent from W. Himalaya are *Choerospondias axillaris*, *Mucuna macrocarpa*, *Rubus mesogaeus*, *Ilex crenata* var. *thomsonii* and species of *Cornus*, *Enkianthus*, *Helwingia*, *Stachyurus*, etc.

- **Tibetan Elements**

The Tibetan vegetation is mainly xerophytic and very different from that of the Himalaya, mainly because of low rainfall and high altitude. This type of vegetation is found in higher riches of Tawang, West Kameng, Kurungkumey district of Arunachal Pradesh and North district of Sikkim and in the cold deserts of Jammu and Kashmir. Some of the important plant species which show distinct Tibetan affinity are *Allium fasciculatum*, *Arenaria bryophylla*, *Braya tibetica*, *Cortiella hookeri*, *Ephedra gerardiana*, *Juncus thomsonii*, *Kobresia schoenoides*, *Lancea* *tibetica*, *Paraquilegia microphylla*, *Phlomis rotata*, *Potentilla armerioides*, *Ranunculus tricuspis*, *Rheum acuminatum*, *Saussurea gossypiphora*, *S. obvallata* and species of *Przewalskia*, *Ribes*, *Stellera*, etc.

- **Euro-Siberian Elements**

Quite a number of temperate and alpine-zone species of Arunachal Pradesh, Sikkim and Jammu and Kashmir are of European and Siberian origin. The European and Mediterranean elements are represented by the species of *Ranunculus*, *Gentiana*, *Swertia*, *Anemone*, *Tamarix*, *Allium*, *Artemisia*, etc.

- **Artic-Alpine Elements**

These elements comprise taxa widespread in arctic region and also found at high altitudes on some of the high mountain ranges of Europe and Asia, showing disjunct distribution. Some of the species that occur in higher ridges of the Himalaya are *Bistorta vivipara*, *Diapensia*, *Koenigia islandica*, *Oxyria digyna*, *Pinguicula alpina*, *Sagina saginoides*, *Thalictrum alpinum*, etc.

## 3.5 Concluding Remarks

The baseline documentation of flora of Indian states and union territories has already been completed. Flora of many states, protected area or designated ecosystem landscapes have already been published. Besides, Indian universities and other taxonomists have been publishing several scientific papers in national and international journals dealing with the flora of the region. These publications contain useful information on the geographic, habitat and distribution aspects of Indian plants. BSI is also publishing regularly the detailed information about new discoveries, thereby providing critical inputs to various national and international agencies for conservation of biodiversity of the region.

India is potentially very rich in floristic wealth. However, some remote pockets and some plant groups like bamboos, sedges, palms and canes and fungi are still unexplored due to various reasons. It is expected that further surveys will yield many more new taxa of different groups of plants and will provide more information about the plant diversity of our country.

**Acknowledgements** A review paper encompassing such an extensive canvas of literature could not have been possible without help from within Botanical Survey of India and various universities and institutes. I thank the staff of Botanical Survey of India, particularly different subject experts, for helping in collating the information on different groups of plants.

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# Chapter 4
# Faunal Diversity of India

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**Abstract** This paper summarizes what is known of the faunal diversity of India – its various ecosystems and species richness. The synthesis of the available relevant literature and studies carried out by scientists at Zoological Survey of India and other research/academic institutes indicates that 1,01,167 species of animals are known from India, out of 15,66,353 species in the world. With only 2.20% of the world's land area, India accounts for 6.45% of its recorded faunal species. However, the inventory is detailed mostly in the case of commercially important higher animal groups, but preliminary with respect to minor phyla or microbial organisms. In terms of geographical coverage, probably only two-thirds of the total area of the country has so far been explored; the remote islands and other such ecosystems are virtually still unexplored. It is, therefore, likely that the magnitude of faunal diversity in India could be several times more than what is scientifically known today.

**Keywords** Fauna · Ecosystems · Diversity · India · Threats to fauna

## 4.1 Introduction

Biodiversity is generally recognized at three levels – species, genetic and ecosystem level. Genetic diversity refers to variation within individual species, species diversity pertains to variety of species, and ecosystem diversity refers to diversity of ecosystems and habitats. At all these three levels, biodiversity is dynamic; the genetic composition of species changes over time in response to natural and

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_4

human-induced selection pressures; occurrence and relative abundance of species in ecological communities change as a result of ecological and physical factors, while ecosystems strongly respond to external dynamics and internal pressures.

Biodiversity also includes countless races, subspecies and local variants of species and the ecological processes and cycles that link organisms into populations, communities, ecosystems and ultimately the entire biosphere. A more easily recognized element of biological diversity, however, is the distinct species. An association of species in an area is another recognizable element of biodiversity which is termed as community. Communities form the biotic components of ecosystems. Biologically diverse communities contain sufficient compositional, structural and functional variety that they are assured a high prospect of continued presence and ecological influence in an area.

India is located in the south of Asia, between latitudes 6° and 38° N and longitudes 69° and 97° E. The Indian landmass, extending over a total geographical area of about 329 million ha, is bounded by the Himalaya in the north, the Bay of Bengal in the east, the Arabian Sea in the west and the Indian Ocean in the south. In terms of landmass, it is the seventh largest country in the world. Its coastline of about 8000 km extends over 200 nautical miles in the off-shore, forming an exclusive economic zone (EEZ) of 2.02 million km$^2$. India has a tropical monsoon climate: the south-west and north-east monsoons bringing rains into it. Rainfall is unevenly distributed, varying both temporally and spatially. Thus, the average annual rainfall in Western Ghats, along the states of Goa, Karnataka, Kerala, West Bengal and Assam, is 2000 mm; in Maharashtra, Bihar and Madhya Pradesh along the Vindhya Mountains, it is 1000–2000 mm; in south coastal plains, northwestern Deccan and upper Gangetic plains, it is 500–1000 mm, whereas in hot desert areas of Rajasthan and Gujarat and the cold desert areas of Ladakh in Jammu and Kashmir and Lahul-Spiti in Himachal Pradesh, it is 100 mm.

India is very rich in terms of biodiversity due to its unique biogeographic location, diverse climatic conditions and enormous eco- and geo-diversity. It embraces three major biological realms, viz. Indo-Malayan, Eurasian and Afrotropical, and is adorned with 10 biogeographic zones and 26 biotic provinces. It is one of the 17 mega-biodiversity countries of the world. With only 2.20% of the land area, India accounts for 6.45% of the recorded faunal species of the world (Plates 4.1 and 4.2).

Biological resources have traditionally been a major source of food for local inhabitants, and of major economic value in terms of commercial utilization. The human exploitation of these biological resources has increased dramatically in the last few decades for both commercial and subsistence reasons. Except for some of the Andaman and Nicobar Islands, no pristine or near-pristine area exists today. Towards the end of the last century and in the beginning of present century, most of the areas in India have suffered deteriorative biodiversity loss; a few areas were severely affected, whereas very few areas remained somewhat unaffected. Conserving what we have today is hampered by lack of management measures, including ill-conceived outreach, inability to predict what would live in India in the wake of unprecedented biodiversity loss and lack of data relating changes in biodiversity to those of the environment.

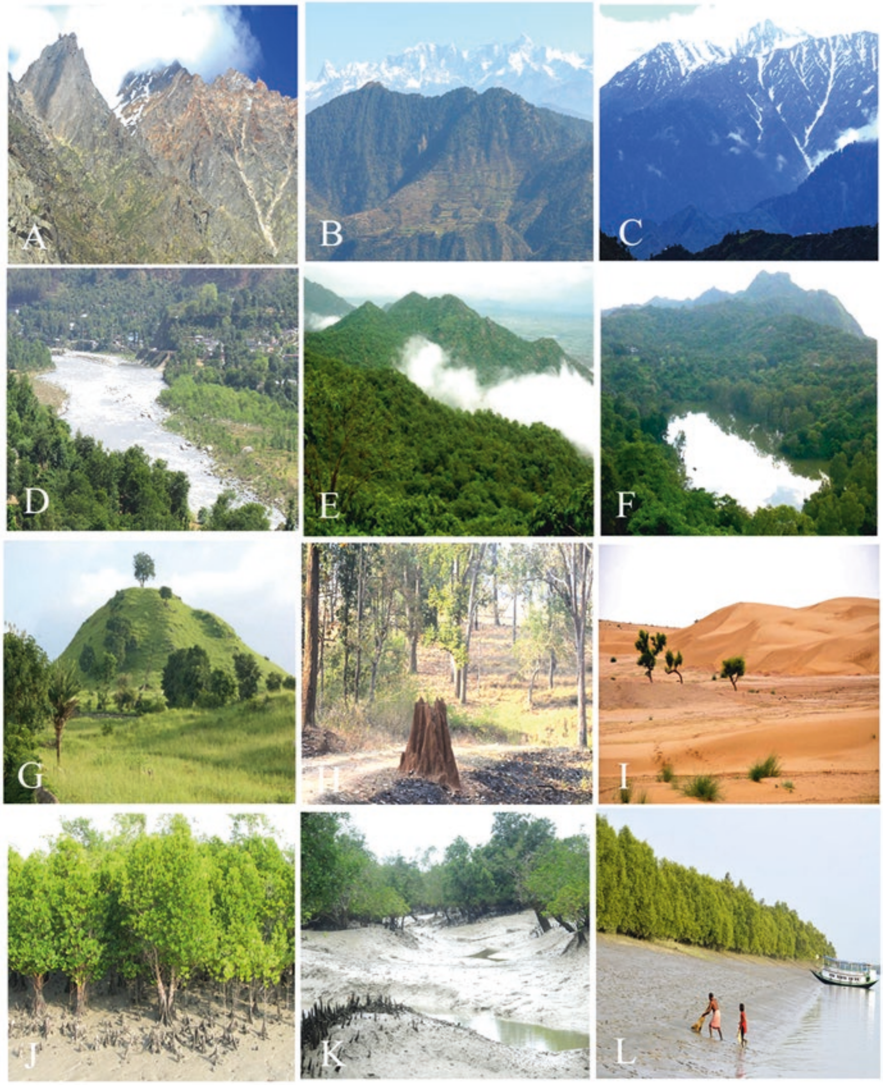


**Plate 4.1** (**A**–**C**) Himalayan ecosystem (**D**) Riverine ecosystem (**E**) Mountain ecosystem (**F**) Wetland ecosystem (**G**) Grassland ecosystem (**H**) Forest ecosystem (**I**) Desert ecosystem (**J**–**L**) Mangrove ecosystem

The major proportion of India's biodiversity is constituted by its rich and varied fauna, which accounts for about 6.45% of the faunal species known worldwide. The exact picture of faunal diversity in the country, however, is not known, more so in lower phyla, including microorganisms and insects. Furthermore, about one-third of the area has not even been surveyed for collection of biota; the knowledge about biodiversity of many remote areas and less-known ecosystems also is not adequate.


**Plate 4.2** (**A**) Asiatic lion, *Panthera leo* (Linnaeus, 1758) (**B**) Tiger, *Panthera tigris* (Linnaeus, 1758) (**C**) Sloth Bear, *Melursus ursinus* (Shaw, 1791) (**D**) Long-tailed Marmot, *Marmota caudata* (Geoffry, 1844) (**E**) Yellow-throated Marten, *Martes flavigula* Boddaert, 1785 (**F**) Long-eared Hedgehog, *Hemiiechinus auritus* (S.G. Gmelin, 1770) (**G**) Chinkara, *Gazella bennettii* (Sykes, 1831) (**H**) Blackbuck, *Antilope cervicapra* (Linnaeus, 1758) (**I**) Baya Weaver, *Ploceus philippinus* (Linnaeus, 1766) (**J**) Indian Roller, *Coracias benghalensis* (Linnaeus, 1758) (**K**) Map Butterfly, *Cyrestis thyodamas* Doyere, 1840 (**L**) Crimson Marsh Glider, *Trithemis aurora* Burmeister, 1839

This prompted the authors to provide an overview of the known faunal diversity in India, dwelling on its major ecosystems, species richness in various groups and impending threats.

## 4.2 Materials and Methods

The data provided in this chapter is based on relevant past literature, museum records and other lesser-known sources of information published (Alfred et al. 2002; Anonymous 1991, 2018; Ghosh et al. 1996; Roonwal 1983; Venkataraman et al. 2012a, b, c etc.).

## 4.3 Results and Discussion

### *4.3.1 Ecosystem Diversity*

The wide variety of physical features and climatic conditions have resulted in diversity of ecological habitats, such as forests, grasslands, wetlands, coastal and marine ecosystems and desert ecosystems, which together harbour and sustain an immense wealth of biodiversity (Alfred et al. 2002).

#### 4.3.1.1 Forest Ecosystems

As per current assessment, the total forest cover of India is 7,08,273 km$^2$ (21.54%) of the geographical area of country (Anonymous 2017). The forests range from the tropical wet evergreen in Northeast to the tropical thorn forests in the Central and Western India. Champion and Seth (1968) divided the forests of the country into 16 major groups comprising 221 types:

1. Tropical wet evergreen (Northeast, South and Andaman and Nicobar Islands).
2. Tropical semievergreen (South and East).
3. Tropical moist-deciduous (Central and East).
4. Tropical littoral and swamp (along the East and West coast).
5. Tropical dry-deciduous (West and Central).
6. Tropical thorn (West and Central).
7. Tropical dry-evergreen (Central and South).
8. Subtropical broad-leaved hill (South).
9. Subtropical pine (sub-Himalayan tract).
10. Subtropical dry-evergreen (Northeast and South).
11. Mountain wet-temperate (Himalaya and Nilgiris).
12. Himalayan moist-temperate (temperate areas of the Himalaya).

13. Himalayan dry-temperate (dry-temperate areas of Himalaya).
14. Subalpine (Himalaya).
15. Moist-alpine shrub (Himalaya).
16. Dry-alpine shrub forests (Himalaya).

These forests perform important ecological functions such as maintaining delicate ecological balance, conserving soil and controlling floods, drought and pollution. Forests provide habitats for innumerable plants, animals and microorganisms. Forests are also a source of recreation and religious inspiration.

Most of the forest ecosystems in India have been acutely degraded mainly due to (1) loss of forest land owing to various developmental activities and expanding agriculture, industries and human settlement; (2) illicit felling/lopping for timber, fuel wood and fodder; (3) overgrazing; (4) introduction of exotics; (5) fire and pollution; and (6) human and cattle population exploitation, besides other causes such as poverty, landlessness, derivation of livelihood from forests, lack of land use planning, biotic interferences and lack of restrictive covenants and punitive legislations.

#### 4.3.1.2 Grassland Ecosystems

Grassland means a landscape in which the grasses are the dominant plants. Grasslands are found in regions where climatic and edaphic conditions are such as to prohibit growth of trees. Lesser rainfall and frequent light showers keep the upper layers of soil moist so that grass continues to grow. In India, grasslands occur in the form of village grazing grounds to extensive low pastures of dry regions to alpine Himalaya, covering an estimated area of 12 million ha (3.9%) and harbouring about 1256 species of fauna. These range from semi-arid pastures in Deccan Peninsula, humid semi-waterlogged grasslands of Terai belt and rolling shola grasslands on the hilltops of Western Ghats to the high-altitude alpine pastures of the Himalaya. Five types of grasslands have been recognized in the country, viz. (1) *Sehima-Dichanthium* type, (2) *Dichanthium-Cenchrus-Leaiurus* type, (3) *Phragmites-Saccharum-Imperata* type, (4) *Themeda-Arundinella* type and (5) temperate-alpine type.

Grasslands are of considerable economic value. They primarily support a large number of herbivore species from minute insects to the largest land animal – the elephant. This in turn makes grasslands hunting grounds for various carnivorous species of different sizes. Most of the grasslands are used for the production of milk, meat, wool and hides. A good stand of grasses and legumes therein checks soil erosion, prevents the loss of nutrients by leaching, improves the physical properties of soil and maintains a well-balanced water regime. They are home to a variety of organisms including wild mammals and birds.

Natural calamities like forest fires, floods, etc., overgrazing and various socio-economic developmental activities are the factors threatening grasslands. Most of the grasslands remain under severe grazing pressure throughout the year. The high-altitude pastures and the arid and semi-arid grasslands in Uttar Pradesh, Madhya

Pradesh, Haryana, Punjab, Rajasthan and Gujarat suffer from severe seasonal grazing stress by migratory livestock.

#### 4.3.1.3 Natural Aquatic Ecosystems

- **Wetland Ecosystems**

Wetlands have been defined in more than 50 different ways to include a wide spectrum of habitats. The Ramsar Convention (1971) has defined wetlands as "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt including areas of marine water the depth of which at low tide does not exceed six meters". Wetlands comprise transitional zones that occupy intermediate position between dry land and open water. Dominated by the influence of water, these ecosystems encompass diverse and heterogeneous habitats ranging from rivers, flood plains and rain-fed lakes to swamps, estuaries and salt marshes.

India, by virtue of its extensive geographical stretch and varied terrain and climate, supports a rich diversity of inland and coastal wetland habitats. Presently, the country has 26 sites designated as Wetlands of International Importance, with a surface area of 6,89,131 hectares and an estimated 4.1 million ha of wetlands (excluding paddy fields and mangroves), of which 1.5 million ha are natural and 2.6 million ha man-made. In addition to natural wetlands, a large number of man-made wetlands also contribute to the faunal and floral diversity. These man-made wetlands, which have resulted from the needs of irrigation, water supply, electricity, fisheries and flood control, are substantial in number (Venkataraman et al. 2003).

Wetlands in India, as elsewhere in the world, are increasingly facing several anthropogenic pressures. The rapidly expanding human population, large-scale land use/land cover changes, burgeoning development projects and improper use of watersheds have all caused a substantial decline in wetland resources of the country. Significant losses have resulted due to conversion of wetlands for various industrial, agricultural and urban development. These have led to hydrological perturbations and pollution and their effects. Unsustainable levels of grazing and fishing activities have also resulted in degradation of wetlands.

- **Lotic Ecosystems**

The Indian subcontinent, bounded by the Great Himalayan Arc in the north and by deep sea in the east, west and south, is traversed by a large number of rivers, which have played a major role in shaping the history of human civilization in the subcontinent. It has very rightly been said that the River Ganga has been cradle of civilization in the Indian subcontinent. The rivers have extensively been used for various purposes, including irrigation, drinking water, recreation, fishing, transport, etc. The rivers in India have been revered as mothers and worshipped as goddesses. In the last few decades, an exponential growth in human population, rapid urbanization and industrialization, intensive agriculture and growing demands for energy have all severely affected the rivers of the country. The regulation of river flows and the discharge of domestic waste water and industrial effluents have degraded the water quality of the rivers and declined their biological resources.

Pollution is a major cause for the degradation of lotic ecosystems. While urbanization is often an integral part of development, rapid and unplanned growth may result in a wide impact on natural resources and the environment. Water pollution and freshwater depletion are currently viewed as the top environmental problems in Asian region. In India, pollution of surface waters has become more severe and critical near the urban areas due to high pollution loads discharged within short stretches of rivers from urban activities. It is believed that the major sources of pollution in Indian rivers are the point sources, viz. domestic sewage, industrial effluents, etc. Moreover, many of the Indian rivers have large catchment areas from where the pollutants from non-point sources flow. The pollutants like organochlorines, organotins and heavy metals in the rivers are mainly from the non-point sources of pollution.

- **Coastal and Marine Ecosystems**

Coastal ecosystems play a vital role in India's economy by virtue of their resources, productive habitats and rich biodiversity. India has a coastline of 7516 km, of which the mainland accounts for 5422 km, Lakshadweep for 132 km and Andaman and Nicobar Islands for 1962 km. Over 250 million people live within a distance of 50 km from the coast. The coastal areas have assumed greater importance in recent years, owing to increasing human population, urbanization and accelerated developmental activities. The coastal regions are thus places of hectic human activity, rendering the coastal ecosystems highly disturbed and threatened.

The Indian mainland coast is divided into two parts: West Coast and East Coast. The West Coast is fronted by the Arabian Sea and the East Coast by the Bay of Bengal. Besides these mainland coasts, there are three island groups – Lakshadweep in the south Arabian Sea and Andaman group and Nicobar group, both in the eastern Bay of Bengal. The East and West Coasts are markedly different in their geomorphology, the West Coast being generally exposed with heavy surf and rocky shores and headlands and the East Coast generally shelved with beaches, lagoons, deltas and marshes. The coastal zone of India is endowed with a wide range of coastal ecosystems, such as estuaries, lagoons, mangroves, backwaters, salt marshes, rocky coasts, sandy stretches and coral reefs, which are characterized by unique biotic and abiotic properties and processes. More than half of the Indian coastline is sandy.

Owing to their multiple uses, the ever-increasing human populations not only exploit the biological resources of coastal ecosystems but also interfere with and modify the basic coastal processes. Traditionally, coastal areas are highly populated and developed because they are the places where trade, transport, communication and civilization are well developed. In India, out of the three megacities, each with population of more than ten million, two are coastal cities, viz. Mumbai and Kolkata. The population density in coastal areas is also much more than the national average; e.g. in the state of Tamil Nadu, the population density in coastal areas is 528 persons/km$^2$ compared to the state average of 372/km$^2$. In parts of coastal metros, such as Mumbai, Kolkata and Chennai, the population density ranges from 20,000 to 50,000 persons/km$^2$. The increased coastal population has led to resource depletion and environmental degradation due to pollution and disposal of domestic and industrial wastes. As in most of the developing nations, the coastal environmental problems and issues in India have led to environmental degradation, resources reduction and user conflicts (Venkataraman et al. 2012a, b, c).

- **Coral Reef Ecosystems**

Coral reefs form the most dynamic ecosystem, providing shelter and nourishment to thousands of species of marine flora and fauna. They are the protectors of the coastlines of the maritime states. A few genera of corals are supposed to be older than prairies. This type of unique ecosystems is the most productive because of its ability to retain and recycle nutrient elements within the ecosystem as well as within animal-plant associations. Though they are the builders of the most massive structures ever created by living beings in the world, coral reefs are very fragile and vulnerable to natural disturbances and human activities. Coastal populations mostly depend upon the coral reef ecosystems for their day-to-day life.

In India, all the three major reef types (atoll, fringing and barrier) occur; the country harbours some of the most diverse, extensive and the least disturbed reef areas in the Indian Ocean, many of which are among the least scientifically known. The mainland coast of India has two widely separated areas containing reefs: the Gulf of Kachchh in the northwest, which has some of the most northerly reefs in the world, and the Palk Bay and Gulf of Mannar in the southeast. There are patches of reef growth on the West Coast, for example, at Malvan. The Andaman and Nicobars have fringing reefs around many islands and a long barrier reef (329 km) on the West Coast, while the Lakshadweep reefs are oceanic atolls. The reefs are poorly known scientifically but may prove to be the best and most diverse in India.

Reefs are home to more species than any other ecosystem in the sea. The total number of reef species in the world is still unknown; however, up to 3000 species can be found together on a single reef in Southeast Asia and over 1000 on a single Caribbean reef; reefs also contain a larger number of vertebrates (due to vast number of fish in them) than rainforests. Reefs also contain more animal phyla than any other ecosystem on land or in the sea.

A total of 262 species of hard corals, 145 species of soft corals and ˃1087 species of reef fish have been recorded from the Indian coral reefs, the diversity varying significantly between areas (Venkataraman et al. 2003, 2004; Venkataraman and Alfred 2011; and Venkataraman and Satyanarayana 2012). A joint survey by the UNDP-GEF and Indian experts in 12 areas of Andaman alone revealed an addition of 111 species of scleractinian corals from the shallow areas (up to 15 m deep), taking the total to 223 species along with those reported earlier by Pillai (1983).

- **Mangrove Ecosystems**

Mangrove is one of the most extraordinary ecological formations occurring almost exclusively in the tropics. Like the tropical rainforests, the mangroves have also played a very important role in the economy of our coastal population for thousands of years, providing a wide variety of goods and services, including recreation, tourism, forestry, agriculture, aquaculture, housing, commercial fishing, salt production and shoreline and coastal erosion control.

Mangroves are salt-tolerant forest ecosystems of tropical and subtropical intertidal coastal regions near river mouths. Between latitudes 30° N and 30° S, the shoreline marsh vegetation is replaced by mangals (community of mangroves is termed as mangal). They form highly productive ecosystems since the inorganic nutrients, brought in by the incoming freshwater from land runoff, are trapped to form the source of energy for many organisms. A mangrove ecosystem constitutes a reservoir, refuge, feeding ground and nursery for many useful and unique plants and animals confined to this region. Through the export of decomposable organic matter into adjacent coastal waters, the mangroves provide an important nutrient input and primary energy source for many tropical estuaries. The mangrove ecosystem also protects coastal areas from sea erosion and from the violent effects of cyclones and tropical storms. The warm, calm waterways of mangroves provide shelter and rich food for many juveniles and larvae of finfish and shellfish.

India has only 2.66% of the world's mangroves, covering an estimated area of 4827 $km^2$; out of this total area, ca. 57% occurs on the East Coast and 23% on the West Coast, while the remaining 20% is on the Bay Islands (Andaman and Nicobar). The East Coast is endowed with the world's largest mangrove forest, the Gangetic Sundarbans in West Bengal. The Sundarbans cover an area of 2109 $km^2$ and contain deltic-type mangroves, with 30 of the 50 species of true mangroves in the world. The mangrove area in Orissa is nearly 200 $km^2$ and in Andhra Pradesh ca. 582 $km^2$, whereas in Tamil Nadu, it is ca. 225 $km^2$. One of the largest and undisturbed mangrove forests in Tamil Nadu is at Pichavaram in Cuddalore district, extending over an area of 1100 ha.

There are three types of mangroves in India, viz. deltaic, backwater-estuarine and insular. The deltaic mangroves occur on the East Coast (Bay of Bengal) where the mighty rivers make the deltas. The backwater-estuarine mangroves occur on the West Coast along the typical funnel-shaped estuaries of major rivers (Indus, Narmada, Tapti) or backwaters, creeks and neritic inlets. The insular mangroves are present in Andaman and Nicobar Islands, where many tidal estuaries, small rivers, neritic islets and lagoons support a rich mangrove flora. A major concern with the increasing use of this zone and its resources, not only for the present but also for posterity, relates to coastal pollution by domestic industrial, municipal and agricultural wastes and, of late, due to oil exploration.

- **Sea Grass and Seaweed Ecosystems**

Sea grasses occur in the infratidal and midtidal zones of shallow and sheltered localities of sea, gulf, bays, backwaters and lagoons. They are submerged monocotyledonous plants adapted to the marine environment for completion of their life cycle under water. They occur along the East and West Coasts and Andaman and Nicobar Islands, forming a dense meadow on sandy and coral rubble bottoms, and sometime in the crevices under water. In India, ca. 14 species are found along the coast, the dominant species being *Cymodium rotundata*, *Enhalus acorodies*, *Halodule pinifolia*, *H. uninervis*, *H. wightii*, *Halophila beccarii*, *H. deeecipiens*, *H. ovalis*, *H. ovta*, *H. stipulacea*, *Syringodium isoetifolium* and *Thalassia hemprichii*. About nine species are extensively found in Andaman and Nicobar Islands. The ecological importance of sea grasses in the conservation of rare and endangered animals, like marine turtles, dugongs, some echinoderms, juvenile prawns and fishes, is very well known.

The seaweed communities prefer somewhat flat and rocky coastal wetlands that gradually slope towards the sea with marked tidal effect of complete submergence during high tide and subsequent exposure during low tide. They are distributed from open shore formations to intertidal lagoons, bays, rock pools and puddles or in creeks and inlets beyond the low tide mark along the infralittoral region of the coast. Different species are abundant along the West Coast, Andaman and Nicobar Islands and Lakshadweep. Except for places like Chilka, Pamban and Cape Comorin, their occurrence along the East Coast is very scanty.

About 120 species of seaweeds have so far been recorded from the coastal wetlands in India. Some of the important ones are *Enteromorpha compressa*, *Ulva lactuca*, *Acetabularia crenulata*, *Dictyosphaeria cavernosa*, *Chaetomorpha media*, *Caulerpa corynephora*, *C. paltata*, *C. tomentosum*, *Odium iyengarii*, *Halimeda macroloba*, *Dictyota atomarica*, *Ectocarpus breviarticulatus*, *Polysiphonia variegata*, *Grateloupia indica* and *Sargassum duplicatum*. These plant communities serve as sustainable life support in the field of food, shelter, fertilizer, production of iodine, potash, glue, agar, algin, vitamin, antibiotic, etc.

#### 4.3.1.4 Desert Ecosystems

Deserts are arid regions, generally receiving less than 25 cm precipitation a year, or regions where the potential evaporation rate is twice as high as the precipitation. Deserts cover more than one-fifth of the Earth's land, occurring in every continent. Far from being barren wastelands, deserts are biologically rich habitats, with a vast array of animals and plants having adapted to their harsh conditions. Some deserts are among the planet's last remaining areas of total wilderness. Yet more than one billion people, one-sixth of the world population, actually live in desert regions.

The Thar Desert or Great Indian Desert is the world's tenth largest desert, forming a significant portion of the Western India. It covers an area of ca. 2,78,330 km$^2$, of which 1,96,150 km$^2$ (70%) is in Rajasthan, 62, 180 km$^2$ (23%) in Gujarat and about 20, 000 km$^2$ (7%) in Punjab and Haryana states. This desert continues into Pakistan as the Cholistan Desert, the entire desert in the Indian subcontinent (India and Pakistan) covering an area of nearly half of the Arabian Desert and one-seventh of the Sahara Desert. This is the most populated desert in the world, having an average density of 83 persons per km$^2$ compared to 6–9 persons in other deserts. The livestock population is also very high and is still increasing, i.e. 46–226/km$^2$ in different districts. About 700 species of flowering plants have been reported from desert ecosystem, of which 345 species are indigenous to Kachchh. The Kachchh coast of the Arabian Sea is ca. 338 km long, covering an area of about 2500 km$^2$, of which

709 km$^2$ are covered with mangrove forest. Fauna of this ecosystem is virtually under-explored, with Roonwal (1983) having reported ca. 1100 species from the arid districts of Rajasthan. A multi-authored compendium *Faunal Diversity in the Thar Desert: Gaps in Research* edited by Ghosh et al. (1996) reports 2043 species.

The Rann of Kachchh, the salt desert, exhibits a spectacular diversity of fauna because of its evolutionary history, geographical location and ecological uniqueness. A review of the literature reveals that it has not been explored significantly for the invertebrate fauna, while significant work has been done on its vertebrate groups except the fishes. Several groups of marine invertebrates, viz. coelenterates (52 spp. of corals), echiurans (11 spp.), molluscs (72 spp.), bryozoans (42 spp.), etc., have been reported from this area. The phylum Arthropoda is represented by 23 species of Isoptera, 6 species of Diptera, 10 species of Coleoptera, 20 species of Lepidoptera, 6 species of Odonata and 9 species of Metastigmata (Acari). About 317 species of vertebrates are known from the Great Kachchh region, i.e. 20 species of fishes, 6 species amphibians, 35 species reptiles, 220 species birds and 36 species of mammals.

The coastal region is a favourite spot for the breeding of hawksbill sea turtle (*Eretmochelys imbricata*), olive ridley sea turtle (*Lepidochelys olivacea*) and green sea turtle (*Chelonia mydas*). The Great Rann of Kachchh is an established nesting and breeding ground for greater and lesser flamingos in India. Due to high concentration of greater flamingos in Khadir and Pachham belts, this breeding place is called as the flamingo city.

### *4.3.2 Species Diversity*

Based on the data collected on different animal groups, the total number of species reported in the Kingdoms Protista (Protozoa) and Animalia from India is 1,01,167, constituting 6.45% of the world faunal species (Table 4.1). Many lower groups of animals, however, have not received adequate attention and are poorly known from India; these include Nemertinea, Nematomorpha, Priapulida, Pogonophora and Pentastomida.

#### 4.3.2.1 Invertebrate Fauna (Other Than Arthropods)

- Protista (Protozoa) are represented by 3525 species in India, compared to 36,400 species in the world. The parasitic species are well studied because many of them are associated with certain dreaded diseases of humans and animals. However, it is estimated that the number of species in Protozoa so far known from India is only one-fourth of the species expected to occur in it. The Mesozoa, known in India by 10 species as against 122 (8.19%) species in the world, remain as a subject for further research.

**Table 4.1** Estimated number of species of protists and animals reported from India (updated December, 2017)

| Kingdom | Taxonomic groups (phylum/subphylum/class) | Number of species | | Percentage (%) in India |
|---|---|---|---|---|
| | | World | India | |
| **(a). Protista** | | **36,400** | **3525** | **9.68** |
| **(b). Animalia** | Phylum Mesozoa | 122 | 10 | 8.19 |
| | Phylum Porifera | 8838 | 545 | 6.16 |
| | Phylum Cnidaria | 11,522 | 1428 | 12.39 |
| | Phylum Ctenophora | 199 | 19 | 9.54 |
| | Phylum Platyhelminthes | 29,487 | 1760 | 5.96 |
| | Phylum Rotifera | 2049 | 466 | 22.74 |
| | Phylum Gastrotricha | 828 | 162 | 19.56 |
| | Phylum Kinorhyncha | 196 | 10 | 5.10 |
| | Phylum Nematoda | 25,033 | 2949 | 11.78 |
| | Phylum Acanthocephala | 1330 | 301 | 22.63 |
| | Phylum Sipuncula | 156 | 41 | 26.28 |
| | Phylum Echiura | 198 | 47 | 23.73 |
| | Phylum Annelida | 17,388 | 1029 | 5.91 |
| | Phylum Onychophora | 183 | 1 | 0.54 |
| | Phylum Arthropoda | 12,57,040 | 75,793 | 6.02 |
| | Subphylum Chelicerata | 1,13,773 | 5991 | 5.26 |
| | Class Arachnida | 1,12,442 | 5953 | 5.29 |
| | Class Merostomata | 4 | 2 | 50.00 |
| | Class Pycnogonida | 1335 | 36 | 2.69 |
| | Subphylum Crustacea | 67,735 | 3835 | 5.66 |
| | Subphylum Hexapoda | 10,63,533 | 65,589 | 6.16 |
| | Class Collembola | 8162 | 329 | 4.03 |
| | Class Diplura | 975 | 18 | 1.84 |
| | Class Protura | 816 | 20 | 2.45 |
| | Class Insecta | 10,53,578 | 65,222 | 6.19 |
| | Subphylum Myriapoda | 11,999 | 378 | 3.15 |
| | Class Chilopoda | 3112 | 101 | 3.24 |
| | Class Diplopoda | 7837 | 270 | 3.44 |
| | Class Symphyla | 204 | 7 | 3.43 |
| | Phylum Phoronida | 16 | 3 | 18.75 |
| | Phylum Bryozoa (Ectoprocta) | 6186 | 327 | 5.28 |
| | Phylum Entoprocta | 186 | 10 | 5.37 |
| | Phylum Brachiopoda | 392 | 8 | 2.04 |
| | Phylum Chaetognatha | 170 | 44 | 25.88 |
| | Phylum Tardigrada | 1167 | 30 | 2.57 |
| | Phylum Mollusca | 84,978 | 5205 | 6.12 |
| | Phylum Nemertea | 1368 | 6 | 0.43 |
| | Phylum Echinodermata | 7550 | 778 | 10.30 |

(continued)

**Table 4.1** (continued)

| Kingdom | Taxonomic groups (phylum/subphylum/class) | Number of species World | Number of species India | Percentage (%) in India |
|---|---|---|---|---|
| | Phylum Hemichordata | 139 | 14 | 10.07 |
| | Phylum Chordata | 71,526 | 6656 | 9.30 |
| | Subphylum Cephalochordata | 33 | 6 | 18.18 |
| | Subphylum Urochordata | 2804 | 528 | 18.83 |
| | Subphylum Vertebrata (Craniata) | 68,689 | 6122 | 8.91 |
| | Class Pisces | 34,362 | 3364 | 9.78 |
| | Class Amphibia | 7667 | 407 | 5.30 |
| | Class Reptilia | 10,450 | 584 | 5.58 |
| | Class Aves | 10,357 | 1340 | 12.93 |
| | Class Mammalia | 5853 | 427 | 7.29 |
| | **Total (b) Animalia** | **15,29,953** | **97,642** | **6.38** |
| **Grand total [(a) Protista + (b) Animalia]** | | **15,66,353** | **1,01,167** | **6.45** |

Source: ZSI, Animal Discoveries 2017- New Species and New Records

- Porifera are represented by 545 species, accounting for over 6.16% of species known from the world. It may be mentioned that the marine fauna known from India shows a close relationship with those in the Australian region, the Pacific Ocean and the Red Sea. While there are 1428 species of the Cnidaria known from India, compared to 11,522 (12.39%) species in the world, the Ctenophores register only 19 species in number.
- The Platyhelminthes or flat worms are mostly parasitic and constitute only 5.96% of the world fauna. The free-living turbellarians, with only 47 species (ca. 1% of world fauna), have received very little attention. Of the trematodes, most of the Monogenea, numbering 295 species, are known from freshwater fishes, but there is a big lacuna with regard to those in marine fishes. The other groups, such as Trematoda and Cestoda, with 750 and 530 species, respectively, are required to be explored with their multiple hosts available in our country.
- Among the plankton, rotifers constitute a dominant phylum with 466 species, a little over 22.74% of the world fauna. A critical analysis of the Indian freshwater rotifers indicates that various planktonic and semi-planktonic taxa are fairly known from this country but periphytic, benthic, colonial and sessile rotifers are still to be much studied. Of the marine meiofauna, 162 species represent Gastrotricha and 10 species Kinorhyncha, accounting, respectively, for 19.56% and 5.10% of their species in the world. It is interesting to note that there is a high degree of endemicity in these groups. Sipuncula and Echiura, with 41 and 47 species in India, account, respectively, for about 26.28% and 23.73% of their species in the world fauna. All these groups exhibit very high biological diversity in Andaman and Nicobar Islands.
- Nematodes constitute ca. 90% of all Metazoa in the world and occur in every possible type of habitat, free-living, predaceous or parasitic in plants and ani-

mals. Animal-parasitic nematodes (numbering 1000 species) and plant, soil and other nematodes (recording 1949 species) account for 11.78% of the world fauna. Our knowledge of the nematode parasites in vertebrate animals is satisfactory; but plant, soil and aquatic (both freshwater and marine) nematodes are poorly known.

- Acanthocephala known to occur in India form nearly 22.63% of the world fauna. Among other minor phyla, Phoronida and Brachiopoda, represented, respectively, by 3 and 8 species, are the least known groups in India. However, Bryozoa with 327 species is known better than the Entoprocta (10 species) or even the Chaetognatha (44 species) and the Tardigrada (30 species).
- Annelida in India constitute about 5.91% of the world fauna; and though polychaetes are comparatively well known, knowledge about brackish water groups is far from satisfactory. Molluscs show great diversity, with 5205 species, which account for ca. 6.12% of this group in the world fauna. Our knowledge about marine molluscs, as compared to the land and freshwater ones, is far from satisfactory. It is interesting to note that both the land and freshwater molluscs have a number of endemic genera and species. Echinodermata, represented in India by 778 species (nearly 10.30% of those in the world fauna), are well studied except for the deep-water forms. Onychophora as a group is extremely rare, being known by a single species discovered at the foot of the Eastern Himalaya in Northeast India.
- **Arthropoda**

The phylum Arthropoda is remarkable in having the largest number of classes, orders, families, genera and species in India. Arachnida is one of the major classes of the phylum with 5953 species, being nearly 5.29% of those in the world fauna. Crustacea, another major class, is known by 3835 species, being over 5.66% of those in the world fauna. Chilopoda and Diplopoda, with 101 and 270 species, are only over 3.24% and 3.44%, respectively, of their species in the world fauna. The other groups in the Arthropoda, except the Insecta, are poorly known. Xiphosura is of special interest, with two species in India. All these groups need special attention because much remains to be known about them.

- **Insects**

Insects so far known from India are grouped under 29 orders, of which 4 are apterygotes, while the remaining 25 are pterygotes.

– Apterygota

Among apterygotes in India, Collembola is known better than the other three groups. It is represented by 329 species in India (4.03% of those in world fauna), out of 8162 species in the world. The other 2 groups, viz. Diplura and Protura, are known by 18 and 20 species, respectively. It may be mentioned that the endemism is quite remarkable in these groups. Indeed, our knowledge about the Indian apterygote groups is poor, and, therefore, much more attention needs to be paid in order to reveal the tremendous diversity among them.

– Pterygota

Of the pterygotes, Coleoptera is the largest of all the orders and is known by 15,500 species (nearly 4.5% of those of world fauna), followed by Lepidoptera with 15,000 (˃ 10.5%) species, Hymenoptera with 10,000 (˃8%) species, Hemiptera with 6500 (˃ 8%) species and Diptera with 6093 (˃6.0%) species. As regards the endemic species of these groups in India, it is estimated that Hymenoptera comprise 9000 species in 516 genera and 65 families; Coleoptera with 3100 species in 923 genera and 104 families; Hemiptera with 2421 species in 579 genera and 77 families; and Diptera with 2135 species in 107 genera and 87 families, while Lepidoptera comprise nearly 1500 endemic species in 100 genera and 84 families.

Besides the above major groups, Orthoptera is ranked next with over 1750 species that account for over 10.0% of those in the world fauna. There are ca. 77 endemic genera with over 200 species in this order. The orders Trichoptera and Thysanoptera so far register 812 species in 112 genera and 693 species in 249 genera, respectively, in India. Trichoptera have 650 endemic species, while Thysanoptera possess 520 such species.

The diversity of the following 5 orders is extremely interesting, viz. Odonata with 499 species in 139 genera, Phthiraptera with 400 species in 85 genera, Neuroptera with 335 species in 125 genera, Dermaptera with 320 species in 74 genera and Isoptera with 253 species in 54 genera. Endemicity in these groups is high: Odonata with 115 endemic species, Phthiraptera with 16 species, Neuroptera with 262 species, Dermaptera with 117 species and Isoptera with 170 such species.

Five groups of insects that register less than 200 species each are the following: Blattaria represented by 186 species (nearly 4.0% of those in world fauna), Mantodea with 162 (˃7.0%) species, Phasmida with 146 (ca. 6.5%) species, Plecoptera with 113 (ca. 5.5%species) and Ephemeroptera with 106 (ca. 5.0%) species; these groups include 60, 86, 70, 66 and 72 species, respectively, as endemic to India. The fauna of the remaining five orders, viz. Psocoptera, Siphonaptera, Embioptera, Mecoptera and Strepsiptera, is insignificantly known, respectively, with 90 (˃3.0%) species, 52 (˃2.5%) species, 33 (16.5%) species, 15 (˃4.0%) species and 18 (˃3.0%) species.

#### 4.3.2.2 Vertebrate Fauna

- Protochordates include two subphyla, viz. Cephalochordata and Tunicata, exclusively distributed in marine environments. The total number of species of protochordates reported from the Indian marine water is 119, a share of 5.65% of the estimated taxa of this group in the world.

- **Pisces**

Fishes comprise about half the number of vertebrate species known so far in the world. The world's fish diversity is estimated to comprise 34,362 extant species, and the Indian fish diversity comprises 3364 species (representing 9.78% of the world fishes).

- **Amphibia**

The Indian amphibian diversity represents 5.30% of that of the world, comprising 407 species. The amphibian species are not evenly distributed throughout the country, the highest concentration being found in the Western Peninsula, followed by the Northeast. Interestingly, all the three living orders of Amphibia, viz. Gymnophiona, Caudata and Anura, are distributed in Northeast India, and the Western Peninsula has Gymnophiona and Anura, while the rest of the country harbours only Anura.

- **Reptilia**

Reptiles were the dominant group of vertebrates during the Mesozoic period; the end of Triassic established most of the orders of reptiles, and some became extinct at that time. Of the 19 orders of reptiles, only 4 survive today (Crocodilia, Testudines, Squamata and Rhynchocephalia). The Indian reptilian diversity represents 5.58% of that of the world, comprising of 584 species. Reptilian fauna has great affinity to that of the Oriental region, as well as a close relationship to that of the Indo-Chinese and Indo-Malayan regions.

- **Aves**

Birds evolved about 150 million years ago, occupied all ecological niches and are distributed in all habitats. The Indian subcontinent avifauna includes Palearctic, Oriental, Ethiopian and Australasian zoogeographic elements and has about 176 endemic forms and 350 species and subspecies which winter in the Indian territory, while a few migrate from India. About 10,357 species of birds are recorded till date from the world; of these, about 437 species are designated as threatened. The Indian subcontinent has 1340 species and subspecies of birds; these represent ca. 12.93% of the world avifauna.

- **Mammalia**

The mammalian fauna of the world is represented by 5853 species, of these 427 species are recorded from India. The egg-laying mammals, belonging to the order Monotremata, are found only in Australia, Tasmania and New Guinea; seven orders of marsupials are found in Australia, Indonesia and South America; orders Hyracoidea, Tilidentata and Macroselidea in Africa; and order Xenarthra in South America, while the order Dermoptera is found in Java, Sumatra and the Philippines.

It has been found that amongst invertebrates, parasitic forms (e.g. Mesozoa, Acanthocephala and Platyhelminthes), some Meiofauna (Kinorhyncha, Gastrotricha), and Soil Fauna (Annelida) exhibit a very high degree of endemism at species level. Overall, 34.90% of insect species are endemic to the Indian region, whereas more than 40% of Indian leech, freshwater sponges and molluscs also show endemism. Among vertebrates, the highest degree of endemism at species level is found in Amphibia, followed by Reptilia, Aves, Mammalia and Pisces.

### *4.3.3 Threats to Faunal Diversity*

Biological resources have traditionally been a major source of food for local inhabitants and of major economic value in terms of commercial exploitation. The human exploitation of biological resources has increased dramatically in the last few decades for both commercial and subsistence reasons. Ecosystems and bioresources of India have been exploited since long time, but it is only in the last century that the rate of exploitation has been increased tremendously, due mostly to the increase in human population. Except for some of the Andaman and Nicobar Islands, no pristine areas exist today. At the end of the last century and in the beginning of present century, most of the areas in India have been affected, some severely so.

#### 4.3.3.1 Natural Threats

The major natural stresses on terrestrial ecosystems have been removal of the top soil by flash floods and destruction due to earthquakes, while the marine ecosystems have suffered through storms and waves, particularly cyclones. Cyclonic disturbances develop during October–November along the coast. These cyclones have sustained winds, with a speed ranging from 65 to 120 km per hour. High-speed winds cause extreme wave action that kills many faunal and floral species and also break coral reefs into rubbles, sometimes dumping huge amounts of sand, etc. into them. Also freshwater runoff kills many animals and plants in semi-enclosed bays and lagoons by lowering salinity and depositing huge amounts of sediments and nutrients.

#### 4.3.3.2 Human Impacts

Varied human activities are a cause of concern over and above natural disturbances. These include deforestation, habitat destruction due to development, industrialization, pollution, eutrophication due to sewage and bad agricultural practices, runoff and sedimentation from developmental activities, physical impact of maritime activities, dredging, collecting, unsustained fishing practices, industrial wastes and oil refineries and the synergistic impacts of anthropogenic disturbances. A general rule for coastal zone is: whatever is used on land today ends up in the aquifer or coastal zone tomorrow. The amount of sediments and chemicals the runoff water carries to the sea has profound effects on fertilization of eggs of marine species. Likewise, the quality of runoff water can affect the metamorphosis of the larvae of many species. Oil pollution induces mortality, decreases fecundity and fails recruitment.

India has three megacities and many small, medium and major ports and industries around the 8000 km coast. The enactment of the Water Pollution Act, 1974, and the Environment (Protection) Act, 1986, have helped in regulating the disposal of wastes from the industries. These measures have resulted in reduction of pollution loads of the coastal waters to certain extent. Major industries pertaining to fertilizer and petro- and agrochemicals are mainly located along the coasts. Besides industrial and municipal wastes, port-related operations, such as continuous movement of marine vessels in the major ports, including oil transport, and also the wastes of aquaculture and agriculture farms are increasingly posing threats to the coastal water quality and to the biodiversity.

Fishing is a major activity in the coastal regions of India; presently about one million people occupy full time in marine fish capture in 3651 fishing villages situated along the country's coastline. Several types of net fishing have also been responsible for over-exploitation of marine resources. The use of fish traps made of long-lasting materials with small mesh sizes results in the capture of pre-reproductive juveniles, affecting their future populations. Fishing operations with latest technologies are causing damage to the marine living resources. Along with increase in the targeted catch, a number of untargeted fish and other biota are removed from their habitat and discarded as waste.

#### 4.3.3.3 Climate Change Impacts

The greenhouse gases of atmosphere that selectively trap thermal radiation from the Earth's surface to make a hospitable surface temperature have been gradually increasing. This has caused fluctuation in global temperature and related aspects of climate. It is reported that the global average temperature has increased by about 0.6 °C in 100 years and is projected to rise further. Changing climate is expected to bring about profound effect on faunal composition in the ecosystems of India. Frequency and transmission of many infectious and vector-borne diseases would be on rise. Animals of high mountains might either shift or disappear from their earlier home zones.

India is one of the largest countries of the world, with unique landscapes making it a distinct geographical entity and one of the megadiversity centres of the world. Climate change will have wide-ranging effects on the environment and socio-economic and related sectors, including water resources, agriculture and food security, forestry, human health, terrestrial ecosystems, coastal zones and biodiversity. It is expected that climate change, on one hand, could benefit certain plant and insect species by increasing their ranges, while on the other hand, it could increase risk of extinction for many species, especially those which are already endangered or at risk due to isolation through geographic or anthropogenic activities, low population numbers or possession of a narrow temperature tolerance. The impacts of climate change on the species assemblage include (1) changes in distribution, (2) changes in reproductive strategy, (3) changes in length of growing seasons for plants and (4) increased extinction rates. Desert ecosystems in Rajasthan are experiencing extreme drought, to which plants and animals therein have adapted by devising water storage means in the body and by losing the minimum water. Deserts are projected to be hotter and drier and that would threaten many organisms, which have reached close to the heat tolerance limits. Island ecosystems, such as Lakshadweep and Andaman and Nicobar, are especially vulnerable to climate change because island species populations tend to be small, localized and highly specialized and, thus, can be driven to extinction. An increased sea temperature has led to coral bleaching (loss of coral-algal symbiont) in major coral reefs, such as in Gulf of Kachchh and Gulf of Mannar along the mainland India, as well as in Lakshadweep and Andaman and Nicobar Islands. Recent studies by scientists of Zoological Survey of India reported that coral bleaching is the significant factor determining reef health in Lakshadweep, Gulf of Mannar and Andaman reefs. Significant reductions in live coral cover and decline in reef health from 2010 were accounted for Lakshadweep and Gulf of Mannar reefs, and recovery from the bleaching event in 2010 is reported for the Andaman reefs, though the long-term impacts of bleaching events, reef up-lift (seismic) and the 2004 tsunami on coral health are observed by the declining trend in reef health. Local-scale stressors are more intense in Gulfs of Kachchh and Mannar reefs; in the latter these are found to compound the climate impacts and impede recovery. Species-wise scleractinian covers clearly indicated the dominance of species, categorized as stress tolerators and competitors, in terms of increased dominance with the corresponding low diversity and evenness indices in reefs where local stressors are more pronounced. Managing coral reef and the associated faunal diversity in Indian reefs, therefore, should be based on identifying and quantifying pressures due to climate change, which include studies on the impacts of local-scale factors in reef communities, quantifying resource's availability and sustenance and long-term monitoring of fish and benthic communities.

## 4.4 Concluding Remarks

Biological resources have traditionally been a major source of food for local inhabitants and of major economic value in terms of commercial exploitation. Ecosystems and biodiversity of India have been exploited since long time but it is only in the last century that the rate of exploitation has increased dramatically, due mostly to the increase in the human population. Except for some of the Andaman and Nicobar Islands, no pristine area exists today. At the end of the last century or in the beginning of this century, very few areas of India remained unaffected, whereas most were partially deteriorated and a few were severely affected. The fauna of India has been adversely affected owing to combined effect of habitat destruction, fragmentation, hunting, poaching, illegal trade, grazing, deforestation, hybridization, random use of pesticides, landslides, cloud bursts, floods, construction of Hydroelectric Projects and others. Himalayan glaciers are shrinking at a faster pace, causing changes in the water dynamics of perennial rivers in the region and affecting faunal components.

Conserving what we have today is hampered by lack of management measures, including outreach and our inability to predict what would live in India, as well as lack of data relating changes in biodiversity to those of the environment. Besides, inadequate protection and awareness, hunting and poaching is still going on in different parts of India, and illegal trade in wildlife products is also recorded. The experts of Zoological Survey of India help the enforcement agencies, viz. Forest Department, Police Department and Custom and Wildlife Crime Control Bureau, in identification of the seized wildlife material; and to monitor the changes in land-use practices, especially in areas of endangered animals. In order to control loss in biodiversity and restore the degraded ecosystems, we need to have a full assessment of the magnitude of such losses, and the factors that promote the unsustainable use of biotic resources. An important aspect is to strengthen the measuring, monitoring and management of biodiversity, and to evaluate our conservation strategies in the light of human needs for biomass with coordinated approach to sustenance of both, the bioresources and their use, as seen in totality. Some species have spread fast to cause great strain on agriculture and forestry. Some others are causative agents of human and veterinary diseases. Hence, control of their population has become a necessity. In recent times, however, many species are facing catastrophic decline in number, so much so that several of them have become scarce or rare, and have been given asylum in Reserve Forests, Wildlife Sanctuaries, National Parks, Biosphere Reserves, etc. Hence, adequate and systematic knowledge of the Indian fauna through taxonomic, distributional and biological studies is necessary, so that ways for species conservation or control may be devised. Lack of trained taxonomists is a serious constraint in achieving complete inventory of the fauna in India.

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# Chapter 5
# Floristic Diversity of the Indian Himalaya

**D. K. Singh and P. K. Pusalkar**

**Abstract** Floristic diversity of land plants (angiosperms, gymnosperms, pteridophytes and bryophytes), and their distribution pattern in the Indian Himalayan region (IHR), is discussed. The angiosperms are represented in the IHR by ca. 8700 taxa, gymnosperms 51 taxa, pteridophytes 766 taxa and bryophytes by 1955 taxa. Families Ranunculaceae, Brassicaceae, Rosaceae, Asteraceae and Orchidaceae have more than 75% each of their Indian taxa represented in this region. Orchidaceae with about 1036 taxa and *Rhododendron* with 121 taxa are the largest family and genus, respectively, with both showing their highest diversity in the eastern Himalaya. About 12% of the Himalayan angiosperms are endemics, while an equal number of taxa, including point endemics, is threatened or vulnerable. Ephedraceae, Dryopteridaceae and Pottiaceae are the dominant families of gymnosperms, pteridophytes and bryophytes, whereas *Ephedra* (with 13 spp.), *Thelypteris* (62 spp.) and *Plagiochila* (51 spp.) are the most diverse genera of these taxonomic groups, respectively. Eight taxa of the Himalayan gymnosperms, 25 pteridophytes and 308 of bryophytes are endemic to India, majority of which are restricted to the IHR. Information on the topography and vegetation of the IHR, its curious and sacred elements, and conservation needs and initiatives is also provided.

**Keywords** Land plants · Floristic diversity · Indian Himalayan Region (IHR) · Conservation

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_5

## 5.1 Introduction

Himalaya, the greatest mountain range, is often known as the third pole due to its largest ice cover on the earth outside the polar region. With north-south width of 200–400 km, it runs uninterruptedly for about 2500 km in NW-SE direction, covering 595,000 km$^2$ in Pakistan, India, China, Nepal, Bhutan and Myanmar. Between the western terminus at Nanga Parbat (8126 m) and eastern anchor of Namjag Barwa (Namcha Barwa) (7756 m), it houses nearly 18,000 glaciers. With peaks averaging 4000 m and over 100 peaks exceeding 7000 m in height, which include the world's highest peak, Sagarmatha (Mt. Everest, 8848 m), this snow-arch of Asia stands on the great Gangetic plain of the south, holding the roof of the world – the high Tibetan plateau – to its north, and leads in the northwest to the mountain ranges of the Hindu Kush and Karakoram. Between the Indus basin in the west and Brahmaputra in the east are located the birth places of the world's seven great rivers, which include three Himalayan rivers, namely, Indus (Sindhu), Ganges (Ganga) and Brahmaputra (Tsangpo), and four circum-Himalayan (Tibetan) rivers, namely, Salveen, Mekong, Yangtze and Huang He.

Geographically, Himalaya is divided into two regions, the eastern Himalaya, which covers parts of Nepal, Bhutan, India (Arunachal Pradesh, Sikkim and Darjeeling subdivision of the Himalaya), southeast Tibet (Autonomous Region of China) and northern Myanmar, and the western Himalaya covering Uttarakhand, Himachal Pradesh, Jammu and Kashmir and northern Pakistan. The deep gorge of Kali Gandaki River between the Annapurna and Dhaulagiri mountains, which serve as an effective barrier to species dispersal, is a natural boundary between eastern and western flanks. Notably, considering political boundary, the Nepal Himalayan ranges are sometimes considered distinct zone and referred to as the central Himalaya. Similarly, based on aspect, which has significant influence on geo-climate, the western Himalaya is also subdivided into the west Himalaya covering Garhwal-Kumaon (or Uttarakhand) region and the northwest Himalaya covering Jammu and Kashmir and Himachal Pradesh.

The Indian Himalayan Region (IHR), covering an area of ca. 4,23,000 km$^2$, biogeographically falls under Boreal zone comprising two subzones, Sino-Siberian (represented by the Trans-Himalayan region of the Indian cold deserts) and the Sino-Himalayan (Rodgers 1985). The Sino-Siberian zone with arctic conditions comprises one biotic province, Ladakh with only one biome known as Tundra. On the other hand, Sino-Himalayan zone has three biotic provinces, namely, northwest, central and eastern Himalaya, with each consisting of three biomes – subtropical, temperate and alpine. The Himalaya, by virtue of its location and height, which enable it to act as the great climate divide, not only controls the weather system of the Indian subcontinent but also exerts a significant influence on the weather of the greater part of Asia as a whole and has governing influence on the vegetation, which is an arctic dry steppe type in the north and moist tropical in the southern parts. The western Himalayan range exhibits cold and arid climate as compared to semi-oceanic humid conditions in the eastern sector, which is one of the wettest regions of the world. The central Himalaya shows the combination of both these situations. The conglomeration of these topographical and climatic regimes has resulted in an unparalleled assemblage of biodiversity, both flora and fauna, and has made the Himalaya the richest Natural Heritage Site in the Indian subcontinent.

According to biogeographic classification of Rodgers et al. (2002), IHR is divided into two zones comprising seven provinces as shown below:

| | | |
|---|---|---|
| 1. | Trans-Himalaya-Tibetan Plateau | |
| | 1A. Himalaya – Ladakh Mountains | Jammu and Kashmir |
| | 1B. Himalaya – Tibetan Plateau | Jammu and Kashmir, Himachal Pradesh (Lahaul-Spiti, Kinnaur) Uttarakhand (Uttarkashi, Chamoli, Pithoragarh districts) |
| | 1C. Himalaya – Sikkim | Sikkim (northern Sikkim) |
| 2. | Himalaya | |
| | 2A. Himalaya – Northwest | Jammu and Kashmir, Himachal Pradesh |
| | 2B. Himalaya – West | Uttarakhand |
| | 2C. Himalaya – Central | Sikkim-Darjeeling Himalaya (Sikkim and adjoining parts of West Bengal comprising Kalimpong, Darjeeling, Kurseong and Mirik subdivisions of Darjeeling district and the northern fringe of Jalpaiguri district) |
| | 2D. Himalaya – East | Arunachal Pradesh |

The Himalaya is traditionally divided into four parallel altitudinal ranges, each with distinct physiographic features originating from different geological events. From north to south, these ranges are called the Tethys (Trans or Tibetan) Himalayan Range, the Great Himalayan Range (Inner or Greater Himalaya), the lesser (Lower) Himalayan Range and the Outer (sub-Himalayan or Shiwalik) Range. Though the Himalayan ranges with complex geological structure showing deeply cut topography forming web of valleys between series of elevational belts and signature features, like deep gorges, giant glaciers and sky-measuring, steep-sided jagged snowy peaks, together with unique biodiversity form a compact biogeographical unit, yet its flanks differ considerably from each other because of their geographical position, trend and climate.

## 5.2 Materials and Methods

The information presented here is based on literature available to the authors as well as their own observations made during the explorations in the region over the past more than three decades.

## 5.3 Results

### *5.3.1 Vegetation*

The Himalaya, with altitudinal variations showing abrupt rise from few hundred meters to more than 8000 m in only a couple of hundred kilometres, has unique geoclimatic conditions, resulting in a vast array of ecosystems from tropical evergreen forests, grasslands, moist mixed deciduous forests, riverine, marshy and swamp forests, dry deciduous forests, subtropical pine forests, broad-leaved temperate forests, temperate coniferous forests, subalpine and alpine vegetation comprising shrubberies, alpine meadows and alpine scrubs (Champion and Seth 1968). These vegetational zones, with characteristic topography and climate, show considerable variation in floristic composition and species dominance.

The tropical evergreen forests are confined to the humid foothills of the eastern and central Himalaya. With decreasing precipitation and increasing elevation westward, the rainforests give way to tropical deciduous forests dominated by sal (*Shorea robusta*) all along. Wet sal occupies lower elevation in Shiwalik and is overtopped by dry temperate sal forests up to 1500 m. Further west, dry deciduous, subtropical thorn steppe and subtropical semidesert vegetation occurs successively. Temperate conifer forests and broad-leaved trees extend from 1200 to 2500 m. Evergreen forests of oaks and conifers are typical of the Lesser Himalaya, being conspicuous on the outer slopes. Chir pine (*Pinus roxburghii*) is the dominant species at elevations from 800 to 1900 m. The giant Himalayan cedar (*Cedrus deodara*) dominates the temperate (1800–2700 m) belt of the western range. This highly valued sacred timber tree sometimes grows at still higher elevations (3200 m) in upper Bhagirathi (Ganges) valley, where oldest and some of the tallest trees of this species are seen. Other conifers of this belt are blue pine (*Pinus wallichiana*), fir (*Abies pindrow* and *A. spectabilis*) and spruce (*Picea smithiana*), which occur at 2200–3100 m altitudes.

The alpine zone (3200–4500 m) between the tree line and permanent snow line is dominated by grassy meadows, locally called 'Bugyals'/'Bahaks' in the western Himalaya. In terms of herbaceous species diversity, this is the richest zone, harbouring a number of medicinal plants. This vegetation is composed of tall forbs, mixed herbaceous formations, *Danthonia* grasslands and *Kobresia* sedge, with intermixed cushionoid species, and is often flanked by scrubs. The extent of this vegetation is so high in the west Himalaya that an estimated 50% of total alpine vegetation of Garhwal-Kumaon (Uttarakhand) falls under Bugyal (Rawat 2005). Associated vegetation here includes juniper and *Rhododendron* shrubberies occupying steep and rocky slopes and drier areas. *Rhododendron*, though common throughout the Himalaya, shows maximum species diversity in wet parts of the eastern Himalaya, where it grows in all sizes from low shrubs to huge trees. Pteridophytes, mosses and liverworts occupy low-level moist shaded areas, whereas lichens grow everywhere from shaded forests to arctic periglacial moraine belts. The higher elevations are occupied by high montane angiosperm flora. The arctic-alpine belt – the topmost elevation where plants can survive – shows two distinct ecosystems with unique floristic composition, viz. the Trans-Himalayan cold desert and the glacial zone.

The western Himalaya largely supports drought-resistant and cold-loving plants belonging mostly to Coniferae, Fabaceae, Asteraceae, Poaceae, Rosaceae, etc. In the cold dry valleys at high altitudes, the landscape is dominated by species of *Abies*, *Cedrus*, *Picea*, *Pinus*, *Quercus* and *Rhododendron*, with the *Betula utilis-Abies spectabilis* and, at places, *Quercus semecarpifolia-Abies pindrow* associations. The tree line in this region is formed by *Betula utilis* at variable height between 3200 and 3600 m. However, in Trans-Himalayan cold deserts covering Ladakh, Lahaul-Spiti, Nelang, Niti-Malari, Lapthal-Rimkhim to Milam, the vegetation is of arctic-steppe type, conspicuous by the absence of tree species, except *Juniperus polycarpos* var. *seravschanica* in Lahaul area. The flora here is mainly represented by alpine scrubs, characterized by highly specialized deep-rooted, compact, cold-desert elements like *Arenaria bryophylla*, *Thylacospermum caespitosum*, *Acantholimon lycopodioides*, *Astragalus munroi*, *A. rhizanthus*, *A. webbianus*, *Corydalis crassisima*, *C. crassifolia*, *C.*, *adiantifolia*, *Caragana versicolor*, *Myricaria rosea*, *Euphorbia tibetica*, *Lancea tibetica*, *Draba lanceophylla*, *Waldheimia tomentosa*, *Thermopsis inflata*, *Pegaeophyton scapiflorum*, *Triglochin maritima*, *Hippophae rhamnoides*, etc., which variously modify themselves to ward off extreme climatic conditions because of almost negligible precipitation and excessive dryness. As a part of their survival strategy, these taxa acquire bushy and diminutive cushion, clump or mat-forming habit, ranging from just a few cm to ca. 50 cm, and often develop blanket of woolly tomentum. Though *Caragana* bushes on barren scree slopes are the most common feature of Trans-Himalayan valleys, typical cold-desert species include *Allium carolinianum*, *Astragalus graveolens*, *A. amherstianus*, *Biebersteinia odora*, *Callianthemum pimpinelloides*, *Clematis ladakhiana*, *Crambe kotschyana*, *Chorispora sabulosa*, *Lindelofia stylosa*, *Myricaria germanica* subsp. *alopecuroides*, *Rhamnus prostrata*, *Rosa webbiana*, *Scrophularia dentata*, *Asperula oppositifolia* ssp. *pseudocynanchica*, etc. Western Himalayan endemic *Prunus jacquemontii*, described from Malari (Chamoli, Uttarakhand), is locally common in the type locality. Species forming this type of vegetation have well-developed, thick, much-branched rootstock and dwarf cushionoid/mound forming, bushy/tufted habit with reduced foliage (Chowdhery and Rao 1990; Murti 2001).

The western Himalaya shows greater luxuriance of gymnosperms, whereas the eastern Himalaya shows higher species diversity. The region harbours nearly 5700 angiospermic taxa with over 4500 reported from west Himalaya and over 5200 taxa from the northwestern range. Angiosperm families, such as Adoxaceae, Circaeasteraceae, Moringaceae, Polemoniaceae, Illecebraceae, etc., present in the western Himalaya are absent from the eastern sector. Similarly, many genera like *Eurycarpus*, *Himgiria*, *Kailashia*, *Kedarnatha*, *Schizotechium*, *Setulocarya*, *Shivparvatia*, *Trachidium*, etc. are hitherto unrecorded in eastern sector. Fantastic four of the west Himalayan species are Himalayan cedar (*Cedrus deodara*), brahma kamal (*Saussurea obvallata*) (the state flower of Uttarakhand), bhojpatra (*Betula utilis*) and burans (*Rhododendron arboreum*) (the state tree of Uttarakhand). Among other notable species, west Himalayan palm (*Trachycarpus takil*) and the Shiwalik endemic (*Catamixis baccharoides*) are very significant.

The central Himalaya shows mixed climate, with dry arctic condition in the north and humid tropical in the south. Tarai of Darjeeling, Kalimpong and Sikkim show lower-hill forests categorized into tropical evergreen forest and tropical moist-deciduous forests at higher altitudes comprising sal (*Shorea robusta*). Outer Himalayan ranges between 500 and 650 m are covered with mixed moist-deciduous forests. Subtropical forests occupy mid-altitudinal belt between 650 and 1500 m and are also called ‘middle hill forests’. Two prominent associations of such forests are *Schima-Castanopsis-Phoebe* at lower elevations and *Engelhardtia-Castanopsis-Schima-Betula* at higher elevations. Extensively planted *Cryptomeria japonica* forms dense forests in 1200–2400 m zone (Srivastava 1998). Bamboo species like *Chimonobambusa griffithianum*, *Thamnocalamus aristatus*, *Drepanostachyum falcatum*, etc. and palms like *Wallichia densiflora* and *Livistona jenkinsiana* grow in this belt. Notably, bamboos of *Arundinaria* group are seen at higher altitudes, while species of *Bambusa* and *Dendrocalamus* occupy varied altitudinal ranges (Kumari 2013). Upper temperate and subalpine zones show dense growth of Lauraceous forests, followed by oak. Rhododendrons, like *R. arboretum*, *R. cinnamomum*, *R. barbartum*, *R. hodgsoni*, *R. griffithianum* and *R. grande*, along with conifers like *Tsuga dumosa*, *Picea spinulosa* and *Abies densa* dominate the highest subalpine forests. Above tree line, beyond 3200 m, *Rhododendron* forms alpine shrubberies. The alpine meadows and arctic periglacial flora here are dominated by species of *Anemone*, *Ranunculus*, *Potentilla*, *Primula*, *Saxifraga*, etc. The angiosperm flora of the region accounts for little over 4500 taxa. Monotypic family Brachycaulaceae, with genus *Brachycaulos*, is endemic here. Genera such as *Cavea*, *Paraoxygraphis* and *Calathodes* are not recorded from western or eastern flanks.

The eastern Himalaya, on the contrary, has cool, humid and semi-oceanic climate, with the vegetation characterized by the abundance of Rhododendrons and the remnants of *Podocarpus* flora of the Gondwanaland. The region, considered as ‘cradle of angiosperms’ by Takhtajan (1969), supports a very rich epiphytic vegetation, both in luxuriance and diversity, dominated mostly by orchids, ferns, bryophytes, lichens, etc., besides the predominant terrestrials like tree ferns, terminalias, oaks, laurels, bamboos, hedychiums and many others, with the tree line as high as 4500 m formed by Rhododendrons. As far as gymnosperm diversity is concerned, the east Himalayan range has greater generic and species diversity. This Himalayan range indeed has very rich floristic diversity comprising as many as 5000 taxa of angiosperms (Chowdhery 2008). Certain angiospermic families, such as Akaniaceae, Diapensiaceae, Chloranthaceae, Stachyuraceae, Clethraceae, Tetracentraceae, Pandanaceae, Musaceae, Dilleniaceae, Clusiaceae, Proteaceae, Vacciniaceae, etc., present in the eastern Himalaya have not been reported in wild from the western part. Similarly, many genera, like *Asteropyrum*, *Beesia*, *Bhutanthera*, *Biswarea*, *Bretschneidera*, *Bryocarpum*, *Bulleyia*, *Indopolysolenia*, *Stapletonia*, etc., are not recorded from western Himalaya.

Himalayan flora shows balanced pattern of species distribution. In addition to approximately one-third of Himalayan endemics, nearly the same number of non-Himalayan endemics has restricted distribution in its different parts, whereas the rest of the species are distributed uniformly all along. Extended range of distribution for central-eastern genera, like *Sarcopyramis* and *Tsuga*, reported from eastern corner (Kumaon) of western Himalaya, are examples of taxa which have successfully crossed Kali Gandaki barrier. Species of disjunct distribution are not of rare occurrence, as *Actinocarya acaulis*, *Sedum fischeri*, *Stellaria congestiflora*, *Rhododendron nivale*, *Saxifraga lepida*, etc. have been recorded disjunctly from central and western Himalaya.

### *5.3.2 Himalaya: A Megadiversity Centre of Flora*

The floristic studies in the Himalaya, dating back to the late eighteenth century, have so far revealed nearly 22,000 taxa, belonging to various groups of plants of which nearly 10,000 species belong to the flowering plants. Over the period of nearly two centuries, several surveyors, mountaineers, botanical explorers, foresters, engineers and scientists from Botanical Survey of India as well as other research and academic institutions have contributed significantly to our knowledge of the vegetation and flora of the Himalaya (Royle 1839; Duthie 1906; Biswas 1966; Nasir and Ali 1971–onwards; Stewart 1972; Rau 1974, 1975; Rao 1974; Chopra 1975; Ohashi 1975; Hara and Williams 1979–1983; Chowdhery and Wadhwa 1984; Polunin and Stainton 1984; Nayar and Sastry 1987–1990; Grierson and Long 1983–2000; Pangtey and Joshi 1987; Gupta 1989; Karthikeyan et al. 1989, 2009; Mukherjee 1988; Chowdhery and Rao 1990; Sahni 1990, 1998; Ohba and Malla 1991; Khoshoo 1993; Singh 1992; Kachroo 1993; Sharma and Balakrishnan 1993; Sharma and Sanjappa 1993; Sharma et al. 1993; Rao 1994; Singh et al. 1994; Hajra and Balodi 1995; Srivastava 1998; Mudgal and Hajra 1995, 1999; Nayar 1996; Hajra et al. 1996a, b; Hajra and Verma 1996; Singh and Chauhan 1997; Chowdhery 1998; Gaur 1999; Pangtey 2000; Press et al. 2000; Singh 2001, 2002; Singh and Singh 2001; Singh et al. 2000, 2002; Zengyi et al. 2000–onwards; Murti 2001; Sharma and Singh 2001, 2002; Kumar and Sane 2003; Dar and Christensen 2003; Rao et al. 2003; Rawat 2005; Uniyal et al. 2007; Misra 2007; Sanjappa and Singh 2008, 2009, 2010; Lucksom 2007, 2008; Mabberley 2008; Giri et al. 2008; Rawat 2008; Chowdhery 2008, 2009; Chandra Sekar and Srivastava 2009; Chowdhery et al. 2009; Singh and Singh 2009; Hajra and De 2010; Irwin and Narasimhan 2011; Singh and Sanjappa 2011; Singh and Singh 2011; Singh et al. 2012, 2013; Pusalkar and Singh 2012; Dey and Singh 2012; Chowdhery and Agarwala 2013; Srivastava and Shukla 2013; Singh et al. 2016; Singh and Dash 2014, 2015, 2016, 2017, 2018a, b; Singh et al. 2018).

According to current estimates, out of ca 18,532 flowering plant species in about 257 families occurring within the present political boundaries of India, the western Himalaya (west of river Kali) harbours nearly 4516 taxa, the central or the Sikkim Himalaya has 4515 taxa, while the eastern Himalaya hosts over 5110 taxa, with considerable commonalities. It is quite significant that though the IHR constitutes

**Table 5.1** Floristic diversity in the Indian Himalayan region and India (approximate)

| Taxonomic group | Number of species | | Percentage of Indian flora |
|---|---|---|---|
| | Indian Himalayan region (IHR) | India | |
| Angiosperms | 8700 | 18,532 | 46.95 |
| Gymnosperms | 51 | 81 | 60.49 |
| Pteridophytes | 766 | 1293 | 59.24 |
| Bryophytes | 1955 | 2765 | 70.71 |
| Lichens | 1197 | 2528 | 47.35 |
| Fungi | 7080 | 15,223 | 46.51 |
| Algae | 1355 | 7396 | 18.32 |

**Table 5.2** Species richness of angiosperms in different sectors of the Indian Himalayan region

| Sectors of Indian Himalayan Region (IHR) | Number of species + infraspecific taxa |
|---|---|
| Trans-Himalaya-Tibetan plateau (IHR-trans) | 2025 |
| Northwest Himalaya (IHR-NW) | 5214 |
| West Himalaya (IHR-W) | 4516 |
| Central Himalaya (IHR-C) | 4515 |
| Eastern Himalaya (IHR-E) | 5110 |

only about 13% of country's geographical area, yet it harbours nearly half of the Indian flora. Table 5.1 briefly outlines the tentative status of various groups of plants in the IHR vis-à-vis India.

#### 5.3.2.1 Angiosperms: The Flowering Plants

Species richness of angiosperms in different regions of the IHR is shown in Table 5.2.

Based on a comparative analysis of the larger families of angiosperms (Nasir and Ali 1971–onwards; Ohashi 1975; Grierson and Long 1983–2000; Karthikeyan et al. 1989, 2009; Sanjappa 1992; Rao and Hussain 1993; Sharma and Sanjappa 1993; Sharma et al. 1993; Press et al. 2000; Singh et al. 2000; Zengyi et al. (2000–onwards); Singh and Singh (2001); Anonymous 2002–onwards; Sanjappa and Singh 2008, 2009, 2010; Singh and Singh 2011; Balakrishnan et al. 2012; Singh et al. 2012, 2013; Singh and Dash 2014, 2015, 2016, 2017, 2018a), the approximate number of taxa in the major families of IHR vis-à-vis those of the Himalaya and India is presented in Table 5.3.

Asteraceae with 1390 taxa represents the largest flowering plant family in the Himalaya, followed by Orchidaceae (1370), Poaceae (1060) and Fabaceae (960). Orchidaceae with ca. 1036 taxa is the largest family in the IHR, followed by Asteraceae (920), Poaceae (755) and Fabaceae (710). However, pattern of dominance is not uniform in different sectors of the IHR, each having its own species composition (Table 5.4). Thus, Asteraceae with 619 taxa is the largest flowering

**Table 5.3** Comparative analysis of ten larger families of angiosperms in the Indian Himalayan region vis-à-vis the Himalayan and Indian flora

| Family | Number of taxa (spp + infra-spp) | | % age of Himalayan flora | India Number of taxa (spp + infra-spp) | % age of Indian flora |
|---|---|---|---|---|---|
| | IHR | Himalaya | | | |
| Orchidaceae | 1036 | 1370 | 75.62 | 1251 | 82.81 |
| Asteraceae | 920 | 1390 | 66.20 | 1120 | 82,14 |
| Poaceae | 755 | 1060 | 71.23 | 1291 | 58.48 |
| Fabaceae | 710 | 960 | 74.00 | 1421 | 49.96 |
| Rosaceae | 406 | 605 | 67.11 | 532 | 76.31 |
| Rubiaceae | 336 | 475 | 70.74 | 679 | 49.48 |
| Cyperaceae | 330 | 460 | 71.74 | 580 | 56.90 |
| Lamiaceae | 310 | 460 | 67.39 | 475 | 65.26 |
| Brassicaceae | 225 | 400 | 56.25 | 242 | 93.00 |
| Ranunculaceae | 220 | 360 | 61.11 | 236 | 93.22 |

**Table 5.4** Comparative species richness in ten larger families of angiosperms in different regions of the Indian Himalayan region

| Western Himalaya | Central Himalaya | Eastern Himalaya |
|---|---|---|
| Asteraceae (619) | Orchidaceae (524)[a] | Orchidaceae (610)[a] |
| Poaceae (481) | Asteraceae (321) | Asteraceae (220) |
| Fabaceae (387) | Poaceae (291) | Fabaceae (214) |
| Rosaceae (302) | Fabaceae (222) | Ericaceae (170) |
| Orchidaceae (290) | Cyperaceae (148) | Rubiaceae (172) |
| Cyperaceae (243) | Rosaceae (138) | Poaceae (156) |
| Lamiaceae (232) | Rubiaceae (110) | Rosaceae (115) |
| Brassicaceae (165) | Lamiaceae (95) | Cyperaceae (105) |
| Ranunculaceae (133) | Euphorbiaceae (94) | Euphorbiaceae (92) |
| Caryophyllaceae (109) | Primulaceae (85) | Acanthaceae (86) |

[a]Numbers in parentheses are estimated number of taxa (spp. + infraspecific taxa) in respective families

plant family in the western Himalaya, followed by Poaceae (481) and Fabaceae (387), whereas family Orchidaceae dominates in the central (524) and the eastern (610) Himalaya. It is followed by Asteraceae (321) and Poaceae (291) in Sikkim-Darjeeling and by Asteraceae (220) and Fabaceae (214) in Arunachal Pradesh.

Orchidaceae, the third largest flowering plant family in India and second in the Himalaya, assumes first place among families in the IHR. Out of 1036 species of orchids in the IHR, 100 species are endemic to this region (Singh et al. 2015; Singh and Dash 2015, 2016, 2017, 2018a, b). In terms of orchid diversity, the eastern Himalaya (Arunachal Pradesh) is the richest (Lucksom 2008; Chowdhery 2009; Nageswara Rao 2010). Himalayan Orchidaceae is also well-known for high concentration of monotypic genera, as also for the non-chlorophyllous orchids belonging to *Epipogium*, *Galeola*, *Gastrodia*, *Cymbidiopsis*, *Eulophia*, *Neottia*, etc. (Chowdhery 2009). *Rhododendron*, with 126 species and infraspecific taxa, is the

**Table 5.5** Larger genera of angiosperms in different sectors of the Indian Himalayan region

| Western Himalaya | Sikkim | Arunachal Pradesh |
|---|---|---|
| *Carex* (97)[a] | *Carex* (64) | *Rhododendron* (120) |
| *Taraxacum* (88) | *Impatiens* (60) | *Bulbophyllum* (62) |
| *Astragalus* (75) | *Primula* (58) | *Impatiens* (57) |
| *Potentilla* (54) | *Pedicularis* (54) | *Dendrobium* (47) |
| *Saussurea* (50) | *Saxifraga* (51) | *Agapetes* (46) |
| *Pedicularis* (50) | *Bulbophyllum* (51) | *Primula* (41) |
| *Saxifraga* (47) | *Rhododendron* (45) | *Ficus* (40) |
| *Poa* (45) | *Juncus* (40) | *Rubus* (34) |
| *Artemisia* (45) | *Dendrobium* (38) | *Corydalis* (34) |
| *Berberis*, *Nepeta* (45 each) | *Ficus* (37) | *Carex* (30) |

[a]Numbers within parentheses denote number of species + infraspecific taxa in respective genera

largest genus in the IHR with nearly all species occurring in the eastern sector, but only 7 of them in the western sector (Mao 2013; Mao et al. 2017). It is closely followed by *Impatiens* (125 spp.), *Primula* and *Carex* (each with ˃100 species), *Taraxacum* (95), *Astragalus* (90), *Saxifraga* (88), *Pedicularis* (83), *Bulbophyllum* (81), *Saussurea* (75) and *Coryadalis* (68) in the IHR. Like Rhododendrons, Hedychiums and bamboos are also more pronounced in the eastern Himalaya (Rao 1993; Seethalalakshmi and Muktesh Kumar 1998; Singh 2012). Differential pattern of generic dominance in different sectors of this region is presented in Table 5.5.

A large number of genera, such as *Actaea*, *Acroptilon*, *Ajania*, *Alliaria*, *Allysum*, *Anthemis*, *Aphragamus*, *Arctium*, *Bennetiodendron*, *Biebersteinia*, *Bixa*, *Calathodes*, *Camelina*, *Capsella*, *Cardaria*, *Cedrus*, *Coptis*, *Coringia*, *Coronopus*, *Crambe*, *Decaisnea*, *Descurainia*, *Dimorphotheca*, *Dicranostigma*, *Dilophila*, *Drabopsis*, *Erophila*, *Eruca*, *Euptelea*, *Goldbachia*, *Hepalica*, *Holosteum*, *Hymenolobus*, *Koelpinia*, *Lipschitziella*, *Myosoton*, *Neselia*, *Notoceras*, *Paeonia*, *Parabaena*, *Petrorhagia*, *Piloselloides*, *Ptilotrichum*, *Serratula*, *Smelowskia*, *Torularia*, *Tsuga*, *Turritis*, *Zoegea*, etc., including over 100 monotypics, viz. *Aboriella*, *Alexya*, *Arcyosperma*, *Artemisiella*, *Aspidocarya*, *Atelanthera*, *Biebersteinia*, *Brachycaulos*, *Brachystemma*, *Catamixis*, *Cucubalus*, *Didicea*, *Eriophyton*, *Euryale*, *Gontscharovia*, *Gynocardia*, *Hedinia*, *Hippuris*, *India*, *Kashmiria*, *Ladakiella*, *Loxostemon*, *Lygeum*, *Milula*, *Myagrum*, *Parakaempferia*, *Paraoxygraphis*, *Paroxygraphis*, *Platystemma*, *Pycnoplinthopsis*, *Pycnoplinthus*, *Roylea*, *Setulocarya*, *Sibbaldianthe*, *Souliea*, *Tauscheria*, *Tetracentron*, *Tibetia*, *Tordyliopsis*, *Tussilago*, etc., are represented in the IHR by a single species each.

#### 5.3.2.2 Himalaya: The Megacentre of Endemism

Nearly one-third of the Himalayan flora is endemic to the region. Of the estimated 10,000 species of flowering plants occurring in the Himalaya, about 3160 (31.6%) are endemic (http://www.conservation.org/where/priority_areas/hotspots/

asia-pacific/Himalaya/ Pages/biodiversity.aspx). Six families, viz. Tetracentraceae, Hamamelidaceae, Circaeasterceae, Butomaceae, Brachycaulaceae and Stachyuraceae, and nearly 71 genera, including *Arcyosperma*, *Actinocarya*, *Bhutanthera*, *Brachycaulos*, *Bryocarpum*, *Bulleyia*, *Catamixis*, *Cautleya*, *Cavea*, *Circaeaster*, *Cyananthus*, *Cyathopus*, *Dodecadenia*, *Dolomiaea*, *Edgaria*, *Eurycarpus*, *India*, *Ivanjohnstonia*, *Jaeschkea*, *Kashmiria*, *Kedarnatha*, *Ladakiella*, *Lalldhowjia*, *Lomatogoniopsis*, *Megacodon*, *Milula*, *Nardostachys*, *Neopicrorhiza*, *Oreosolon*, *Orthoraphium*, *Platystemma*, *Parakaempferia*, *Paroxygraphis*, *Parrotiopsis*, *Pycnoplinthus*, *Pycnoplinthopsis*, *Picrorhiza*, *Piptanthus*, *Pseudodanthonia*, *Roylea*, *Risleya*, *Setulocarya*, *Sphaerosacme*, *Solms-laubachia*, *Stapletonia*, *Stelbanthus*, *Stracheya*, *Tibetia*, *Tordyliopsis*, *Trachydium*, etc., are endemic to the Himalaya. Of these, nearly one-third genera are monotypic (Uniyal and Mathur 1994; Rana and Ranade 2009).

Considering the political boundaries, a large number of taxa belong to near endemic or broad-range endemic category. This includes disjunct endemics known from adjoining countries. Some such examples include Indo-Nepalese endemics (e.g. *Berberis koehneana*, *B. kumaonensis*, *Calamagrostis garhwalensis*, *Corydalis elegans*, *Cyananthus microphyllus*, *Hedysarum kumaonense*, *Ilex pseudodorata*, *Maharanga egregium*, *Silene kumaonensis*, *Trigonotis rotundifolia*), Indo-Pak endemics (e.g. *Campanula tenuissima*, *Cynoglossum stewartii*, *Picrorhiza kurroa*, *Silene kunawarensis*, *Spiraea zabeliana*) and Sino-Indian endemics (e.g. *Astragalus aegacanthoides*, *Ladakiella klimesii*, *Leontopodium junpeianum*, *Saxifraga lepida*, *Waldheimia huegelii*, *W. vestita*, etc.).

In addition, genera such as *Ladakiella*, *Solms-laubachia*, *Pycnoplinthus*, *Stracheya*, *Tibetia*, etc. are endemic to northern Trans-Himalayan cold desert, whereas others such as *Catamixis* and *Parakaempferia* are endemic to southern Himalayan Shiwalik ranges. Of 8700 species of angiosperms known from the IHR, nearly 1000 (ca. 12%) taxa and also six genera and one family (Brachycaulaceae) are endemic to this region. Among the IHR endemic genera, *Ivanjohnstonia*, *Kashmiria* and *Pseudodanthonia* are restricted to Uttarakhand, *Parakaempferia* and *Stapletonia* to Arunachal Pradesh and *Brachycaulos* to Sikkim. Based on the concentration of endemic taxa, the IHR can be divided into two subcentres – western and eastern Himalaya – and five microcentres (Table 5.6).

**Table 5.6** Number of endemic taxa in different subcentres in the Indian Himalayan region

| Subcentre | Microcentre |
|---|---|
| Western Himalaya: 526[500 taxa][a] | 1. Trans-Himalayan cold desert |
| | 2. Northwest Himalaya |
| | 3. West Himalaya (including Garhwal-Kumaon Himalaya and trans-Himalayan cold desert of Uttarakhand) |
| Eastern Himalaya: 584 [544 taxa][a] | 1. Central Himalaya [IHR-C: Sikkim-Darjeeling Himalaya (including trans- Himalayan cold desert of Sikkim Himalaya]. |
| | 2. Eastern Himalaya [IHR-E: Arunachal Pradesh] |

[a]Numbers within parentheses represent the Himalayan endemics

Notably many endemic species, such as *Anaphalis himachalensis*, *Arenaria curvifolia*, *Berberis lambertii*, *Brachycaulos simplicifolius*, *Dolomiaea baltalensis*, *Carex munroi*, *Cotoneaster parkinsonii*, *Impatiens polysciadia*, *I. reidii*, *Ivanjohnstonia jaunarensis*, *Jasminum parkeri*, *Kedarnatha sanctuarii*, *K. meifolia*, *Lactuca benthamii*, *Parakaempferia synantha*, *Pegaeophyton purii*, *Poa garhwalensis*, *Pseudodanthonia himalaica*, *Ranunculus uttaranchalensis*, *Risleya atropurpurea*, *Saxifraga minutissima*, *Senna davidsonii*, *Solms-laubachia lanuginosa*, *Spiraea parkeri and S. raizadae*, are point endemics and known only from their type localities, in some cases just by the type collection(s) and not recollected for over a century. Some, such as *Heracleum jacquemontii*, are known without precise locality in the region. Others, like *Catamixis baccharoides*, *Gentiana saginoides*, *G. tetrasepala*, *Kailashia robusta*, *Kashmiria himalaica*, *Ladakiella klimesii*, etc., though also known from outside their type localities, are very narrow-range endemics or sub-point endemics, hence highly threatened.

Apart from the endemics, some families such as Caryophyllaceae, Brassicaceae Ranunculaceae, Fumariaceae, Berberidaceae, Flacourtiaceae, Saxifragaceae and Crassulaceae have more than 80% of their representatives restricted to the Himalayan region.

#### 5.3.2.3 Himalaya: Centre of Origin and Speciation

The eastern Himalaya is known as the ‘cradle of angiosperms’, with a number of primitive flowering plants, viz. species of *Magnolia*, *Euptelea* (Magnoliaceae) and *Tetracentron* (Tetracentraceae), showing their maximum diversity in the region. While this region is the epicentre for the origin and diversification of many taxa including Himalayan endemics, it is also the meeting ground of floristic elements migrated from adjoining areas older than the Himalaya.

The Himalayan region is also a centre of speciation for many genera, such as *Astragalus*, *Berberis*, *Carex*, *Corydalis*, *Cotoneaster*, *Gentiana*, *Impatiens*, *Kobresia*, *Nepeta*, *Pedicularis*, *Potentilla*, *Primula*, *Rhododendron*, *Rubus, Saussurea*, *Saxifraga*, *Spiraea*, *Taraxacum*, etc. With 37 endemics (out of 75 species indigenous to Indian Himalaya), the west-central Himalaya is recognized as secondary centre of origin and differentiation for the genus *Cotoneaster*. The Himalaya is also considered as a centre of diversity for polypodiaceous taxa of pteridophytes (Bir 1993). While the western Himalaya is the prime speciation centre for the genus *Taraxacum*, the eastern Himalaya is the centre of genetic diversity for *Bambusa*, *Dendrocalamus*, *Arundinaria* and *Cephalostachyum* (Rao 1993).

#### 5.3.2.4 Himalaya: The Phytogeographers’ Delight

The Himalayan flora presents a conglomeration of floristic elements from various adjoining as well as far off biogeographic regions. Situated at a transition zone between the Palaeoarctic and Indo-Malayan realms, it shows floristic representatives from both these realms. The contiguity of the Himalayan territory with Tibeto-Chinese mainland has facilitated southward spread of species from much older Chinese territory of Qinghai-Tibetan Plateau, resulting in the region being dominated by Sino-Himalayan flora. The richness of the Himalayan flora is not only contributed by the floristic elements from neighbouring territories, such as Afghanistan, China and Myanmar, but is also due to significant presence of Eurasian, Sino-Siberian, Central Asian, East Asian and Southeast Asian elements. Some of the genera recorded in the Himalayan flora are interestingly common with Africa (e.g. *Colutea*, *Pittosporum*, *Malaxis*, *Remusatia*, *Satyrium*, etc.), America (e.g. *Arenaria*, *Cupressus*, *Draba*, *Magnolia*, *Polemonium*, *Rubia*, *Rumex*, *Saurauia*, *Silene*, *Spiraea*, *Pinguicula*, etc.) and Australia (e.g. *Phalaeonopsis*, *Polyosma*, *Vanda*, etc.). It is estimated that over 80% nonendemic flora is contributed by the Sino-Himalayan, East Asian, Southeast Asian and Central Asian elements. Geographic affinities of some of the Himalayan genera are as follows:

**Cosmopolitan:** *Cuscuta*, *Cyperus*, *Drosera*, *Euphorbia*, *Juncus*, *Liparis*, *Luzula*, *Plantago*, *Polygonum*, *Poa*, *Solanum*, etc.

**Tropical:** *Crotalaria*, *Desmodium*, *Ficus*, *Musa*, *Sida*, *Rotala*, *Saccharum*, *Strobilanthes*, *Ziziphus*, etc.

**Central Asian:** *Allardia*, *Anthogonium*, *Aphragmus*, *Atelanthera*, *Christolea*, *Desideria*, *Lindelofia*, *Lasiocaryum*, *Leptorhabdos*, *Lipschitziella*, *Mandragora*, *Paraquilegia*, *Pegaeophyton*, *Phaeonychium*, *Perovskia*, *Thylacospermum*, etc.

**Sino-Himalayan:** *Chaetoseris*, *Decaisnea*, *Dicranostigma*, *Diphylax*, *Diplanche*, *Dobinea*, *Drepanostachyum*, *Echinacanthus*, *Herpetospermum*, *Holboellia*, *Lamiophlomis*, *Leycesteria*, *Lithostegia*, *Maharanga*, *Merillopanax*, *Meconopsis*, *Microula*, *Monochosorum*, *Neillia*, *Oreocomopsis*, *Omphalogramma*, *Onosma*, *Orinus*, *Toricellia*, *Ponerorchis*, *Prinsepia*, *Pseudostachyum*, *Pterocyclus*, *Risleya*, *Roscoea*, *Sinocrassula*, *Soroseris*, *Spongiocarpella*, etc.

**East Asian:** *Aucuba*, *Boenninghausenia*, *Cardiocrinum*, *Cephalotaxus*, *Cleyera*, *Gamblea*, *Gastrochilus*, *Hemiphragma*, *Hydrangea*, *Leptodermis*, *Lasionotus*, *Neottianthe*, *Oreorchis*, *Phryma*, *Phyllostachys*, *Tricyrtis*, etc.

**Southeast Asian:** *Boeica*, *Buchnania*, *Caulokaempferia*, *Clarkella*, *Colquhounia*, *Corallodiscus*, *Cranitome*, *Dittoceras*, *Engelhardtia*, *Exbucklandia*, *Falconeria*, *Lasiococca*, *Leucosceptrum*, *Loxostigma*, *Monomeria*, *Natsiatum*, *Papilionanthe*, *Phaialacanthus*, *Pleione*, *Poikilospermum*, Sabia, *Sarcopyramis*, *Streptolirion*, etc.

**Eurasian:** *Atropa*, *Biebersteinia*, *Carum*, *Lamium*, *Lathraea*, *Lomatogonium*, *Paeonia*, *Patrinia*, *Peucedanum*, *Rheum*, *Saussurea*, *Saxifraga*, *Sedum*, *Taucheria*, etc.

#### 5.3.2.5 Himalaya: Home to Wonder Plants and Botanical Curiosities

The Himalaya is not only known for the tallest peaks, the deepest gorges, and the largest ice cover outside the polar regions, but it also holds the highest-altitude habitats for nearly all groups of plants. In spite of extremely harsh conditions in rocky moraines above permanent snowline at 5500–6000 m, where sustenance of life is very difficult, there are reports of plants occurring at some of the highest elevations on Earth. Of these, *Arenaria bryophylla* collected by A.F.R. Wollaston [Sept. 1921, coll. No. 45 (K)] at 20,400 ft. (ca. 6126 m) on way to Mt. Everest (see also Mabberley 2008) and *Ranunculus lobatus* along with *Desideria himalayensis* collected at 6300 m on the slopes of Mt. Kamet in the vicinity of Valley of Flowers in Chamoli district of Uttarakhand in western Himalaya are perhaps the flowering plant species recorded at the highest altitude on Earth (Rau 1974). Some other plant species recorded above 6000 m include *Arenaria kumaonensis*, *Corydalis nana* and *Delphinium brunonianum*. Similarly, the moss *Aongstroemia julacea* has been found growing at an altitude of 6480 m on way to Mt. Everest (Singh and Hajra 1996), while the lichen *Umbilicaria virginis* is recorded at 6300 m (Awasthi 2007).

*Arceuthobium minutissimum*, a stem parasite on *Pinus wallichiana* recorded from the western Himalaya, is the smallest parasitic angiosperm. *Sapria himalayana*, a root parasite from the eastern Himalaya and Northeast India, with flower diameter up to 30 cm, has the largest flower in India. *Ephedra gerardiana*, with altitudinal reach up to 5450 m, is the highest-altitude gymnosperm (Sahni 1990). Report of *Abies spectabilis* growing at an altitude of 5350 m in Kashmir is probably the highest limit for any tree species (Sahni 1990, after Thierot 1980 in Encyclopaedia Britanicca, vol. 8). A *Cedrus deodara* tree at Manali in Himachal Pradesh, reaching the height of 76 m and the girth of 13.7 m (Sahni 1990, 1998), is perhaps the tallest and the stoutest gymnosperm tree in the Himalaya. Again, *Cedrus deodara* with age reports between 800 and 900 years (Brandis 1874; Kanjilal 1928) and *Cupressus torulosa* (age up to 1000 years, Brandis 1874) are possibly longest living Himalayan trees. With less than 10 cm height, *Ephedra regeliana* of Trans-Himalayan cold desert is the smallest gymnosperm (Sahni 1990).

The IHR also abounds in many botanical curiosities, such as *Balanophora involucrata* (fungus-like root parasite); *B. dioica*, *Boschniakia himalaica*, *Orobanche alba*, *O. solmsii*, *Aeginetia indica*, *Rhopalocnemis phalloides*, *Sapria himalayana*, etc. (root parasites); *Epipogeum roseum*, *Cymbidiopsis macrorhizon*, *Neottia listeroides*, *Galeola falconeri*, *Monotropa hypopitys*, *M. uniflora*, etc. (microtropic saprophytes); and *Pinguicula alpina*, *Drosera peltata* and species of *Utricularia* (insectivores). Some other curious-looking Himalayan plants include species of *Androsace*, *Saxifraga*, *Rhodiola*, *Thylacospermum*, *Arenaria*, *Acantholimon*, etc. (forming cushions), or *Saussurea gossypiphora* and *S. graminifolia* (looking like snow ball) in the western Himalaya, which assume unusual life forms to adapt to harsh cold, arid conditions and the ‘Sikkim Sundari’/‘Sikkim Soldiers’ (*Rheum nobile*) in Sikkim and Arunachal Pradesh.

#### 5.3.2.6 Himalaya: The Epitome of Medicinal and Aromatic Plants (MAPs)

The Himalaya is home to rich medicinal and aromatic plant diversity (Chopra et al. 1956; Kaul 1997; Arora 1993; Rai and Sharma 1994; Samant and Dhar 1997; Samant and Palni 2000; Samant et al. 1998, 2001; Pal and Samant 2003; Shah 2006; Chaurasia et al. 2007; Samant et al. 2007; Kala 2010). Many high-value medicinal plants having great demand in national and international markets are found here. Besides some selective medicinal herbs of pharmacopoeial importance, a large number of others are used in indigenous medicines (ethno-medicines), as well as raw drugs by different ethnic communities in the region. It is estimated that nearly 50% natives of the Greater-Himalayan and nearly 80% of the Trans-Himalayan region are still dependant on traditional medicines based on wild herbs. A large number of Himalayan plant species are also significant from ethno-veterinary point of view. The western Himalaya is much richer in medicinal plant diversity as compared to its eastern counterpart.

About 1748 species of angiosperms, gymnosperms, and pteridophytes in the IHR have medicinal and/or aromatic potential (Samant et al. 1998), whereas about 675 wild plant species in this region are edible (Samant and Dhar 1997). Majority of these MAPs are used in different Indian systems of medicine and pharmaceutical and oil industries. Over 1000 medicinal plant species are recorded from the Western Himalaya, 400 from Trans-Himalaya, and 500 from the northwest Himalaya (Srivastava and Shukla 2013). Samant et al. (2007) reported 643 species of MAPs from Himachal Pradesh, while Kala (2010) reported 964 species from Uttarakhand. Medicinal uses of 424 species are reported from Sikkim Himalaya. About 118 plant species of IHR yield essential oils (Samant and Palni 2000).

The Himalaya is also recognized as a precious treasure house for a large number of plant species which are collectively known as non-timber forest products (NTFP) or the minor forest products (MFP). A large number of plant species, which are important sources of essential oils, spices, food/food supplements, gums, resins and oleoresins, fatty oils, tanins, natural organic colouring materials, katha and cutch, oxalic acid, fibres and flosses, beverages and narcotics, fodder and forage, saponins, fish poisons, insecticides, green manure, etc., are recorded from here (Singh and Arora 1978; Arora 1993; Singh et al. 1993; Krishnamurthy 1993). About 184 species of edible fruits are recorded from Uttarakhand (Upreti et al. 2010). Besides, there are a number of multipurpose plants which play an important role in the socio-economic life of the people in this region, e.g. species of bamboos (Handique et al. 2010), *Hippophae rhamnoides*, *Diploknema butyracea* (Cheura), *Grevia optiva*, etc.

#### 5.3.2.7 Himalaya: The Centre of Origin of Crop Plants

The Himalaya is recognized as one of the major Vavilovian centres of diversity of crop plants (Vavilov 1951). Of 167 plant species which have originated and diversified in eight Indian subcentres (Khoshoo 1991, Khoshoo 1993), 125 species are reported from the western Himalaya and 82 from the eastern Himalaya (Arora 1993). The source of wild germplasm in the western Himalaya includes species of *Aegilops*, *Allium*, *Carum*, *Cicer*, *Cucumis*, *Ferula*, *Lepidium*, *Linum*, *Lilium*, *Prunus*, *Pyrus*, etc., whereas the eastern Himalaya is the centre for species of *Amomum*, *Atylosia*, *Brassica*, *Citrus*, *Coix*, *Curcuma*, *Digitaria*, *Dioscorea*, *Eriobotrya*, *Gossypium*, *Moghania*, *Musa*, *Myrica*, etc. The Himalayan region also has rich diversity of forage plants, including about 100 species in 13 genera of legumes and 160 species in 22 genera of grasses.

#### 5.3.2.8 Himalaya: The Abode of Sacred Flora

Himalaya, considered home of the mythical ‘Mrit Sanjeevani’ – a life-saving herb – abounds in a number of plants of religious significance. Many species, from deodar (*Cedrus deodara*) – the “Tree of God” – to bhojpatra (*Betula utilis*, bark used for writing religious text in ancient times), brahmakamal (*Saussurea obvallata*), shivkamal (*Saussurea gossypiphora*), jatamansi (*Nardostachys grandiflora*), dhoop (*Dolomiaea macrocephala*), badri tulsi (*Origanum vulgare*) and ganga tulsi (*Artemisia gmelinii*), are associated with various religious ceremonies and offered to deities in the region. A number of different trees, such as deodar, sal, surai, and pine, are worshiped as tree deities, whereas flowers/leaves of number of other species are offered to gods in different parts of the IHR.

Apart from individual plants, patches of vegetation are preserved on religious grounds and are known as sacred groves. There are about 150 such sacred groves in Jammu and Kashmir (http://www.apforgen.org/FGR%20Coimbatore/08072010/3.Kannan_APFOR GEN%202,010.pdf), 5000 in Himachal Pradesh, 22 in Uttarakhand, 56 in Sikkim and 101 in Arunachal Pradesh (http://ecoheritage.cpreec.org/viewsacdetail.php?$mFJyBfK$ MOIb-B5vugEjcB5Mu5Xu5fK). These groves, varying from a single protected tree to small/large patches of vegetation /forests, and sometimes an entire and unique ecosystem like meadow or lake, often surrounding a temple or abode of local deity, are sanctified under the protection of God or Godess. These groves are either of general composition or species-oriented. Important Himalayan plants of religious significance include bael (*Aegle marmelos*), kurinda or kunja (*Artemisia indica*), ganga tulsi (*Artemisia gmelinii*), bhojpatra (*Betula utilis*), deodar (*Cedrus deodara*), dub or dubla (*Cynodon dactylon*), chambi (*Daphne papyrifera*), kumkum (*Euonymus tingens*), bargad/bar (*Ficus benghalensis*), pipal (*Ficus religiosa*), dhoop (*Dolomiaea macrocephala*), thelu (*Juniperus* spp.), aam (*Magnifera indica*), jatamansi (*Nardostachys grandiflora*), kedar pat (*Skimmia anquetilia*), lesar (*Pleurospermum candollei*), mansi (*Valeriana jatamansi*), badri tulsi (*Origanum vulgare*), jayan or ram jayan (*Primula macrophylla*), surai (*Cupressus torulosa*), chir or kulain (*Pinus roxburghii*), burans (*Rhododendron arboreum*), brahmakamal (*Saussurea obvallata*), til (*Sesamum orientale*), thuner (*Taxus wallichiana*), timru (*Zanthoxylum armatum*), etc.

#### 5.3.2.9 Gymnosperms

Gymnosperms occupy extensive landscapes in the Himalayan territory, forming signature conifer forests. In the western Himalaya, gregarious forests of chir pine (*Pinus roxburgii*) dominate the southern subtropical to mid-temperate regions (500–2300 m), Himalayan cedar or deodar (*Cedrus deodara*) covers 1700–3200 m, cypress (*Cupressus torulosa*) 1800–2800, spruce (*Picea smithiana*) 2150–3300 m and fir (*Abies* spp.) 2300–3300 m, while mixed conifer and blue pine (*Pinus wallichiana*) forests occur between 1800 and 3900 m from upper temperate to alpine zone. Extensive shrubberies of *Ephedra gerardiana* form arctic-steppe vegetation in the Trans-Himalayan cold desert (3500–4500 m). Despite quantitative dominance of gymnosperms in the western province, the central and eastern Himalayan regions show significantly higher diversity at the genus and species levels. Of the 81 species and infraspecific taxa of gymnosperms hitherto known to naturally occur in India, 51 taxa in 16 genera are found in the Himalayan region (Singh et al. 2018) between 500 and 5450 m altitudes. In addition, there are 37 exotic species belonging to 12 genera, such as *Agathis*, *Auracaria*, *Callitris*, *Cryptomeria*, *Cunninghamia*, *Gingko*, *Taxodium*, *Thuja*, etc., which are cultivated in different parks and gardens and along roadsides in the region.

Though many genera are distributed throughout the Himalaya, yet their dominance and species distribution pattern is well defined. *Cycas*, *Gnetum* and *Podocarpus* are the only genera that show extra-Himalayan distribution, and *Larix* and *Podocarpus* are known only from the central and eastern Himalaya in the Indian flora, while *Amentotaxus* and *Cephalotaxus* are confined to the eastern Himalaya (Arunachal Pradesh). *Juniperus*, though distributed throughout, prefers dry arctic west Himalayan conditions, with all but *J. recurva* var. *coxii* (Tsangpo gorge) occurring in this sector and only three species found in the eastern part. Himalayan cedar, which along with chir pine is the most dominating gymnosperm of the western Himalaya, has yet not been recorded from the east. On the other hand, its eastern counterpart, Indian hemlock fir (*Tsuga dumosa*) has managed to cross Kali-Gandaki barrier and forms pure strands in the eastern Kumaon region of western Himalaya. Among Himalayan spruces, west Himalayan spruce (*Picea smithiana*) dominates western flank between 2150 and 3300 m being often associated with deodar, blue pine and Himalayan yew (*Taxus wallichiana*). East Himalayan spruce (*Picea spinulosa*) is distributed from central (Sikkim) to eastern Himalaya, whereas *Picea brachytyla* is restricted to eastern Himalaya, either forming pure patches (Kameng division in Arunachal Pradesh) or mixed with other species like *Pinus wallichiana*, *Abies densa*, *Tsuga dumosa* and *Taxus wallichiana*. Similarly, among pines, while two species of vertical extremities, the northern (*Pinus wallichiana*) and southern (*Pinus roxburghii*), are distributed throughout the Himalaya, others have restricted distribution. Eastern region is the richest with six species of pines out of seven reported from the IHR, while *Pinus gerardiana* is restricted to the western Himalaya. The same trend is seen in case of firs as well, with *Abies spectabilis* being the only common species all along. Of the remaining species, *A. pindrow* is known only from western part, *A. delavayi* is restricted to eastern flank, whereas *A. densa* occurs in both central and eastern Himalaya (Sahni 1990; Singh and Mudgal 1997).

*Ephedra*, with 13 taxa (10 species and 3 varieties), is the most prolific genus not only in the IHR but also in India, being followed by *Juniperus* and *Pinus* (both with 7 taxa each). Eight genera, viz. *Amentotaxus*, *Cycas*, *Cedrus*, *Larix*, *Nageia*, *Podocarpus*, *Taxus* and *Tsuga*, are represented by just a single species each in this region. While *Ephedra przelwaskii* and *Picea smithiana* are endemic to west Himalayan territory, *Amentotaxus assamica*, *Ephedra gerardiana* var. *sikkimensis*, *Picea spinulosa*, *Pinus wallichiana* var. *parva* and *Gnetum montanum* f. *megalocarpum* are endemic to the eastern sector. *Ephedra gerardiana* and *E. nebrodensis*, which are good source of alkaloid ephedrine, and *Taxus wallichiana*, a source of taxol, are considerably exploited. Similarly, species of *Pinus*, *Picea*, *Abies*, *Cedrus*, *Cephalotaxus* and *Taxus* are highly exploited in the region for timber and non-timber produce, leading to considerable depauperization of their populations in some areas.

Apart from the most important timber trees of India, gymnosperms are also the prime source of turpentine and are also revered religiously. *Cedrus deodara* is the most sacred Himalayan tree and often worshiped as 'Tree Deity'. Many deodar, pine and *Cupressus* sacred groves are the centres of in situ conservation in the western Himalaya. Powdered juniper leaves are used in making incense fires in religious ceremonies. A rejuvenating tea is prepared in the Kumaon Himalaya by boiling bark of *Taxus wallichiana*. It is notable that some of the places in the western Himalaya are named after locally abundant gymnosperms, e.g. Suraitoli in Chamoli district of Uttarakhand is named after locally dominating *Cupressus torulosa* called 'surai'; chirwasa, on way to Gomukh (source of river Ganga), is named after dominating *Pinus wallichiana*, and one peak in Bhagirathi-Nila divide in northern Garhwal is called Thellu after its slopes commonly covered with junipers, locally known as Thelu. It is rather sad to record here that *Cupressus cashmeriana*, last collected by Royle from Ladakh, has probably become extinct in the wild.

#### 5.3.2.10 Pteridophytes: The Ferns and Fern Allies

Pteridophytes are widely distributed throughout the Himalayan region from foothills to about 4500 m (even above 5000 m) altitude, but they are more prolific between 1500 and 2700 m. Review of literature (Dixit 1984; Khullar 1994, 2000; Fraser-Jenkins 1997, 2008; Chandra 2000; Pande and Pande 2002a, b, 2003; Singh and Panigrahi 2005; Joshi et al. 2008; Kholia 2010, 2011; Pande et al. 2012) shows that though pteridophytes grow in a variety of habitat conditions, both mesophytic and xerophytic, they usually prefer shady and hygroscopic conditions. Accordingly, they are less prolific in the western sector as compared to the east Himalaya and the western Ghats. Out of over 1293 species of pteridophytes recorded from India, about 766 species are reported from the IHR (Singh and Dash 2018a); this includes 57 species of fern allies. Eastern Himalaya is the richest with over 629 taxa, followed by central (511) and western Himalaya with 407 taxa. Dryopteridaceae, Thelypteridaceae, Pteridaceae, Polypodiaceae, Woodsiaceae and Aspleniaceae are the dominant families in the region, whereas *Thelypteris* with 63 species is the largest genus in the IHR, followed by *Asplenium* (50), *Dryopteris* (47), *Athyrium* (45), *Pteris* (45), *Polystichum* (36), *Selaginella* (31), and *Diplazium* (30). Thirteen genera in India, viz. *Matteuccia*, *Notholaena*, *Anogramma*, *Coniogramme*, *Gymnopteris*, *Peranema*, *Cystopteris*, *Ceterach*, *Woodwardia*, *Diacalpe*, *Woodsia*, *Onychrium* and *Christensenia* are confined to this region.

Among the fern allies, about two-third of the taxa reported from India occur in the Himalaya, the family Selaginellaceae (with 15 species) being the largest family in the western Himalaya. Genera *Psilotum*, *Actiniopteris* and *Pellaea* (the last two believed to be Mediterranean-African in origin) occur only in the western Himalaya; *Brainea*, *Davallia*, *Gymnogrammitis*, *Histiopteris*, *Cibotium*, *Dipteris*, *Acrorumohra*, *Acrophorus*, *Ctenitis*, *Pleocnemia*, *Pteridrys*, *Gleichenia*, *Scleroglossum*, *Micropolypodium*, *Christensenia*, *Belvisia*, *Pseudodrynaria*, *Lemmaphyllum*, *Neocheiropteris*, *Thylacopteris*, *Tricholepidium*, *Cerosora*, *Doryopteris*, *Pityrogramma*, *Taenitis* and *Antrophyum* are restricted to the central and eastern Himalaya, while *Lomagramma* and *Taenitis* are confined to Arunachal Pradesh in India. Whereas western region is characterized by the presence of maximum species of *Equisetum*, about 70% of polypodiaceous taxa in India are concentrated in the eastern Himalaya, with genera like *Lepisorus*, *Phymatopteris*, *Phymatosorus*, *Polypodium*, *Microsorium* and *Pyrrosia* showing greater diversity. According to Bir (1988), Himalaya is the route for migration of ferns from east to west and vice versa. Dhir and Saikia (1984) considered Kumaon region in Uttarakhand as meeting ground for the pteridophyte elements of the western and eastern Himalaya and that some far western and Mediterranean elements reached up to Kumaon or western Nepal. In general, east to west migration of Himalayan ferns is more than west to east, and this rate is enhanced several times due to recent climate change (Kholia et al. 2013).

The Sino-Himalayan region, especially the Yunnan province of China at the trijunction of India, Myanmar and China, is considered the centre of diversity of Dryopterido-Polystichoid and Polypodioid ferns of the Himalaya (Ching 1978, 1979; Ching and Wu 1980; Kung 1984; Bir 1988; Kholia 2011). More than 2000 species of ferns occur in this region, particularly in China. The climate change effected by the rise of the Himalayan mountain system resulted in the evolution of many new species (Wang et al. 2012). The higher number of hybrids indicates that the Himalayan fern flora is still in the process of evolution and speciation. *Woodsia cycloloba* and *Cystopteris fragilis* have recently been collected from Gurudongmar Lake environs in North Sikkim at 5200 m, which is perhaps the highest altitude for the ferns in the IHR (Kholia personal communication). While tree ferns (represented by eight species in the Himalaya) and *Angiopteris evecta* are among the gigantic pteridophytes in the region in terms of plant size, *Azolla pinnata* and *Trichomanes parvulum* represent the other end of the spectrum in this category.

The endemism in pteridophytes in the IHR is very low as compared to other groups of plants, and only about a dozen species are presently considered as endemic to the region (Fraser-Jenkins 2008). Some of the endemic ferns and fern allies in the

IHR are *Selaginella adunca*, *Athyrium kumaonicum* (western Himalaya), *Thelypteris kingii*, *Selaginella pentagona*, *Arthromeris notholanoides* and *Osmunda cinnamomea* subsp. *asiatica* (central and eastern Himalaya). Out of 414 species belonging to different IUCN threat categories recorded from India (Chandra et al. 2008), nearly 175 species are from the Himalayan region. Some of the critically endangered taxa are *Psilotum nudum*, *Anogramma leptophylla*, *Athyrium duthiei*, *Christella kaumanica*, *C. clarkei*, *Christopteris tricuspis*, *Cyclogramma squamaestipes*, *Metathelypteris decipiens*, *Selaginella adunca*, *Dryopteris gamblei* and *Stenogramma himalai*ca. *Selliguea tricuspis* (Sikkim, Darjeeling), *Cyathea contaminans*, *Pteris barbigera* (Darjeeling) and *Dennstaedtia wilfordii* (Jhelum Valley, Jammu and Kashmir) have not been collected since long and may have become locally extinct in wild. On the other hand, *Thelypteris kingii*, *Lycopodium annotinum* subsp. *alpestre*, *Pellaea calomelanos* and *Ophioglossum pendulum* have recently been recollected after long intervals.

#### 5.3.2.11 Bryophytes: The Mosses, Liverworts and Hornworts

The bryophytes represent a small yet significant component of Himalayan landscape. With over 2760 species reported to be occurring in India, the bryophytes constitute one of the largest groups of green plants in the country next only to the angiosperms. They constitute a little known group of plants in India. While the moss *Aongstroemia julacea* has been found growing at the highest latitudes from where a plant has ever been collected, in polar regions (Alaska, Antarctica), bryophytes, especially mosses, together with lichens, form the major component of vegetation. In India, they are more prolific in the Himalaya, with about 1955 taxa of mosses, liverworts and hornworts having been reported from the region, which accounts for over 70% of the total Indian bryophytes. Though found growing beyond 6000 m altitude in the Himalaya, they exhibit their maximum luxuriance and diversity between 1000 and 3000 m altitudes. At a given altitude in the IHR, their diversity increases from west to east.

Mosses constitute the major component of bryophytes with about 1295 taxa (out of about 1818 taxa belonging to 355 genera in 62 families reported from India) occurring in the IHR. Of these, ca. 884 species are found in the eastern Himalaya and 747 in the western Himalaya (Lal 2005; Sanjappa and Singh 2010; Dandotiya et al. 2011; Singh and Singh 2011; Singh et al. 2012, 2013; Singh and Dash 2014, 2018a). All of them are autotrophic, except *Buxbaumia himalayensis* – a saprophyte described from Deoban (near Chakrata) in Uttarakhand, western Himalaya (Udar et al. 1971). Pottiaceae with 138 species is the dominant moss family in the IHR, followed by Dicranaceae (118) and Bryaceae (98). While Pottiaceae and Bryaceae dominate in the western Himalaya, Dicranaceae exhibits maximum diversity in the eastern Himalaya. Similarly, *Fissidens* with 47 species is the largest genus in the Himalaya, followed by *Brachythecium* (34) and *Bryum* (27). Genera like *Acroporium*, *Aloina*, *Amblyodon*, *Atractocarpus*, *Buxbaumia*, *Cyathophorella*, *Ganguleea*, *Leptobryum*, etc. are known in Indian moss flora from the Himalaya only. While 32 genera, like *Campyliadelphus*, *Conostomium*, *Cyathothecium*, *Encalypta*, etc., are known from western Himalaya only, 63 genera, viz. *Clastobryopsis*, *Daltonia*, *Dendrocyathophorum*, *Gammiella*, *Garovaglia*, etc., are restricted in India to eastern Himalaya. Eleven genera of Indian mosses, viz. *Cyathothecium*, *Macrothamniella*, *Mitrobryum*, *Octogonella*, *Orontobryum*, *Ortholimnobium*, *Orthotheciadelphus*, *Osterwaldiella*, *Pylaisiopsis*, *Retidens* and *Stenotheciopsis*, are endemic to the IHR. Similarly, 175 species of Himalayan mosses are endemic to the country, 23 of which are restricted to the western Himalaya (*Habrodon kashmiriensis*, *Homalothecium integerrimum*, *Hygroamblystegium gangulianum*, etc.), 134 to the eastern Himalaya (*Heterophyllum renitens*, *Homalothecium incompletum*, *H. neckeroides*, *Hygrohypnum choprae*, *Raphidorrhynchium confertissimum*, *Trolliella euendostoma*, etc.), while 5 species are common to both the territories.

While 18 species of the Himalayan mosses, like *Ditrichum darjeelingense*, *Pteridium tenue*, *Pylaisiella extensa*, *Hymenostylium shepheardae*, *Microdus assamicus*, *Mitrobryum koelzii*, etc., could never be collected again since their type collections, a large number of taxa are considered threatened due to various anthropogenic factors (Vohra and Aziz 1997). *Mitrobryum koelzii* (from Tehri) and *Takakia ceratophylla* (from Sikkim) are among the globally threatened bryophytes (Tan et al. 2000).

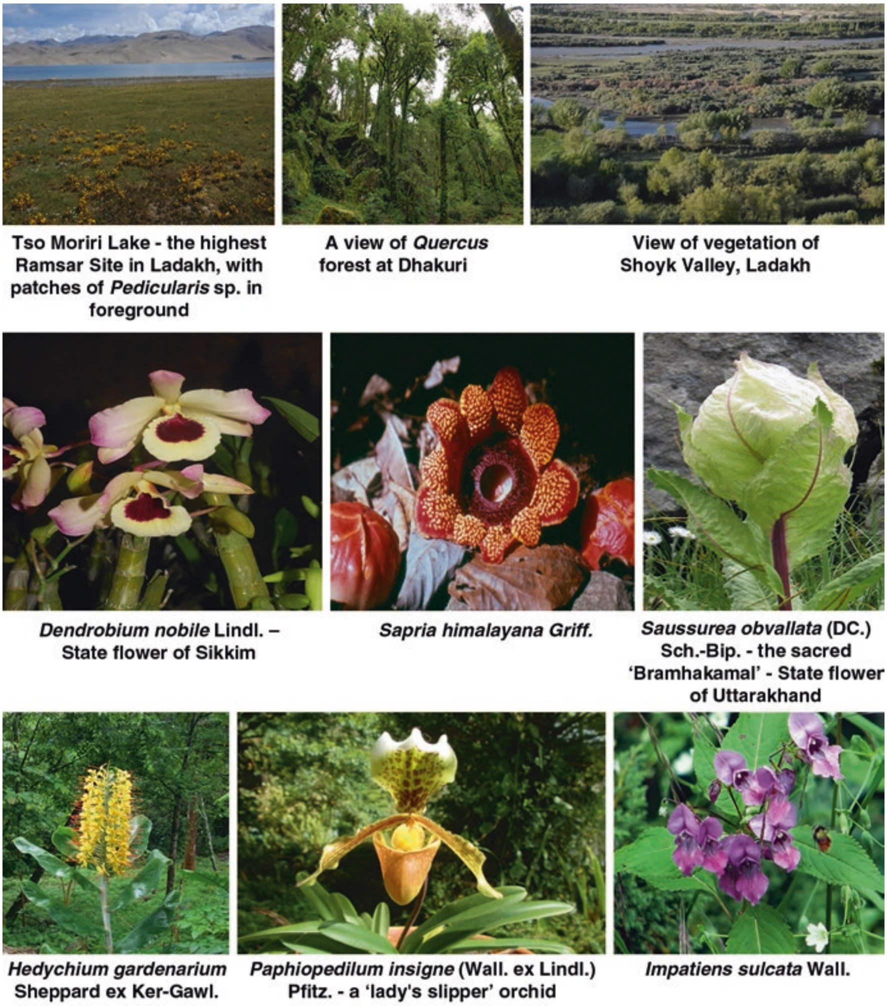
The liverworts are represented in the IHR by ca. 674 species, spreading across 114 genera in 52 families, which account for over 74% of the total Indian liverwort flora (Singh 1997, 2001; Sanjappa and Singh 2008, 2009, 2010; Singh and Singh 2011; Singh et al. 2012, 2013; Singh and Dash 2014, 2018a; Singh et al. 2016; Singh 2018). Sikkim Himalaya, covering the State of Sikkim and Darjeeling district of West Bengal, has the maximum diversity of liverworts with ca. 378 taxa. This is followed by about 158 taxa from Himachal Pradesh, 260 from Uttarakhand, 220 from Arunachal Pradesh and 84 from Jammu and Kashmir (Sharma and Srivastava 1993; Dar et al. 2002; Srivastava and Srivastava 2002; Asthana and Srivastava 2003; Srivastava and Singh 2005; Ghosh 2006; Rawat and Srivastava 2007; Singh and Singh 2008, 2009; Singh et al. 2008; Dey and Singh 2012; Singh and Singh 2013; Singh et al. 2016; Singh 2018). These figures, however, will be revised once bryofloristic explorations in Jammu and Kashmir and Himachal Pradesh are complete and the collections are identified and documented. Families like Antheliaceae, Blasiaceae, Delavayellaceae, Gymnomitriaceae, Haplomitriaccae, Pleuroziaceae, Pseudolepicoleaceae, Ptilidiaceae, etc. and genera *Acrobolbus*, *Apometzgeria*, *Aitchisoniella*, *Anastrepta*, *Andrewsianthus*, *Anthelia*, *Diplocolea*, *Horikawaella*, *Apotreubia*, *Blasia*, *Blepharostoma*, *Cryptomitrium*, *Geocalyx*, *Haplomitrium*, *Isopachis*, *Liochlaena*, *Mastigophora*, *Saccogynidium*, *Plagiochilion*, *Pleurozia*, *Prasanthus*, *Preissia*, *Pseudolepicolea*, *Ptilidium*, *Sauteria*, *Stephensoniella*, *Temnoma*, *Tritomaria*, *Tuyamaella*, *Wiesnerella*, etc. are confined to the Himalayan region alone in the Indian bryoflora.

Lejeuneaceae, with 19 genera and 126 species, subspecies and varieties, is the most dominant liverwort family in the IHR, followed by Plagiochilaceae (3/55), Solenostomaceae (4/51), Frullaniaceae (1/40), Scapaniaceae (8/35), Porellaceae (1/26), Lophocoleaceae (4/26) and Lepidoziaceae (4/23). Similarly, *Plagiochila* with 51 species is the dominant genus in the region, followed by *Solenostoma* (43), *Frullania* (40), *Cololejeunea* (33), *Lejeunea* (30), *Porella* (26), *Riccia* and *Radula* (24 each), *Scapania* (23) and *Metzgeria* (16). On the other end of the spectrum, 8 families and 48 genera in the IHR are represented by just a single species each. The genus *Sewardiella* and 43 species (*Cyathodium indicum*, *Riccia indica*, *Porella borellii*, *Jubula himalayensis*, *Lophozia piacenzai*, *Plagiochila nana* var. *robusta*, *Chiloscyphus campanulatus*, *Sewardiella tuberifera*, etc.) are endemic to the western Himalaya and genus *Udaria* and 61 species (*Trichocolea indica*, *Scapania schljakovii*, *Frullania dilatata* subsp. *asiatica*, *F. hattoriantha*, *Cephalozia pandei*, *Nardia flagelliformis*, *Solenostoma suborbiculatum*, *Udaria lamellicaulis*, etc.) to the eastern Himalaya, while five species are common to both the sectors.

A number of Himalayan liverworts, viz. *Aitchisoniella himalayensis*, *Cyathodium acrotrichum*, *C. indicum*, *C. tuberculatum*, *Diplocolea sikkimensis*, *Haplomitrium blumii*, *H. hookeri*, *Horikawailla subacuta*, *Kurzia pauciflora*, *Lejeunea bidentula*, *Porella berellii*, *P. variabilis*, *Riccardia villosa*, *Sauteria alpina*, *S. spongiosa*, *Sewardiella tuberifera*, *Southbya gollanii*, *Stephensoniella brevipedunculata*, etc., are either rare or threatened due to loss of habitat. Some of them, like *Kurzia pauciflora*, *Porella berellii*, *P. variabilis*, etc., are so far known only through their type collections and could never be collected again (Udar and Srivastava 1983; Pant 1983; Pant et al. 1992, 1994; Singh 1997, 1999, 2008; Singh and Singh 2009; Asthana and Saxena 2011; Srivastava and Rawat 2011).

The hornworts are the least diverse group of bryophytes in the IHR, being represented here by 26 species belonging to 6 genera in 3 families. This accounts for about 67% of the Indian hornwort flora (Asthana and Srivastava 1991; Singh 1993, 2002; Singh et al. 2016; Singh 2018). Again, the Sikkim Himalaya with 18 species shows the maximum diversity of hornworts in the region, followed by Uttarakhand (14), Himachal Pradesh (10), Arunachal Pradesh (08) and Jammu and Kashmir (02). Anthocerotaceae with 13 species is the dominant family in the region, followed by Notothyladaceae with 10 species. While family Dendrocerotaceae is represented by just *Megaceros tjibodensis* throughout the Indian Himalaya, the monotypic genus *Hattorioceros* (*stratisporus*) is confined to the western Himalaya (Himachal Pradesh) in India. Twelve species of the Himalayan hornworts are endemic, of which *Folioceros indicus*, *Notothylas himalayensis*, *N. kashyapii*, *N. udarii* and *Phaeoceros udarii* occur in western Himalaya, *Folioceros kashyapii*, *F. paliformis*, *F. physocladus* and *Notothylas khasiana* in the eastern Himalaya, while *Anthoceros alpinus*, *A. bharadwajii* and *Phaeoceros kashyapii* are present in both the sectors of IHR. Among the Himalayan hornworts, *Anthoceros alpinus*, *Folioceros indicus*, *F. physocladus* and *Phaeoceros kashyapii* are considered rare.

In addition, the IHR harbours about 1197 taxa of lichens, 7080 taxa of fungi and 1355 taxa of algae (Plates 5.1, 5.2, and 5.3).



Tso Moriri Lake - the highest Ramsar Site in Ladakh, with patches of *Pedicularis* sp. in foreground

A view of *Quercus* forest at Dhakuri

View of vegetation of Shoyk Valley, Ladakh

*Dendrobium nobile* Lindl. – State flower of Sikkim

*Sapria himalayana Griff.*

*Saussurea obvallata* (DC.) Sch.-Bip. - the sacred 'Bramhakamal' - State flower of Uttarakhand

*Hedychium gardenarium* Sheppard ex Ker-Gawl.

*Paphiopedilum insigne* (Wall. ex Lindl.) Pfitz. - a 'lady's slipper' orchid

*Impatiens sulcata* Wall.

**Plate 5.1** Glimpses of floristic diversity of Indian Himalayan region

## 5.4 Conservation: Issues and Initiatives

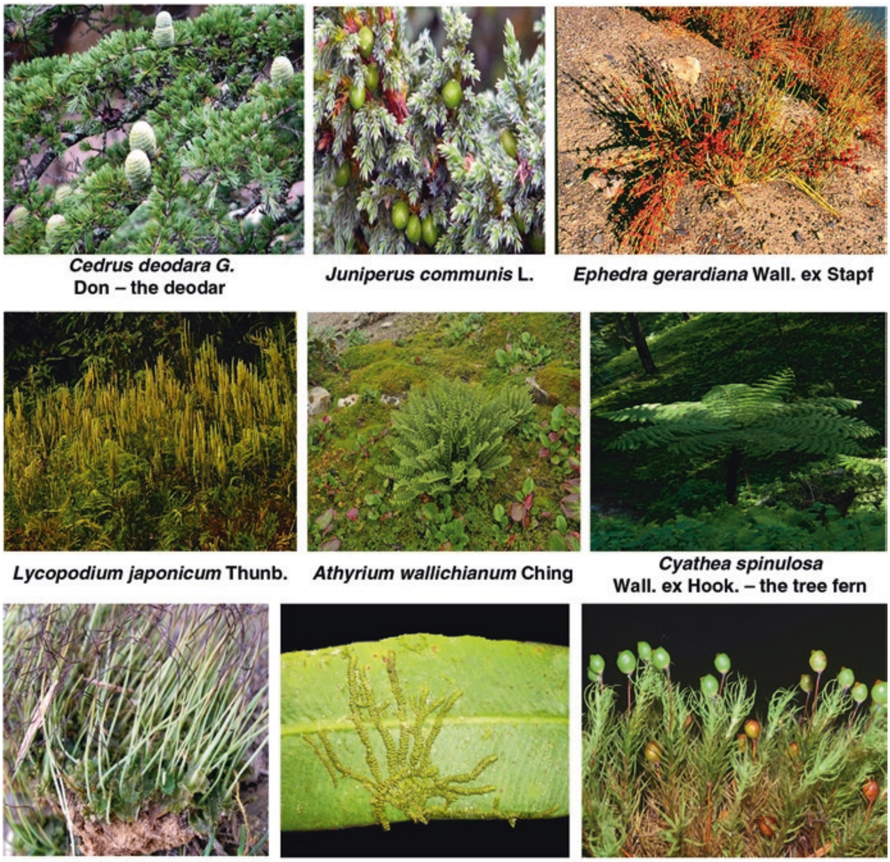
The rich plant diversity of the IHR is under great stress of alteration and depletion due to various threats, such as deforestation, livestock pressure, invasive species, tourism, exotic plantation, medicinal plants and NTFP extraction, climate change, developmental activities, etc. Livestock pressure beyond carrying capacity impacts the natural ecosystems severely. Invasive alien species not only cause changes in vegetation composition and dominance but also have long-term effect by destroying the fabric of endemic flora (Chandra Sekar 2012). Climate change has significantly affected Himalayan ecosystems and biodiversity, more adversely so the fragile


**Plate 5.2** Glimpses of flowering plant diversity of Indian Himalayan region

ecosystems. Increased rate of glacial retreat in the last decade as a consequence of climate change and increasing temperatures at high altitudes has affected arctic-alpine flora in general and periglacial flora in particular due to loss of habitats.

Considering the overextraction of large number of Himalayan medicinal plants, the prevention of extinction of known threatened plants which are on decline, as stated in NBAP Target 12, will be an uphill task. This will be far more difficult in species where extracted medicinal part (roots, rhizome, corms, bulbs, tubers) is an organ of perennation (e.g. *Aconitum heterophyllum*, *Dactylorhiza hatagirea*, *Picrorhiza kurroa*, *P. scrophulariaeflora*, *Paris polyphylla*, *Swertia chirayita*, *Nardostachys jatamansi*, etc.). Medicinal and aromatic plant assessment and conservation has been getting considerable attention in recent years, all the Himalayan states having initiated this programme. Though a number of medicinal and aromatic plant-rich areas are marked and declared as Medicinal and Aromatic Plants Conservation Areas (MAPCAs), further expansion of MAPCA network to include nearly all the Himalayan elements is necessary.

Nearly 1000 Himalayan plant species are estimated to be rare, while another 1000 species (including vulnerable point endemics) fall in various threat categories. Still worse is the case of monotypic point endemics known only by their types and not recollected for over a century now, e.g. *Brachycaulos* sp. collected from Gaoring, Sikkim, in 1910. Possible extinction is also feared for many other species known by type collections only, hence vulnerable. A single catastrophic stroke, natural or anthropogenic, would cause extinction of these taxa. Thus, in addition to intensive floristic exploration in unexplored areas, species-oriented surveys should focus on locating the species that could not be collected since a long time. Rediscovery of



*Cedrus deodara* G. Don – the deodar; *Juniperus communis* L.; *Ephedra gerardiana* Wall. ex Stapf; *Lycopodium japonicum* Thunb.; *Athyrium wallichianum* Ching; *Cyathea spinulosa* Wall. ex Hook. – the tree fern; *Phaeoceros laevis* (L.) Prosk.; *Cheilolejeunea trapezia* (Nees) Mizut. – growing on fern; *Bartramia ithyphylla* Brid.

**Plate 5.3** Glimpses of non-flowering plant diversity of Indian Himalayan region

many plant species after more than a century since their last collections from the wild fully underlines the need for such exploratory surveys.

The Protected Area Network (PAN) in the IHR, comprising 20 national parks, 71 wildlife sanctuaries and 41 conservation reserves, covering a total area of about 48,377,254 km$^2$ (ca. 8%) of the total Himalayan landscape across different ecoclimatic zones of the region (http://www.wii.gov.in/nwdc_national_parks accessed on 20.01.2019), is provided for in situ conservation, both to representative ecosystems and the flora and also to a number of threatened taxa. The IHR has also over 5000 sacred groves, including lakes, hills, forests and meadows, which represent true natural repositories. In addition to the protected areas, this traditional way of ecosystem protection has been proved to be most important means of in situ conservation. Completing the inventory of the flora of all protected areas in the IHR, including sacred groves and reserve forests, has been a priority objective of the Botanical

Survey of India (BSI). Recent inventories (Chandra Sekar and Srivastava 2009; Singh and Singh 2009; Pusalkar and Singh 2012) of such areas are more inclusive. In Uttarakhand alone, about 75% of angiosperms, 100% of gymnosperms and 66% of pteridophytes are conserved within protected areas of the state, comprising six national parks, seven wildlife sanctuaries and four conservation reserves, besides the Nanda Devi Biosphere Reserve. Interestingly, 48% of liverworts and hornworts of the IHR are occurring in protected areas and reserve forests in the region (Singh et al. 2016). The BSI is actively engaged in ex situ conservation of endemic and threatened plant species through its Acharya Jagadish Chandra Bose Indian Botanic Garden at Howrah, Botanic Garden of the Indian Republic at NOIDA and five associated botanic gardens established in the Himalayan region. It also facilitates ex situ conservation of such species undertaken by other academic and research institutions in the region under the 'Assistance to Botanic Garden' scheme of the Ministry of Environment, Forests and Climate Change, Govt. of India.

The BSI has provided baseline data on nearly 1000 threatened plant species of India, which include 209 taxa from the Himalaya (Jain and Sastry 1983). Based on these studies and those carried out by the scientists in other institutions, the Survey has compiled Red Data sheets on 137 such plant species from this region, of which 71 are confined to the eastern Himalaya, 56 to the western Himalaya, while 10 species are common to both the sectors (Jain and Sastry 1984; Nayar and Sastry 1987–1990; Rao et al. 2003). Proper inventorying and assessment of species belonging to different Red Data categories as per latest IUCN criteria is a prerequisite for evolving any effective conservation strategy.

The IHR is currently under strong threshold of development, as a result of which its fragile ecosystems face threat to their existence due to various factors – largely man-made. As the threats to the Himalayan ecosystems are now almost understood, what is needed is sincere, result-oriented and integrated approach by governmental and non-governmental agencies, as well as scientific bodies.

## 5.5 Concluding Remarks

In spite of numerous floristic explorations throughout the IHR for nearly three centuries, 10–20% of the non-accessible terrain and international border areas still remains unexplored. Bulk of epiphytic flora of the eastern Himalaya, ranging from orchids to rhododendrons, liverworts, mosses and fungi, growing on giant trees is out of reach and yet to be explored thoroughly. Despite the Indian Himalaya's being bestowed with a large number of natural wetlands in tropical, subtropical, temperate and alpine zones, our knowledge about the wetland flora of this region is quite meager. The floristic composition of majority of over 5000 sacred groves in the IHR is yet to be fully understood and documented. Similarly, the periglacial and high-montane zones remain thoroughly under-explored. As a result, our knowledge about the flora of IHR is still incomplete. Therefore, the present statistics about diversity of various components of flora is expected to change considerably once the explorations in all its areas are complete and the plant species are fully documented. The addition of couple of thousand species of flowering plant species since the publication of Sir J. D. Hooker's *Flora of British India* (Hooker 1872–1897) till today and the regular discovery of novelties and new records, including three new families [Brachycaulaceae (*Brachycaulos simplicifolia*) from Sikkim, Clethraceae (*Clethra monostachya*) and Akaniaceae (*Bretschneidera sinensis*) from Arunachal Pradesh)], many new genera [e.g. *Kailashia* (Apiaceae), *Crucihimalaya*, *Ladakiella*, *Scapiarabis* (Brassicaceae), *Devendraea* (Caprifoliaceae), *Himgiria*, *Shivparvatia*, *Schizotechium* (Caryophyllaceae), *Pseudoyoungia* (Asteraceae), *Stapletonia* (Poaceae), *Asteropyrum*, *Beesia* (Ranunculaceae), etc.] and a large number of new species from the Himalaya bear ample testimony to this fact (Sanjappa and Singh 2008, 2009, 2010; Singh and Singh 2011; Singh et al. 2012, 2013; Singh and Dash 2014, 2018a).

**Acknowledgements** The authors thank the Director, Botanical Survey of India, for the encouragement and facilities and to Dr. B.S. Kholia, Scientist D, Northern Regional Centre, BSI, Dehradun, for valuable inputs with regard to the Himalayan pteridophytes.

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# Part III
# Biodiversity of Jammu and Kashmir State: General Account

# Chapter 6
# Jammu and Kashmir State: An Overview

**Shakil Ahmad Romshoo, Irfan Rashid, Sadaff Altaf, and Ghulam Hassan Dar**

**Abstract** The state of Jammu and Kashmir (J&K), lying between latitude 32.28–37.06° and longitude 72.53–80.32°, is located in the northwestern part of the Himalayan mountain arc in India, at an altitudinal range of 220 to 8611 m (amsl). The state shares border with the neighboring Indian states of Himachal Pradesh and Punjab on the south and has international border and Line of Control (LOC) with Pakistan and China in the west and east, respectively. It comprises mountain ranges starting from the Siwaliks in the south, followed by the Pir Panjal, the Greater Himalaya, the Zanaskar range, and finally the Karakoram in the north. Climatologically, the state is divided into subtropical Jammu in the south, temperate zone of Kashmir in the middle, and cold desert of Ladakh in the east. Administratively, the state comprises 22 districts, 10 each in Jammu and Kashmir provinces and 2 in Ladakh. Out of the total state's land area of 101,386 km$^2$, Kashmir occupies 15.73%, Jammu 25.93%, and Ladakh 58.33%. Geologically, the state reveals rocks of all ages, from the Archean to the recent alluvium, and preserves a chronological record of the sedimentation, tectonics, and volcanism that accompanied the Himalayan orogeny. The areas above the altitude of 3600 m in the state are mostly covered with snow and glaciers, the largest being the Siachen glacier in Ladakh. The snow- and ice-melt waters emanating from the region sustain three major rivers – Indus, Jhelum, and Chenab – providing water, food and energy security to ~300 million people living up- and downstream in the Indus basin. The state is known for its freshwater lakes and wetlands, having more than 3650 wetlands and waterbodies. Having a population of 12.55 million in 2011 with average density of ~100/km$^2$, J&K is a quilt of different people and regions with a rich cultural diversity. With a GDP of USD 21 billion in 2016–2017, economy of the state is mainly dependent on agriculture, horticulture, handicrafts, tourism, and hydropower generation. Possessing highly varied topography, altitude, and climate, J&K supports a very

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_6

rich biodiversity; indeed, it belongs to the global biodiversity hotspot – the Himalaya – and represents three biogeographic zones: Trans-Himalayan zone of Ladakh, northwest Himalaya, and semiarid plains of Jammu. Owing to its unique geological, geomorphic, and climatic settings, the sate is vulnerable to all types of disasters, particularly earthquakes, floods, landslides, and avalanches.

**Keywords** Jammu · Kashmir · Ladakh · Himalaya · Tectonics · Biodiversity · Glaciers

## 6.1 Physiographic Description of Jammu and Kashmir State (J&K)

### *6.1.1 Location, Demography, and Area of J&K*

The picturesque state of Jammu and Kashmir (J&K) is located in the northwestern part of the Himalayan mountain arc in India, between the latitude 32.28–37.06° and longitude 72.53–80.32°, at an altitudinal range of 220 to 8611 m amsl (Fig. 6.1).

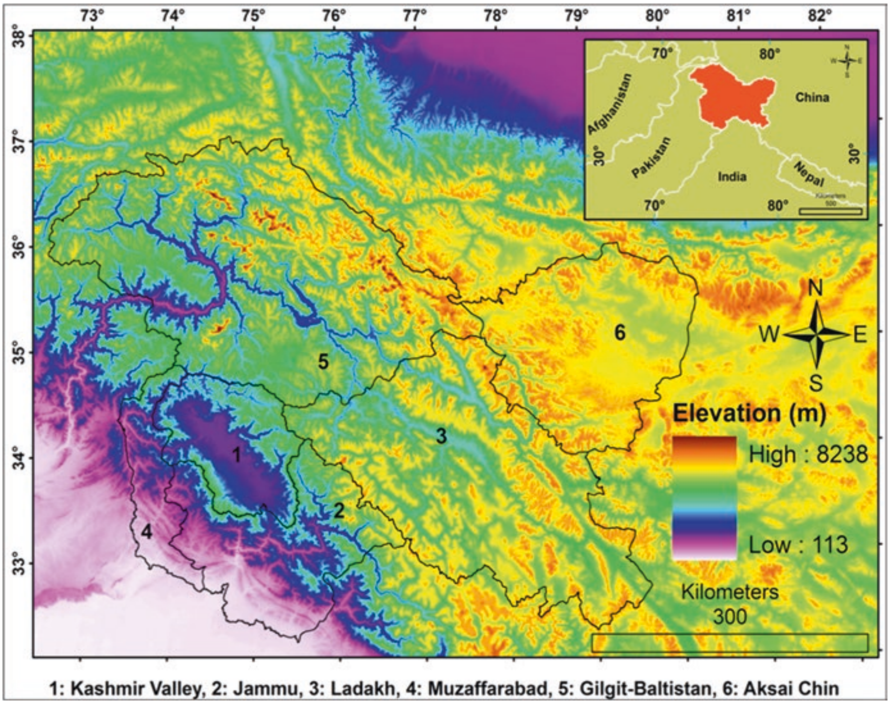


**Fig. 6.1** Location of the study area (Jammu and Kashmir State)

Out of the total geographical area of 222,236 km$^2$ of the erstwhile Pre-1947 J&K state, only ~101,386 km$^2$ is with India, while ~78,114 km$^2$ is with Pakistan, and 42,736 km$^2$ is with China. The state comprises three administrative divisions: Jammu, Kashmir, and Ladakh, having a unique administrative setup with two capital cities – Srinagar (summer) and Jammu (winter). There is the Kashmir Valley, fount of florid Mughal and Sufi poetry; the barren, arid, vast, and sparsely populated Ladakh region in the east; and the low-lying hilly areas in the south forming the Jammu region. Ladakh is the largest of the three provinces, occupying 58.33% of the states' geographical area, followed by Jammu with 25.93%, and Kashmir with 15.73% of the total area. In all, there are 22 districts – 10 each in Jammu and 10 Kashmir divisions and 2 in Ladakh (Fig. 6.2). J&K is the fifth largest state by area and the nineteenth most populous state of India.

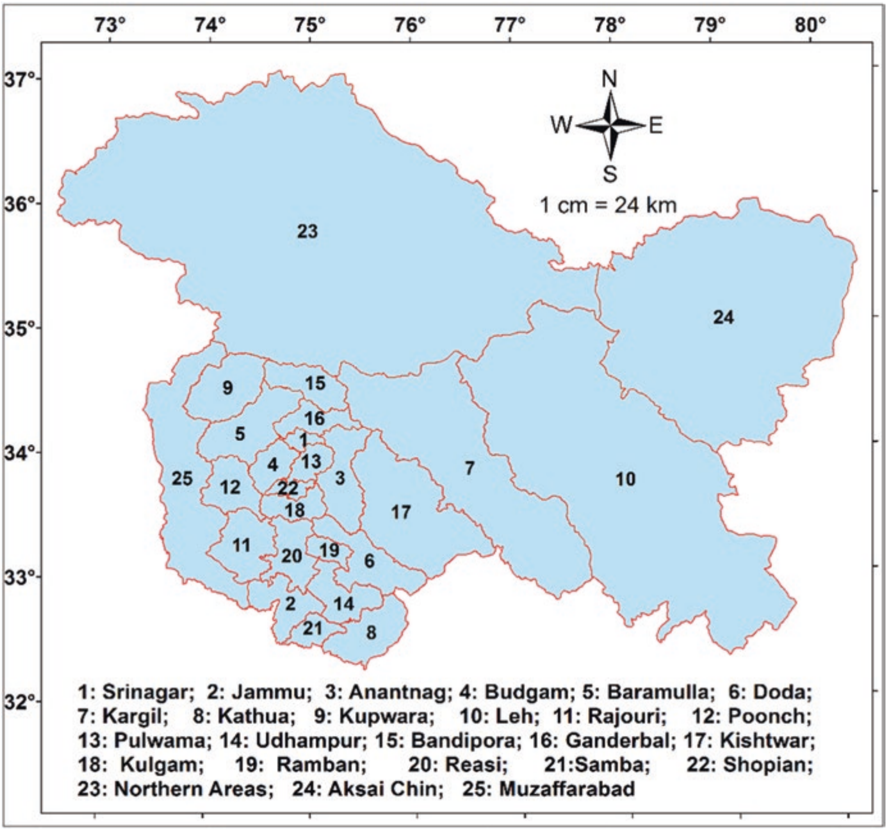


**Fig. 6.2** Districts of the J&K state

### 6.1.2 J&K: The Land of Mountain Ranges

Situated in the northwestern extremity of the Indian Himalayan Region (IHR), J&K is often called as the *land of mountain ranges*: starting from the Siwaliks in the south, followed by the Pir Panjal, the Greater Himalaya, the Zanaskar range, and finally the Karakorum in the north. An analysis of Global TOPOGraphy (GTOPO) elevation dataset with a spatial resolution of 0.862 km (Fig. 6.1, Table 6.1) reveals that 75% of the area of J&K falls above the alpine zone (altitude range 3300–8238 m amsl), while 25% area falls under the subalpine zone (up to 3300 m amsl).

Natural vegetation in the form of forests, scrublands, and meadows is found below the altitude of 3800 m amsl. The terrain is very undulating, being traversed by mountains, hills, and plains. Approximately 29.5% of the area has relatively flat slope (0–5°), 42% has moderate slope (6–$15^0$), while 28.5% of the area has very steep slope (16–54°) (Fig. 6.3, Table 6.2).

The mountain ranges of J&K (Fig. 6.4) have a special geographical importance in determining the climate regimes, vegetation types, and snow and glacier resources in the State. Some of the famous mountain ranges in J&K are as follows:

*Karakoram (Karakorum)* and *Kunlun (Kyunlun) Ranges:* These two mountain ranges lie to the north and northeast of J&K, separating the state from the Chinese Turkistan and the Chinese Tibet.

*Hindu Kush Range:* This range continues in the northwest toward the Karakoram range, where K2 peak, the second highest peak (8611 m) in the world, is situated. Two lofty peaks of Gasherbrum (8570 m) and Masherbrum (7827 m) also lie in this range. Notable passes in this range include Karakoram Pass (5353 m), Nubra Pass (5800 m), Khardung La Pass (5557 m), and Chang La Pass (5609 m). In the past, people of Ladakh used to cross over the Karakoram and Nubra passes to reach the Chinese Turkistan and Khattan, a route famously known as the *Silk Route*.

*Zanskar Range:* It is about 6000 m amsl and separates the Indus Valley from the Kashmir Valley. This mountain range prevents southwest cold winds from reaching Kashmir. Famous passes in the range include Zoji La (3528 m) and Poat (5716 m). Ladakh region terminates at the Zoji La from where the Kashmir Valley begins.

*Ladakh Range*: To the north of Leh lies the Ladakh range, an important part of the trans-Himalayan range that merges with the Kailash range in Tibet. The important passes of the range are the famous Khardung La (5359 m) and Digar La, which lie to the northeast of Leh.

**Table 6.1** Area under different elevation ranges in J&K State

| S. no. | Elevation (m) | Category | Area ($km^2$) |
|---|---|---|---|
| 1 | 0–1400 | Plain | 153201.69 |
| 2 | 1400–3000 | Low elevation | 5952.03 |
| 3 | 3000–4000 | Moderate elevation | 5252.07 |
| 4 | 4000–5000 | High elevation | 9327.11 |
| 5 | 5000–8238 | Very high elevation | 9303.28 |

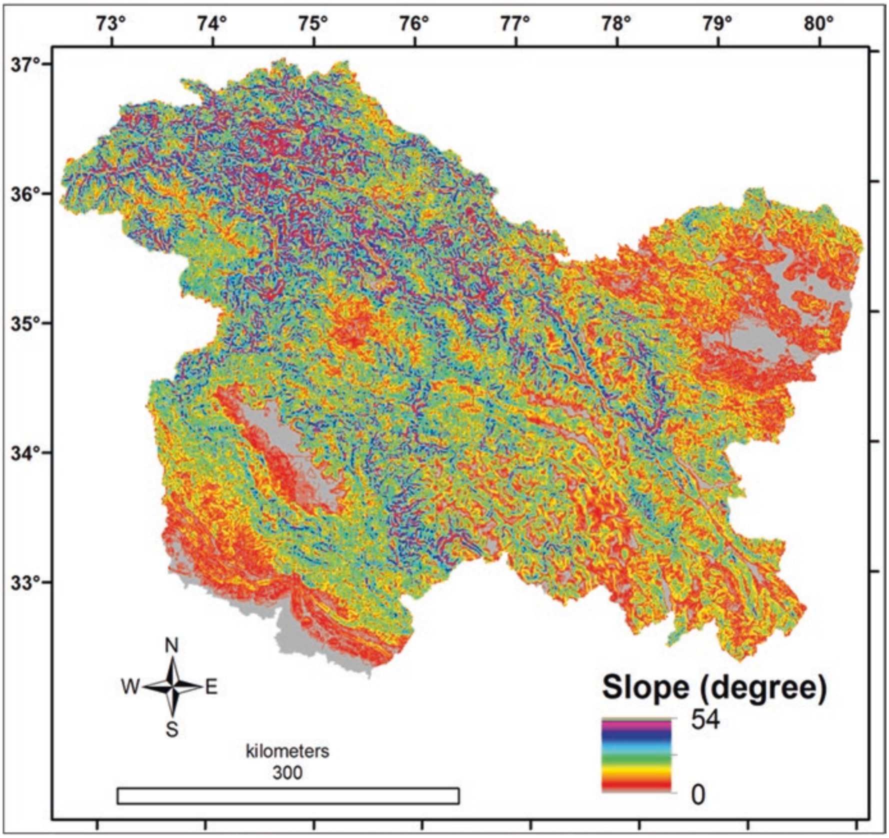


**Fig. 6.3** Slope variation in the J&K state

**Table 6.2** Area under different slope ranges in J&K

| S. no. | Slope° | Category | Area (km$^2$) |
|---|---|---|---|
| 1 | 0–5° | Very gentle slope | 153201.69 |
| 2 | 5–10° | Moderate slope | 5952.03 |
| 3 | 10–15° | Strong slope | 5252.07 |
| 4 | 15–25° | Very strong slope | 9327.11 |
| 5 | 25–35° | Extreme slope | 9303.28 |
| 6 | 35–55° | Very steep slope | 39603.65 |

*Pir Panjal Range:* This mountain range separates Kashmir Valley from the outer Himalaya. In the southeast part of Kashmir Valley lies the Banihal Pass (2832 m). The Pir Panjal remains covered with snow during winter, making it impassable to cross over. On the other end of this range lies the Baramulla Pass (1582 m) and the Hajipir Pass (2750 m), the latter connects Poonch with Uri.

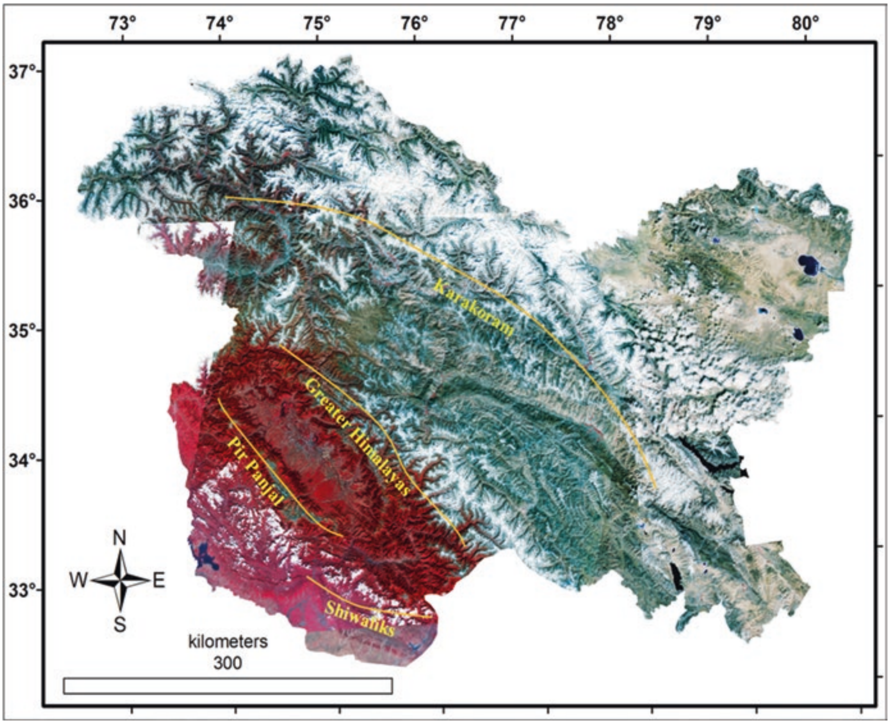


**Fig. 6.4** The major mountain ranges of the J&K state

*Shiwalik Range:* The Siwaliks represent the foothills of the Himalaya and extend from the north of the outer plains to the middle mountains of the state, reaching heights varying from 600 m to 1500 m amsl. The Siwaliks is geologically the youngest mountain range in the Himalaya.

### *6.1.3 Geological Setup of J&K*

Geology of the state preserves a chronological record of the sedimentation, tectonics, and volcanism that accompanied the Himalayan orogeny (Singh 1971). Rock specimens belonging to all ages, beginning from Archean complexes which formed the floor of the Himalayan geo-syncline right up to the recent alluvium, are found in the state. The region also exhibits remnants of glacial deposits at lower altitudes as a testimony of climate changes that have occurred throughout the course of its geological history. Evidences of structural deformations like folds, faults, thrusts, and huge igneous intrusions are also found. Major geological formations and their geographical expanses are shown in Fig. 6.5 and Table 6.3.

The inner tertiary belt of the sub-Himalayan zone is formed of both the Subathu formation and the Murree group, ranging in age from Paleocene to early Miocene.

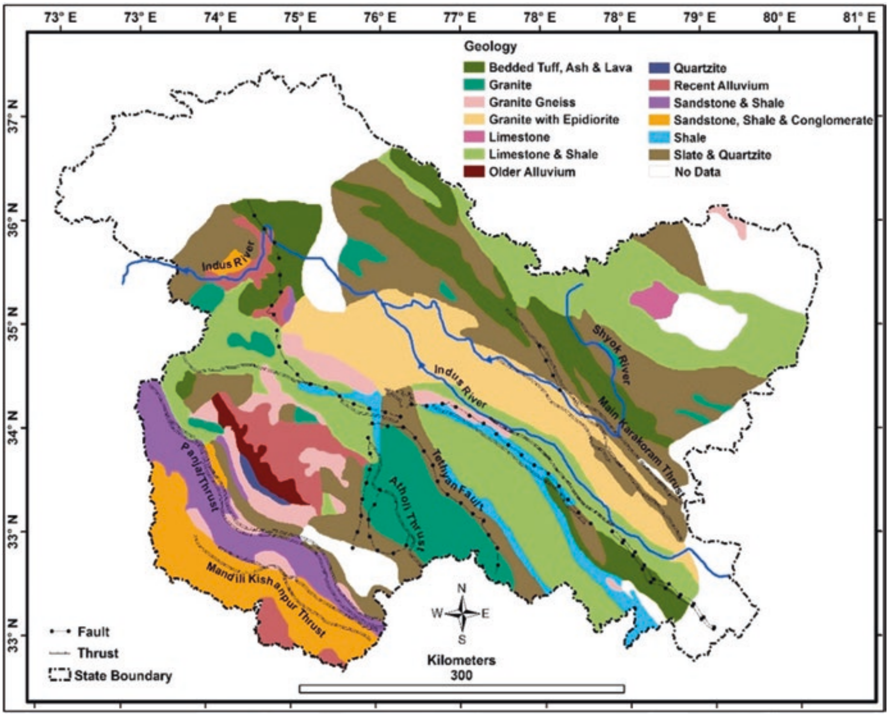


**Fig. 6.5** Geological map of the J&K state

**Table 6.3** Areas under different geological formations in the state of J&K

| S. no. | Category | Area (km$^2$) |
|---|---|---|
| 1. | Bedded tuff, ash, and lava | 17024.17 |
| 2. | Granite | 11596.41 |
| 3. | Granite gneiss | 7981.83 |
| 4. | Granite with epidiorite | 19743.30 |
| 5. | Limestone | 936.53 |
| 6. | Limestone and shale | 40345.86 |
| 7. | Older alluvium | 1533.78 |
| 8. | Quartzite | 471.17 |
| 9. | Recent alluvium | 7337.54 |
| 10. | Sandstone and shale | 8295.06 |
| 11. | Sandstone, shale, and conglomerate | 11265.97 |
| 12. | Shale | 4827.19 |
| 13. | Slate and quartzite | 40004.17 |
| 14. | No data | 49564.65 |

These lower tertiary rocks are exposed along the northwestern Himalaya. In Jammu region, the Subathu formation, comprising of shale and limestone, crops out occasionally in isolated places, whereas the Murree group of rocks extend laterally for several kilometers. Singh and Andotra (2000) carried out detailed facies analysis and concluded the presence of barrier-lagoon and tidal environmental setting for the whole Subathu formation. The Murree group contains mudstone, siltstone, and sandstone. Some have suggested a southerly source (Indian Craton) for the Murree rocks and recognized as brackish-water deposits (Wadia 1928; Gansser 1964). Khan et al. (1971) reported marine as well as nonmarine fauna from the Murree group. However, Ranga-Rao (1971) and Mehta and Jolly (1989) concluded that nonmarine/freshwater condition started with the deposition of the Murree sediments. Singh (1996, 2000) concluded a northerly source for the Murree sediments based on the sandstone mineralogy, nature of rock fragments, and pattern of paleocurrents.

The mid-Cretaceous to early Paleocene Ladakh granitoids represent a composite Andean-type calc-alkaline magmatic belt. The batholith bounds the eastern Karakoram to the southwest and is part of the Gangdese plutonic belt that extends from Afghanistan to Lhasa. Compositionally, it varies between olivine-norite and granite (Weinberg and Dunlap 2000). The Ladakh volcanics are extrusive equivalents of the Ladakh batholith and include the Khardung formation, the Khardung andesites and the Shyok formation. The Khardung formation is a broad sequence of steeply dipping felsic pyroclastic flows that are parallel to the Ladakh batholith in the Nubra–Pangong region. The upper segments of the formation are reported to contain bedded chert, limestone, and lapilli-bearing tuff (Thakur and Misra 1984). Near Khalsar, at the Shyok–Nubra confluence, the Khardung formation is intruded to the northeast along the Khalsar thrust and to the southwest by the Khardung andesites. The andesitic unit represents a 2-km-wide sill that forms part of the larger suite of intrusive dykes and sills evident within the Ladakh batholith. Finally, the Shyok formation is a basaltic sequence that intrudes the Ladakh granitoids near Diskit. The basalts display a deformation fabric associated with shear within the Khalsar thrust zone (Phillips 2008).

### *6.1.4 Tectono-Geomorphic Setting of J&K*

The Tertiary Period witnessed the formation of several Himalayan intermontane basins due to the compressional and extensional tectonic activity (Burbank and Johnson 1983; Ori and Friend 1984; Ricci-Lucchi 1986; Agarwal and Agrawal 2005). During the extensional phases of tectonic activity, “horst-graben” structures are formed (Balestrieri et al. 2003). Kashmir Valley, bounded by the Great Himalayan Range to the northeast and the Pir Panjal Range to the southwest, preserves a record of the tectonic activity and the consequent landscape evolution in the form of various sedimentary and tectonic features. The Quaternary Karewa deposits constitute the overall basinal fill of the Kashmir Valley (Bhatt 1975, 1976; Singh 1982; Burbank and Johnson 1983). The tectono-geomorphic studies carried out in the

Kashmir Valley reveal that the Pir Panjal upliftment around ~4 Ma impounded the primeval drainage, giving rise to a vast lake in which the sediments of Karewa group were deposited as intermontane valley fill deposits (Burbank and Johnson 1983; Dar et al. 2014). This lake, geologically known as Lake Karewa, occupied the whole Kashmir Valley and received sediments from the uplifted mountain range (Fig. 6.6a). The sedimentation in the Lake Karewa started around Pliocene time in the first phase as Hirpur formation (Lower Karewa), followed by the second phase of sedimentation designated as the Nagum formation belonging to Upper Karewa (Singh 1982). The Lower Karewa sediments are gently inclined and better developed on the Pir Panjal range flank, having an unconformable contact with the overlying nearly horizontal Upper Karewa sediments. The thick fanglomerate beds of the Shopian member shed from the faulted basin margins at about 1.7, 2.1, 2.7, and 3.0–3.5 Ma ago are well developed on the southwest and southeast side of the Karewa Basin

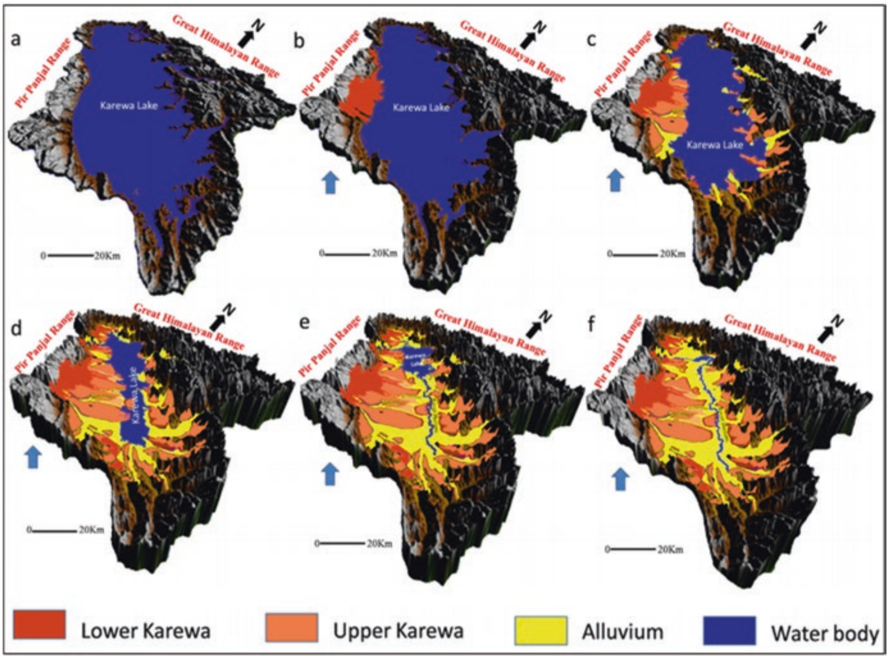


**Fig. 6.6** Geomorphic evolution of Karewa Basin of Kashmir Valley. (**a**) Extent of the Karewa Lake at ~4.0 Ma. (**b**) Upliftment of the Pir Panjal Range (blue arrow) and changing climatic conditions resulted in the shifting of the Karewa Lake towards the axial part of the Kashmir Valley. (**c**) Shrinkage of the Karewa Lake, emergence of the Upper Karewa sediments, and the deposition of the loessic sediments of the Dilpur Formation at ~2 Ma. (**d**) Additional shift of the Karewa Lake and the emergence of more Karewa landscape for the deposition of loessic sediments. (**e**) Exposure of Karewa Group of sediments and draining out of the Karewa Lake through Baramulla gorge as Jhelum River ~85 ka. The remnants of the Karewa Lake towards the north-eastern side of the Karewa Basin are also visible. (**f**) Present landscape scenario in the Karewa Basin. The distribution of the Upper Karewa, remnants of the Karewa Lake (Wular and Dal Lake), and the current course of Jhelum River. (Source: Dar et al. 2014)

(Burbank and Johnson 1983; Basavaiah et al. 2010). The lacustrine sediments of the Pampore member are well developed in the middle and northeast side of the Kashmir Valley. The lithostratigraphy and regional tectonic framework of the Kashmir Valley confirm that the tectonic activity along the Panjal thrust resulted in the uplift of the southwestern side and shifting of the Lake Karewa (Dar et al. 2014) toward northeast side of the Kashmir Valley (Fig. 6.6b). The uplifted southwestern side also effectively blocks out the southwestern monsoon winds and has changed the climatic conditions from tropical to more arid in the Kashmir Valley. Loess deposition initiated at about 200 Ma on the exposed Karewa group of sediments in the southwest side due to the changing climatic conditions resulted in continued shrinking of the Karewa Lake toward the northeast side (Fig. 6.6c). Continuous shrinking of the lake resulted in the formation of the River Jhelum and the associated drainage system across the Kashmir Valley about 85 Ma (Fig. 6.6d, e). The loess commonly linked to arid glacial conditions is marked by interbedded paleosol profiles typically associated with wetter interglacial conditions (Kemp 2001) and occurs as cap sediments to the preexisting topography of Karewas (Fig. 6.6f).

In Jammu region, the Shiwalik group of rocks is exposed on the northern and southern limbs of the thrust-cored Suruin–Mastgarh anticline, extending from west to east as a connecting link between the Shiwalik rocks exposed in Pakistan and beyond Ravi River (India). The Shiwalik group represents the Lower, Middle, and Upper Shiwalik subgroups and is disposed in parallel folded zones. These rocks generally dip in southwest–northeast direction at varying angles between 80° (the Lower) and 10° (the Upper). The Ramnagar area of the Udhampur district in J&K State exposes a thick pile of the Lower Shiwalik rocks classified as Ramnagar formation by Gupta and Shali (1989) and is famous for its rich vertebrate fossil record. These rocks have been divided into Dodenal (Kamlial formation) and Ramnagar (Chinji formation) members by Gupta (2000). The Dodenal member, lower part of the subgroup, has very good exposures along the Kalaunta locality and consists of brown, reddish brown, gray, and buff sandstones, reddish brown to dark brown siltstones, and light brown to reddish brown mudstones. The upper part of the subgroup, Ramnagar member, is exposed along the Ramnagar Khad (seasonal stream) and comprises of multistoried sandstone bodies with fine- to medium-grained gray, greenish gray, buff, purple to dull gray sandstones, reddish brown to dark brown siltstones, and bright red to reddish brown mudstones. These rocks are sandwiched between the Murree formation and the Middle Shiwalik on both the limbs of the doubly plunging Udhampur Syncline (Pandita et al. 2014).

The Ladakh batholith forms part of the trans-Himalayan Batholith system that defines the southern boundary of the Tibetan Plateau from Ladakh in northern India east to Bhutan. To the southeastern side of the batholiths, the high relief, deformed Tertiary sediments of the Zanskar zone form the southern margin of the Indus Valley. Ladakh is located between two major tectonic suture zones, the Shyok to the north and the Indus–Tsangpo to the south. The former represents the remnants of an ancient back-arc basin complex, and the latter represents the main boundary zone between the Indian and Asian plates (Searle et al. 1990). The predominantly granodioritic Ladakh batholith forms part of the plutonic remnants of the island arc that rimmed the Asian continent from Cretaceous to Eocene times (Weinberg et al. 2000). The structural deformation of the batholith is minimal, although the evidence of localized ductile deformation is present. Crystallization ages from the main batholith range from 65 to 50 Ma (Weinberg and Dunlap 2000). Apatite fission track ages from the batholith, reveal cooling through the approximately 110° isotherm during progressive un-roofing in the early Miocene (Sinclair and Jaffey 2001). In the more easterly portions, the batholith is bound to the northeast by the Karakoram Fault, a major dextral strike slip fault that bounds the southwestern margin of the Tibetan Plateau (Searle 1996). South of the batholith are the deformed sedimentary successions of the Indus Molasse. These contain an Eocene to Miocene succession of sediments comprising limestones, mudstones, and conglomerates (Searle et al. 1990). This succession contains younger apatite fission track ages (approximately 14 Ma) and has been thrust northwards onto the Ladakh Batholith from early Miocene times to recent (Sinclair and Jaffey 2001). Over 36 km of shortening has been proposed between the Eocene and the late Miocene (Searle et al. 1990).

### *6.1.5 Drainage and Hydrography of J&K*

Main rivers in J&K include the Indus, Jhelum, Kishanganga (Neelum), Suru, Chenab, Zanskar, Shyok, and Ravi (Fig. 6.7). The state encompasses the Upper Indus Basin (UIB) drained by three major tributaries of Indus: Jhelum, Chenab, and Indus (World Atlas 1999; Albinia 2010). The waters emanating from the state are shared between India and Pakistan under the Indus Waters Treaty (IWT 1960).

River Indus is a gigantic trans-Himalayan river of South Asia and one of the longest rivers in the world, with a length of some 3200 km. Its total drainage area is about 1,165,000 km$^2$, of which 453,000 km$^2$ lies in the ranges and foothills of the Himalaya, the Hindu Kush, and the Karakoram ranges, the rest being mostly in the semiarid plains of Pakistan (Shroder 1993; Meadows and Meadows 1999). The river rises in the southwestern Tibet, near Lake Mapam, at an elevation of about 5500 m. For about 320 km, it flows northwest, crossing the southeastern boundary of J&K at about 4600 m. A short way beyond Leh, in the Ladakh region, it is joined on its left by its first major tributary, the Zanskar River. Continuing for 240 km in the same direction into the Pakistani-administered areas of J&K, the Indus is joined by its notable tributary, River Shyok, on the right bank. Below its confluence with the Shyok, as far as the Kohistan region of Pakistan's Khyber Pakhtunkhwa province, it is fed by mighty glaciers on the slopes of the Karakoram Range, the Nanga Parbat massif, and the Kohistan highlands. The Shyok flows through the northern Ladakh in India and the Ghangche district of Gilgit–Baltistan, Pakistan, spanning some 550 km.

River Jhelum ascends from the southeastern Pir Panjal range in the Kashmir Valley and comprises 24 watersheds. The river travels through the Valley toward Lake Wular, and finally finds its exit through a deep narrow gorge before entering into Pakistan administered Kashmir'耐 (Sharma et al. 2012). The upper catchment

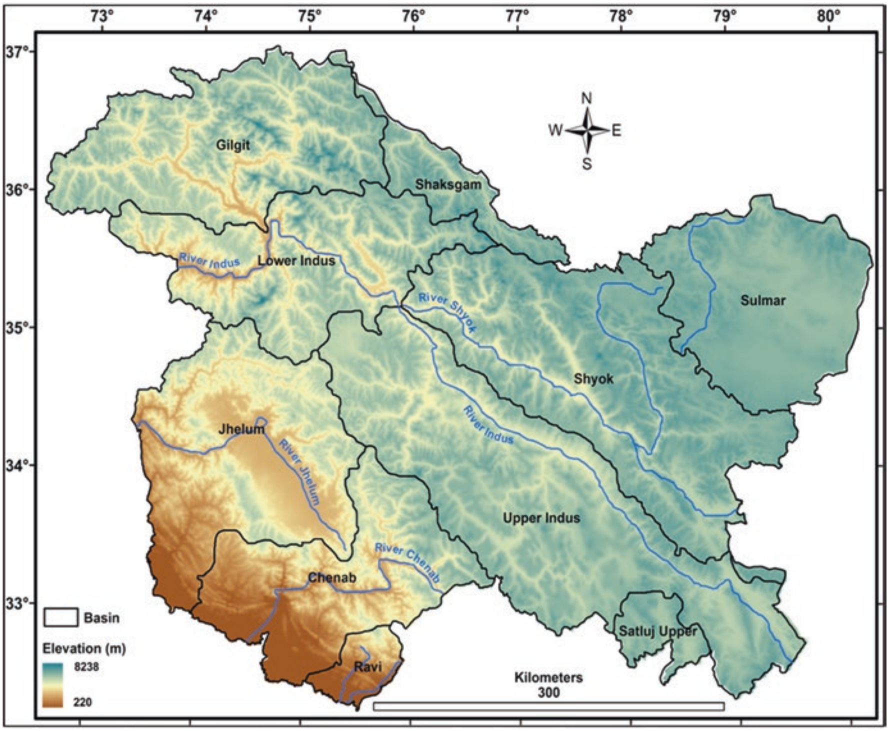


**Fig. 6.7** Rivers of the J&K state

of the river is mountainous, whereas the lower catchment is pretty flat, making the floodplains vulnerable to the recurrent flooding in the basin. Historically, the Kashmir Valley has regularly witnessed high-magnitude floods resulting in significant loss of life and property (Romshoo et al. 2018). The river water comes mostly from snow melt in the spring and summer, supplemented by the monsoon from June to September. Due to the extreme low temperatures and limited rainfall during the winter, the river water level is usually lower contrary to the summer months (Archer and Fowler 2008). The glacier melt significantly contributes to the streamflow during the summer and autumn seasons.

River Chenab originates from near the Bara-lacha Pass in the Lahaul–Spiti part of the Zanskar range in the neighboring Himalayan state of Himachal Pradesh. The river drains a total catchment area of ~22,015 km$^2$ of J&K State. The Chenab (or Chandrabhaga) is formed after the two streams – the Chandra and the Bhaga merge with each other at an altitude of 4900 m. The united stream, Chenab, further receives many tributaries, namely, Milang, Jankar, Miyar, Saichu, Bhariang, Marusudar, Kentha, Kalnai, Kiar, Lokut Zaz, Gumbar, Thirot, Niru, Nail, Gen, Tsingan, Dun, Tawi, Liddar, Mohu, Sohal, Bhut, Thathri, Bichleri, Dudahar, Chainj, Rad Khad, Ans, Ranbir Singh Pura, Qaraqash, Dhaler, Toana, Halsi, and Chaukiwala (CGWB 2013). The river crosses the Pangi Valley before entering the Paddar area of Kishtwar district in Jammu province of J&K. The total length of the river from the confluence of Chandra and Bhaga to Akhnoor is about 504 km. Chenab empties into the Sutlej River after receiving the Jhelum River near Trimmu (in Punjab, Pakistan) which feeds several irrigation canals.

The Ravi River rises in the Himalaya in Himachal Pradesh and flows past Chamba and boundary of J&K, emptying into the Chenab River near the international border with Pakistan (Kumar and Dua 2009). The water in the river is received from snowmelt and the monsoon rains from June to September and is used for irrigating large areas of land along its course. Under the Indus Waters Treaty (1960), the waters of the Ravi and five other rivers are divided between India and Pakistan for domestic use, irrigation, hydropower generation, and multipurpose projects (Thomas and Sharma 1998; Jain et al. 2007; Romshoo 2012).

### *6.1.6 Wetlands and Waterbodies of J&K*

The J&K state is known for its freshwater bodies such as lakes and wetlands. There are about 3651 waterbodies in the state (Panigrahy et al. 2010), covering an area of 3915 km$^2$ (Fig. 6.8). These include high-altitude lakes, valley lakes, rivers, riverine wetlands, reservoirs, and barrages (Table 6.4). Most of the lakes and wetlands lying at low altitudes and in the vicinity of human settlements are facing multiple signs of deterioration, mainly due to anthropogenic activities (Romshoo et al. 2011; Badar et al. 2013a, b; Rashid and Romshoo 2013; Mushtaq and Pandey 2014; Romshoo and Rashid 2014; Mushtaq and Nee Lala 2016). There are four wetlands designated as Ramsar Sites in the State: Hokersar, Wular, Tso Morari, and Surinsar-Mansar. Other noted lakes of the region are Pangong, Manasbal, Dal, and Tso Kar.

Despite their tremendous scientific and societal importance, the picturesque lakes and wetlands of the State, particularly in the Kashmir Valley, are shrinking due to rapid and unplanned urbanization, reckless deforestation, increased pollution, and silt load from the catchments. All these factors have caused reduction in the size and depth of most of the wetlands and lakes in the state. Over the years, increased sediment and silt load from the catchments have caused a reduction in the size and depth of most of these wetlands and lakes, besides impacting their functionality. During the last 50 years, about 20 wetlands and waterbodies in and around Srinagar city – summer capital of the State – have been lost to urbanization and agricultural expansion. This rapid urbanization of the catchments, together with reckless deforestation and uncontrolled use of fertilizers and pesticides in catchments, has led to excessive nutrient load and decrease of water depth in most of the wetlands and waterbodies of Kashmir, resulting in colonization of open waters by weeds and other aquatic vegetation (Romshoo and Rashid 2014).

The loss and deterioration of wetlands in Kashmir Valley during the last five decades was the single most important factor for exacerbating the flooding scenario in September 2014 (Romshoo et al. 2018). The flood vulnerability scenario in the Jhelum basin has worsened during the last few decades as a significant number of

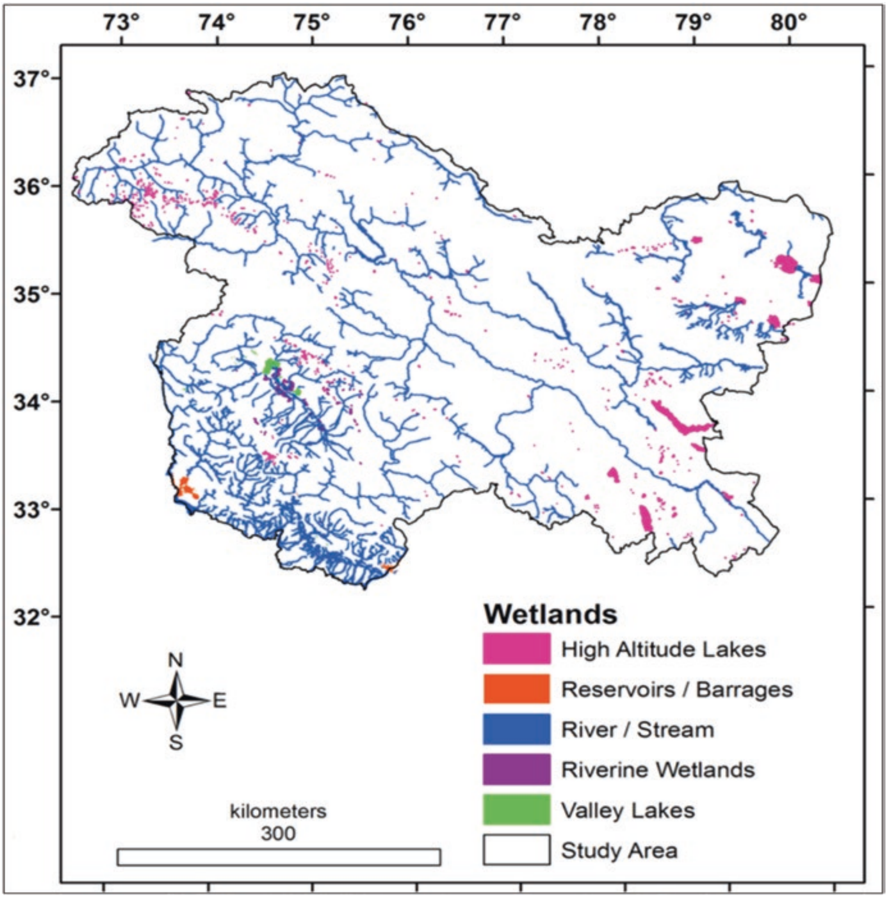


**Fig. 6.8** Wetlands and waterbodies of Jammu and Kashmir

**Table 6.4** Spatial extents of wetlands and waterbodies in J&K

| S. no. | Category | Area (km$^2$) |
|---|---|---|
| 1. | High-altitude lakes | 1091.70 |
| 2. | Reservoirs/barrages | 251.32 |
| 3. | Rivers/streams | 2315.97 |
| 4. | Riverine wetlands | 95.94 |
| 5. | Valley lakes | 137.67 |
| 6. | Wetlands (<2.25 ha) | 22.4 |

the lakes and wetlands in the basin, which used to store floodwaters and act as sponge during flooding, have been urbanized and converted into concrete landscape in the entire Kashmir Valley. Most of the wetlands and waterbodies in the Jhelum basin are fighting a losing battle for their survival due to the official and public apa-

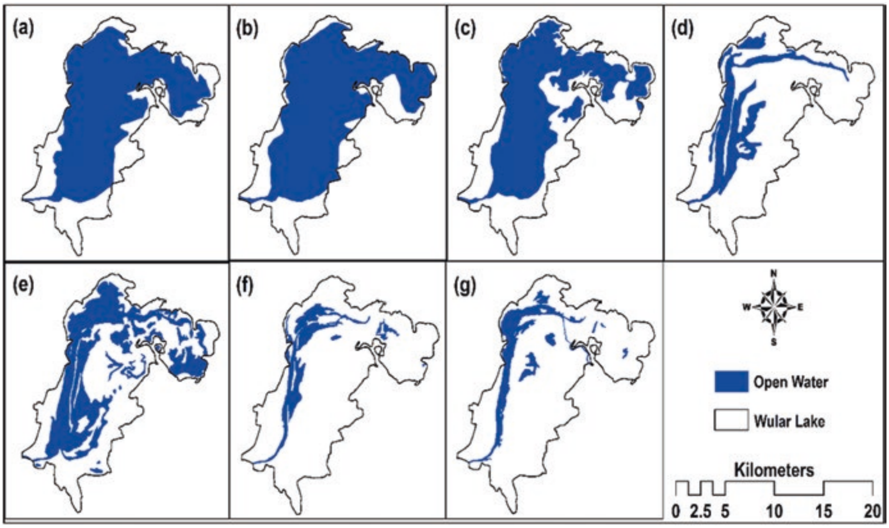


**Fig. 6.9** Open water extent of the Wular Lake at different points in time: (a) 1911, (b) 1954, (c) 1962, (d) 1979, (e) 1992, (f) 2001, (g) 2013

thy (Mushtaq and Pandey 2014). The functionality of wetlands and waterbodies, having strong linkages with the hydrological cycle, has got adversely affected due to their encroachment, seasonal changes in the precipitation patterns, and depleting streamflows attributed to the climate change (Lal et al. 2001; Romshoo et al. 2015). Wular on the Jhelum River is the biggest floodwater storage lake in the basin, but the storage capacity of the lake has significantly reduced during the last century (WI 2007; Romshoo et al. 2018) (Fig. 6.9), because of the massive siltation of the lake from the catchment.

### *6.1.7 Snow and Glacier Resources of J&K*

The snow and glacier resources of J&K are important sources of freshwater vital for agriculture, industries, tourism, and hydropower generation. The cryosphere is important to sustain the economic development of the state in various sectors – be it agriculture, horticulture, energy generation, tourism, etc. (Dar et al. 2013; Romshoo et al. 2015) – and influences the high mountain ecology of the region. The state harbors snowcapped peaks and glaciers, and the melt water from snow and glaciers is the source of headwater for the rivers and streams emanating from the region (Romshoo et al. 2015). There are 11,436 glaciers covering an area of 16,261.8 km$^2$, distributed in 14 basins within the boundary of J&K (Bajracharya and Shrestha 2011). Most of the glaciers are concentrated in the Karakoram range, followed by the Zanskar mountain range. The Shyok basin in Karakoram houses the largest number with 3608 glaciers, corresponding to an area of 5947.19 km$^2$. The areal extents of glaciers in the Shyok basin range from 0.23 km$^2$ to 925.93 km$^2$. The Indus in Pakistan administered Kashmir is the second largest glacier reserve with 1506 glaciers covering an area of 792.43 km$^2$, followed by Hunza and Zanskar basins with 1346 and 1024 glaciers, respectively. The Jhelum basin in the Pir Panjal range and Greater Himalaya has 147 glaciers, covering an area of 101.73 km$^2$ (Meraj et al. 2015a). The glaciers in the Jhelum basin range in size from 0.013 to 10.92 km$^2$. Most of the glaciers in the Jhelum are small in size as is suggested by the glacier area in the basin. Basin-wise glaciers and their area in Jammu and Kashmir are shown in Fig. 6.10 and Table 6.5. Some of the important glaciers include Siachen, Baltoro, Biafo, Drang-Drung, Machoi, Kolahoi, Parkachik, etc.

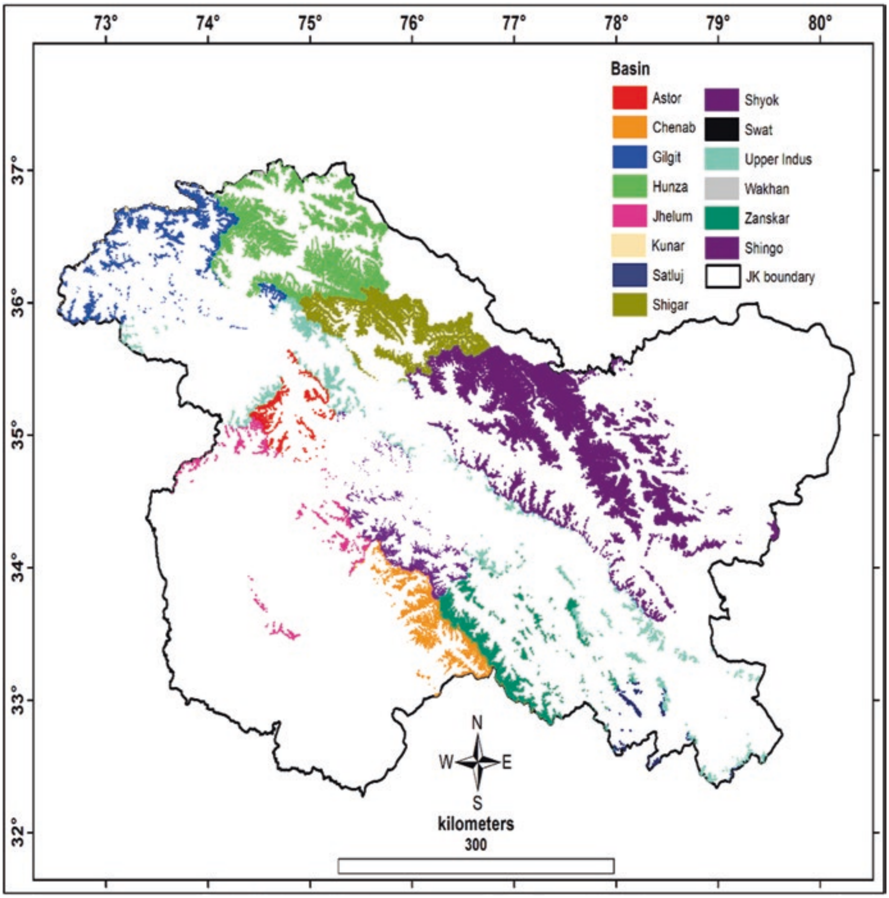


**Fig. 6.10** Basin-wise glacier cover in the J&K state

**Table 6.5** Basin-wise glaciers and their area in J&K state

| S. No. | Basin | Number of glaciers | Area (km$^2$) |
|---|---|---|---|
| 1. | Astor | 372 | 239.41 |
| 2. | Chenab | 978 | 1155.15 |
| 3. | Gilgit | 930 | 907.05 |
| 4. | Hunza | 1346 | 2724.90 |
| 5. | Jhelum | 147 | 101.73 |
| 6. | Kunar | 21 | 383.52 |
| 7. | Satluj | 170 | 85.10 |
| 8. | Shigar | 439 | 2373.46 |
| 9. | Shingo | 881 | 612.08 |
| 10. | Shyok | 3608 | 5947.19 |
| 11. | Swat | 4 | 0.76 |
| 12. | Upper Indus | 1506 | 792.43 |
| 13. | Wakhan | 10 | 49.87 |
| 14. | Zanskar | 1024 | 889.15 |
| | Total | **11,436** | **16261.8** |

### *6.1.8 Geo-Regions of J&K*

A detailed classification based on the concept of *geo-regions* (Maxey 2007), which considers geological control on biological functioning, has been provided by Singh (1993). According to this classification, J&K is divided into 24 geo-regions as shown in Fig. 6.11 and Table 6.6.

The geo-regions recognized in the Kashmir Valley, Jammu, and Ladakh regions are also discussed in the following subsections.

#### 6.1.8.1 Kashmir Valley

*Jhelum Plains* in the Kashmir Valley extend from Khanabal to Baramulla and include the floodplains of the meandering Jhelum. Through siltation and sedimentation in the region, fresh alluvium covers cultivable land, increasing soil nutrients in the valley bowl. The Bahil (loam) region of the floodplain constitutes the main agricultural zone of the Valley and constitutes the “Rice Bowl of Kashmir” in the south Kashmir.

*Karewas (Uplands)* are the shelving shores of an inland lake called “Satisar,” lacustrine and fluvio-glacial in origin. Irrigation facilities and increasing population have pushed the frontiers of cultivation in Kashmir Valley to these terraces. Orchards (with apple, pear, plum, peach, and almond crops) are dominant here, while saffron is also specifically cultivated at some places around Pampore and Budgam.

*Rimlands* are dominated by thick forests, meadows, and mixed conifers in the north and deciduous forests and plantations in the Pir Panjal. These lands serve as grazing grounds for nomads, and tourist resorts like Gulmarg, Pahalgam, Sonamarg, Yusmarg, Dodhpathri, etc. are located in this geo-region.

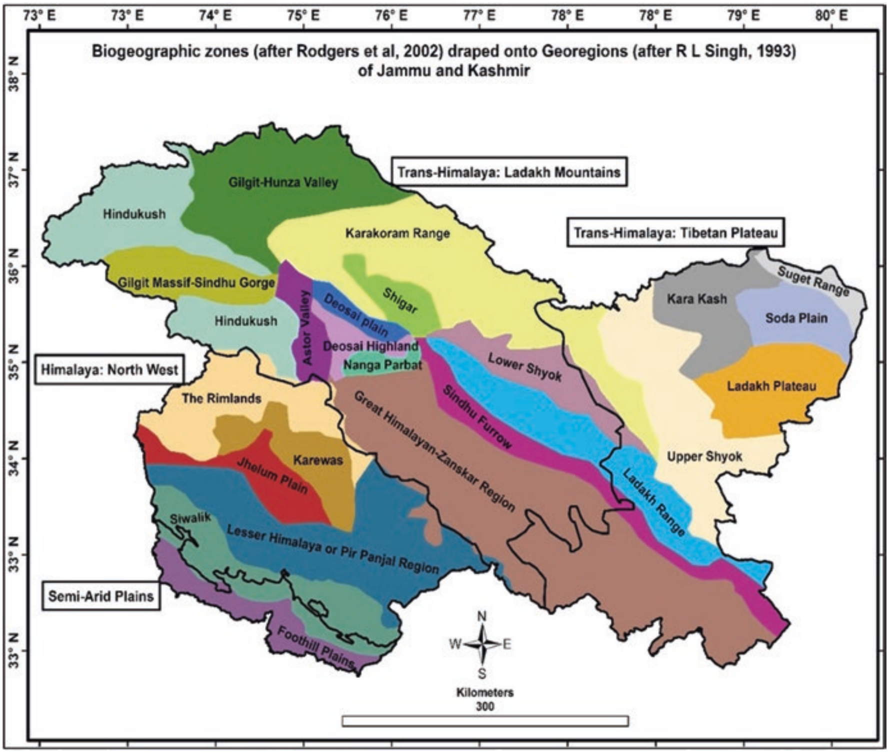


**Fig. 6.11** Biogeographical zones and Geo-regions in the J&K state

### 6.1.8.2 Jammu

*Foothill Plains* are considered as the "wheat belt" of the state. Agroclimatologically, the region is suitable for the cultivation of cereals such as paddy (basmati) and wheat. The region hosts many important towns like Jammu, Kathua, Samba, etc.

*Siwalik Region* consists of forested and furrowed hills enclosing the structural depressions like Duns, as those in Udhampur. It is in these depressions that maize, millet, and barley are cultivated. Elsewhere agricultural activity is poor due to the eroded soil cover and limited means of irrigation.

*Lesser Himalaya or Pir Panjal Region* varies in elevation from 3000 to 4500 m amsl, with almost bare scrap faces and forested tops receiving seasonal snowfall. Population is sparse and human activities are also limited.

### 6.1.8.3 Ladakh

*Greater Himalayan–Zanskar Region* distinguishes itself by the higher altitude along with relatively high rainfall (500–900 mm) and thick vegetation cover than its counterparts in the Ladakh region. Its floodplains grow some vegetation of Tamarisk,

**Table 6.6** Area under different geo-regions in Jammu and Kashmir

| S. No. | Category | Subcategory | Area (km$^2$) |
|---|---|---|---|
| 1. | Kashmir Valley | Jhelum plain | 2911.81 |
| | | Karewas (terraces) | 1969.50 |
| | | Rimlands | 1707.16 |
| 2. | Jammu–Mirpur region | Foothill plains | 5181.08 |
| | | Siwalik region | 5782.20 |
| | | Lesser Himalaya or Pir Panjal region | 14181.47 |
| 3. | Zanskar–Ladakh region | Great Himalayan–Zanskar region | 36657.94 |
| | | Sindhu furrow | 15272.36 |
| | | Ladakh range | 4898.08 |
| | | Upper Shyok valley | 7108.22 |
| 4. | Deosai–Skardu region | Deosai highland | 22427.05 |
| | | Deosai plain or Skardu region | 5801.45 |
| | | Astor valley | 7981.38 |
| | | Nanga Parbat | 11372.19 |
| 5. | Gilgit–Baltistan region | Lower Shyok valley | 18578.03 |
| | | Karakoram range | 6199.34 |
| | | Shigar valley | 1345.55 |
| | | Gilgit–Hunza valley | 9926.71 |
| | | Hindukush region | 2836.92 |
| | | Gilgit massif–Sindhu gorge region | 7496.91 |
| 6. | Aksai Chin region | Suget range (kun Lun) | 10301.59 |
| | | Soda plain | 4913.20 |
| | | Ladakh plateau | 2018.03 |
| | | Kara Kash valley | 14067.21 |

while the slopes are clothed with burtse; higher up in the region are the patches of grass which support the yaks and wild asses. Warm springs are also present in the region.

*Sindhu Furrow* accounts for most of the human activities in the region. The Indus furrow is barren, rocky, and dry in general, dotted with fans and drained by the snow-fed tributaries. The fans are supporting the fruit trees and arable lands are grown with barley. Wheat, pulses, and root crops are grown only on the irrigated fans. The semi-nomadic people rear the sheep, dzo, and yak here.

*Ladakh Range* with almost regular crest and limited snowy peaks has gentle northern slopes. The narrow valleys of 2–3 km width are found in this zone, which indicates clearly evidences of preglacial erosion levels by the interglacial uplift. The human occupancy is sparse and mostly involved in grazing and pastoral activities.

*Shyok Valley* is close to the Nubra Valley, with Khardung La on the Ladakh range as the gateway to both the valleys. Amidst the Shyok Valley flows through the Shyok River, a tributary of the Indus River, originating from the Rimo Glacier, one of the tongues of Siachen Glacier. The river flows in a south easterly direction and joins the Pangong range. The river has five tributaries: *Chang Chen Mo River*, *Galwan River*, *Nubra River, Saltoro River,* and *Masharbram* River (Bennett-Jones et al. 2004).

## 6.2 Climatology and Climate Change in J&K

Climatologically, the state is divided into the *hot plains of Jammu in the south* (annual minimum temperature: 17.9 °C, annual maximum temperature: 29.6 °C, and annual precipitation: 1331 mm), *the temperate zone of Kashmir in the middle* (annual minimum temperature: 7.3 °C, annual maximum temperature: 19.7 °C, and annual precipitation: 710 mm), and *the cold desert of Ladakh in the east* (annual minimum temperature: 1.2 °C, annual maximum temperature: 12.3 °C, and annual precipitation: 102 mm). According to Bagnolus and Meher-Homji (1959), the climate of Kashmir falls under the sub-Mediterranean type with four seasons (spring, summer, autumn, and winter) based on mean temperature and precipitation. Most of the annual precipitation in the state is received in the form of snow and rain, except in the Jammu plains, where precipitation is only in the form of Monsoon rains. The snow occurs mainly in winter and early spring season in high-altitude regions of the state, originating mainly due to weather mechanisms of the cold and moist anticyclones from the North Atlantic Ocean (NAO) and the Mediterranean Sea known as western disturbances (Pisharoty and Desai 1956). The general orographic and urban heat effects also cause local precipitation events in different regions of the state. Because of the large variation in climate, topography, and geology, the region supports a rich biodiversity (Champion and Seth 1968; Dar et al. 2002).

Over the last few decades, clear indicators of climate change are discerned in the Himalaya, including the J&K, in the form of increasing temperatures, shrinking glaciers, and diverse precipitation patterns (Bahuguna et al. 2014; Rashid et al. 2015; Romshoo et al. 2015; Rowan et al. 2015). The Himalaya is very sensitive to climatic variations because of its fragile environmental and climatic settings. Based on the analysis of the monthly average surface temperature and precipitation at six widely separated stations (Gulmarg, Pahalgam, Kokernag, Qazigund, Kupwara, and Srinagar) and ERA-interim (model- and observation-based reanalysis data)-based potential vorticities in the upper troposphere over J&K, the detailed characteristics of the long- and short-term, as well as localized, variations of temperature and precipitation were studied for a period of 37 years during 1980–2016 (Zaz et al. 2018). The results showed an increase of 0.8 °C in the average annual temperature over 30 years, with higher increase in the maximum temperature (0.97 °C) compared to the minimum temperature (0.76 °C). The analyses of the annual mean temperature at all the stations revealed higher rise at high-altitude stations of Pahalgam (1.13 °C) and Gulmarg (1.04 °C) at the confidence level of S = 99%. Precipitation patterns in the valley show slight decrease in the annual precipitation at Gulmarg and Pahalgam stations at the confidence level of S = 90%. The seasonal analyses showed an increase in winter and spring temperature at all the stations at the confidence level of S = 95%, with prominent decrease in spring precipitation at S = 99%. The study revealed that variation in temperature and precipitation during northern winter (December–March) has close association with the North Atlantic Oscillation (NAO).

## 6.3 Soils of J&K

Very little information is available on the soils of J&K. Analysis of the soil dataset, based on FAO-UNESCO Soil Map of the World (FAO 2007, 2014) at 1:5,000,000 scale, reveals that a thick soil cover is confined only to the Valley bottoms and terraces. Immature soils are found as the altitude rises on the mountain slopes, where low temperature slows down weathering. Higher up, the soil cover becomes thinner till the alpine pastures appear. Altogether, five soil types have been recognized in the state according to FAO-UNESCO soil standard (Fig. 6.12).

*Calcaric fluvisols* are mostly present in the foothill plains of Jammu region, spread over an area of ~588 km². *Eutric cambisols* are predominant in the Lesser Himalaya, Jhelum plains, Karewa, Sindhu furrow, and the Lower Shyok, covering an area of ~43,262 km². As per the FAO data, the glaciated areas are abundant in Karakoram, Great Himalayan–Zanskar region, covering an expanse of ~37,396 km². *Lithosols* cover the maximum portion of the state, spread over an area of ~127,629 km². *Orthic Acrisols* are present in parts of the Great Himalayan–Zanskar ranges, Ladakh range, and Sindhu furrow, spread over an area of ~7409 km². *Orthic Luvisols* are confined to the Siwaliks in the Jammu region over an area of ~5174 km².

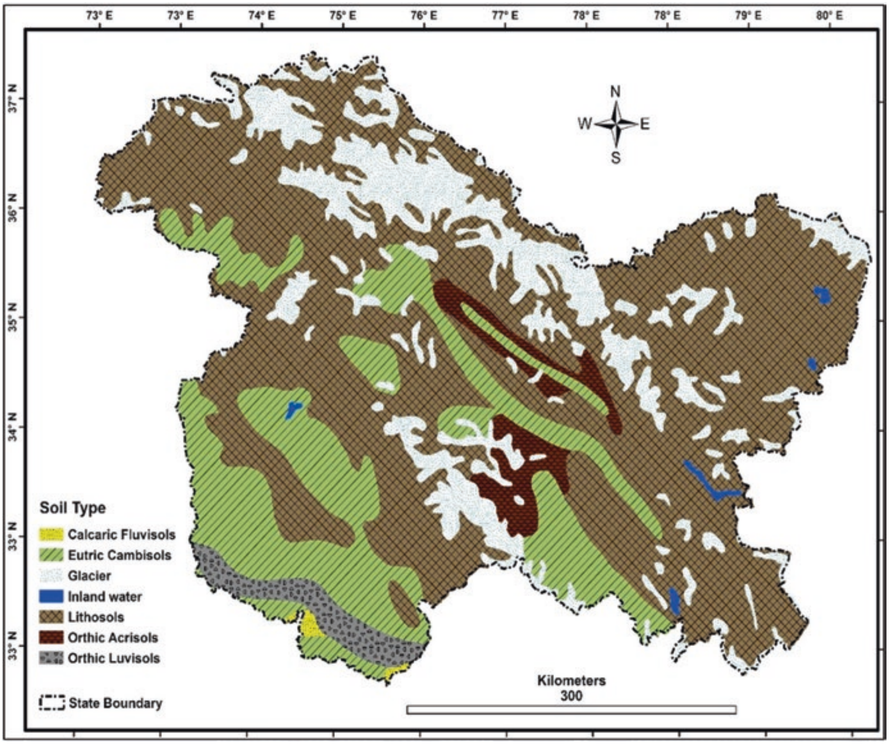


**Fig. 6.12** Soil types of the J&K state (Source:FAO-UNESCO)

Erosion assessment revealed that more than 48.27% of the area in the Kashmir Valley is under very high erosion risk (Zaz and Romshoo 2012). The Pir Panjal watersheds are under high erosion risk as compared to the Greater Himalayan watersheds due to the weak lithological Karewa formation that is more widespread along the Pir Panjal range.

## 6.4 Biogeography and Biodiversity of J&K

With its unique climatology and a highly complex topography, J&K falls under four biogeographic zones as suggested by Rodgers et al. (2002): Trans-Himalayan zones of Ladakh and Tibetan plateau, northwest Himalaya, and semiarid plains of Jammu (Fig. 6.11). These zones have been identified based on various factors such as altitude, moisture, topography, rainfall, fauna and flora:

*Trans Himalayan zone:* Usually referred to as cold desert because of the harsh climate, this is the northern most area of the state and covers mainly the areas of Ladakh with elevation varying from 2800 m in the Indus to over 7000 m in the Himalayan and Karakoram ranges (Mehta and Julka 2002). The zone is the habitat of wild sheep and superior goats that produce the richest quality wool. Snow leopard is a special animal habituating this zone. Migratory birds like black-neck crane are also seen here. The great Indian bustard, an endangered species, is also seen in the grasslands of Gilgit Baltistan and Ladakh areas.

*Northwest Himalayan Zone:* This is the southwestern region of the state including Kashmir Valley and parts of Jammu region with rich flora and fauna. There are several National Parks in this zone.

*Semiarid Plains:* Some parts of J&K in the Jammu region fall under this zone (Rodgers et al. 2002). In this area, groundwater and surface water resources are scanty, which has led to predominance of xerophytic vegetation and minimum fauna. A few orchids, bamboo, and other plants are seen in this zone.

Owing to the complex terrain and varied climatology, the state harbors very rich biodiversity and lies in the global biodiversity hotspot – the Himalaya (Rashid et al. 2010; Rashid et al. 2013; Malik et al. 2015). The flora has passed through various stages of succession during the geomorphological evolution of this region. This region has been colonized at different times in the past by humid tropical Malayan, tropical African, temperate and alpine north Asiatic-European, sclerophyllous Mediterranean, temperate East Asian, and semiarid Central Asian forms. Floristically, vegetation of the state can be classified into three types:

(i) *Cold Desert vegetation of Ladakh:* The region is an almost treeless expanse, primarily because of its scanty precipitation. Plants are generally found growing along moist river margins or in moist rock crevices. There are three main elements in the vegetation of Ladakh: alpine, desertic, and oasitic.
(ii) *Temperate Vegetation of Kashmir:* Vegetation of the Kashmir Valley varies greatly with altitude. Extensive cultivation of cereal crops and plantation

predominate the plains (<2000 m amsl), while the landscapes at higher altitudes are covered by dense evergreen coniferous forests up to an elevation of 3200 m amsl. Areas above 3200 m are covered with alpine pastures and scrublands. Beyond the altitude of 3800 m, all the areas are denuded, either rocky or covered with perennial snow and glaciers.

(iii) *Subtropical Vegetation of Jammu:* Vegetation of the Jammu region is of dry, mixed deciduous type, although areas above 1200 m amsl are rich in dense coniferous forests dominated by *Pinus roxburghii*.

J&K is bestowed with lush green forests, predominantly of temperate coniferous type. 56% of the total area of the state is covered by vegetation, while the non-vegetated areas cover ~44% (Rashid et al. 2015). The major vegetation types include forests and grasslands. Due to the ever-increasing population (human as well as livestock), the forests are facing a direct pressure due to the open grazing and allied biotic interference (Rather et al. 2016). The state has a total forest cover of 20,230 km$^2$, which accounts for 19.95% of its total geographical area. Overall, the Kashmir region has 40.17%, Jammu 59.64%, while the Ladakh region has 0.17% area under forest cover. It is pertinent to mention that during 2013–2014 financial year, a revenue of Rs. 337.39 million was realized from the forestry sector against a set target of Rs. 609.95 million (JK Economic Survey 2013–14).

## 6.5 Fossil Records of Biodiversity in J&K

Various studies have been carried out during the last century on fossil records of flora and fauna in J&K State (Waagen 1889; Reed 1910, 1934; Wadia 1934; Bhat 1965; Shah 1973, 1982, 1993; Whittington 1986). Pleistocene flora of Kashmir from fossil records has been reported in terms of 128 extant species of angiosperms, spread over 69 genera in 34 families (Puri 1946, 1947, 1948, 1958; Mittre 1964). Various types of flora identified from fossils in the Valley are as follows:

*Liddermarg Flora*: It comprises mainly of *Quercus leucotrichophora* and *Q. glauca*, which are completely extinct from the Valley. The other prominent genera include *Pinus*, *Cedrus*, *Mallotus*, *Ficus*, *Acer*, *Litsaea*, *Cinnamomum*, *Machilus*, *Phoebe*, *Buxus*, *Skimmia*, *Toddalia*, *Pittosporum*, *Rhamnus*, *Berchemia*, *Myrsine*, *Syringa*, *Wendlandia*, *Pyrus*, *Cotoneaster*, *Alnus*, *Berberis*, *Cornus*, *Parrotiopsis*, *Desmodium*, *Inula*, *Acorus*, *Scirpus*, *Cyperus*, etc.

*Laredura Flora*: Both the tropical and temperate species have been discovered in this type of flora, but the tropical species are predominant. Main tropical species recorded are *Woodfordia fruticosa*, *Mallotus philippinensis*, and *Olea cuspidata*. The temperate species include *Ulmus wallichiana*, *Quercus semicarpifolia*, *Q. dilatata*, *Quercus ilex*, *Betula alnoides*, *B. utilis*, *Acer caesium*, *A. villosum*, *Berberis lyceum*, and conifer genera *Pinus*, Cedrus, and *Abies*. Temperate species still exist in the Valley, but subtropical taxa like species of *Mallotus*, *Woodfordia*, *Myrsine*, and *Olea* are nonexistent today; this supports the view that Liddermarg flora is developed under tropical conditions.

*Ningal Nallah Flora*: This flora was usually represented by forms like poplars, willows, cherries, walnuts, maples, elms, and alders, with an abundance of spruce, silver fir, pine, and cedar. Various modern representatives of these plants still flourish in the Valley on northern side of the Pir Panjal. This indicates that at least in this part of Kashmir, there persisted temperate climate during the Pleistocene.

The earliest flora reported from J&K is from the Early Carboniferous of Kashmir (in the Lidder Valley and Banihal) to late Pleistocene (Shiwalik strata of Jammu; Karewas of Kashmir). Other reports of the past flora from J&K state are about *Gangamopteris* and *Glossopteris* reported from Zewan and Nishat Bagh beds of Kashmir. Micro flora obtained from Nagrota formation, that is, upper Siwalik sediments exposed at Bantalab–Jammu Bye Pass road, reveals a total of 30 species in 24 genera of gymnospermous and angiospermous pollen, pteridophytic spores, and fungal spores and conidia. The distribution pattern of spores and pollen grains in this Bantalab upper Shiwalik succession indicates the presence of stagnant freshwater conditions in view of the high incidence of zygospores of *Zygnema* and *Spirogyra*.

The state of J&K is also endowed with rich fauna, ranging in age from the Cambrian to the recent period, including both invertebrates and vertebrates. The vertebrate fauna reported from the state is mostly from the Siwaliks and Karewa strata. The Cambrian fossils of Kashmir may include Trilobites and Brachiopods, Pteropod Hyolithes, and cysted Eucystites. The Ordovician–Silurian fauna fossils include Brachiopods and Crinoids, Corals, and Strophomenids. The Carboniferous fossils include Brachiopods, Bryozoans, Trilobites, Lamellibranchs, Amphibian *Archegosaurus ornatus*, and Fishes – *Amblypterus kashmirensis* and *A. symmetricus*. The Triassic fossils of Kashmir include ammonoids (*Meekoceras*, *Ophioceras*, *Otoceras*), lamellibranchs, and brachiopods. The Jurassic fossils comprise of ammonites, beleminites, lamellibranchs, and brachiopods. The Cretaceous fossils include *Foraminifera*, gastropods, and corals. The Tertiary fossils in Karewas include representatives of mollusks, elephas, rhinoceras, bovids and mammoths, birds, fish, and some plants. The Tertiary fossils in Siwaliks include representatives of Equidae, Rhinoceratidae, Suidae, Giraffidae, Bovidae, Proboscidea, Anthracotheriidae, Hippopotamidae, Primates, etc. A bed found in the Muree formation called Larea bed is lenticular with a Palkhai syncline. The fauna collected here consists of two fragments of ridge crest of Proboscidea molar and a dozen species of Lamellibranchia, which include species of *Nucula*, *Acila*, *Nuculana*, *Mytilus*, *Unio*, *Tellina*, *Apolymetis*, *Solecurtus*, *Venus*, *Meretrix*, *Pitar*, *Pholadomya*, *Lyonsia*, and *Thracia.*

The changes in physical conditions at the Paleozoic–Mesozoic boundary, about 250 million years ago, had a strong influence on biota, and most groups of organisms in the marine realm became extinct. The Upper Permian and Lower Triassic marine sediments, known as Zewan and Khunamuh formation, are well exposed in many localities of Kashmir. The best development of continuous Upper Permian to Lower Triassic marine strata is seen at Guryul ravine in the Kashmir Valley. Among

Foraminifera, as many as 14 families have become extinct during the Permian period, while many new families evolved in the Mesozoic. There has been a gap in the record of Foraminifera from the late Permian and the earliest Triassic, because of the absence of marine strata representing this time span due to the global regression of epicontinental seas.

## 6.6 Demography and Socioeconomics of J&K

The state is a quilt work of different people and regions with a rich cultural diversity. There was a total population of 12,541,302 in 2011, making J&K the nineteenth most populous state of India (Census of India 2011). The district-wise population density is shown in Fig. 6.13, whereas the percentage of rural and urban population is given in Figs. 6.14 and 6.15, respectively. Kashmir province has the highest population (54.97%) in the state, followed by Jammu (42.49%) and Ladakh (2.18%). The state has a population density of ~100/km$^2$ and literacy rate of about 69%. With a GDP of USD 21 billion in 2016–2017, the economy of the State is mainly dependent on agriculture, horticulture, handicrafts, tourism, and hydropower generation.

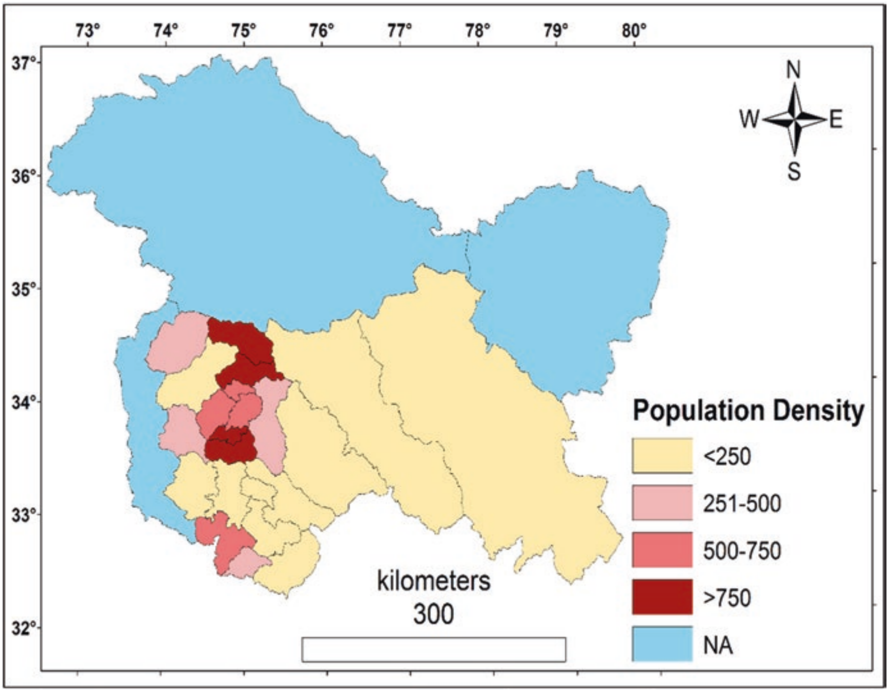


**Fig. 6.13** District-wise population density of the J&K state

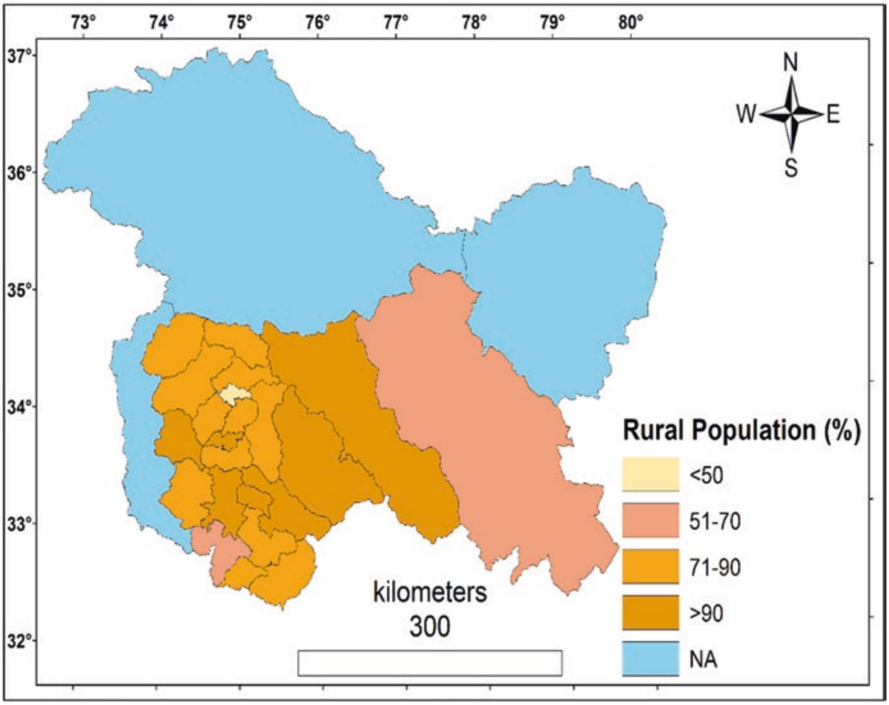


**Fig. 6.14** Rural population in the J&K state

The state's economy is projected to grow at 6.9% in 2018–2019. This is less than the 8.5% growth rate estimated for 2017–2018 (JK Budget 2018–19). The Gross Domestic Product of J&K for 2018–2019 (at constant prices) is estimated to be Rs 116,637 crores. This is 6.9% higher than the estimate for 2017–2018. The total expenditure for 2018–2019 is estimated to be Rs 80,313 crore, a 15.2% increase over the revised estimates of 2017–2018. The total receipts (excluding borrowings) for 2018–2019 are estimated to be Rs. 71,180 crores, an increase of 14.4% as compared to the revised estimates of 2017–2018. The revenue surplus for the 2018–2019 financial year is targeted at Rs 13,084 crores, or 8.3% of the state's Gross Domestic Product (GDP). Fiscal deficit is targeted at Rs 9673 crores (6.1% of State GDP). Primary deficit is targeted at Rs 4948 crores (3.1% of State GDP).

Agriculture sector, including crops, livestock, forestry, and fishing, is expected to grow at 6.8% during 2018–2019. This is less than the growth rate (8.4%) estimated for 2017–2018. The industry sector, including manufacturing, electricity, water supply, construction, and mining, is expected to grow at 6% during 2018–2019 as compared to 6.8% in 2017–2018. The services sector is the major contributor to the state economy and is estimated to contribute 56% in 2018–2019. It includes trade, tourism, real estate, broadcasting, and financial services. In 2018–2019, the sector is expected to grow at 5.7% as compared to 8.2% in 2017–2018 (JK Budget 2018–19).

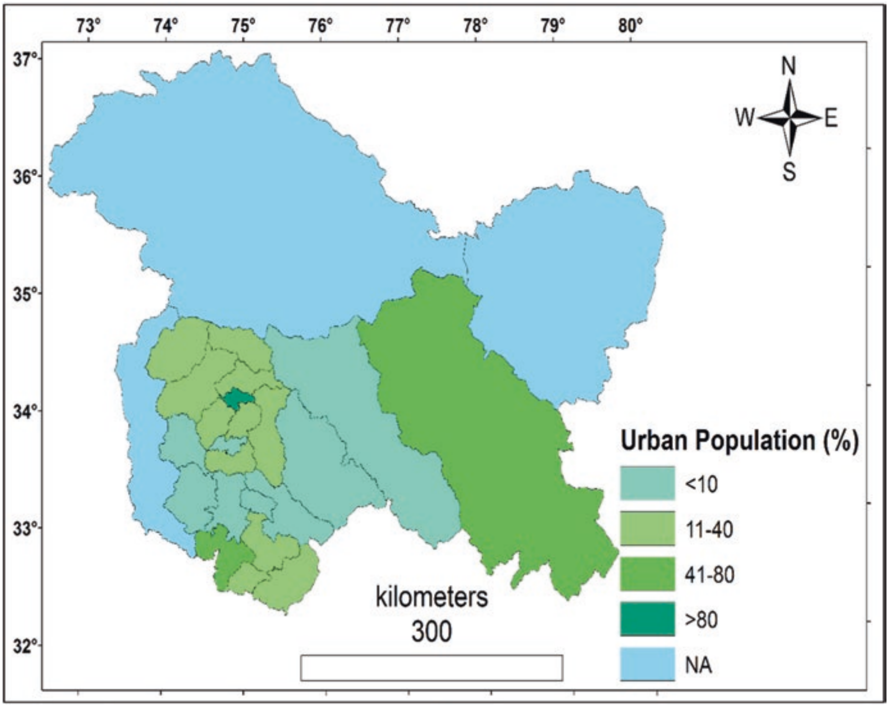


**Fig. 6.15** Urban population in the J&K state

## 6.7 Agriculture, Horticulture, and Livestock in J&K

Agriculture plays a very important role as far as the economy of the state is concerned. Approximately 70% of the population is directly or indirectly dependent on agriculture and allied sectors. Jammu, Kashmir, and Ladakh lie in distinct geographical agroclimatic settings, which determine their cropping pattern and crop productivity. Paddy is the main crop in Kashmir, followed by maize, oilseeds, pulses, vegetables, fodder, and wheat. In the Jammu region, wheat is the prominent crop, followed by maize, paddy, pulses, oil seeds, fodder, vegetables, and other crops; while in Ladakh, barley is the major cereal crop, followed by wheat. Kashmir is one of the few places around the world where high-quality saffron is cultivated. However, saffron is now also grown in Kishtwar district of the Jammu region. Traditional basmati rice of RS Pura in Jammu, Rajmash in Bhaderwah, Kishtwar, Bani, and other temperate areas is also important agricultural crop. Production of the three major crops – paddy, maize, and wheat – in J&K constitutes more than 90% of the total food grain production of all crops in the state, the rest being shared by other cereals and pulses as shown in Table 6.7.

Over the years, horticulture also has emerged as an important subsector of economy. This has been made possible with the state offering incentives for the cultivation

**Table 6.7** Cropping patterns and yield of food products over J&K during 2013–2014

| S. no. | Crop type | Area (in 000 s Ha) | | | Yield (Tons per Ha) | | |
|---|---|---|---|---|---|---|---|
| | | Jammu | Kashmir | Ladakh | Jammu | Kashmir | Ladakh |
| 1. | Rice | 116.00 | 158.00 | – | 2.83 | 3.64 | – |
| 2. | Maize | 207.00 | 100.00 | – | 1.98 | 1.80 | – |
| 3. | Pulses | 32.20 | 26.10 | – | 0.32 | 1.15 | – |
| 4. | Vegetables | 32.70 | 32.00 | 1.23 | 21.34 | 26.19 | 23.49 |
| 5. | Fodder | 20.00 | 35.50 | – | 40.00 | 69.19 | – |
| 6. | Wheat | 247.40 | 6.15 | 5.50 | 2.04 | 2.41 | 1.82 |
| 7. | Oilseed | 40.10 | 86.00 | – | 0.24 | 1.00 | – |
| 8. | Oats | – | | 5.60 | – | – | 21.48 |
| 9. | Barely | – | | 3.05 | – | – | 1.00 |

**Table 6.8** Horticulture crops cultivated in J&K state

| S. No. | Zones | Areas | Suitable fruits |
|---|---|---|---|
| 1. | Temperate zone | Kashmir Valley, parts of Poonch, Rajouri, Doda, Kathua, and Udhampur | Apple, cherry, pears, almond, walnut, chestnut, grapes, and strawberry |
| 2. | Subtemperate zone | Parts of Kathua, Poonch, Rajouri, Reasi, Doda, Kishtwar, Ramban, Baramulla, and Kupwara | Plum, apricot, peach, almond, pears, olive, and kiwi |
| 3. | Subtropical zone | Jammu, parts of Kathua, Rajouri, Udhampur, Reasi, and Doda | Mango, citrus, guava, litchi, grapes, and amla |
| 4. | Arid-temperate zone | Leh and Kargil | Grapes, resins, prunes, dry apricot, sea buckthorn, walnut, and currants |

and promotion of horticultural crops (Table 6.8), covering a variety of temperate fruits (like apple, pear, peach, plum, apricot, almond, cherry), as well as subtropical fruits (like mango, guava, citrus). Besides, medicinal and aromatic plants, valued flowering plants, mushrooms, plantation crops, and vegetables are profitably cultivated in the state. Apart from these, well-known spices like black cumin (kala zeera) are also cultivated in some pockets of the state. The area under horticulture in the state has increased ~28 times since 1950s (Table 6.9), and its contribution to GDP of the state remains around ~8%. Around 6 lakh families are directly or indirectly associated with horticulture in the state (Socio Economic Profile 2007–2008).

Livestock sector has recently emerged as one of the key components of agricultural growth. Apart from the production of meat, milk, and eggs, which grant employment to producers, livestock provides the major contribution to agriculture growth through manure as a fertilizer. The division-wise distribution of livestock population in J&K is shown in Table 6.10. The total estimated milk production for the state is ~2000 thousand metric tons. The average per capita availability of milk in J&K is 375 g per day, which is higher than the national average of 356 g per person per day. The total wool production estimated for the state is ~75 lakh kg.

**Table 6.9** Area under horticulture in J&K state during 1953–1954 to 2016–2017

| Year | Total area (ha) | Year | Total area (ha) |
|---|---|---|---|
| 1953–1954 | 12,400 | 1992–1993 | 184,621 |
| 1955–1956 | 14,000 | 1993–1994 | 187,502 |
| 1960–1961 | 16,000 | 1994–1995 | 191,729 |
| 1965–1966 | 23,000 | 1995–1996 | 198,467 |
| 1969–1970 | 45,600 | 1996–1997 | 205,543 |
| 1970–1971 | 48,000 | 1997–1998 | 211,158 |
| 1971–1972 | 52,000 | 1998–1999 | 213,728 |
| 1972–1973 | 56,000 | 1999–2000 | 217,545 |
| 1973–1974 | 60,000 | 2000–2001 | 219,039 |
| 1974–1975 | 82,486 | 2001–2002 | 221,589 |
| 1975–1976 | 85,508 | 2002–2003 | 231,727 |
| 1976–1977 | 89,216 | 2003–2004 | 242,546 |
| 1977–1978 | 94,029 | 2004–2005 | 258,311 |
| 1978–1979 | 99,299 | 2005–2006 | 268,284 |
| 1979–1980 | 103,002 | 2006–2007 | 283,085 |
| 1980–1981 | 131,008 | 2007–2008 | 295,141 |
| 1981–1982 | 134,579 | 2008–2009 | 305,621 |
| 1982–1983 | 138,030 | 2009–2010 | 315,089 |
| 1983–1984 | 141,376 | 2010–2011 | 325,133 |
| 1984–1985 | 145,044 | 2011–2012 | 342,791 |
| 1985–1986 | 148,164 | 2012–2013 | 347,223 |
| 1986–1987 | 160,000 | 2013–2014 | 355,092 |
| 1987–1988 | 166,422 | 2014–2015 | 359,089 |
| 1989–1990 | 172,929 | 2015–2016 | 337,677 |
| 1990–1991 | 176,297 | 2016–2017 | 338,528 |
| 1991–1992 | 180,994 | | |

**Table 6.10** Division-wise distribution of estimated livestock population in J&K for 2011–2012

| S. No. | Division | Livestock (in Lakhs) | % share of the state |
|---|---|---|---|
| 1. | Jammu | 78.90 | 49.2 |
| 2. | Kashmir | 74.99 | 46.7 |
| 3. | Ladakh | 6.51 | 4.1 |
| Total livestock: | | 160.40 | 100.00 |

Total fishermen population in the state is presently estimated at 91,984. The 27,781 km length of rivers/streams facilitates farming of more than 40 million tons of fish annually. Despite huge water reserves that the state has, there still exists a huge gap between the demand and supply of fish. The total fish catch was 19.95 thousand tons during 2012–2013, as compared to 18.47 thousand tons in 2001–2002, indicating a rise of 1.48 thousand tons over the years.

## 6.8 Disaster and Hazard Profile of J&K

The state has distinct topography, climate, economy, social setting, and strategic location. It is a multi-hazard-prone region with natural disasters like earthquakes, floods, landslides, avalanches, high-velocity winds, and snowstorms, besides human-induced disasters including road accidents, fires, etc., occurring in its various parts (Altaf et al. 2014; Romshoo et al. 2018).

(i) *Earthquakes* are predominant in most parts of the Kashmir Valley (11% of total area of the state) covering the districts of Srinagar, Ganderbal, Baramulla, Kupwara, Bandipora, Budgam, Anantnag, Pulwama, Doda, Ramban, and Kishtwar, which come under Seismic Zone V and where ~60% of the population live. The rest of the state including the whole of Ladakh and Jammu divisions (90% of total area of the state) are under Seismic zone IV (Fig. 6.16).

(ii) *Floods* occur in low-lying areas of the Kashmir Valley, especially in Sonawari, Anantnag, Awantipora, and Srinagar (Meraj et al. 2015b), along with several parts of Jammu and Ladakh. Upper catchments of all tributaries of the Jhelum, Indus, Chenab, and Tawi rivers are prone to flash floods. There have been almost 30 major floods in the archived history of Kashmir Valley (Romshoo et al. 2018). Floods in the state are primarily triggered by extreme rainfall events and cloudbursts. Such incidents have been reported from Kashmir in

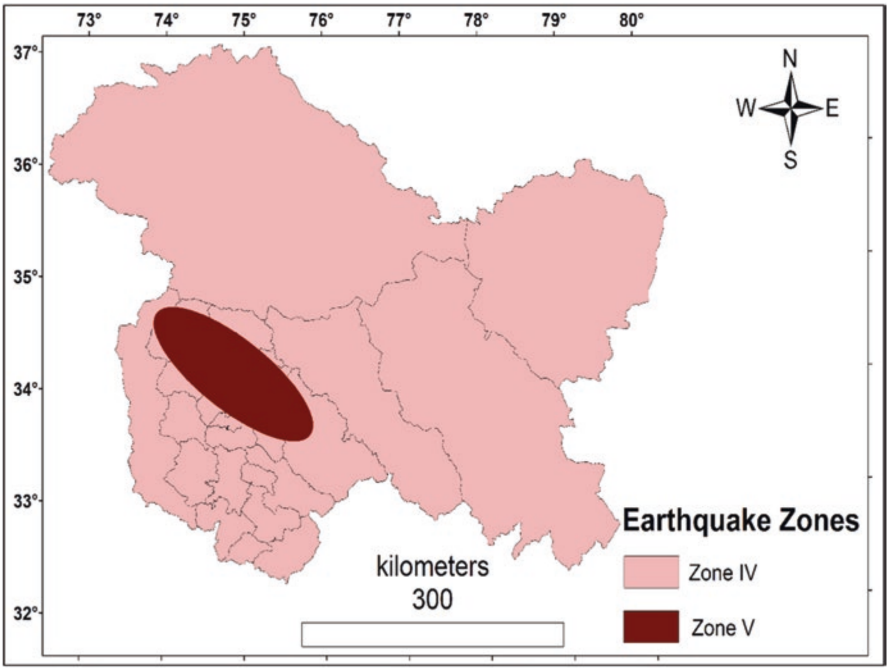


Fig. 6.16 Earthquake zones in the J&K state

the month of September 2014 due to the extreme rainfall and catastrophic flash floods, and in Leh during August 2010 due to cloudbursts.

(iii) *Avalanches and Snow Blizzards:* It is estimated that about 10% of Asia is affected by avalanche activity (Akif'eva Akif'eva 1992); according to Troshkina et al. (2007), the largest number of avalanche accidents from 1995 through 2006 occurred in India. The avalanche activity in the west Himalayan region becomes vicious from January to March (Ganju and Dimri 2004). Data collected over the last three decades indicates that on an average 30–40 lives and property worth a few million rupees are lost every year in avalanches. Actual figures are likely to be many times higher since a number of incidents go unreported (Ganju and Dimri 2004). In J&K, avalanches are confined to higher mountain reaches, including those of Doda, Kishtwar, Ramban, Banihal, Anantnag, Kulgam, Gurez, Kargil, Leh, etc.

(iv) *Landslides* occur in the areas along major highways. Ramban, Panthial, Banihal, Doda, Kishtwar, Pahalgam, Gulmarg, Zoji La, Dawar, Gurais, Tangdhar, Mughal Road, etc. are particularly landslide prone (Fig. 6.17). Slope failures/landslides are one of the most frequent geological catastrophes along road network in the hilly areas of Jammu region and the National Highway from Kargil to Leh. One such example is on 8 October 2005, when an earthquake in Kashmir triggered several thousand landslides (Owen et al. 2007). Besides earthquakes, the human impact in triggering landslides is due

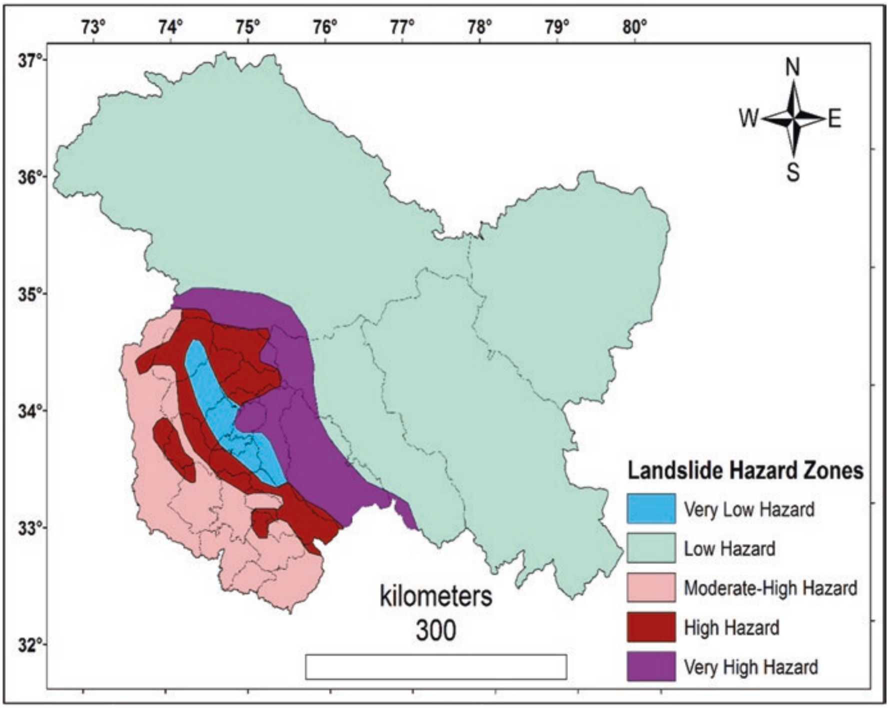


**Fig. 6.17** Landslide prone areas of the J&K state

to construction of dams, roads, and other infrastructure along the slopes without proper scientific study and planning. Singh et al. (2012) provide one such example of slope failure along the Batote–Doda road within the reservoir area of the Baglihar hydropower project that took place on 5 February 2009. The prolonged rainfall in the area frequently triggers landslides, which have become a recurrent phenomenon in hilly places due to over saturation of slope-forming material, causing considerable damage to life and property (Singh et al. 2012).

(v) *Drought*: Most parts of the Jammu division including Doda, Udhampur, Kathua, Jammu, etc. are drought prone. Droughts in the Himalayan region are caused by the reduction in precipitation brought by the summer monsoon rains/western disturbances in monsoon/westerly dominated regions (Singh et al. 2017). Pai et al. (2011) suggest that there is >20% drought probability in J&K. One incidence of drought in the state has been during 1983–1987, when it prolonged for 5 consecutive years (Shewale and Kumar 2005).

(vi) *Windstorms* usually destroy agriculture and horticulture crops and occasionally even rooftops of houses. Ladakh is prone to high-speed winds, though damages due to windstorms are nominal, perhaps due to the sparse population and traditional house construction practices. Gokul et al. (2017) opined that one of the biggest challenges in the implementation of wind turbines in J&K state is the occurrence of windstorms, with Leh region having higher potential as compared to others.

(vii) *Fires:* All district headquarters/densely populated towns, especially in Gurez, Doda, Kishtwar, and other inaccessible areas, particularly their wooden structures, are prone to fire incidents. However, such incidents are equally high in the plains, as well as in Srinagar city. Moreover, a study conducted by the Forest Survey of India reveals that 46% of the forest area in J&K is subject to repeated annual fires, the major loss being suffered by chir pine forests (Sharma et al. 2009).

(viii) *Road and Rail Accidents:* Hilly and tough roads, especially in Doda, Kishtwar, Ramban, Udhampur, Rajouri, Reasi, Poonch, Baramulla, Anantnag, Pulwama, Budgam, Jammu, Kathua, Kargil, Leh, etc., are prone to minor and major accidents. Among the top 5 states of India, J&K is at the fifth position in the rate of accidental deaths per thousand vehicles (Ruikar 2013).

(ix) *Cloudbursts:* All hilly areas of the state are prone to cloudbursts, with Leh 2013 cloudburst having been a recent massive one (Thayyen et al. 2013). The authors have reported regular occurrence of cloudburst events over the Leh (Ladakh) region in the recent past.

(x) *Others:* Several parts of the state, from time to time, face other hazards, such as thunderstorms, hailstorms, dam bursts, heavy snowing, human and livestock epidemics, etc., few of which occasionally transform into situations like a disaster.

## 6.9 Concluding Remarks

Possessing highly varied and unique topography, altitude, and climate, J&K supports a very rich biodiversity; indeed, the state belongs to the global biodiversity hotspot – the Himalayas – and represents three distinct biogeographic zones: trans-Himalayan zones of Ladakh, northwest Himalayas, and semiarid plains of Jammu. The flora has passed through various stages of succession during the geomorphological evolution of this region. This region has been colonized at different times in the past by various biotic forms.

The state of J&K is bestowed with lush green forests, predominantly temperate coniferous type; 56% of the total area of the state is covered by vegetation, the major vegetation types being forests and grasslands. Due to the ever-increasing population (human as well as livestock), the forests are facing a direct pressure due to open grazing and allied biotic interference. The state has a total forest cover of 20,230 $km^2$, which accounts for 19.95% of its total geographical area. Overall, the Kashmir region has 40.17%, Jammu 59.64%, while the Ladakh region has 0.17% area under forest cover.

Pleistocene flora of Kashmir from fossil records has been reported in terms of 128 extant species of angiosperms, spread over 69 genera in 34 families. The earliest flora reported from J&K is from the Early Carboniferous of Kashmir to late Pleistocene (Shiwalik strata of Jammu; Karewas of Kashmir). Other reports of the past flora from J&K are about *Gangamopteris* and *Glossopteris* reported from Zewan and Nishat Bagh beds of Kashmir. The changes in physical conditions at the Paleozoic–Mesozoic boundary, about 250 million years ago, had a strong influence on biota, and most groups of organisms in the marine realm became extinct. The Upper Permian and Lower Triassic marine sediments, known as Zewan and Khunamuh formation, are well exposed in many localities of Kashmir. The best development of continuous Upper Permian to Lower Triassic marine strata is seen at Guryul ravine in the Kashmir Valley. Among Foraminifera, as many as 14 families have become extinct during the Permian period, while many new families evolved in the Mesozoic.

Over the last few decades, clear indicators of climate change are discerned in the Himalayas, including the J&K state, in the form of increasing temperatures, shrinking glaciers, and diverse precipitation patterns. The Himalayas are very sensitive to climatic variations because of its fragile environmental and climatic settings, and the impacts of the climate change on the Himalayan biota are evident. Several studies have predicted species range shifts and changes in community composition over the J&K Himalayas under the changing climate. Owing to its unique geological, geomorphic, and climatic gradients, J&K provides an ideal natural experimental system for studying the effects of climate change on a highly biodiverse mountainous area.

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## *Web Resources*

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JK Economic Survey (2013–2014) http://www.indiaenvironmentportal.org.in/files/file/J&K%20EconomicSurvey%202013-2014.pdf
Socio Economic Profile (2007–2008) http://www.ecostatjk.nic.in/publications/Socio%20Economic%20Profile%202007-08.pdf

# Chapter 7
# Vegetation of Jammu and Kashmir State: A General Account

**Vir Jee**

**Abstract** The state of Jammu and Kashmir serves as a unique bounty of nature and reveals considerable Himalayan influence in shaping its extant vegetation. The overall vegetation not only manifests a remarkable degree of differentiation but also a vivid contrast within the delineated phytochoria. In Kashmir, vast and varied extant vegetation reveals a typical blend of temperate, subalpine, and alpine elements; however, no such stratification is discernible in Ladakh in view of its spatial features. The phytosociological structure of oastic, desert, and alpine types has been analyzed along horizontal and vertical gradients, covering different mountain systems of this zone. In Jammu, the predominantly subtropical vegetation reflects some inherent peculiarities within the level land, kandi, and foothill types. However, an admixture of some temperate elements renders a transitional touch to the prevailing vegetation along Rajouri–Poonch and Doda–Kishtwar ranges. The Pleistocene events and fossil records are suggestive of major geoclimatic perturbations experienced by the State in recent geological past. As a result, only few Pleistocene taxa (conifers, birches, barberries, alders, figs, cherries, horse chestnuts, etc.) thrive in Kashmir today, while majority of them have emigrated toward more congenial habitats (Shivaliks) in the outer Himalaya. The general floristic richness and representativeness in different biomes of the State indicate a wide range of adaptive potential vis-à-vis varied environmental conditions. The alien plant invasions and biotic stress have, however, considerably increased in the recent past, and an untouched State is barely discernible. Unless conservational priorities are initiated in right earnest, this native green-gold diversity, which is the resource base for millions of people in the country, is going to get depleted in impending future.

**Keywords** General vegetation · Past vegetation · Extant diversity · Biotic stress · Jammu and Kashmir state

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_7

## 7.1 Introduction

The state of Jammu and Kashmir is divided into three political provinces: Jammu, Kashmir, and Ladakh. Following Kanth (1985), these subdivisions share a disproportionate physical area of 19%, 11%, and 70%, respectively (Fig. 7.1), and manifest a remarkable degree of individuality and isolation in their geophysical, ecogeographical, and climatic regimes. Two high-altitude passes, namely, Zoji la (3500 m) toward northeast and Pir Panjal pass (3500 m) in southwest, however, serve as notable corridors and discern a transitional character of vegetation along their respective slopes. Schweinfurth (1984) also held aspect differences quite relevant in the differentiation of vegetation. The Zanskar range guards the Valley from cold blasts of Ladakh, while the Pir Panjal range checks subtropical (Shivalik) influence of the north Indian plains. The Ravi, Chenab, Jhelum, and Sind constitute the main river systems flowing through different parts of the state, and along with their tributaries help in irrigating the level land at lower elevations. Concomitant with these diverse peculiarities, the study area is bestowed with varied ecological niches and habitat systems; these include snowcapped mountains, undulating meadows, deep ravines and gorges (Fig. 7.2), alpine peaks and glaciers, slopes and terraces, foothills and forests, plains and deserts, swamps and marshes, lakes and rivers, etc. Such an array of heterogeneous physiographic features not only supports a rich diversity of floristic wealth, but also provides an ample scope for plant speciation and diversification. The rich representation of range-restricted taxa in different biogeographic units of the study area lends much support to this assertion (Dhar and Kachroo 1983; Jee et al. 1989). Besides topographic uniqueness, climatic contrast is readily discernible and exercises a deterministic influence on vegetation pattern; the latter ranges from warm subtropical (Jammu) to extreme cold-arid desertic type

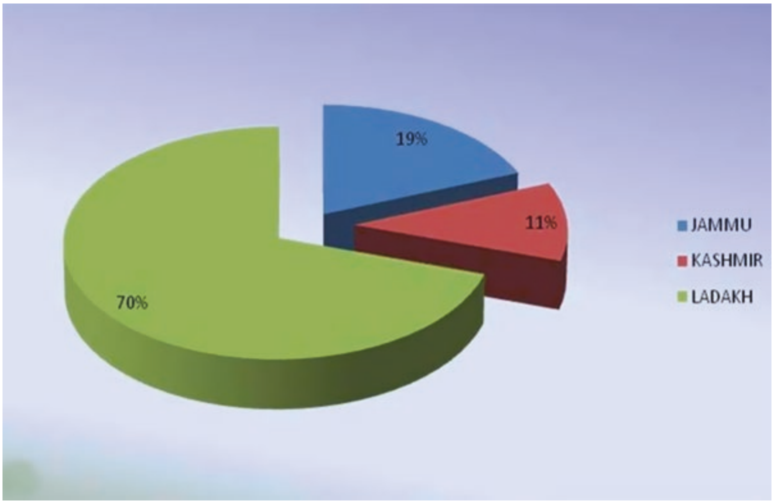


**Fig. 7.1** Provincial physical area of Jammu and Kashmir state

**Fig. 7.2** An alpine gorge across Zoji La (Gumri 3380 m)

(Ladakh) through predominantly temperate (Kashmir). Legris (1963), while discussing bioclimates of the Himalayas, grouped valleys of Jammu and Kashmir under climate of Mediterranean and subdesert cold type. Further, in each of these major vegetational groups, seasonal dynamics and broad profile structure of vegetation are equally quite revealing. Together with native floristic diversity, a number of exotic elements (roses, jasmines, carnations, irises, lilies, daffodils, and tulips) also got introduced and acclimatized over the years in different biogeographic zones of the state (Singh and Misri 1974; Singh and Kachroo 1983; Ara et al. 1995; Vidyarthi 2003; Bhellum et al. 2013, etc.) and led to an increase in its vegetation pool.

The alien plant invasions and biotic stress have, however, added a new dimension to the indigenous diversity in the recent past. Many alien invasive species have encroached upon natural ecosystems at a rapid pace and endangered their survival and sustenance under changing environmental conditions (Khuroo et al. 2009). The biotic stress is equally disconcerting and has assumed dangerous proportions in both the cis- and trans-Himalayan part of the state. Mc Neely (1985) stressed upon an immediate need for addressing this issue by reorienting conservation policies and programs with new cultural means, based on ecological, political, and economic reality so that “human” and “nature” can both prosper together.

## 7.2 Materials and Methods

A careful scrutiny of the relevant literature including floras, fascicles, monographs, and other floristic accounts pertaining to all the three phytochoria was carried out (including accounts of Royle 1839; Duthie 1893–94; Coventry 1923–1930; Blatter 1927–1929; Hooker 1872–1897; Stewart 1916, 1967a, b, 1972, 1982; Pennel 1943; Puri 1943, 1947; Rao 1960, 1961; Raven 1962; Kapoor et al.1963; Van Soest 1963; Vishnu Mittre 1963; Grierson 1964; Wali 1964; Wali and Tiku 1964; Kazmi 1970–1971; Kachroo et al. 1971, 1977; Singh and Gohil 1972; Singh and Wafai 1973; Rau 1975; Sapru et al.1975; Singh and Kachroo 1976, 1983, 1994; Kachroo 1980, 1985, 1993; Sharma and Kachroo 1981, 1983; Singh and Kiran 1981; Anonymous 1982; Dhar and Kachroo 1982, 1983; Dar et al. 1983, 1995, 2002; Hartmann 1984, 1987; Naqshi et al.1984, 1988; Gupta and Kachroo 1985; Javeid 1985; Kaul and Dar 1985; Seybold and Kull 1985; Kaul 1986; Munshi and Javeid 1986; Sharma and Jamwal 1988; Hamal et al.1990; Kak 1990; Kapur and Sarin 1990; Dar and Kachroo 1982, 1983, 1992; Ara and Naqshi 1993, 1995; Ara et al. 1995; Navchoo and Kachroo 1995; Swami and Gupta 1998; Bhellum and Magotra 1992, 1996, 2007, 2012; Dar and Naqshi 2002; Nasreen et al. 2003; Khuroo et al. 2005; Bhellum et al. 2013; Ahmed and Sharma 2014; Dad 2016; Dad and Reshi 2015).

The information thus gathered has been adequately complemented with practical experience gained while undertaking field surveys and collection trips in different parts of the state during the past three decades.

## 7.3 Results and Discussions

### *7.3.1 Geophysical Setting*

Before analyzing the vegetational spectrum, it seems plausible to dwell upon some unique geological and geohistorical perturbations experienced by different biomes of the state in geological past. Many workers (including Gondwin-Austen 1862, 1880; Lydekkar 1883; Dainelli 1922–35; Trinkler 1932, etc.) have collected substantial data and contributed handsomely to geological evolution of the State.

The Jammu hills lying outside Pir Panjal and between Jhelum and Ravi are characterized by two distinct geological formations – the Shivaliks and alluvium. The Shivalik system mostly extends north of Tawi and reveals a sedimentary character; its lower divisions resemble with Murrees, while the middle and upper parts manifest lithological similarity with adjacent salt range and Potwar plains (Wadia 1931, 1975).

De Terra and Peterson (1939) drew an analogy between the main Himalayas and Kashmir in their tectonic behavior and Pleistocene events. Koul (1977) also correlated geological history of Kashmir with the Himalayas, barring some local variations. It is now established that during ice age, the successive glacial and interglacial

**Fig. 7.3** An exquisite rugged and barren topographical feature of Lamayuru (3340 m) Ladakh

periods gave final touches to physiography of Kashmir and the shrinking remnants of old Lake Satisara (present Kashmir Valley) are today represented by the Dal, Manasbal, and Wular lakes (Sahni 1936a, b).

Ladakh (also referred to as western Tibet) is situated in highland crystalline mass of the Trans-Himalayan zone. Chatterjee (1987) traced its landscape formation through glaciofluvial processes, while Wadia (1975) attributed its abundant detrital accumulation to great insulation and insignificant precipitation. The bare mountains thus exhibit exquisite desert coloration of rocks due to peculiar solar weathering (Fig. 7.3).

### *7.3.2 Past Vegetation*

According to Meher-Homji (1971a, b), the Quaternary vegetation in India is nowhere as remarkably preserved as in Kashmir Valley and Kumaon. Guinet (1962) believed that the lower Karewas in Kashmir were grasslands during this period. The post-glacial vegetational history of Kashmir has been reviewed by various workers (Gondwin-Austen 1880; Sahni 1921, 1926, 1935; Puri 1943, 1948a, b, 1957; Rao 1958; Nair 1960; Vishnu Mittre et al.1962; Vishnu Mittre 1963, 1964; Vishnu Mittre and Sharma 1966; Tripathi and Chandra 1972, etc.) The various fossils identified by them include many forest trees and shrubs, like oaks, willows, poplars, alder, rose, rhododendron, barberry, cinnamon, holly box, etc., besides aquatics – species of *Trapa* and *Vallisneria* and members of Charophyta. These aquatic species presently inhabit different lakes of the Valley floor, while most of land plants are restricted to lower ranges in Kashmir.

The disappearance of some Pleistocene elements (oaks, laurels, *Woodfordia*, *Mallotus*, *Pittosporum*, *Myrsine*, *Rhamnus*, etc.) in the modern flora of Kashmir implies that such taxa flourished under tropical conditions. Agarwal (1988) also opined that Holocene climate was quite warmer and wetter. The subsequent change in the Valley climate, together with altitudinal expanse of Pir Panjal range, led to emigration of tropical elements towards more warm and precipitous areas of the outer Himalaya. Vishnu Mittre (1963), however, attributed extermination of oaks from the valley to anthropogenic factor, as oaks provide good fuel and thus suffered heavily at the hands of humans. Conversely, Puri et al. (1983) believed that survival of some past temperate elements (conifers, willows, poplars, cherries, walnuts, maples, elms, alders, etc.), whose modern representatives still exist in the Valley, indicates that temperate (mesic type) conditions too must have prevailed, at least in some part in the Valley during Pleistocene period. Earlier, Tripathi and Chandra (1972) also favored a shift from warm-humid climate of Pleistocene to cool-moist type prevailing at present in the Valley which, in turn, affected the vegetation. Apart from conifers, some other Pleistocene taxa still surviving in Kashmir Himalaya include *Parrotiopsis jacquemontiana*, *Berberis lycium*, *Syringa emodi*, *Betula utilis*, *Pyrus communis*, *Trapa natans*, *T. bispinosa*, and species of *Skimmia*, *Acer*, *Ulmus*, *Rhus*, *Cotoneaster*, *Spiraea*, *Aesculus*, *Clematis*, *Quercus*, etc. However, glaciations have considerably modified their vertical distribution, and majority of these taxa thrive at lower elevations today.

### *7.3.3 Extant Vegetation*

The Himalayas guarding the state in northwest has served both as a bridge and a barrier in facilitating the flux of various taxa and in promoting endemism, respectively (Mani 1978; Singh and Singh 1987). Troll (1972) first proposed a three-dimensional frame of the Himalayan vegetation reflecting a transition from south to north, southwest to northeast, and low lands to high lands. Later, Schweinfurth (1984) brought to fore a characteristic contrast in “outer Himalaya” with luxuriant monsoon forest, “inner Himalaya” with moderately moist boreal coniferous forest, and “arid Tibetan Himalaya” supporting a high-altitude steppe vegetation. He further recognized “aspect” as an important physiographic factor for vegetation characterization as manifested by Pir Panjal range in Kashmir. The south-facing slopes of this range harbor mixed oak-conifer forest, while northern slopes have the west Himalayan coniferous forest; the former receives considerable summer (monsoon) precipitation, while the latter receives winter snow. Gupta (1989), while reviewing vegetation pattern of the Himalaya, recognized “Kashmir scrub” vegetation at the foot of Pir Panjal and a subtropical, semi-desert, steppe-type vegetation in Ladakh dominated by *Artemisia maritima*. Meusel (1971) analyzed colline, montane, and subalpine vegetation of Kashmir Himalayas, and later Meusel and Schubert (1971) identified some Mediterranean plant communities in west Himalayas, in which "Kashmir scrub" discerns strong affinity with semiarid and arid vegetation of Central Asia. Mani (1978) carried out an ecological and biogeographic appraisal of the northwest Himalayas and revealed the maximum generic diversity (80–90%) within the altitudinal gradient of 3600 m to 4500 m, besides bearing floristic lineage with the Middle Asia. During the last four decades, several local botanists undertook extensive explorations in many parts of the state, which resulted in some notable publications in the form of several floras, revisions, and other floristic accounts.

Being intrinsically influenced by the Himalayan orogeny in general and that of the west- and Trans-Himalayas in particular, the state of Jammu and Kashmir finds considerable variance in the delimitation of its geopolitical units (Clarke 1898; Hooker 1906, Chatterjee 1939; Razi 1955; Kachroo, 1980; Bhat 1987, etc.). Subsequently, Rodgers and Panwar (1988) employed conservational imperatives of biodiversity in delineating these units; the latter treatment, however, requires more holistic approach and analysis (Khoshoo 1992, 1993).

The extant floristic wealth of the state is remarkably diverse (Table 7.1). Along with tropical and temperate elements, the alpine wealth is also quite significant especially in Kashmir Himalayas. The low floristic count of Jammu pertains only to small physical area (erstwhile Jammu district) and does not correspond to province as a whole. However, the floristic impoverishment of Ladakh, despite its vast geographic size (ca. 70%), is distinctly linked to its harsh and hazardous environment, characterized mainly by inhospitable climate and high-montane barren topography (ca. 74% of land above 4500 m).

The species composition and rank spectrum of some dominant families within various geopolitical units of the state (Table 7.2) reveal some interesting results.

Six of the 10 major families, namely, Asteraceae, Poaceae, Papilionaceae, Cyperaceae, Scrophulariaceae, and Lamiaceae, maintain their respective dominance within the designated phytochoria; the latter, however, is least represented in Ladakh (tenth rank). The remaining four families, namely, Brassicaceae, Ranunculaceae, Rosaceae, and Apiaceae, being essentially temperate in character, reveal codominance in Valley. Expectedly, these temperate families rank far behind in floristic wealth of Jammu in comparison to their other tropical counterparts – Euphorbiaceae, Acanthaceae, Amaranthaceae, Malvaceae, Rubiaceae, and

**Table 7.1** Floristic analysis of the state of Jammu and Kashmir

| Physical area/range | Taxonomic categories | | | Sources |
|---|---|---|---|---|
| | Families | Genera | Species | |
| Jammu (erstwhile district) | 109 | 431 | 660 | Sharma and Kachroo (1981) |
| Kashmir | 132 | 710 | 2000 | Dar and Naqshi (2002) |
| Ladakh | 74 | 324 | 1030 | Vir Jee (Unpubl.) |
| Kashmir Himalaya (incl. Ladakh) | 151 (64)[a] | 872 (381)[a] | 3054 (1610)[a] | Jee et al.(1989) |

[a]Bracketed figures are after Dhar and Kachroo (1983) for alpine/subalpine flora of Kashmir Himalaya (excl. Poaceae)

**Table 7.2** Species composition and rank spectrum in 10 dominant families of Jammu and Kashmir

| Families | Species composition | | | Rank spectrum | | |
|---|---|---|---|---|---|---|
| | J | KH | L | J | KH | L |
| Asteraceae | [a]39(52)[b] | 78 (391) | 45 (175) | 3 | 1 | 1 |
| Poaceae | 54(71) | 108(314) | 30(94) | 2 | 2 | 2 |
| Papilionaceae | 36(79) | 38(181) | 13(56) | 1 | 3 | 4 |
| Cyperaceae | 07(38) | 09(156) | 04(49) | 4 | 4 | 6 |
| Brassicaceae | 09(10) | 51(134) | 35(63) | 10 | 5 | 3 |
| Lamiaceae | 17(22) | 40(127) | 11(35) | 6 | 6 | 10 |
| Scrophulariaceae | 14(23) | 26(120) | 09(50) | 5 | 7 | 5 |
| Rosaceae | 04(05) | 20(111) | 08(34) | 15 | 8 | 11 |
| Ranunculaceae | 02(07) | 17(98) | 11(43) | 13 | 9 | 7 |
| Apiaceae | 07(07) | 41(96) | 16(25) | 13 | 10 | 14 |

[a]Number of genera
[b]Number of species within parenthesis
*J* Erstwhile Jammu district, *KH* Kashmir Himalaya (incl. Ladakh), *L* Ladakh

Verbenaceae. However, Brassicaceae holds the last rank (10th) among dominant families in Jammu. In Ladakh also, Rosaceae and Apiaceae are feebly represented in comparison to Polygonaceae, Boraginaceae, Chenopodiaceae, and Primulaceae, occupying the 8th, 9th, 12th, and 13th rank, respectively.

### *7.3.4 Vegetation Profile*

A profile of general vegetation encountered along different topographical features can be best conceived by studying inherent characteristics of the vegetational matrix within each biogeographic zone of the state.

#### 7.3.4.1 Jammu Zone

The Jammu zone, though quite variable, reveals a predominant subtropical influence in its vegetational frame. Nevertheless, some temperate elements characteristic of the Valley manifest themselves along Rajouri–Poonch and Doda–Kishtwar ranges (Singh and Kiran 1981; Bhellum and Magotra 2012). The physical proximity and geoclimatic similarity of these ranges with Kashmir have promoted such an admixture of vegetation. The recent opening of two alternate highways through these ranges would further facilitate interprovincial communication and tourist trade. Notwithstanding this, a critical analysis of the broad contours of vegetation characteristic of Jammu zone is clearly reflected in an important floristic treatise of erstwhile Jammu district (Sharma and Kachroo 1981, 1983). The general vegetation, categorized under level land, kandi, and foothills, is of dry, mixed deciduous, or scrub type with a small area under subtropical pine forest.

The level land covers a vast area south and southwest of River Tawi and is virtually devoid of any natural forest due to large-scale urbanization and cultivation. However, patches of *Butea monosperma* and *Acacia modesta* at occasional sites represent relics of past vegetation. The planted trees or their escapes mostly include *Mangifera indica*, *Syzygium cumini*, *Dalbergia sissoo*, *Acacia nilotica*, *Ficus* spp., *Crataeva* sp., and *Sapium sebiferum*. Some other trees and shrubby elements forming hedges around agricultural fields mostly include *Flacourtia indica*, *Casearia elliptica*, *Euphorbia royleana*, *Capparis* sp., *Vitex negundo*, *Lantana camara*, and *Ipomoea fistulosa*. *Calotropis procera* is a common ruderal (Fig. 7.4), while some climbers extend up to the foothills. The herbaceous species, comprising a variety of annual and perennial weeds, belong to *Argemone*, *Cassia*, *Trianthema*, *Xanthium*, *Solanum*, *Datura*, *Boerhavia*, *Euphorbia*, *Martynia*, *Cirsium*, and *Cannabis*. *Saccharum spontaneum* forms vast sandy stretches in and around the vicinity of rivers. The swampy sites are usually inhabited by species of *Typha*, *Sagittaria*, *Monochoria*, and some sedges, while *Saccharum bengalense*, *Sorghum halepense*, *Imperata cylindrica*, *Nichanthium* sp., and *Arundo donax* represent conspicuous elements of perennial grasslands.

The low-elevation dry hillocks of Kandi belt support a dense mixed xerophytic vegetation of shrubs and small trees. Three characteristic types of forests have been recognized in this belt, namely, *Acacia-Bauhinia-Ougenia* and *Lannea-Hymenodictyon* forests. The *Acacia* forests cover an extensive area along with some other sparsely distributed trees and shrubby elements (species of *Capparis*, *Adhatoda*, *Lantana*, *Ziziphus*, *Hibiscus*, *Flacourtia*, etc.). The climbers also reveal good representation and include *Tinospora cordifolia*, *Cayratia trifolia*, *Abrus precatorius*, *Trichosanthes cucumerina*, *Jasminum auriculatum*, *Telosma* sp., *and Ipomoea* spp., while the understory remains clothed with perennial grasses such as

**Fig. 7.4** *Calotropis procera* (Willd.) R.Br. – a common ruderal growing on level land in Jammu zone

*Apluda mutica*, *Bothriochloa pertusa*, *Chrysopogon fulvus*, *Dichanthium annulatum*, *Chloris dolichostachya*, and *Cymbopogon stracheys*.

*Bauhinia-Ougenia* forest is predominant on eroded sites (Fig. 7.5), together with representative species of *Emblica*, *Premna*, *Acacia*, *Zizyphus*, *Flacourtia*, and *Dalbergia*. The shrubs generally resemble those of *Acacia* forest, while climbers include species of *Ichnocarpus*, *Vallaris*, *Cryptolepis*, *Dregea*, and *Dioscorea*. *Saccharum bengalense* and *Aristida* sp. constitute additions to the usual grass flora.

*Lannea-Hymenodictyon* forest remains generally restricted to cool shady parts of hillocks. Apart from the dominant constituents, *Aegle marmelos*, *Diospyros cordifolia*, *Capparis* sp., *Adhatoda vesica*, *Bombax ceiba*, *Xeromphis spinosa*, *Mitragyna parviflora*, and *Albizzia* sp. may form scattered patches. The climbers and grasses are, however, akin to those in *Acacia* forests.

The Jammu foothills extend beyond Nagrota to Jhajar Kotli and manifest a transition from semi-deciduous tropical vegetation to subtropical chir pine type along the vertical gradient. Three main recognizable vegetational groups include *Dodonaea* scrub, mixed semi-deciduous forest, and subtropical pine forest. The former covers a vast area usually as pure formations but sometimes gets interspersed with species of *Carissa*, *Adhatoda*, *Butea*, *Elaeodendron*, *Flacourtia*, *Mallotus*, *Wendlandia*, *Colebrookea*, etc. *Atylosia scarabaeoides*, a straggling undershrub, is quite prominent here besides some sedges and usual perennial grasses of sub-hilly

**Fig. 7.5** Dense growth of *Bauhinia* L. forest on dry hillocks along Kandi belt in Jammu

areas. The mixed semi-deciduous forest is predominant on lower slopes and ravines along Nandani hills. Despite floristic richness, only few trees (*Mitragyna*, *Trema* etc.) tend to become dominant, while other inhabitant taxa showing patchy distribution include *Grewia optiva*, *Nyctanthes* sp., *Mallotus* sp., *Premna* sp., *Xylosma* sp., *Terminalia* sp., *Glochidion* sp., *Bridelia* sp., and *Ficus* spp. The shrubby vegetation is dominated by *Reinwardtia indica*, *Antidesma diandrum*, *Caesalpinia decapetala*, *Eranthemum pulchellum*, etc. and generally inhabit shady situations. The mass effect of yellow racemes of *Caesalpinia* lends charm to the vegetation during spring, while *Aechmanthera gossypina* shows floral prominence in autumn. Some typical climbers thriving in this area include *Hiptage benghalensis*, *Shuteria densiflora*, *Clematis gouriana*, *C. graveolens*, *Dregea* sp., *Porana* sp., and *Cissampleos pariera*. The grasses mostly correspond to those of Kandi area with *Themeda anathera*, *Eremopogon foveolatus*, *Paspalum commersonii*, *and Thysanolaena maxima* as additions. The pure and dense stands of subtropical pine forest (*Pinus roxburghii*) are restricted to higher ridges and steep rocky slopes (Fig. 7.6). The undergrowth is represented, besides usual grasses, by isolated patchy scrubs of *Woodfordia*, *Dodonaea*, *Carissa*, and *Nyctanthes*. At some places, *Ougenia* and *Wendlandia* trees intrude into the chir pine forest. *Euphorbia royleana* is common on sites affected severely by biotic and anthropogenic activities and remains associated with *Grewia optiva* and *Zizyphus mauritiana* near habitations.

**Fig. 7.6** A dense chir pine (*Pinus roxburghii* Sarg.) growing at Patnitop (2040 m) foothills in Jammu

**Fig. 7.7** Profile pattern reflecting vegetational transition from valley subzone to montane subzone in Kashmir

#### 7.3.4.2 Kashmir Zone

This zone is predominantly temperate and is further divisible into the Valley and montane subzones (Fig. 7.7).

(a) **Valley Subzone**

This subzone (1600 m) is mostly under cultivation and supports scattered or patches of cultivated trees (or their escapes). Chief among these are the species of *Salix*, *Populus*, *Morus*, *Robinia pseudoacacia*, *Juglans regia*, *Platanus orientalis*, *Celtis australis*, *Ailanthus altissima*, *Aesculus indica*, *Prunus armeniaca*, and *Melia azedrach*. Higher up, the level-land rice cultivation gets replaced by terrace fields of rice and maize. The shrubby elements mostly include *Berberis* sp., *Rosa* sp., etc., while herbaceous cover is dominated by *Plantago lanceolata*, *P. major*, *Cynodon dactylon*, *Stellaria media*, *Sorghum halepense*, *Capsella bursa-pastoris*, *Veronica persica*, and species of *Ranunculus*, *Medicago*, *Geranium*, *Bothriochloa*, *Echinochloa*, *and Trifolium*.

(b) **Montane Subzone**

This subzone (above 2300 m) reveals a vivid transition from temperate–subalpine–alpine vegetation. The temperate elements lying at the foot of montane slopes include pure or mixed communities of conifers, interspersed with some broad-leaved arboreal taxa. The conifers mostly include *Pinus wallichiana*, *Picea smithiana*, and *Cedrus deodara*, while broad-leaved elements mainly comprise *Crataegus oxycantha*, *Euonymus* spp., *Berberis lycium*, *Parrotiopsis jacquemontiana*, *Daphne oleoides*, *Cotoneaster numularia*, *Viburnum foetens*, *Skimmia anquetilia*, etc. The

**Fig. 7.8** *Abies pindrow* Royle in association with *Juniperus communis* L. growing on Apharwat slopes (3700 m) near the limit of subalpine range in Kashmir

ground cover is inhabited, besides the forbs, by such elements as *Fragaria vesca*, *Origanum vulgare*, *Delphinium denudatum*, *Oxalis acetosella*, *Ferula sp.*, *Primula rosea*, *P. denticulata*, *Gentiana carinata*, *Anemone obtusiloba*, *Veronica spp.*, *Corydalis diphylla*, *Podophyllum hexandrum*, etc. Higher up in subalpine range, the above arboreal elements usually start dwindling, while *Abies pindrow* assumes dominance (Fig. 7.8) along with *Padus cornuta*, *Acer caesium*, and *Prunus prostrata. Taxus wallichiana* is rarely present. The herbaceous components include *Anemone tetrasepala*, *Iris hookeriana*, *Euphorbia wallichii*, *Fritillaria roylei*, *Callianthemum spp.*, *Sedum spp.*, *Buplurum spp.*, *Corydalis govaniana*, *Aconitum laevae*, *Leonotopodium spp.*, etc. From subalpine to alpine zone, *Abies* is gradually replaced by *Betula utilis*, the latter represents last tree element in Kashmir; sometimes both occur together. Some dwarf shrubs frequently encountered in this area include prostrate willows (*Salix flabellaris*, *S. karelina)*, *Juniperus communis*, *Lonicera quinquelocularis*, *Rhododendron campanulatum* (Fig. 7.9), and *R. hypenanthum*. The understory is dominated by characteristic taxa such as *Saxifraga flagellaris*, *Polygonum affine*, *Salvia hians*, *Picrorhiza kurroa*, *Bergenia himalaica*, *Meconopsis aculeta*, *Papaver nudicaule*, *Aconitum heterophyllum*, *Gentiana kurroa*, *Allium humile*, *A. thomsonii*, *Saussurea* spp., *Androsace* spp., *Aquilegia nivalis*, *Paraquilegia* sp., and *Dolomiaea macrocephala* (Fig. 7.10), etc.

**Fig. 7.9** *Rhododendron campanulatum* D. Don – a typical alpine shrub in Kashmir mounts

In general, the vegetation pattern of Kashmir is almost similar on all high-mountain ranges with minor topographical differences. For example, *Cedrus* may not be as frequent anywhere as in Lolab valley; *Bergenia* is more common on northern slopes, while *Wulfenia amherstiana* on the southern slopes. Dhar and Kachroo (1983) attributed general similarity in community pattern and profile structure along Kashmir mountains to their same age and endemic behavior.

#### 7.3.4.3 Ladakh Zone

Despite extreme environmental conditions, the vegetation wealth is quite significant and reveals widest transition in Suru Valley (Zanskar) due to Nun-Kun peaks and glaciers. This Himalayan range acts as a barrier for the moist-laden rain clouds from the Arabian Sea, with the result that little rain gets across the alpine ranges of Ladakh, Rupshu, and Tibet. Kachroo et al. (1977) designated the area as an alpine forest scrub zone, while Stewart (1972) related it to "dry Tibetan zone." In sharp

**Fig. 7.10** *Dolomiaea macrocephala* DC. – an alpine rosette plant growing at Razdan pass (4300 m) Kashmir

contrast to Kashmir vegetation, natural forests are altogether absent here. The exotics, now naturalized in some parts, include species of willows and poplars. The arboreal elements represent some indigenous trees (*Juglans regia*, *Ulmus parviflora*, *Prunus armeniaca*, etc.) and shrubs (*Juniperus squamata*, *Hippophae rhamnoides*, *Myricaria prostrata*, *Elaegnus hortensis*, *Caragana pygmaea*, *Berberis lvcium*, *and Rosa* sp.). These usually occur in the vicinity of streams, river banks, and settlements, serving as a means for food, fodder, and timber. The herbaceous flora is very significant and thrives up to 5000 m or even more. The overall vegetation envisages a significant modification to withstand the extremes of natural environment. The plants are usually xerophytic and represented by dwarf perennials, tufted grasses, sedges, thistles (Fig. 7.11), cushioned, and rosette types (Durani et al.1975; Jee 2012).

Although vegetation structure is quite diverse, yet a distinct profile cannot be visualized in view of spatial features. Stewart (1916) first attempted to study the vegetational zonation of Ladakh and grouped it into three types, namely, oastic, desert, and alpine, characterized by marked differences in their constituent elements. These types are briefly described below:

(a) **Oastic Type**

The introduction of agriculture has led to the formation of this vegetation (Fig. 7.12). The melt water from the high-altitude mountains is diverted to irrigate the low land. At the edges of the villages and near stream banks sprout both indigenous and exotic elements like *Hippophae rhamnoides* and species of *Salix*, *Populus*, *Myricaria*, and *Rosa*. These trees and shrubs in turn provide shelter for many damp-

**Fig. 7.11** *Cousinia thomsonii* Clarke – a spinescent desert thistle growing at Bodhkharbu (3305 m) Ladakh

**Fig. 7.12** Agricultural activity along oastic sites in Suru valley (Zanaskar)

loving taxa, including *Plantago lanceolata*, *Ranunculus lobatus*, *Clematis orientalis*, *Centaurea iberica*, *Ranunculus pulchellus*, and *Lepidium apetalum*.

(b) **Desert Type**

The desert vegetation covers a vast area between oastic and alpine types and is mostly adapted to thrive on barren and sandy–loam soils with insignificant precipitation. Such arid desert conditions support sparse and isolated vegetation, comprising *Nepeta spicata*, *Ephedra gerardiana*, *Corydalis adiantifolia*, *Christolea*

**Fig. 7.13** *Waldheimia nivea* (H. & T.) Regel – an alpine growing among boulders at Khardung La pass (6200m) Ladakh

*crassifolia*, *Echinops cornigerus*, *Euphorbia tibetica*, *Artemisia* spp., *Chrysanthemum tibeticum*, *Tanacetum artemisioides*, *Physochlaina praealta*, and *Youngia tenuifolia*, etc.

(c) **Alpine Type**

The alpine vegetation is mostly confined to high-mountain regions which lie in close proximity with glaciers and snow cover. During summer, the melt water supports alpine vegetation which mostly comprises *Saussurea sacra*, *Sedum tibeticum*, *Astragalus tibetanus*, *Lloydia serotina*, *Saxifraga flagellaris*, *Dracocephalum heterophyllum*, *Senecio tanacetum*, *Cerastium bungeana*, *Valeriana himalayana*, *Waldhemia nivea* (Fig. 7.13), *Potentilla bifurca*, *Brachyactis umbrosa*, *Lactuca tatarica*, and *Swertia thomsonii*.

No doubt the above classification categorizes the entire vegetation into three broad groups, but it does not provide sufficient data on different patterns along varied mountain chains. This limitation was overcome by Dhar et al. (1994) by considering vegetation analysis along both the horizontal and vertical gradients together with degree of swing in major groups in transitional mountain system (TMS), Zanskar mountain system (ZMS), and Ladakh mountain system (LMS).

## 7.4 Concluding Remarks

The vegetation of Jammu and Kashmir is quite diverse, thriving in several ecosystems with unique roles and functions in the biological context. Located at the cross roads of various floristic regions, together with considerable influence offered by the Himalayan orogeny, geologic recency, and Pleistocene events, the three geopolitical units (provinces) of the state manifest a striking contrast in their corresponding topographic, geoclimatic, and vegetation pursuits. The profile pattern of vegetation, typified by predominantly subtropical Jammu, temperate Kashmir, and arid Ladakh, reveals many inherent peculiarities within the constituent types. Floristically, the area discerns considerable richness, which conforms to its strong evolutionary activity and speciation potential. Besides, many areas of the state in general and Ladakh in particular have remained floristically underexplored due to inaccessible terrain, strategic situation, and inhospitable climate, thereby leaving ample scope for future expeditions and explorations to enrich the native stock of biodiversity. Some notable contributions already attempted in this direction include those of Sharma and Kachroo (1981), Anonymous (1982), Bhellum and Magotra (1992), and Dar et al. (1995).

Notwithstanding such a phenomenal diversity, a floristic compendium of the state is still lacking. No doubt, during the past few decades, a number of floristic accounts have been attempted, but these remain largely confined either to a particular taxonomic category or to a specific area. Therefore, even after the lapse of more than a century, one is still bound to rely largely on Hooker's *The Flora of British India* (1872–1897) for gathering information about the native plant diversity abounding the state. Another ailing factor is the paucity of grid system which provides a dot map of geographic range of each species. The availability and wider application of this system would definitely help in monitoring location-specific data for evaluating and refining specific attributes of the vegetation matrix. The alien plant invasions and biotic stress have added a new dimension to the extant vegetation of the State in recent past (Figs. 7.14 and 7.15). Apart from natural stresses, increased anthropogenic factors involving deforestation and urbanization, mining and industrialization, transhumance and grazing, fuelwood gathering and forest fires, tourist influx and trekking tourism, etc. have obliterated many habitat systems in the state and rendered them quite vulnerable. Walker (1992), while emphasizing upon functional attributes of an ecosystem, remarked that all species in an ecosystem are not created ecologically equal; some act as determinants or "drivers," while others as "passengers." The loss of the former could trigger cascading effects in comparison to latter in the rest of the ecosystem. In a similar context, Joshi and Joshi (2004) stressed upon conservation of "key stone" species in regulating sustenance of an ecosystem. Tucker (1987) explicitly documented extensive deforestation in the western Himalayas during the nineteenth century when vast quantities of wood were extracted for construction of extensive railway network in India. In this backdrop, extension of GIS network, as suggested by Bawa (1993), could go a long way in assessing the biodiversity loss by comparing past and present structure and

**Fig. 7.14** *Parthenium hysterophorus* L. (congress grass) – an alien species gregariously invading level land in Jammu

**Fig. 7.15** Deforestation taking its toll along Pir Panjal range (3100 m) in Kashmir

distribution patterns of vegetation and subsequently help in devising effective conservation strategies in order to save the region from diverse eco-crises.

**Acknowledgments** The author expresses gratitude to his teacher and guide – Late Professor P. Kachroo, former Head, Department of Botany, University of Kashmir, for stimulating interest even in metaphysical form. Special thanks are also due to Dr. U. Dhar, Ex-Director, G.B. Pant

Institute of Himalayan Environment and Development, Almora (Uttrakhand), for providing constant encouragement, guidance and generous help. Sincere thanks are extended to Professor (Dr.) G. H. Dar, Ex-Fellow, Mahatma Gandhi Chair on Ecology and Environment, BGSB University, Rajouri (J&K) for providing an opportunity for this write-up. Dr. Koushal Samotra, Principal, Government P.G. College for Women Gandhi Nagar, Jammu, is equally acknowledged for providing working facilities and support.

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# Chapter 8
# Forest Ecosystems of Jammu and Kashmir State

**Shiekh Marifatul Haq, Anzar A. Khuroo, Akhtar H. Malik, Irfan Rashid, Rameez Ahmad, Maroof Hamid, and Ghulam Hassan Dar**

**Abstract** Forests play critical ecological and socio-economic roles by providing life-supporting ecosystem goods and services to humankind, including provisioning (e.g. food, fuel and timber), regulating (e.g. climate, water and soil conservation), and cultural (e.g. recreation) services. In the recent past, increasing anthropogenic pressure on forest ecosystems has altered their structure and functioning. The present chapter deals with the forest ecosystems of Jammu and Kashmir (J&K) state, with an aim to analyse their vegetation composition, structure, distribution, current threats and conservation needs. Six major forest types can be recognized in the J&K; these are (1) subtropical dry evergreen, (2) subtropical broad-leaved, (3) subtropical pine, (4) Himalayan moist temperate, (5) Himalayan dry temperate and (6) subalpine forests. Currently, the forest ecosystems in J&K are increasingly impacted by a variety of human disturbances, such as deforestation, habitat loss and fragmentation, land encroachment, biological invasion, fire, overexploitation of forest resources and overgrazing. Hopefully, the present synthesis on forest ecosystems of J&K will provide a baseline for scientific understanding of their rich biodiversity to enable undertaking effective initiatives for long-term conservation and management of these fragile ecosystems.

**Keywords** Forest ecosystems · Community architecture · Jammu and Kashmir · Threats · Conservation

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_8

## 8.1 Introduction

The common idea of general public is that the forests are just a collection of trees. However, they are much more than that. They are complex functional systems of interacting and interdependent biological, physical, and chemical components. Food and Agriculture Organization (FAO 1998) defines a forest as ‘land with a tree canopy cover of more than 10% and an area of more than 0.5 hectare’. Forests constitute one of the largest, complex and most important natural ecosystems, mostly dominated by trees. These include both closed forest formations, where trees of various forms and undergrowth cover a high proportion of the ground, and open forest formations with a continuous herbaceous layer in which trees cover at least 10% of the ground. Of course, trees are the most conspicuous component in forest ecosystems, but the wide variety of other life forms and the biotic components in different forest types are also important. The other elements, such as wildlife, soil type, litter and associated shrubs and herbs, are equally important in forest ecosystems. Forest ecosystem represents a basic ecologic unit in a natural landscape that serves as an abode for biotic community. It is characterized collectively by constituent biotic and abiotic components that coexist together in symbiosis to create a unique ecosystem (Mori 2017).

The diverse assemblages of species within a forest ecosystem, shaped by environmental as well as anthropogenic variables, are necessary to generate and support the fundamental ecological functions and the resultant ecosystem services they provide (Shaheen et al. 2012; Bisht and Bhat 2013). In mountainous regions, such as the Himalayas, many factors – slope, aspect, edaphic factors, vegetation type and altitude – determine the community composition, structure and distribution pattern of different forest types (Kessler 2001; Schmidt et al. 2006; Sharma et al. 2009, 2010; Gairola et al. 2011; Khan et al. 2015; Ullah et al. 2015). In the Himalayas, forest-dominated mountainous ranges are complex and dynamic ecosystems that provide a wide range of forest-based resources for the inhabitants, as well as for people residing in foothills and plains (Grêt-Regamey et al. 2013). The forest and forest-based resources possess priceless economic and ecological values, being directly linked with agriculture, fodder, fuel wood, timber, resins, fruits and compost source, promoting the mountain springs recharge (Valdia 1998; Maren et al. 2014; Dhyani and Dhyani 2016). The local communities are directly and/or indirectly dependent on the forest ecosystems for their sustainable livelihood (Rasul 2014; Tiwari and Joshi 2015).

Among the terrestrial ecosystems, forests particularly have been threatened by anthropogenic disturbances, such as deforestation, loss and fragmentation of habitats, fire, climate change and pollution. Consequently, diverse life forms, often in higher numbers in forests than in other terrestrial ecosystems, are increasingly at risk (Schmitt et al. 2009). This demands thorough understanding of the forest ecosystems, which are home to huge biodiversity and have been sustaining humankind since its setting foot on the planet Earth. The reported forest and tree cover of India is 78.29 mha (23.81%) of its geographical area (FSI 2011). The forest ecosystems of the country are extensively diverse. Champion and Seth (1968) classified forests of India into 6 'major groups' ranging from tropical to alpine, 16 'groups' and more than 200 'group categories'. According to this classification, forest type is a unit of vegetation having physiognomic and structural features so pronounced that it appears distinct from other units.

The Himalayas, one of the richest and ecologically important mountainous landscapes on the planet Earth, supports a variety of forest types due to wide altitudinal and climatic variations from the lower hills to alpine peaks (Mani 1978). The Jammu and Kashmir (J&K) state, forming a part of the Himalayan biodiversity hotspot, harbours a rich forest wealth. As per Champion and Seth's classification scheme, forests of J&K can be categorized under seven types: subtropical pine, subtropical dry evergreen, Himalayan moist temperate, Himalayan dry temperate, subalpine and moist alpine forests and dry alpine scrub. Singh and Singh (1987) classified the Himalayan vegetation into 11 forest formations on the basis of leaf characters (leaf drop pattern, leaf size, texture, shape) and elevation, but they did not use the term 'alpine' because they considered Himalayan conditions as not analogous to those of the Alps. Furthermore, in view of its typical temperate climate, some local foresters pleaded to recognize forests of the Kashmir Valley under a distinct subtype, 'Kashmir Valley Temperate Forests' (Inayatullah and Ticku 1964, 1965, Kawoosa 1977, Ticku 1978, Wadoo and Zadoo 1980, Kema 1983). Accordingly, Dar et al. (2002) have classified the forests of Kashmir into three main groups: Kashmir temperate forests, Kashmir subalpine forests and Kashmir alpine forests. The first of these corresponds to groups 12 (Himalayan moist temperate forests) and 13 (Himalayan dry temperate forests) of Champion and Seth's classification and is very diverse with several subtypes (see Dar et al. 2002). Notwithstanding this, so far, research efforts on forest ecosystems in this biodiversity-rich Himalayan region have been inadequate. As of now, there is little information available on scientific characterization of different forests types occurring in the state. It is in this context that the present study aimed to analyse the vegetation composition, structure, distribution, current threats and conservation needs in the forest ecosystems of Jammu and Kashmir.

## 8.2 Materials and Methods

### *8.2.1 Study Area*

The state of J&K, located along the north-western boundary of the Himalayas, in its entirety has an area of 2,22,236 km$^2$, of which about 101,387 km$^2$ is presently under Indian administration which constitutes ca. 24% of total land area of the Indian Himalayan region. The state lies between 32°17′ and 37°05′ N latitudes and 72°31′ and 80°20′ E longitudes. It is divided into three biogeographic provinces – Jammu, Kashmir and Ladakh, which differ in terms of climate, physiography and culture

(Husain 2001). Climatically, cold-desert-like conditions prevail in Ladakh, continental temperate climate occurs in the Kashmir Valley, while the subtropical climate of Jammu is characterized by very hot summer and monsoon rains during June–August (Joshi et al. 2001). The recorded forest area of the state is 2,023,041 hectares (20,230.41 $km^2$) which constitutes 19.95% of its present geographical area and 2.62% of the country's forest cover, with 18% very dense, 39% moderately dense and 43% open forests (FSI, 2017). The species-wise cover reveals that *Abies pindrow* covers 17% of the total forest area, followed by *Pinus wallichiana* 10%, *Pinus roxburghii* 9%, broad-leaved species 9% and *Cedrus deodara* 5%. According to the *India State of Forest Report-2017*, the details of circle-wise forest divisions and their area are given in the Table 8.1.

Generally, a forest type is defined by a common set of characteristics that make the forest of a particular area unique. These sets of forest conditions are characterized to isolate and classify the structural patterns that continually reoccur in a particular forest type. In the present study, each forest type has a two-part name that describes the dominant tree species that form the canopy and the habitat. The classification of forest vegetation follows a physiognomic–ecological approach. The clustered species are said to be associated with each other and to be members of a biotic community. In a community, every species is not equally important, some species are dominant, some species are rare and most are intermediate in abundance. Thus it is the relative scale of importance of each species that collectively gives the community its unique physiognomy. These forest communities are then named for the dominant overstorey tree (s) and key indicator plant species that live together in the understorey.

### *8.2.2 Field Survey and Sampling*

The forest sampling sites were surveyed in the representative forest types across the state of J&K. The working plans of different forest divisions of J&K were also consulted for the verification of details. After the reconnaissance survey, six major forest types were recognized, and sampling was undertaken. These include (i) subtropical dry evergreen, (ii) subtropical broad-leaved, (iii) subtropical pine, (iv) Himalayan moist temperate, (v) Himalayan dry temperate and (vi) subalpine forests. The selected forest types were named according to the classification given by Dar et al. (2002) and Reddy et al. (2015). At each selected forest site, communities and their vegetation structure were characterized on the basis of external appearance along the vertical structure and the dominant growth forms in the canopy layer.

**Table 8.1** Details of forest administrative circles and divisions with their area in Jammu and Kashmir state

| Region | Forest circle | Forest division | Area in hectares |
|---|---|---|---|
| **Kashmir** | **Srinagar** | Budgam/Tangmarg | 76,588 |
| | | Sindh | 37,956 |
| | | Bandipora | 199,396 |
| | | **Total** | 313,934 |
| | **South** | Shopian | 81,270 |
| | | Anantnag | 96,016 |
| | | Liddar | 106,591 |
| | | **Total** | 283,877 |
| | **North** | Langate | 35,495 |
| | | Kamraj | 71,146 |
| | | Kehmil | 62,472 |
| | | Baramulla | 45,906 |
| | | **Total** | 215,019 |
| **Ladakh** | **Central** | Leh | 2937 |
| | | Kargil | 651 |
| | | **Total** | 3588 |
| **Jammu** | **East** | Jammu | 79,289 |
| | | Kathua | 46,364 |
| | | Billawar | 68,247 |
| | | Ramnagar | 37,065 |
| | | Udhampur | 60,465 |
| | | **Total** | 291,430 |
| | **West** | Poonch | 95,137 |
| | | Rajouri | 71,456 |
| | | Nowshera | 58,600 |
| | | Reasi | 45,039 |
| | | Mahore | 89,563 |
| | | **Total** | 359,795 |
| | **Chenab** | Kishtwar | 138,775 |
| | | Bhaderwah | 89,116 |
| | | Doda | 62,146 |
| | | Ramban | 48,279 |
| | | Batote | 31,631 |
| | | Marwah | 185,451 |
| | | **Total** | 555,398 |
| **Grand total** | | | 2,023,041 |

### 8.2.3 Crown Density

The crown density of the selected forest sites was estimated by visual observation. For this, a small hole was made in leaf/paper, and then sky or crown cover hits and steps were counted. The value, which is less in count across both diagonals of the sampling plot, is used to determine the crown density of the sampled forest site.

$$\text{Canopy density}\left(\%\right)=\frac{\text{Number of canopy hits}}{\text{Total number of steps}}\times 100$$

### 8.2.4 Soil Classification

The standard USDA (1999) soil taxonomy was followed up to order and suborder level for the classification of soil in the different forest types (Fitzpatrick 1983).

## 8.3 Results and Discussion

### 8.3.1 Forest Types

The present study has recognized the following six broad types of forest ecosystems in the J&K State: (i) subtropical dry evergreen, (ii) subtropical broad-leaved, (iii) subtropical pine, (iv) Himalayan moist temperate, (v) Himalayan dry temperate and (vi) subalpine forests (Plate 8.1). The community composition, structure, soil, regional distribution and other attributes of each of these forest types is given as follows:

(i) **Subtropical Dry Evergreen Forests**

This forest type possesses evergreen trees and shrubs, including thorny species. More than 75% of trees remain green throughout the year. The canopy is never without green foliage, normally growing in areas having a prolonged hot and dry season. It generally has trees with shiny leaves that have a varnished look. Shrubby growth predominates. Annual herbs and grasses are commonly seen during and after monsoon rains. *Pinus roxburghii* is the top canopy tree species. *Cassia fistula*, *Flacourita indica*, *Lannea coromandlica*, *Mallotus philippinesis*, *Quercus incana* and *Wendlandia heynei* form the first and second storey in these forests. The associated shrubs are *Adhatoda vasica*, *Colebrookea oppositifolia*, *Cotoneaster microphyllus*, *Dodonaea viscosa*, *Ipomoea carnea* and *Rubus ellipticus*. The herbs and ferns are *Adiantum venustum*, *Cassia tora*, *Conyza canadensis*, *Dryopteris stewartii*, *Fragaria nubicola*, *Pennisetum purpureum* and *Thymus linearis*. The soil type

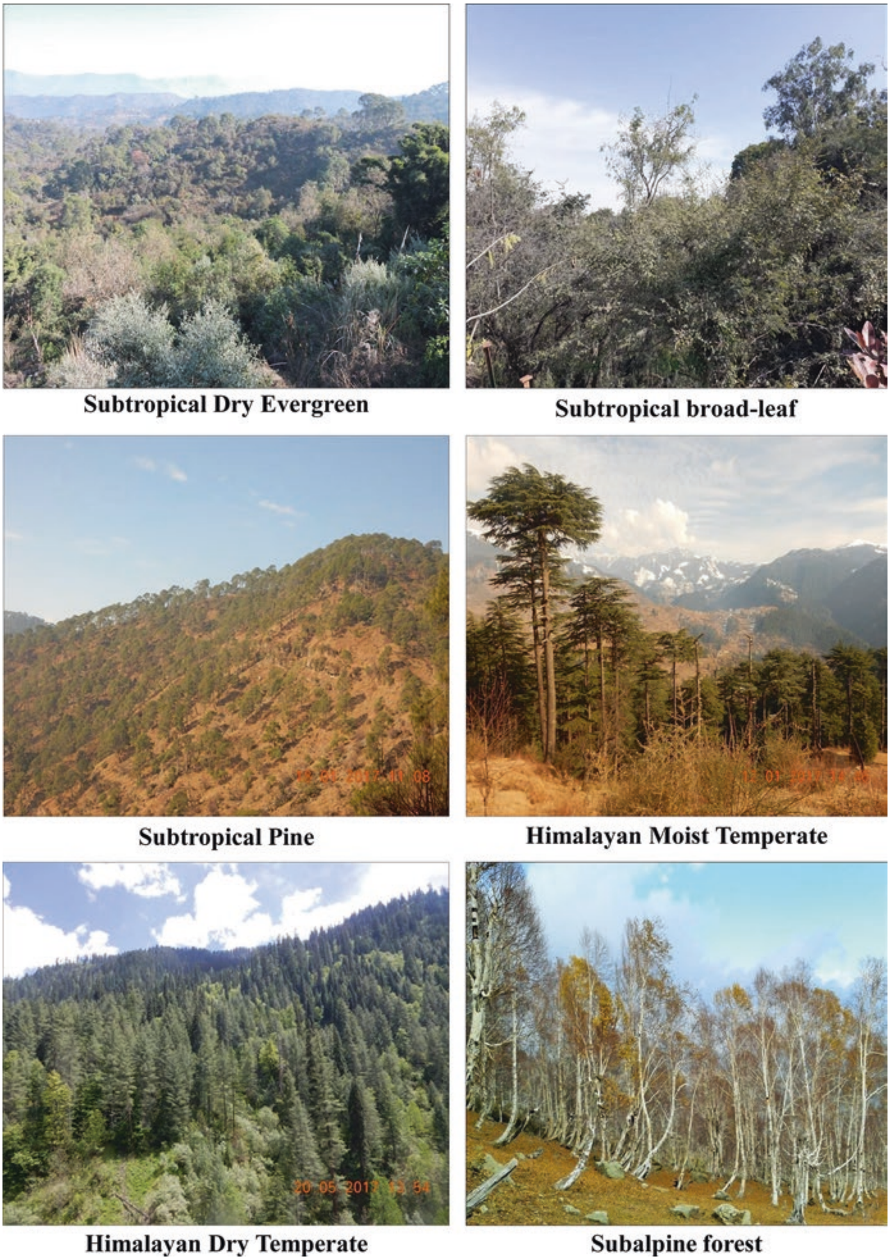


**Plate 8.1** Forest types of Jammu and Kashmir State

is mainly oxisols with red, yellow or grey colour and less quantity of organic matter. The humus is brown to black, having a thickness of 1–2.5 cm. This forest type occurs along an altitudinal range of 800–1800 m (asl), mostly found in Nowshera, Jammu and Rajouri forest divisions, particularly in Lamberi, Sunderbani, Kalidhar and Rajouri forest ranges. Our field studies show that the regeneration in this forest type is quite low with a canopy cover of 45–60%. The anthropogenic disturbances in these forests include grazing, lopping, cutting and forest fire.

(ii) **Subtropical Broad-Leaved Forests**

The vegetation is a mixture of wet evergreen and temperate forests. These forests show luxuriant growth of evergreen species and are rich in bamboos and creepers. In this forest type, board-leaved tree species, such as *Acacia modesta* and *Lannea coromandlica*, form the top canopy. *Cassia fistula*, *Dalbergia sissoo* and *Flacourtia indica* form the first- and second-storey canopy. The associated shrubs are *Adhatoda vasica*, *Lantana camara*, *Mallotus philippinesis*, *Murraya koenigii* and *Ziziphus mauritiana.* The associated herbaceous layer includes *Ageratum conyzoides*, *Cymbopogon martini*, *Cynodon dactylon*, *Daucus carota*, *Oplismenus undulatifolius* and *Parthenium hysterophorus.* The soil type is ustox, belonging to the suborder of oxisols. The soils are usually red and dry but are moist for at least 90 days per year; and the most nutrients are concentrated in the upper few inches with low levels of fertility. The humus is brown, having a thickness of 1.5–2.5 cm. Being limited to lower slopes of the Himalayas in the state, these forests are restricted within an altitudinal range of 400–600 m (asl). They occur in Kathua and Jammu forest divisions, particularly in Kathua, Samba and Bahu forest ranges. The natural regeneration in this forest type is very low, and it has a canopy cover of 30–40%. These forests are under high biotic pressure from local population and are severely affected by the shifting cultivation, forest fires and grazing.

(iii) **Subtropical Pine Forests**

The vegetation in this forest type has predominance of evergreen conifers, mostly pines, and is considerably influenced by periodic fires. The shrubs are few, climbers mostly absent, but the annual and bulbous herbs are quite common. *Pinus roxburghii* forms the top canopy, whereas *Cassia fistula, Mallotus philippinensis* and *Pyrus pashia* form the understorey canopy. The associated shrub species are *Berberis lycium*, *Carissa spinarum*, *Cotoneaster microphyllus* and *Ipomoea carnea.* The major portion of the ground in these forests is covered by the litter of *P. roxburghii* needles, leaving little chance for the growth of understorey layer. The associated herbs and ferns in this forest include *Adiantum venustum*, *Ageratum conyzoides*, *Conyza canadensis*, *Dryopteris stewartii*, *Fragaria nubicola*, *Heteropogon contortus*, *Oplismenus undulatifolius*, *Parthenium hysterophorus*, *Pteris cretica*, *Taraxacum campylodes*, *Thymus linearis* and *Trifolium pratense.* The soil is torrox, belonging to suborder of oxisols; they are predominantly red with little organic matter and high base saturation. Humus is brown, 0.5–1 cm in thickness. This forest type is prone to seasonal fires, mainly during the dry season. In J&K State, this forest type occurs along an altitudinal range of 500–1600 m (asl), being mostly found along the steep dry slopes in Jammu, Billawar, Reasi and Mahore forest divisions, particularly in Thakarkot, Jindrah, Ramkot and Gulabgarh forest ranges. The regeneration in this forest type is moderate, and it has a canopy cover of 40–75%. Currently, the anthropogenic disturbances in these forests are grazing, lopping, cutting, resin extraction and fire.

(iv) **Himalayan Moist Temperate Forests**

The conifers predominate in these forests, with tree height ranging from 20 to 40 m. The deciduous shrubs form the undergrowth cover. Mosses and ferns are abundant on branches of trees. Luxuriant herbaceous vegetation grows during summer after the winter snowmelt and rains during rainy season. *Cedrus deodara* is the top canopy tree; *Abies pindrow* and *Pinus wallichiana* with a few broad-leaved tree species such as *Pyrus pashia*, *Quercus dilatata* and *Q. incana* form the first and second canopy, respectively. The associated shrubs are *Berberis lycium*, *Carissa spinarum*, *Hedera nepalensis*, *Indigofera heterantha* and *Sarcococca saligna.* The associated herb and ferns are *Achillea millefolium*, *Adiantum venustum*, *Ageratum conyzoides*, *Asplenium ofeliae*, *Cirsium wallichii*, *Conyza canadensis*, *Dryopteris stewartii*, *Fragaria nubicola*, *Thymus linearis*, *Pennisetum purpureum, Saccharum spontaneum, Geranium wallichianum*, *Taraxacum campylodes* and *Viola odorata.* The soil type is mainly ultisol of mid to low latitudes called humults, mainly dark in colour with low natural fertility. The humus is brown to black, with a thickness of 1.5–2.5 cm. In J&K, this forest type occurs along an altitudinal range of 1700–2100 m (asl), mostly found in Udhampur, Ramnagar and Billawar forest divisions, particularly in Basantgarh, Dudu and Bani forest ranges. The regeneration in this forest type is moderate, and it has a canopy cover of 55–75%.

(v) **Himalayan Dry Temperate Forests**

These forests comprise a variety of pure and mixed stands of coniferous and broad-leaved tree elements. The conifers dominate this forest type, with abundant shrubby species forming the understorey. *Cedrus deodara* and *Pinus wallichiana* cover the top canopy in these forests; *Abies pindrow*, *A. spectabilis*, *Picea smithiana* and *Taxus wallichiana* with a few broad-leaved species, such as *Acer caesium*, *Celtis australis* and *Prunus cornuta*, form the first and second canopy storey. The shrubs associated are *Berberis lycium*, *Parrotiopsis jacquemontiana*, *Rosa webbiana*, *Sorbaria tomentosa*, *Skimmia anquetilia* and *Viburnum grandiflorum*, also with subshrubs such as *Sambucus wightiana*. The herbaceous layer grows luxuriantly during the summer season. The herbs are *Aconitum heterophyllum*, *Atropa acuminate*, *Ajuga parviflora*, *Dactylorhiza hatagirea*, *Digitalis purpurea*, *Fragaria nubicola*, *Geranium robertianum*, *Persicaria amplexicaulis*, *Phytolacca acinosa*, *Polygonatum acuminatifolium*, *Primula denticulata*, *Stipa sibirica*, *Thalictrum cultratum*, and *Trillium govanianum*. The climbers, such as *Hedera nepalensis*, *Smilax aspera* and *Dioscorea deltoidea*, are present in this forest type. The soil type is orthods, belonging to the suborder of spodosols; it has coarse texture and is usually acidic and infertile, with reddish-brown or black subsoil. The humus is black, with a thickness of 2.5–3 cm. This forest type occurs along an altitudinal range of

1500–3000 m (asl). It is commonly found in the Kamraj, Kehmil, Baramulla, Langate, Budgam, Anantnag, Lidder, Shopian, Tangmarg and Bandipora forest division of the Kashmir region. The regeneration in this forest type is relatively fast, and it has a canopy cover of 65–80%. The anthropogenic disturbances in these forests are grazing, lopping, cutting, road construction, etc.

(vi) **Subalpine Forests**

These forests comprise almost pure stands of *Betula utilis*, which occur at high altitudes between 3000 and 3500 m (asl) in the subalpine zone. *Abies pindrow*, *A. spectabilis* and *Betula utilis* cover the top canopy in this forest type, with a few broad-leaved trees, such as *Acer caesium*, *Prunus cornuta* and *Sorbus lanata*, forming the second canopy storey. The shrubs associated are *Juniperus squamata*, *Rhododendron campanulatum*, *Rosa webbiana*, *Salix denticulata* and *Viburnum grandiflorum.* The herbaceous layer grows luxuriantly during the summer season. The common associated herbs are *Aconitum chasmanthum*, *A. heterophyllum*, *Atropa acuminata*, *Ajuga parviflora*, *Bergenia ciliata*, *Fragaria nubicola*, *Jurinea dolomiaea*, *Persicaria amplexicaulis*, *Salvia hians Sedum ewersii and Sibbaldia cuneata*. The regeneration in this forest type is low, and it has a canopy cover of 55–70%. The anthropogenic disturbances in these forests are grazing, lopping, fire and tourism. The soil type is of spodosols, tending to be acidic and infertile, with coarse texture, reddish brown or black subsoil. The humus is brown to black, with a thickness of 1.5–3 cm. This forest type is common in the Tangmarg, Kamraj, Lidder, Sind, Shopian and Bandipora forest divisions.

### *8.3.2 Currents Threats*

The Himalayan forests in general and the J&K forests in particular are currently facing many threats and are considered to be among the world's most threatened forests (Shaheen et al. 2015). In the past three decades, there has been 24% loss of forest cover in the entire Indian Himalaya range (Behera et al. 2018). Despite their immense ecological and economic importance, the forests in the region are increasingly subjected to the threats, such as habitat loss and fragmentation, primarily incurred through agricultural expansion, the establishment of invasive alien species, overgrazing deforestation and degradation, fire, overexploitation of forest resources, land-use change and urbanization (Plate 8.2).

- **Deforestation**

Food and Agriculture Organization (FAO 2010) of United Nations defines deforestation as the conversion of forest to another land use or the long-term reduction of the tree canopy cover below the minimum 10% threshold. In J&K, unplanned and unsustainable human activities are the major cause of forest destruction, whether for the industries or to make space to grow our food. The major impact of these activities has been on the forest ecosystems, due to increasing demand for transfer of

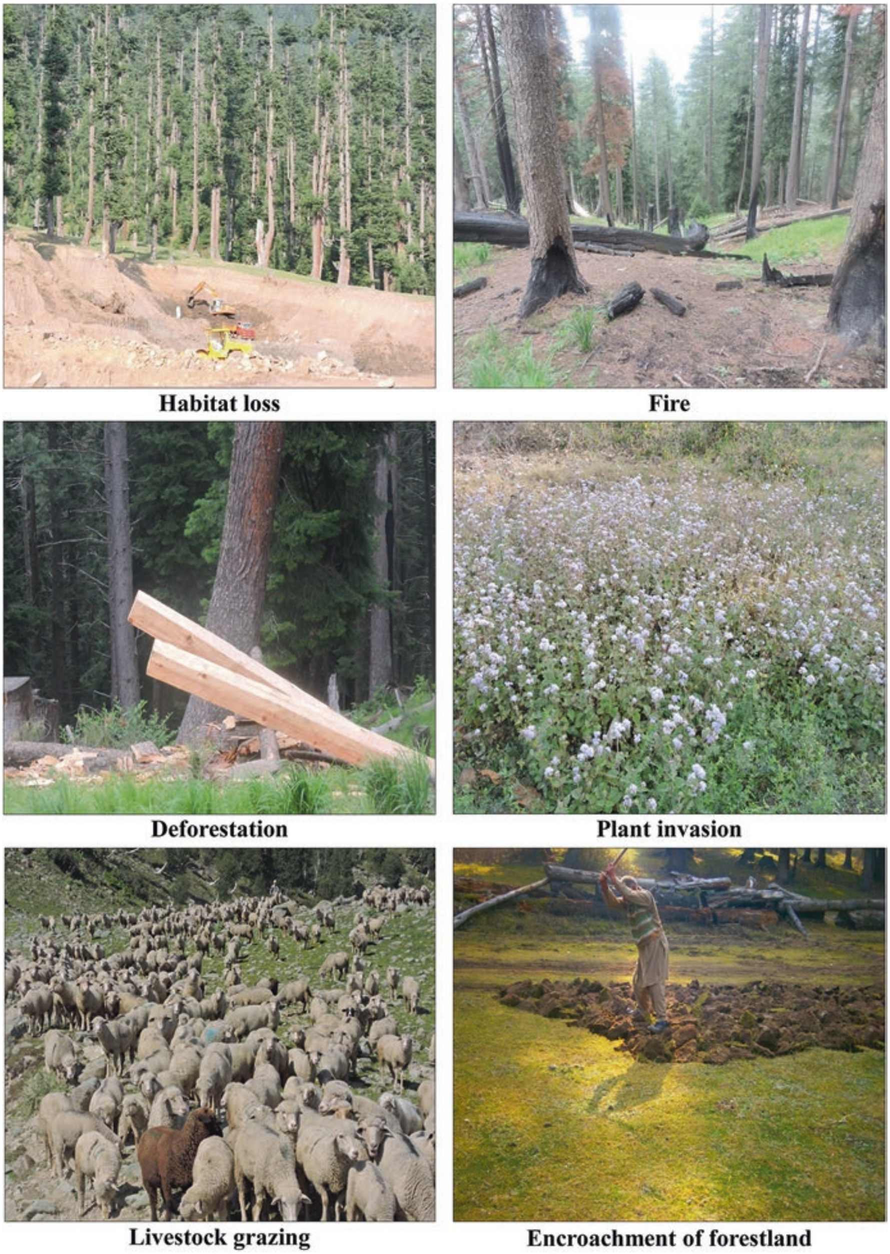


**Plate 8.2** Threats to forests of Jammu and Kashmir State

forestland for various non-forestry uses. In addition to this, massive annual loss in forest area happens due to unabated degradation of existing natural forests, mainly through timber extraction and logging activities. The growing forest-land diversion, particularly for human developmental activities, has been very harmful for the wealth of overall forest ecosystem in the state. A development project starts by destroying the forest vegetation even before it goes into production. The process begins with building of infrastructure in the form of roads, railway lines, township, offices, etc. Construction of linear corridors in fragile landscapes of hilly areas alters the stability of mountain slopes and damages the vegetation cover and the natural environment. The construction of roads has adversely affected the ecological balance in all the hilly areas of the J&K state. In most cases, the construction of these roads in forest areas happened without giving much consideration to the environmental issues. For instance, large-scale deforestation is underway for the construction of National Highway (NH1) from Jammu to Srinagar. Similarly, the Bahu forest range in Jammu division is under high biotic pressure due to construction of infrastructure in this forest area. Similarly, the forests lying in almost all tourist resorts of the state have suffered a lot by way of construction of roads, buildings and other infrastructure for accommodating ever-increasing rush of tourists. Increased demand of timber has led to intense pressure on forests of the State which has led to illicit felling of trees.

- **Loss of Habitat and Fragmentation**

Food and Agriculture Organization (FAO 2010) of United Nations defines habitat loss as the conversion of former habitat (forest) to an area where that species can no longer exist, be it still forest or not. The forest fragmentation is the cause of habitat loss and refers to any process that results in the conversion of formerly continuous forest into patches of forest separated by non-forested land. The fragmentation transforms large continuous vegetation or landscape patterns into smaller patches by disturbances. Land-use changes are collectively a major driver of the biodiversity crisis via habitat loss and fragmentation (Sala et al. 2000, Foley et al. 2005). Human-induced forest fragmentation factors include land use (e.g. agriculture, grazing) and construction of residential areas, roads and other infrastructure (Haq et al. 2019). It leads to land degradation, producing several ill impacts on forest ecosystems. The fragmentation of habitats creates forest gaps, which alter microclimatic conditions and make them favourable for spread of invasive weeds at the cost of native flora. In almost all the forest ranges in J&K, the pace of fragmentation of forest habitats is fast which can lead to loss of habitats for the native flora. The soil erosion along the hill slopes may also alter future soil productivity. Soil movement in the streams, lakes, etc. may deteriorate water quality and change the geomorphic and hydrologic characteristics of these systems (Murtaza and Romshoo 2014, Romshoo and Rashid 2014). As a result of the increased soil erosion, delivery of the sediment in large quantities to water bodies may also affect aquatic animals and their habitats.

- **Invasive Alien Species**

The invasive alien species (IAS) are those naturalized plants that produce reproductive offspring, often in very large numbers, at considerable distances from parent plants and thus have a potential to spread over a considerable area (Richardson et al. 2000; Khuroo et al. 2007). The IAS can impact forests through herbivory, predation, habitat change, competition, alteration of gene pools via hybridization with natives and disease (as either pathogens or vectors). They can alter the native diversity, nutrient cycles and forest succession and alter ecosystem pools and fluxes (Dale et al. 2001). The effects of IAS should be considered concurrently with changes in native species' distribution and abundance that occur as a consequence of climate change (Hansen et al. 2001). In the Himalayan dry temperate forests of J&K, invasive species, such as *Conyza canadensis* and *Leucanthemum vulgare*, and trees, such as *Aesculus indica*, *Ailanthus altissima*, *Robinia pseudoacacia*, have invaded many open and degraded patches. Invasive shrub species, such as *Lantana camara*, have invaded the subtropical broad-leaved forests. Some of invasive herbs, such as *Parthenium hysterophorus*, *Ageratum conyzoides* and *Cassia tora*, have invaded the subtropical pine forests. These IAS have overall negative ecological impacts in these forest ecosystems (Khuroo et al. 2007). The fragmentation of forests into patches is prone to edge effects, and the edges are favourable for spread of invasive weedy species. For instance, the Sunderbani forest range in the Jammu region is invaded by the invasive herb *Cassia tora* that is spreading fast. The Kathua, Samba and Bahu forest ranges are invaded by notorious invasive plants, such as *Lantana camara*, *Parthenium hysterophorus* and *Ageratum conyzoides* – all spreading rapidly in these forests.

- **Encroachment of Forestland**

The forests of J&K are facing the threat of encroachment by locals. While increase in the population is the root cause of encroachment, forestland conversion for agriculture and other purposes has also accelerated in the recent past. The escalating land prices have further intensified this practice in the rural areas. The most evident impact of weak forest protection practices is the violation of forest boundaries through organized land mafia. The forest boundaries are also penetrated through illegal peripheral occupation by communities living around the forests. They first encroach upon some treeless piece of land or even land with scattered trees inside the forest area and then start cultivation in it, followed by construction of huts. This way, vast expanses of forestland have been encroached upon in the Rajouri, Poonch, Kathua, Kamraj, Kehmil, Langate, Tangmarg, Liddar, Shopian and Sind and other forest divisions in the state of J&K.

- **Overexploitation of Forest Resources**

The overexploitation of forest resources such as resin, timber, medicinal plant and other nontimber products is another threat to the J&K forests. The overextraction of resin in the chir pine (*Pinus roxburghii*) forests, mostly in the Jammu region, makes them prone to wind-breaking and fire and susceptible to various types of infectious agents. The deeper cut in the stem and excessive use of acid, both in quantity and concentration, are injurious to the living tissues of the tree. The formation of rills, and leaving of interspaces between the adjoining rills, leads to the drying of trees. Breaking by wind and frequent fires also accelerate the process of drying. Tali et al. (2015) reported that medicinal plants of the Kashmir Himalayas are ruined at an alarming rate as a result of extraction and overexploitation. The overharvesting of non-timber forest products, such as wild fruits and medicinal plants, particularly *Trillium govanianum*, *Bergenia ciliata*, *Atropa acuminata* and *Aconitum heterophyllum*, by local inhabitants residing near the forest areas has greatly increased in the forest divisions including Tangmarg, Kamraj, Kehmil, Langate and Baramulla.

- **Overgrazing**

The illegal grazing and overgrazing in the forest ecosystems is also a serious threat (Dar et al. 2006) and has been primarily responsible for forest degradation. The trampling of the forest soil in the course of overgrazing by livestock has far-reaching effects, such as loss of porosity of soil, soil erosion, and desertification of the previously fertile forest area. The seedlings and saplings are damaged, thus having adverse impacts on the natural forest regeneration and growth (Malik et al. 2016).

- **Forest Fires**

Forest fire may be defined as freely spreading combustion that consumes the natural vegetation occurring in that forest area due to natural or artificial means. The frequency, intensity, size, seasonality and type of fires depend on weather and climate, in addition to forest structure and composition. Fire initiation and spread depend on the amount and frequency of precipitation, the presence of ignition agents and conditions (e.g. temperature, relative humidity, fuel availability and distribution, topography and wind velocity) (Dale et al. 2001). When fire runs out of control, it is known as wild fire. Fire, even if it is non-stand replacing, consumes litter, small live branches, foliage and organic soil horizons. During fire, an immediate transfer by combustion of a portion of ecosystem carbon to the atmosphere takes place (Harden et al. 2000). The effect of fire on different forest types is not equal. Depending upon the type of vegetation and climatic conditions, the same fire can prove beneficial for one ecosystem and may be dreadful for the other (Whelan 1995). It is the fact that the limited and controlled forest fires have proved very useful for healthy forest growth however at the same time the uncontrolled forest fires can destroy thick forest cover within no time. Besides direct loss to forest cover, forest fire also affects wildlife greatly, degrades soil quality and damages environment at a large scale (Alexander and Cruz 2017). Patterns of forest regeneration are determined by interactions between the disturbance regime (i.e. intensity, frequency, scale) and the biology of species (i.e. life history, physiology, behaviour) (Kennard et al. 2002).

The most damaging impact of forest fire on ecosystem is very evident in the Himalayas, where hills between the altitudes of 1000 to 1800 m are dominated by *Pinus roxburghii* and seem to be more fire prone. In J&K, the forest types mostly affected by fire are the subtropical pine and subtropical dry evergreen forests. These forest types are common in the Jammu region, particularly in Billawar, Ramnagar, Nowshera, Jammu, Rajouri, Ramban, Batote, Reasi and Mahore forest divisions. The surface forest fire is the most common in these forest ranges. Although the forest fire can occur throughout the year, its incidence is common in dry season, mainly during summer and autumn seasons. The crucial period of forest fires in the state is from ending May to mid-June (FSI, 2017). Due to dry weather condition and prolonged drought during these seasons, the litter of chir pine easily catches fire. The main cause of forest fires in the state is the careless activities of local people and nomadic shepherds. The forest smugglers also contribute to these fires. The trespassers and nomads by careless scattering of burning butts and matches on the forest floor often cause forest fires. Forest fire is also intentionally ignited by the locals living adjacent to forests for the purpose of land clearing.

### *8.3.3 Need for Conservation*

The conservation strategies to address various threats faced by forests are influenced by the importance of the forest, the naturalness of the threat and the range of acceptable management options. However, current understanding of the threats provides roadmap for forest management. The management plan in dealing with various forest threats/disturbances can involve managing before the disturbance. These include putting in place regulations that limit the introductions of invasive alien species and enhance habitat recovery by altering structure through facilitating regeneration and planting alternative tree species. Managing the disturbance itself, for example, fire, can be managed during the disturbance through preventive measures that affect the intensity or frequency of the disturbance. The recovery efforts can focus either on managing the state of the system immediately after the disturbance (e.g. deforestation and degradation) or managing to speed recovery (e.g. planting and regeneration) and reducing the vulnerability to future disturbances. Monitoring for adaptive management programme should be used to determine how disturbances affect forests and to continually update the understanding of how land use and climate changes are potentially influencing the disturbance regimes. Such information is crucial in initiating management actions and to optimize the desired outcomes.

Keeping in view the severity of the problem, the J&K State Forest Policy approved in 2011 lays special emphasis on the role of forest in water conservation, livelihood support for the local communities, poverty alleviation, protection of forestland from encroachment and climate change mitigation. Recently, under the Compensatory Afforestation Fund Management and Planning Authority (CAMPA), conservation programmes for afforestation, regeneration of forest ecosystem, development and management of forests and wildlife protection have been initiated. The degraded forests are fenced, and nurseries are developed in different forest divisions of J&K to realize the objectives of the conservation programmes. Nonetheless, more efforts are required to increase the participation of local communities in the conservation of forests through socio-economic reforms and ecological evaluation of forests, with focus on conserving specific forest types and vulnerable areas. By providing information on resource management alternatives, forest conservation and sustainable management can be achieved through furnishing alternative livelihood opportunities to local communities, which will eventually reduce pressure on forest ecosystems.

## 8.4 Concluding Remarks

Forests draw their importance from the ecosystem goods and services that they supply. These goods and services have been perceived as free benefits by the society with virtually infinite potential, while the forestland has been seen as land readily available for conversion to other uses. Given the complexity of society's demands for a wide range of goods and services from the forests, maintaining and restoring biodiversity in forests can promote their resilience to human-induced pressures. The present chapter on forest ecosystems of J&K offers crucial baseline data that will facilitate undertaking biodiversity conservation initiatives and effective management of these fragile ecosystems.

**Acknowledgements** The authors are thankful to the Head, Department of Botany, University of Kashmir for providing working facilities. The support of the research scholars at the Centre for Biodiversity & Taxonomy, University of Kashmir, is highly acknowledged. The financial support by National Remote Sensing Centre (NRSC), Hyderabad, India under the project *Measurement of Vegetation and Biomass Parameters Under Vegetation Carbon Pool Assessment* is also acknowledged. Thanks are due to the Principal Chief Conservator Forests, Government of Jammu and Kashmir, India, for permission and support during field work in the study area.

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# Chapter 9
# Aquatic Ecosystems of Jammu and Kashmir State

**Manzoor A. Shah, Ayaz B. Shah, and Zafar A. Reshi**

**Abstract** The aquatic ecosystems are of pivotal significance in view of provisioning of a range of valuable economic goods and invaluable ecosystem services. The state of Jammu and Kashmir has exceptionally great diversity of these ecosystems, and this aquascape comprises an integral part of its paradisiac landscape. The greater proportion of aquatic ecosystems reported in this state is represented by lakes, followed by wetlands and rivers. These aquatic ecosystems also vary in their altitudinal amplitude. The overall assessment of the distribution pattern of aquatic bodies reveals their more occurrences at high altitudes, followed by mid- and low altitudes, respectively. These aquatic bodies harbour rich diversity of macrophytes, phytoplankton, zooplankton and macrofauna. However, the aquatic ecosystems of this Himalayan state are over the years under tremendous anthropogenic pressures, and their ecological status has significantly deteriorated. In this direction, the present chapter provides an overview of diversity of aquatic ecosystems in the state, with a bird's-eye view of their biodiversity status. Subsequently, the major threats to these ecosystems are highlighted and some management models discussed.

**Keywords** Ecosystems · Aquascape · Lakes · Wetlands · Biodiversity · Jammu and Kashmir State

## 9.1 Introduction

The aquatic ecosystems provide a range of valuable economic goods and invaluable ecosystem services. The state of Jammu and Kashmir, in view of its characteristic climatic, physiographic, cultural and ethnic diversity across three main territories (Jammu, Kashmir and Ladakh), abounds in enchanting diversity of aquatic ecosystems. These aquatic systems include wetlands, lakes, rivers, springs and streams

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_9

along altitudinal and trophic status gradients. There are some spectacular, crystal-clear alpine lakes on one hand and some highly polluted lakes and wetlands on the other hand, coexisting in the region. Overall, these biodiversity-rich aquatic ecosystems support a multitude of aquatic species. The high-altitude lakes situated above 4000 m in the Pir Panjal Himalayan Range and in Ladakh are devoid of macrophytic vegetation, whereas the lakes situated in the pine forest zone of the Pir Panjal and Kashmir valley have well-developed stratified vegetation.

The lakes are characterized by typical zonation of plant communities and associated biotic assemblages. While the central open water zone has submerged plants, though with flowers and fruits above the water surface, in the relatively shallower waters, there are rooted floating-leaf type plants that have their leaves floating on the surface of water. Along lake margins, the emergent plants stand in water with greater portion visible above water surface. Small, free-floating plants occur in the shallow waters and along lake margins. A characteristic feature of Kashmir lakes is the presence of floating islands, which are strips of land artificially created and towed along from place to place and used for growing crops and horticultural plants.

## 9.2 Materials and Methods

### *9.2.1 Aquatic Ecosystems*

Aquatic ecosystems include all environments where water is a dominant physical and chemical factor affecting plant and animal survival. Aquatic systems can be categorized by their relative position on a gradient of wetness, ranging from deep-water lake and marine habitats dominated by planktonic algae to shallower ponds, rivers and estuaries often dominated by floating or submerged plants, including freshwater and saltwater wetlands that can support rooted emergent plants tolerant of continuous to intermittent flooding. Since water is the basis for all life on Earth, human and environmental systems are inextricably linked with aquatic ecosystems.

Aquatic systems can be broadly classified into two major categories: freshwater and marine. Freshwater ecosystems differ from marine ones in several ways. The amount of salt present is much less, the temperature of water can change greatly, the water is in the process of moving to the ocean, oxygen can often be in short supply and the organisms that inhabit freshwater systems are different. Freshwater ecosystems can be generally divided into several categories, such as streams and rivers, wetlands, lakes, ponds and pools. A brief description of these categories is provided as follows:

#### 9.2.1.1 Streams and Rivers (Lotic)

Lotic ecosystems refer to systems with rapid-flowing waters that move in a unidirectional way. Since the water in streams and rivers is moving, planktonic organisms are less important than the attached ones. Most algae grow attached to rocks and other objects on the bottom. This collection of attached algae, animals and fungi is called the periphyton. Since the water is shallow, light can penetrate easily to the bottom (except for large or extremely muddy rivers). Even so, it is difficult for photosynthetic organisms to accumulate the nutrients necessary for growth, and most streams are not very productive. As a matter of fact, the major input of nutrients is from organic matter that falls into the stream from terrestrial sources.

#### 9.2.1.2 Lakes, Ponds and Pools (Lentic)

Lentic ecosystems are still waters such as lakes and ponds that have a community of biotic (living organisms) and abiotic (physical objects) interactions. The species found in freshwater lakes are different from those found in the ocean, but the roles played are by and large similar, and as such, almost similar terminology is used. Along the shore and in the shallower parts of lakes, many kinds of flowering plants are rooted in the bottom. Some have leaves that float on the surface or protrude above the water and are called emergent plants. Cattails, bulrushes, arrowhead plants and water lilies are examples. Rooted plants that stay submerged below the surface of the water are called submerged plants, for example, *Chara*. Many kinds of freshwater algae also grow in the shallow water where they may appear as mats on the bottom or attached to vegetation and other objects in the water. Associated with the plants and algae are a large number of different kinds of animals. Fish, crayfish, clams and many kinds of aquatic insects are common inhabitants of this mixture of plants and algae.

#### 9.2.1.3 Wetlands

Wetlands are areas where water is the primary factor controlling the environment and the associated plant and animal life. They occur where the water table is at or near the surface of the land or where the land is covered by water. The Ramsar Convention, an international watchdog of wetland conservation, defines wetlands as ‘areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres’. Wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface (Cowardin 1978). Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation and other factors, including human disturbance. Indeed, wetlands are found from the tundra to the tropics and on every continent except Antarctica. The best examples of wetlands include swamps and marshes, where the water is completely or partially shallow. Biologically, wetlands are known to be too diverse as they harbour numerous animal and plant species. Plants, such as water lilies, mangrove, tamarack and sedges, are commonly found in wetlands, besides various species of reptiles and amphibians. Many swamps and marshes are successional States that eventually become totally terrestrial communities.

## 9.3 Results and Discussion

Jammu and Kashmir is a landlocked state having no marine ecosystems but abounding in enchanting diversity of freshwater ecosystems. As per the report of the Department of Ecology, Environment and Remote Sensing (National Wetland Atlas, Jammu & Kashmir 2010), this Himalayan state is dotted with more than 1200 lakes and water bodies. Inventory of water bodies in western Himalayan Region: Part 1 (J&K, 1999–2000) and other field surveys carried out by different workers enlisted 50 water bodies (Fig. 9.1) in Jammu and Kashmir (excluding the areas administrated by Pakistan and China). The greater proportion of aquatic ecosystems reported in this state is represented by lakes, followed by wetlands and rivers (Fig. 9.2). These aquatic ecosystems also vary in their altitudinal amplitude (Fig. 9.3). The overall assessment of the distribution pattern of water bodies reveals their many more occurrences at high altitudes, followed by mid- and low altitudes, respectively.

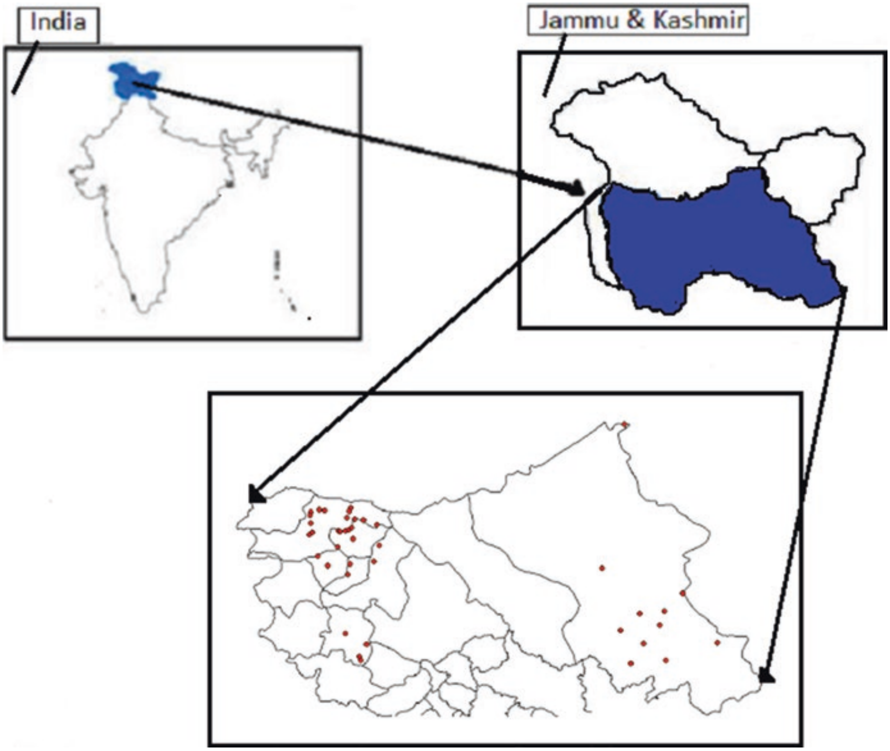


**Fig. 9.1** Map showing distribution of water bodies in Jammu and Kashmir. Red dots represent major aquatic ecosystems of the state

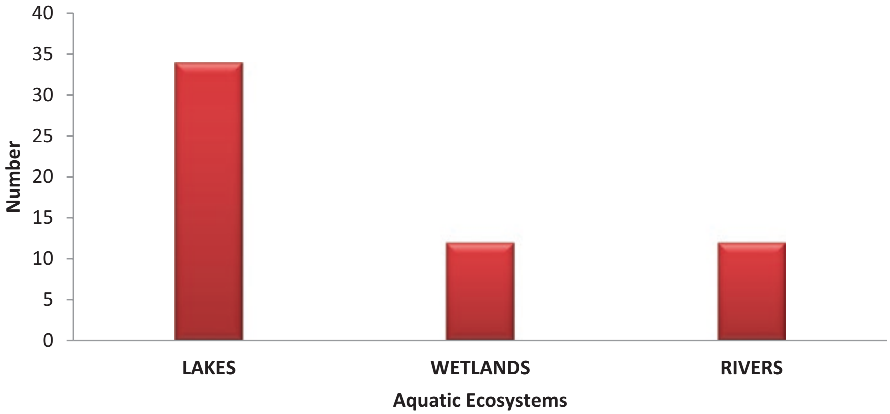


**Fig. 9.2** Proportion of different aquatic ecosystem types in Jammu and Kashmir state. (*Sources:* Inventory of water bodies in the Western Himalayan Region: Part 1 (J&K) 1999–2000; field surveys by authors)

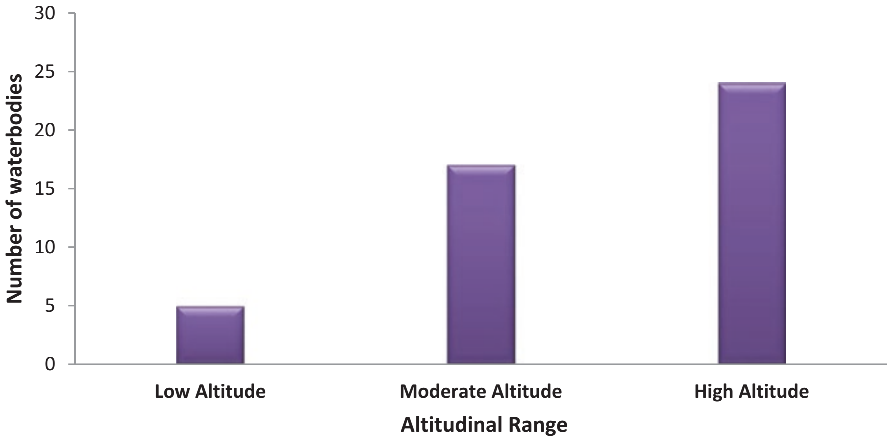


**Fig. 9.3** Distribution of aquatic ecosystems along altitudinal gradient in Jammu and Kashmir

### *9.3.1 Lakes of Jammu and Kashmir State*

The lakes of Jammu and Kashmir have been known for centuries for their serene and pristine beauty. Most of the lakes in the state are remnants of ancient oxbows created by numerous rivers as they meandered within the valleys. Having a complex and vibrant ecosystem, the lakes also became the centre of life for the inhabitants of the state. These lakes and other waterways of Kashmir have had a profound influence on the people. A balance and interdependence between human and nature developed; as a result, a unique culture emerged on the banks of these lakes surrounded and protected by the Himalayan mountains on all sides. Lakes of the state are listed in Table 9.1.

**Table 9.1** Distribution of lakes in Jammu and Kashmir

| Name of lake | District | River basin | Latitude | Longitude | Elevation (m asl) |
|---|---|---|---|---|---|
| Dal | Srinagar | Jhelum | 34° 06′ 25″ | 74° 50′ 10″ | 1586 |
| Gangabal lake | Ganderbal | Jhelum | 34° 27′ 33″ | 74° 54′ 56″ | 3569 |
| Marsar | Srinagar | Jhelum | 34° 07′ 18″ | 75° 08′ 30″ | 3849 |
| Nigeen lake | Srinagar | Jhelum | 34° 08′ 45″ | 74° 49′ 23″ | 1604 |
| Nundkol | Ganderbal | Jhelum | 34° 26′ 45″ | 74° 55′ 45″ | 3607 |
| Anchar lake | Srinagar | Jhelum | 34° 09′ 22″ | 74° 47′ 30″ | 1584 |
| Nilnag | Budgam | Jhelum | 33° 51′ 22″ | 74° 41′ 36″ | 2180 |
| Bodh Sar | Budgam | Jhelum | 33° 50′ 47″ | 74° 26′ 18″ | 3956 |
| Tarsar | Anantnag | Jhelum | 34° 08′ 00″ | 75° 10′ 08″ | 3785 |
| Sheshnag | Anantnag | Jhelum | 34° 13′ 24″ | 75° 8′ 25″ | 3572 |
| Konsar nag | Pulwama | Jhelum | 33° 30′ 21″ | 74° 50′ 00″ | 3585 |
| Gadsar | Ganderbal | Jhelum | 34° 24′ 51″ | 75° 04′ 38″ | 3810 |
| Gundi-I- Khalil | Baramulla | Jhelum | 34° 13′ 18″ | 74° 36′ 23″ | 1569 |
| Krishansar | Ganderbal | Jhelum | 34° 24′ 12″ | 75° 05′ 35″ | 3819 |
| Madmattisar | Bandipora | Jhelum | 34° 31′ 17″ | 74° 54 50″ | 4449 |
| Salnaisar | Bandipora | Jhelum | 34° 28′ 14″ | 74° 53′ 00″ | 4055 |
| Vishansar | Ganderbal | Jhelum | 34° 23′ 27″ | 75° 06′ 48″ | 3677 |
| Manasbal | Ganderbal | Jhelum | 34° 16′ 05″ | 74° 38′ 38″ | 1600 |
| Trigam | Ganderbal | Jhelum | 33° 17′ 23″ | 75° 43′ 33” | 1510 |
| Tilwan | Ganderbal | Jhelum | 34° 22′ 33″ | 74° 53′ 49″ | 1565 |
| Mansar | Udhampur | Chenab | 32° 41′ 30″ | 75° 07′ 30″ | 700 |
| Surinsar | Udhampur | Chenab | 32° 47′ 21″ | 75° 00′ 48″ | 736 |
| Sanasar | Udhampur | NA | 33° 07′ 32″ | 75° 15′ 35″ | NA |
| AmtoGor | Leh | Shyok | 35° 08′ 28″ | 79° 43′ 18″ | NA |
| Kartso | Leh | Indus | 33° 19′ 35″ | 77° 56′ 45″ | 4537 |
| Kyule Tso | Leh | Indus | 33° 26′ 00″ | 78° 26′ 57″ | 5400 |
| Kyun Tso | Leh | Indus | 32° 55′ 46″ | 78° 34′ 00″ | 5000 |
| Pangong Tso | Leh | Shyok | 33° 40′ 58″ | 78° 40′ 39″ | 4250 |
| Startsapuk Tso | Leh | Indus | 33° 15′ 48″ | 78° 00′ 00″ | 4337 |
| Tazangkuru Tso | Leh | Indus | 33° 06′ 23″ | 78° 15′ 53″ | 4800 |
| Tso Kar | Leh | Indus | 33° 04′ 14″ | 79° 05′ 32″ | 4225 |
| Yaye Tso | Leh | Indus | 33° 19′ 05″ | 78° 26′ 14″ | 4800 |
| Yusup Tso | Leh | Indus | 33° 27′ 41″ | 78° 27′ 30″ | 5400 |

*Sources*: Inventory of water bodies in the Western Himalayan Region: Part 1(J&K) 1999–2000; field surveys (2011–2013) of Kashmir Himalayan aquatic ecosystems by authors

### *9.3.2 Wetlands of Jammu and Kashmir State*

The state of Jammu and Kashmir is dotted with several wetlands (Table 9.2) that play a highly significant role in maintaining the hydrological regimes of the entire Valley. There are varied assessments of the extent of wetlands within the Valley, owing to difference in the interpretation of definition of wetlands. The present assessments, ranging from 236.5 km$^2$ (Space Applications Center 1998) to 256 km$^2$

**Table 9.2** Distribution of major wetlands in Jammu and Kashmir

| Name of wetland | District | River basin | Latitude | Longitude | Elevation |
|---|---|---|---|---|---|
| Nambi Narku | Srinagar | Jhelum | 34° 03′ 37″ | 74° 45′ 34″ | 1583 |
| Rakhi Gandkashah | Srinagar | Jhelum | 34° 05′ 53″ | 74° 46′ 23″ | 1583 |
| Naranbagh | Srinagar | Jhelum | 34° 58′ 49″ | 74° 51′ 19″ | 1587 |
| Bod Sar | Pulwama | Jhelum | 34° 02′ 18″ | 74° 55′ 43″ | 1593 |
| Unnamed | Pulwama | Jhelum | 33° 55′ 48″ | 74° 55′ 08″ | 1591 |
| Hygamjhil | Baramulla | Jhelum | 34° 15′ 06″ | 74° 32′ 28″ | 1569 |
| Rakhi Malang | Baramulla | Jhelum | 34° 18′ 59″ | 74° 38′ 56″ | 1538 |
| Unnamed | Baramulla | Jhelum | 34° 24′ 10″ | 74° 39′ 01″ | 1581 |
| Hokersar | Budgam | Jhelum | 34° 06′ 02″ | 74° 43′ 08″ | 1584 |
| Tso Moriri | Leh | Indus | 32° 48′ 16″ | 78° 12′ 51″ | 4527 |
| Gharana | Jammu | Tawi | 32° 50′ 28″ | 74° 35′ 04″ | 400 |
| Wular | Bandipora | Jhelum | 34° 19′ 15″ | 74° 30′ 42″ | 1580 |

*Sources:* Inventory of water bodies in the Western Himalayan Region: Part 1(J&K) 1999–2000, field surveys (2011–2013) of Kashmir Himalayan aquatic ecosystems by authors

**Table 9.3** Brief description of the major rivers in Jammu and Kashmir

| River | Course | Source | Approx. length (km) |
|---|---|---|---|
| Indus | Tibet–Pakistan | Mansarovar lake | 3180 |
| Markha | Ladakh | Markha valley | NA[a] |
| Jhelum | Kashmir–Pakistan | Verinag | 813 |
| Chenab | Chenab valley–Pakistan | Lahaul and Spiti, Himachal | 960 |
| Dras | NA[a] | Machoi glacier | NA |
| Suru | NA | Zanskar | NA |
| Doda | NA | Drang-Drung | NA |
| Shingo | NA | NA[a] | NA |
| Ravi | India and Pakistan | NA | 720 |
| Nubra | NA | NA | NA |
| Shyok | NA | Rimo glacier | 550 |
| Tawi | NA | Kali-kudi glacier | NA |

[a]NA denotes not available

(National Wetland Inventory, Salim Ali Centre for Ornithology and Natural History 2001), are significantly underestimated considering the comprehensive definition of wetlands on hydrological basis.

### *9.3.3 Major Rivers in Jammu and Kashmir State*

The state of Jammu and Kashmir is home to many rivers. Most of the rivers (Table 9.3) of the state have their origin in the Himalayas. River Jhelum is the sole important river in the Himalayan mountain range that runs across the Kashmir basin. The Tawi, Indus, Chenab and Ravi are the other important rivers running across the state. The longest rivers in the state are Chenab, Jhelum and Indus. All these rivers have their head waters in the Himalayan mountain range. The Ganges and Yamuna are two great rivers of India that also have their sources in the same mountain range. River Indus has its source in the Lake Mansarovar, situated in the Tibetan territory.

## 9.4 Biodiversity in Aquatic Ecosystems

Floristic assemblage of freshwater body reflects the ecosystem's structural and functional complexities. Macrophytes contribute to the general fitness and diversity of a healthy aquatic ecosystem (Flint and Madsen 1995) by acting as indicators for water quality and aiding in nutrient cycling (Carpenter and Lodge 1986). Misra (1994) for the first time in India made comprehensive ecological studies pertaining to habitat analysis and vegetation dynamics of aquatic ecosystems. Since then, a number of reports have appeared mostly pertaining to floristic composition and zonation patterns (see, e.g. Mirashi 1954; Sen 1959; Jha 1965; Gopal 1990; Sahai and Sinha 1969). Similar reports have appeared in the past on Jammu and Kashmir aquatic ecosystems with more dent towards water bodies of Kashmir Valley (Zutshi 1968; Zutshi and Vass 1976, 1978, 1982; Kaul et al. 1978; Kak 1981, 1982, 1990; Anand and Sharma 1991).

### *9.4.1 Biotic Components of Aquatic Ecosystems*

The biotic component in the aquatic ecosystems includes both primary and secondary producers, as well as the consumers. Amongst the producers, the dominant components are macrophytes and phytoplankton. Diverse kinds of macrophytes, including emergents, rooted floating-leaf and submerged types, depending upon water depth and associated factors inhabit the aquatic ecosystems. It is estimated from various studies that around 200 flowering plant species, belonging to 82 genera in 44 families, are present in aquatic ecosystems of Jammu & Kashmir. Kaul and Zutshi (1967) recorded in Srinagar 117 species of aquatic and marshland plants, belonging to 69 genera in 42 families. Handoo and Kaul (1982) reported 42, 32, 19 and 18 species, respectively, in the Malangpora, Kranchu, Shallabugh and Hokersar wetlands, whilst Pandit (1991) reported 29, 24, 20, 21 and 37 taxa of macrophytes in Haigam, Hokersar, Mirgund, Nowgam and Malgam wetlands, respectively.

Nutrient availability, temperature, light penetration, grazing pressures and other associated factors determine planktonic diversity in aquatic ecosystems. It has been observed that planktonic productivity in wetlands is relatively low compared to natural lakes, because they are dominated by a profuse growth of macrophytes. Pandit (1980) reported a total of 190 species of phytoplankton in Kashmir Valley, including Cyanophyceae (20), Chlorophyceae (72), Bacillariophyceae (60), Xanthophyceae (3), Chrysophyceae (3), Dinophyceae (3) and Euglenophyceae (29). Compere (1983), provided an account of some algae from Kashmir and Ladakh. Kant and Vohra (1999), in their detailed review paper on algal flora of Jammu and Kashmir state, reported the existence of 406 species of algae distributed over 108 genera from Kashmir, inhabiting river, streams, ponds, pools, lakes and soil.

Consumers in aquatic ecosystems comprise those animals which live in or visit water bodies and which depend on these habitats for food, refuge or breeding sites. Jammu & Kashmir as a whole has rich faunal diversity, which plays an important role in maintaining the quality of natural ecosystems, besides providing numerous benefits, directly or indirectly, to people associated. Amongst invertebrates, the dominant taxonomic groups encountered in the wetlands are Mollusca, Annelida, Crustacea, Arachnida and Insecta. Earlier reports pertaining to general invertebrate fauna of Kashmir were given by Hora (1943); Hora et al. (1955) reported on aquatic invertebrates. Das (1966), for the first time, published a checklist of invertebrate fauna of this region, incorporating 7 genera under Rotifera, 2 genera under Porifera, 9 genera under Annelid, 10 species under Mollusca, 4 genera under Crustacea, 2 genera under Myriapoda and 6 species under Arachnida. Ghosh (1996) gave an account of faunal diversity in the Himalayas, including western Himalaya and Kashmir. In Jammu region, studies related to faunal diversity were carried by Dutta and Malhotra (1986), Dalpatia (1998), Gupta (2002) and Chanderkiran (2008).

## 9.5 Values and Functions of Aquatic Ecosystems

Aquatic ecosystems are amongst the most productive life support systems in the world and are of immense socio-economic and ecological importance to mankind. They are of critical importance for the survival of natural biodiversity and provide habitat for a wide variety of flora and fauna, besides recreation for people. They play an important role in water quality improvement, sediment control, oxygen production, nutrient recycling, flood control, aquifer recharging, groundwater discharge, shoreline protection and stabilization of local climatic conditions. Ecosystems and the biodiversity contained within them provide a stream of goods and services, the continued delivery of which remains essential to our economic prosperity and other aspects of welfare. In a broad sense, ecosystem services refer to the range of conditions and processes through which natural ecosystems, and the species that they contain, help sustain and fulfil human life (Daily 1997). Ecosystem services have been grouped into six categories, mainly based on their ecological and economic functions, as follows:

- Purification and detoxification: filtration, purification and detoxification of air, water and soils.
- Cycling processes: nutrient cycling, nitrogen fixation, carbon sequestration and soil formation.

- Regulation and stabilization: pest and disease control, climate regulation, mitigation of storms and floods, erosion control and regulation of rainfall and water supply.
- Habitat provision: refuge for animals and plants and storehouse for genetic material.
- Regeneration and production: production of biomass providing raw materials and food, and pollination and seed dispersal.
- Information/life-fulfilling: aesthetic, recreational, cultural and spiritual role, education and research.

The great economic importance of freshwater ecosystems worldwide has not been fully appreciated, and in Kashmir, a great proportion of population depends directly on aquatic ecosystems. These ecosystems serve as a precious ecological resource which provides food, fodder, fish, wildlife, green manure, medicinal plants, timber, firewood and other useful products, as well as huge quantities of vegetables. These resources have been extensively exploited for a variety of purposes since historic times, and their importance can be judged by large human population living in their vicinity. Over 30,000 people reside permanently in houseboats, the number swelling temporarily during the summer months due to influx of tourists. The aquatic ecosystems are not only crucial as a life-support system for local people but also as a firm foundation for subsistence economics of the state.

### *9.5.1 Wetland Plants as Phytoremediation Species*

Macrophytes have been shown to play important role in marsh biogeochemistry through their active and passive circulation of elements. Through their action as 'nutrient pumps' (Odum 1988), active uptake of elements may promote immobilization in plant tissues, as seen in wetlands constructed for wastewater treatment (Kadlec and Knight 1996) and in the use of wetland plants for phytoremediation. Phytoremediation is considered an effective, low-cost, preferred clean-up option for moderately contaminated areas. Wetlands are often considered sinks for contaminants, and there are many cases in which wetland plants are utilized for removal of pollutants, including metals. The approach is generally one of 'phytostabilization', where the plants are used to immobilize metals and store them below ground in roots and/or soil, in contrast to 'phytoextraction', in which hyper accumulators may be used to remove metals from the soil and concentrate them in above-ground tissues. These latter plants must be, in turn, harvested and disposed of to prevent recycling of accumulated metals when the plants decompose.

A rapid population increase, accompanied by unplanned developmental works, has led to the pollution of surface waters due to residential, agricultural, commercial and industrial wastes/effluents and decline in the number of water bodies. Increased demands for drainage of wetlands have been accommodated by channelization, resulting in further loss of stream habitat, which has led to aquatic organisms becoming extinct or imperilled in increasing numbers, and to the impairment of many beneficial uses of water, including drinking, swimming and fishing. Various anthropogenic activities have altered the physical, chemical and biological processes within aquatic ecosystems. An integrated and accelerated effort towards environmental restoration and preservation is needed to stop further degradation of these fragile ecosystems. Failure to restore these ecosystems will later result in sharply increased environmental costs, the extinction of species or ecosystem types and in permanent ecological damage.

## 9.6 Ecological Threats to Aquatic Ecosystems

Freshwater ecosystems that dominate the aquascape in Kashmir Himalaya are threatened with a range of anthropogenic pressures, such as sediment loading, eutrophication, biological invasion and increasing loss of native biodiversity. Recently, the extinction rates of several invertebrates and vertebrates have increased mainly because of overfishing and other related activities. The main disturbance in lakes is from the heavy silt flowing from the adjacent nallahs. The siltation process has greatly affected the lake ecosystems, resulting in the formation of the extensive marshlands. Large chunks of peripheral areas have been encroached upon by people, by filling it and changing it into vegetable gardens and even into residential areas. Large quantities of domestic and agricultural wastes enter a water body throughout its periphery. In 1993, the UEE Department laid sewers pouring raw sewage from the catchment and settlements without any treatment, which accelerated the rate of eutrophication and pollution, resulting in serious ecological changes. These ecological changes have seriously affected the biodiversity of the aquatic systems. Populations of aquatic birds, both resident and migratory, have also been affected, with subsequent considerable reduction in their food supplies. Marshes within the lakes are being mainly used for the cultivation of *Salix* spp. (willows). The young branches of this plant are extensively used for the fabrication of wooden baskets and furniture; as such, most of the lake area has been brought under willow plantation, reducing the open water surface at an alarming rate. The wetlands support large stands of aquatic plants, particularly *Nelumbo nucifera* (nadroo). The fishing for mirror carp and harvesting of *Nelumbo* stems, besides collecting of aquatic weeds for fodder, have remained the attraction for locals and fishermen. The overexploitation and the rapid urbanization, coupled with expansion of the Srinagar city, have put these wetlands under tremendous stress, and as a result, they are experiencing the cultural eutrophication.

The entry of raw sewage from the immediate catchment, and managed carrying of sewages from the adjoining areas, accounts for huge amount nitrogen and phosphorus resulting in serious weed infestation and water quality deterioration. The water of wetlands is insecure for human consumption as all the chemical parameters in it have far exceeded the permissible levels. The wetland dwellers, particularly the fishermen, are suffering from water-borne diseases like pyrexia, ascariasis, hepatitis and other gastrointestinal and skin diseases.

The problem of growing biological invasion severely threatens aquatic biodiversity, yet this has been a neglected area of research till now. Recently, Shah and Reshi (2014) worked out the current invasion status of aquatic ecosystems in Kashmir Himalayas and categorized the alien species into different stages of invasion on the basis of the extent of spatial spread measured in terms of the frequency and cover percentage across sites. Their results yielded 129 alien plant species, belonging to 68 genera and in 42 families, representing four major life forms, including emergents (69.1%), rooted floating-leaf types (15.6%), submerged types (10.1%) and free-floating types (7%). Majority of alien plant species are native to Europe (63%), followed by North America (14%), Asia (12%), South America (4%), Australia and Africa (3%). Cyperaceae (22 spp.) and Potamogetonaceae (10 spp.) were the two most species-rich families, followed by Polygonaceae (8 spp.) and Lemnaceae (7 spp.). *Potamogeton* and *Cyperus* with 10 species each were the two largest genera. Moreover, the Colautti and MacIsaac model was tested for classification of alien species into different stages of invasion; this yielded 16 species at Stage IVa (widespread but rare), 26 species at Stage IVb (localized but dominant) and 29 species at Stage V (widespread and dominant). Similar documentation studies need to be carried out for other taxa in aquatic ecosystems of this Himalayan state.

## 9.7 Restoration, Conservation and Management of Aquatic Ecosystems

Aquatic ecosystem restoration aims to restore degraded ecosystems to a level that can be permanently sustained through protection and conservation. More realistically, restoration mitigates effects of anthropogenic influences and/or remediates degraded ecosystems to levels that have a higher order of ecological sustainability. Restoration usually involves reduction of stress, such as nutrient or contaminant loads. There are a number of impediments in restoration and management of aquatic ecosystems: noncomparable and insufficient data, mainly due to uncoordinated and incomplete data collection programmes, less reliability of scientific data and uncertainty relating to understanding of ecosystem behaviour.

Clearly, these types of barriers and impediments need to be overcome, and this can be done in a broader framework through long-term data collection and effective bio-monitoring programmes. This is the most right time for critical assessment of the proximal and ultimate causes that have led to the slow deterioration in the quality of the aquatic ecosystems. There are clear-cut deficiencies in institutional arrangements for the sustainable management of the aquatic ecosystems. The policies and plans are not taking into account environmental externalities and deterioration of public goods, and there is lack of an integrated approach to water resources management, especially due to lack of involvement of key stakeholders, particularly local communities, in key management processes. Moreover, knowledge is limited about the ecological consequences of use practices, including effluent discharge and diversion of water flows. There are policies that have been responsible for converting parts of the lakes and wetlands for agriculture, settlements and plantations. The loss of connectivity of interlinked wetlands, and degradation of catchment area, has led to increased silt deposition and decreased water absorption capacity of water bodies. Furthermore, inflow of vast quantities of untreated sewage into the lakes, such as Dal Lake, leads to nutrient enrichment, spread of invasive macrophytes, algal blooms and loss of biodiversity.

In fact, critical assessments of degraded aquatic ecosystems allow decisions to be made as to what to control in order to remediate effects or how much can be relied on nature to clean itself. To achieve ecosystem stability or sustainability, decisions on what to do, including in situ options such as bioremediation or bio-manipulation, as well as the development of ecosystem indicators of progress towards restoration, have to be taken. Restoration towards a less degraded, but not necessarily pristine, ecosystem requires decisions as to how far the ecosystem has to be restored. To arrive at such conclusions, and to monitor progress towards them, requires the development of indicators of ecosystem health, stability and sustainability. If these criteria are met, the ecosystem can be declared as remediated to acceptable conditions, perhaps even restored.

The level of protection or control or regulation required to reach this state is dependent on the recovery or restoration of the ecosystem and the state that needs to be maintained. Restoration means the degraded aquatic ecosystems are remediated to some level of stability or sustainability involving minimization of stress, in situ treatments and probably conservation of components of the total aquatic ecosystem that have not yet been degraded. Restoration should be, however, viewed in the watershed context. Abatement of eutrophication, siltation and contaminant problems are more effective when inputs are controlled. Reduction of inputs enhances the long-term effectiveness of in-lake approaches. The watershed is the natural scale for restoration and would be self-sustaining. Effective restoration can be achieved through collaboration amongst scientists, economists, managers, policy makers and local people.

The behaviour of water quality constituents and their interactions, while complex, has been well studied in the past and can be monitored and predicted with some degree of confidence. In contrast, management of aquatic ecosystems is less well developed. Because aquatic ecosystems are highly complex and variable, many differences in response to different stressors are possible under different circumstances. Most predictions relating to ecosystem behaviour carry a high degree of uncertainty. For this reason, management of aquatic ecosystems needs to be adaptive and flexible (ANZECC, 1992). In particular, managers need to be able to make effective decisions without access to detailed knowledge. Thus, ecosystem management presents demanding challenges (Plates 9.1 and 9.2).

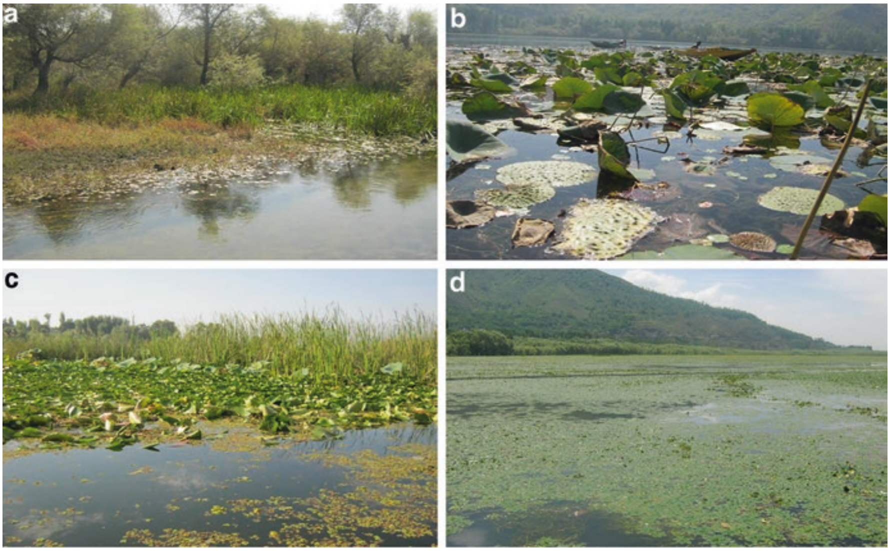


**Plate 9.1** An overview of some lakes and wetlands in Kashmir showing macrophyte infestation. a. Hokersar wetland b. Manasbal lake c. Nigeen lake d. Wular lake

**Plate 9.2** An overview of some high altitude lakes in the region

## 9.8 Concluding Remarks

The aquatic ecosystems are of pivotal significance in view of provisioning of a range of valuable economic goods and invaluable ecosystem services. Jammu and Kashmir has exceptionally great diversity of these ecosystems, and this aquascape comprises an integral part of its paradisiac landscape. These water bodies harbour rich diversity of macrophytes, phytoplankton, zooplankton and macrofauna. However, the aquatic ecosystems of this Himalayan state are over the years under tremendous anthropogenic pressures, and their ecological status has significantly deteriorated. Such a deterioration, in view of huge socio-economic implications, calls for urgent restoration measures and effective management strategies. Habitat preservation, law enforcement, public awareness and management are all important strategies to be undertaken in concert if the survival of these prized systems and their embodied biodiversity is to be ensured. Equally important for the conservation of the wetlands is that their ecological status should be effectively monitored over a long time period. Priorities need to be fixed, and coordinated projects on the Himalayan aquatic ecosystems, which would require considerable scientific input, would be a step in the right direction towards the preservation and judicious use of these natural resources.

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# Part IV
# Biodiversity of Jammu and Kashmir State: Genetic Diversity

# Chapter 10
# Genetic Diversity in Rosaceous Fruits of Jammu and Kashmir State: Apple, Apricot, and Almond

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**Abstract** The Jammu and Kashmir State, located at the confluence of Holarctic and Paleotropical Floristic Realms, is endowed with rich floristic diversity, including agro-biodiversity. Rosaceae is one of the most important families and constitutes the economic backbone of the State. The State is ideally suited to the cultivation of different kinds of fruits. The present chapter aims at assessment of germplasm of rosaceous fruits grown in the region. A variety of rosaceous fruits like apple, apricot, almond, pear, plum, and cherry are grown in the State. Apple, ranking first in area and production, is represented by ca. 190 genotypes. The most prominent cultivars include Red, Royal, Shimla, Kullu, and Mollies Delicious; American Trel; Maharaji; Razakwari; and Kesri. Due to the monoculture of Delicious group, many indigenous cultivars, including Ambri, Kashur Farash, and Shireen Dahan, are at the verge of extinction. Kashmir Valley and particularly Ladakh region also host a rich diversity of apricot germplasm. Some of the important apricot genotypes include Afghani, Raktsey-Karpo, Halman, Australian Sweet, and Charmagz. Almond is yet another important stone fruit of Kashmir. Broadly, three types of almonds, sweet hard-shelled, bitter hard-shelled, and paper-shelled, are cultivated in the State. Some important almond varieties include Shalimar, Makhdoom, Waris, Nonpareil, and Kagzi. Due to high economic returns in apple, cultivation of other rosaceous fruits

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_10

in Kashmir has not received due attention. As a result, precious germplasm of the traditional cultivars of these fruits have suffered genetic erosion.

**Keywords** Genetic diversity · Apple · Apricot · Almond · Jammu and Kashmir

## 10.1 Introduction

The Jammu and Kashmir (J&K) State is well known for its rich history of fruit cultivation. The agroclimatic conditions prevailing in the region are conducive for the production of a large variety of rosaceous fruits on commercial scale. Important among these are apple, almond, apricot, cherry, peach, pear, and plum. These crops, although labor intensive, are more profitable per unit area and generate enough employment opportunities compared to cereal crops. Research on temperate fruits in the State was initiated at the Fruit Research Station, Shalimar, Srinagar, in 1945 with the survey of deciduous fruits by the Indian Council of Agricultural Research (ICAR). Subsequently, in 1955, another scheme, "Research in Fruits of Kashmir," was started in collaboration with ICAR. Four years later, in 1959, it eventually led to the establishment of the "Regional Fruit Research Station" for carrying out extensive research on temperate fruits in Kashmir. In 1972–1973, a substation at Gopalpora, Budgam, was created to cater to the needs of high-altitude fruit growing. The entire horticultural research in the State was finally brought under the purview of the Sher-e-Kashmir University of Agriculture Sciences and Technology (SKUAST) established in 1982 at Shalimar, Srinagar (Chadha 1993).

The post-independence era witnessed substantial improvement in production and acreage under horticulture in the State. Both area under rosaceous fruit trees and production in the State increased from 12,400 hectares (HA) and 16,000 metric tons (MT) in 1953–1954 to 3.47 lakh hectares and 17.42 lakh metric tons in 2012–2013 (Table 10.1). Specific details about the area under cultivation of various rosaceous fruits, their production, and productivity for the year 2012–2013 as summarized by the Directorate of Horticulture, J&K Government are reproduced in Table 10.2. About five lakh families are involved directly in fruit cultivation, and around 25 lakh persons, in one way or the other, are benefitted by the fruit industry

**Table 10.1** Area and production trends of rosaceous fruits in Jammu and Kashmir State

| Year | Area (Ha) | Percent increase | Production (MT) | Percent increase |
|---|---|---|---|---|
| 1953–1954 | 12,400 | – | 16,000 | – |
| 1980–1981 | 131,008 | 956.51 | 563,028 | 3418.92 |
| 1990–1991 | 176,297 | 34.57 | 769,949 | 36.75 |
| 2000–2001 | 219,039 | 24.24 | 931,800 | 21.02 |
| 2004–2005 | 258,311 | 6.49 | 1331,861 | 4.56 |
| 2007–2008 | 295,141 | 14.26 | 1636,203 | 22.85 |
| 2012–2013 | 347,223 | 17.65 | 1742,142 | 6.47 |

Source: Directorate of Horticulture J&K State/Banday and Sharma (2010)

**Table 10.2** Area, production, and productivity of rosaceous fruits in Jammu and Kashmir State

| Varieties | Area (Ha) | Production (MT) | Productivity (MT/Ha) |
|---|---|---|---|
| Apple | 157,280 | 13,48,149 | 10.27 |
| Almond | 15,932 | 8208 | 0.69 |
| Pear | 13,883 | 54,847 | 3.79 |
| Apricot | 6287 | 14,501 | 2.67 |
| Peach | 2772 | 4855 | 1.91 |
| Plum | 4828 | 8682 | 2.03 |
| Cherry | 3728 | 11,122 | 3.39 |
| Total fresh fruits | 23,6780 | 15,24,593 | – |
| Total dry fruits | 110,443 | 217,549 | – |
| Total fruits | 347,223 | 1742,142 | – |

Source: Directorate of Horticulture J&K State (2012–2013)

of the State. The State generates around Rs. 17,000 crores from fresh and Rs. 300 crores from dry fruits annually (Banday and Sharma 2010).

Apple dominates the fruit industry of the State and at present covers an area of more than 1.57 lakh Ha constituting about 43.30% of the total fruit area and contributing about 50.48% of the total fruit production (fresh as well as dry). Among the different regions of the State, Kashmir produces bulk of the temperate fruits, except apricot, which are grown at a much larger scale in Ladakh region. Among the various districts, district Baramulla leads in apple production, district Budgam in almond and pear production, district Anantnag in peach and plum, district Shopian in cherry, and district Kargil in apricot production (Banday and Sharma 2010). The horticulture sector in the State, thus, plays a significant role in the economy of the State. However, a huge untapped potential remains to be exploited, which can further boost the economy of the State as well as contribute to the food security in the face of looming climate change and booming population.

The present study was undertaken to investigate the germplasm status, develop passport data information, and create a germplasm repository of some important rosaceous fruit crops with special focus on apple and apricot germplasm of the State. The data collection was carried out both at primary and secondary levels. At primary level, data were collected, particularly for apple and apricot, through extensive field surveys in different apple orchards of the Kashmir Valley during 2011 to 2016 growing seasons. For generation of passport data information as per DUS guidelines on apricot and apple, one tree from each cultivar was used for collection of flower buds, leaves, and fruits for cytological, morphological, and biochemical studies. Secondary data were collected from the Department of Horticulture and other allied web sources. Websites of SKUAST, Directorate of Horticulture, J&K Government, Checklist of Commercial Varieties of Fruits, and Government of India and the relevant material in the form of books and journals were also consulted for the study.

## 10.2 Germplasm Status of Different Rosaceous Fruits in J&K State

Current status of the germplasm of different rosaceous fruits, with special reference to apple, apricot, and almond in the J&K State, is presented below.

### *10.2.1 Apple (*Malus *x* domestica *Borkh)*

Cultivated apple (*Malus* x *domestica* Borkh.) is economically the most important and viable fruit crop of the temperate zones and is under cultivation in Europe and Asia since times immemorial. It is a cosmopolitan fruit, grown throughout the world except Antarctica. At global level, more than 10,000 cultivars are known (Janick et al. 1996), of which only 15–20 (0.2% of the total) are said to be commercial. Apple is a deciduous tree 6–15 ft. tall and around 30 ft. wide. The size, shape, and branch density are determined by the rootstock selection and pruning methods. Blossoms are produced in spring (late March), concurrently with the budding of leaves. Flowers produced on spurs and some long shoots are white in color with a pinkish tinge that gradually fades. Flowers are assembled in cymes with 5–6 flowers in a whorl. The central flower of the inflorescence called "kind bud" opens up first and develops into a large fruit.

Apple originated in Central Asia, where its wild ancestor (*Malus sieversii* M. Roem.) is found even today (Harris et al. 2002; Luby 2003). Recently, complete genome of apple has been decoded using cv. Golden Delicious (Velasco et al. 2010), wherein around 57,000 genes have been identified, the highest number of any plant genome studied till date. Decoding of apple genome has also provided proof that *M. sieversii* is the wild ancestor of the domestic apple—an issue that has long been debated in the scientific community.

In India, apple is grown mainly in Jammu and Kashmir, Himachal Pradesh, and Uttarakhand, although a little is also grown in Arunachal Pradesh, Nagaland, and Karnataka. The Jammu and Kashmir State, owing to its suitable climate, contributes 60–65% of apple to the total apple produce of the country. In the horticulture sector of the State, apple occupies the largest area (138,191 Ha; 43.53%) of the total area under fruit cultivation and 65.46% of the fresh fruit area (Reshi et al. 2010), thereby making it the largest contributor to the State's GDP among the horticulture produce. The commercial cultivars grown in most of the Valley's orchards are exotic, introduced from Britain and other European countries. Reports from previous studies (Fougat 1984; Singh and Wafai 1984; Koul et al. 1984, 1985, 1988; Singh et al. 1987; Raina 1989; Farooqi 1999) reveal that more than 150 cultivars identified by specific exotic and local Kashmiri names, and a large number of unnamed variants, are grown in the State.

The authors of this chapter are currently reinvestigating the apple germplasm of the State under the Department of Biotechnology (DBT), Government of

India-sponsored multi-institutional project "Creating a Genomics Platform for Apple Research in India," with the main aim of generating reliable passport data information on apple germplasm of the State. After extensive field surveys in almost all parts of Kashmir division, 190 genotypes have been documented, of which only 110 are known by specific names, while the rest are unnamed and probably originated as chance seedlings or bud sports. Morphological and biochemical characterization of ca. 100 cultivars have been completed. As reported by earlier workers (Fougat 1984; Singh and Wafai 1984; Koul et al. 1985), our studies also reveal enormous diversity and polymorphism in tree, foliar, and fruit characteristics in the apple germplasm of the State. Besides, most of the cultivars are diploid ($2n = 2x = 34$); with a few polyploids ($2n = 3x = 51$; $2n = 4x = 68$). The diploid cultivars are, however, commercially more successful than their polyploid counterparts. Molecular characterization through SSR and AFLP analysis has unravelled the actual amount of genetic diversity available in the crop (Najar 2007), besides setting stage for marker-assisted selection of agronomically important traits.

Being essentially an outbreeding crop, cross-compatible breeding system has over the years given birth to innumerable inter-cultivar variants as hybrids, popularly known as chance seedlings. The successful chance seedlings have subsequently taken shape of commercial cultivars. Similarly, establishment of certain bud mutations (bud sports) has further widened the level of variability in the crop. The most important commercial cultivars growing in the State and their salient features are depicted in Appendix Table 10.6. In general, these cultivars can be categorized into three broad groups (Singh 2010) as follows:

- Early season—Hazratbali, Saharanpuri, Benoni, Michal, Mollies Delicious, and Tydeman's Early.
- Mid-season—Razakwari, Jonathan, Cox's Orange Pippin, Red Gold, Rome Beauty, Scarlet Spur, Royal Delicious, Rich-e-Red, Red Delicious, Starkrimson, Red Chief, Oregon Spur, Gala, Granny Smith, Gala Must, Vance Delicious, Silver Spur, and Golden Spur.
- Late season—American, Ambri, Sunhari, Kitheheme Trel, Chamura, Golden Delicious, Firdous, Lal Ambri, Top Red, Red Gold, and Fuji.

At the turn of the century, the Delicious group dominated the apple-growing regions in the State, and 45% of the entire fruit area came under its cultivation. Red Delicious, Royal Delicious, Shimla Delicious, Golden Delicious, Kullu Delicious, and Mollies Delicious emerged as the most prominent cultivars in Kashmir, besides some others like American Trel, Maharaji, Razakwari, and Kesri. The monoculture of Delicious apple resulted in the shrinkage and eventual erosion of other important exotic as well as indigenous cultivars. Many apple varieties, such as Ambri, Kashur Farash, Shireen Dahan, and Marchewangan Trel, with only one or a few representative trees in some old orchards are at the verge of extinction. The overall gene pool of the apple in the State is depleting, cultivars are at the brink of extinction (Table 10.3), and there is an urgent need to conserve them.

In recent years, however, there has been a dramatic shift from Delicious group to improved spur types and standard color mutants in the State. The spur types and

**Table 10.3** Apple cultivars grown in the Kashmir Valley

| Cultivars | Cultivars | Cultivars | Cultivars |
|---|---|---|---|
| Ambri Kashmiri[c] | Royal Delicious[a] | Golden Delicious[a] | Kichhema Trel[a] |
| Ambri Pokhla[b] | Maharaji II[a] | Golden Delicious[c] | Red Gold[a] |
| American Pippin[b] | Pokhla[a] | Cross delicious | Dilruba[b] |
| Bulgarian[a] | Red Delicious[a] | American Trel[a] | Lal Cider[b] |
| Bulgaria White[b] | Red Golden[b] | Daba Hour[c] | Kesari Single[a] |
| Chamura[a] | Reeka Red[a] | Shanshah[a] | Kesari Double[a] |
| Chuk Pokhla[a] | Marchewangan Trel[c] | Razakwari[a] | Gala Must[b] |
| Kashur Farash[c] | Mahadbati[c] | Hazratbali[a] | Delicious Kashur[a] |
| Johnbaz Trel[a] | Saharanpuri[a] | Hazratbali II[a] | Mollies Delicious[a] |
| Kinore[b] | Shakarkand[c] | Royal Misree[a] | Titoo[b] |
| Kullu Delicious[a] | Shireen Pokhla[b] | Shireen Dahan[c] | Rikhal Saharanpuri[a] |
| Maharaji I[a] | Toath Pokhla[b] | Shandgund[c] | Kharoo[b] |
| Rasella[b] | Shimla Delicious[a] | Nawabi[c] | Sasakul[c] |
| Gold Shireen[b] | Shireen[c] | New Pokhla | Candle[b] |
| Queen Apple[b] | Rosulbati[c] | Turush[c] | Hamdard Shireen[c] |
| Lal French | Kali Devi[c] | Jonathan[a] | White Cider[c] |
| Blood Red[3] | Ladakhi Ambri[b] | | |

[a]Well known
[b]Less known
[c]Vanishing apple cultivars of Kashmir

color mutants have higher yield, in addition to early fruit maturity and better fruit color. Some of these promising mutants include Starkrimson, Oregon Spur, Red Chief, Vance Delicious, and Top Red. Recently, a number of scab-resistant mutants (Florina, Prima, Liberty, and Freedom) have also been introduced. Cultivars like Firdous and Shireen have been released for commercial cultivation as scab-resistant varieties. Hybridization program in the State resulted in the release of Lal Ambri (Red Delicious x Ambri) and Sunhari (Ambri x Golden Delicious).

Most of the apple varieties require 800–1500 h of chilling temperature (below 7 °C) during winter for successful bud breaking in the spring. These conditions are found in the Himalayan ranges between an elevation of 1500–2700 m amsl. The average summer temperature for apple growth should be 21–24 °C. Low temperature, excessive rains, and cloudy weather during the flowering period hamper pollinator activity, thus affecting pollination and eventually fruit set. The optimal temperature for pollen germination and fruit setting is 21–26 °C. Apple grows in wide range of soil types. But, the best soil type is from sandy loam to sandy clay loam with a pH range of 5.8–6.5. Well-distributed rainfall of 100–125 cm throughout the growing season is most favorable for optimal growth and fruitfulness. The long drought spells during fruit development and excessive rains and foggy conditions at fruit maturity hamper fruit size and fruit quality.

Although apple production contributes significantly to the economic growth of the State and provides employment to a large section of the society, the full exploitation of the apple industry in J&K State is impeded by various factors. The apple trees are plagued by a number of fungal, bacterial, and insect pests such as apple scab (*Venturia inaequalis*), fire blight (*Erwinia amylovora*), black rot (*Physalospora obtusa*), mildew (*Podosphaera leucotricha*), crown rot (*Phytophthora cactorum*), aphids (*Aphis pomi* and *A. spiraecola*), and codling moth (*Cydia pomonella*) inflicting heavy losses. Besides diseases and pests, various infrastructural handicaps such as lack of cold storage, standard grading and packaging systems, and nonavailability of standard pesticides are regarded as the major threats to the apple production in the State, which heavily influence the quantity as well as quality of the apple produce (Reshi et al. 2010). Furthermore, there is an immense potential in the region to increase per hectare apple production, which is dismally low at 10.27 MT/Ha compared to other countries like Belgium (46 MT/Ha), Denmark (41 MT/Ha), the Netherlands (40 MT/Ha), and Brazil (38 MT/Ha).

### *10.2.2 Apricot (***Prunus armeniaca** *L.)*

Apricot, commonly known by various names such as khubani, zardalu, chulu, chuli, and cher, is one of the most well-known temperate fruit trees grown world over (Faust et al. 1998; Ercisli 2009). Apricot ranks as the third most economically important stone fruit crop after peach and plum (OECD 2002; FAOSTAT 2009). It is widely distributed in West and Central Asia, Europe, and China with total world production reaching around 2–6 million tonnes (FAOSTAT database). There are around eight different species of apricot, but the most widely cultivated at the global level is *Prunus armeniaca* L. (Rehder 1967), which is native to Asia and the Caucasus region of Europe. Three important regions have been designated as the centers of origin for cultivated apricots. These are i) the Chinese Center (China and Tibet), ii) the Central Asian Center (from Tian Shan to Kashmir), and iii) the Near-Eastern Center (Iran, the Caucasus, and Turkey) (Vavilov 1951). It is believed that in recent history, apricots moved from Central Asia through Iran and Armenia to the West, reaching Europe during the Roman era (Watkins 1979; Zohary & Hopf 1993; Layne et al. 1996; Faust et al. 1998). Based on enormous world collections, four major eco-geographical groups within *P. armeniaca*, namely, the Central Asian group, the Irano-Caucasian group, the European group, and the Dzhungar-Zailij group, have been recognized (Kostina 1969). The Central Asian group includes local apricots from Central Asia, Xinjiang, Afghanistan, Balochistan, Pakistan, and Northern India (Kashmir). This group is the oldest and richest in diversity. Most of them are self-incompatible, produce small to medium-sized fruits, and require a long resting period prior to first flowering.

Apricot is believed to have been introduced in cold arid Ladakh via Baltistan or may have been introduced directly from China via Tibet. In India, this species includes a number of botanical varieties and cultivated types which are sometimes considered as distinct species and needs further investigation. Cultivars of American and European origin are usually grown in the Himalaya at different altitudes in

Uttarakhand, Himachal Pradesh, and Kashmir. Cultivars with red- and white-fruited types are widely grown in Kashmir, Himachal Pradesh, and Ladakh region. “Safeda Parachinar” and “Ladakhi” are popular cultivars in Himachal Pradesh, while “Charmagz” with sweet flesh is a popular desert type (Anonymous 1969). Wild type *P. armeniaca* (Himalayan apricot) occurs at high-altitude regions in cold desert in Northwest Himalaya, Kashmir Valley, Chenab region, and Kullu and Shimla hills in Himachal Pradesh. It has unique traits that distinguish it from cultivated apricots (e.g., small sized, inferior quality fruits borne in dense clusters). This type is commonly called “Guhi Cher” in Kashmir. Of the three wild types, chuli, sahara, and zardalu, the first two are considered to be distinct botanical varieties of *P. armeniaca*, whereas the last one is the wild form (Sharma 2000). According to Ghosh (2001), 81 apricot cultivars were introduced in the mid hills and cold desert areas of Northwest Himalaya, and several semi-wild types have also been located in the region.

Among the rosaceous fruits, apricot is unique in that the fruit is marketed fresh as well as sun-dried. The latter form is one of the most cherished and highly prized table dishes, which is nonperishable, without any transportation problem attendant on other perishable fruits. The dried kernels of the fruit are yet another novel dry fruit export commodity, which earns substantial revenue to the stakeholders and finds enormous market in the country as well as abroad. Even the wood of dried, diseased, and aged trees is a prime revenue generator in the local market as fuel for bakery. Apricot wood is acclaimed to be one among the most efficient fuels, hence given top priority for the purpose.

The Ladakh division of Jammu and Kashmir State, India, located between 8500–12,000 ft. amsl, holds a rich diversity of traditional land races of apricot, which exhibit high degree of diversity in fruit size and quality. Locally known as chuli, apricot is the main fruit crop in this region distributed randomly with highest abundance in Shan areas (lower Ladakh) including Dha-Hanu, Garkhon, Skurbuchan, Domkhar, Wanla, Khaltse, and Tingmosgang. The tree thrives well in sandy and wasteland conditions and can tolerate water stress and temperatures as low as −30 °C (Dwivedi et al. 2003), thereby making it an ideal crop in changing climate with dwindling water resources. The total apricot production in the State during 2012–2013 was 14,501 MT from an area of 6287 hectares (Table 10.2). Many varieties of apricot are grown in Ladakh; some important ones include Afghani, Raktsey-Karpo, Khantay, Koban, Kaisi, Halman, Nari, Nari Special, and Safeda, and those of Kashmir include Australian Sweet, Kaisha, Conian Italy, Rounded, Quetta, and Charmagz. These cultivars differ in taste (sweet, bitter, sour), size, shape, and physical appearance (see Appendix Table 10.6). Halman and Raktsey-Karpo are the most preferred for commercial purposes in Ladakh and are the major source of income for Ladakhis.

In order to assess the present status of apricot germplasm in J&K State with the support of a DBT-funded project entitled “Characterization and conservation of apricot (*Prunus armeniaca* L.) germplasm in J&K State,” extensive field surveys were conducted during growing seasons of years 2015–2017. A total of 59 cultivars/genotypes from Kashmir region and 72 cultivars/genotypes of apricot from Ladakh region of J&K State have been identified and labeled so far (Tables

**Table 10.4** List of apricot (*Prunus armeniaca* L.) cultivars from Kashmir region of J&K State

| S. no. | Name of the cultivar | S. no. | Name of the cultivar | S. no. | Name of the cultivar |
|---|---|---|---|---|---|
| 1. | Awal number | 20. | Raktsey-Karpo | 39. | Australian sweet |
| 2. | Kabule Cher | 21. | Gold cot | 40. | Viva god |
| 3. | Khajoora Cher | 22. | Amba | 41. | Italian apricot 01 |
| 4. | Maaz Cher | 23. | CITH AP-01 | 42. | Italian apricot 02 |
| 5. | Poeh Cher | 24. | CITH AP-02 | 43. | Italian apricot 03 |
| 6. | Yerwani | 25. | CITH AP-03 | 44. | Amb Cher |
| 7. | Stanei | 26. | Harcot | 45. | Khubani |
| 8. | Gold rich | 27. | Balcota | | |
| 9. | Tilton | 28. | Chinese | | |
| 10. | Perfection | 29. | Rival | | |
| 11. | Shireen Dahan | 30. | Afghani | | |
| 12. | Badaam Cher | 31. | TokPopaNemu | | |
| 13. | Boett Cher 01 | 32. | New Castle | | |
| 14. | Boett Cher 02 | 33. | Fairmedcester | | |
| 15. | Chunun Cher | 34. | Turkey | | |
| 16. | Goal Cher | 35. | Heartly | | |
| 17. | Konge Cher | 36. | Communis Holly | | |
| 18. | Ladakhi | 37. | Erani | | |
| 19. | Halman | 38. | Communis | | |

Note: Some unknown types (without name) have not been included in the above list

10.4 and 10.5). In general, it has been observed that, unlike huge apple orchards in the State with each orchard comprising several varieties of apple, apricot trees are found occasionally in some orchards, mostly single trees of a specific cultivar. There is no apricot orchard in the Kashmir Valley probably due to more emphasis on apple trade by the local farmers. On the other hand, we found huge reserves of wild apricot in almost all explored areas. These wild apricot reserves are mostly found on wastelands near foothills. Compared to Kashmir, Ladakh region of J&K State has a rich repository of apricot germplasm, and in fact, apricot cultivation is the major source of economy for the region. A small germplasm repository of around 60 apricot cultivars comprising of 30 cultivars from Kashmir and 30 cultivars from Ladakh have been established under the afore-mentioned project at field station, University of Kashmir, Zakura Campus, Srinagar.

In apricot, flowering starts in late March to early April in Kashmir and in second or third week of May in Ladakh. Accordingly, the maturity dates vary between the two regions. Yield and quality of the fruit are heavily affected by the stage of maturity at which fruits are harvested. Apricot fruits develop maximum flavor when ripened on the tree, but such fruits cannot be transported to distant markets because of their perishable nature (Bhat et al. 2013). Apricot cultivars are most often grafted on plum and peach rootstocks. The scion wood of apricot contributes to the fruit characteristics, whereas the rootstock provides the growth characteristics to the new plant. Apricots have a chilling requirement of 300–900 chilling units. The trees prefer well-drained soils with a pH of 6.0–7.0. Some cultivars are self-compatible and do not require pollinizer trees, while others are self-incompatible and must be

**Table 10.5** List of apricot (*Prunus armeniaca* L.) cultivars in Ladakh region of J&K State

| S. No. | Name of the cultivar | S. No. | Name of the cultivar | S. No. | Name of the cultivar |
|---|---|---|---|---|---|
| 1. | Quvannarmo | 25. | AamChuli | 49. | Wan chuli |
| 2. | KhantayGosmin | 26. | Rgasat | 50. | GounChuli |
| 3. | Narmokarpochuli (white kernel) | 27. | NarmoRilbo-seir | 51. | Shakchuli |
| 4. | MotitilleBatalik | 28. | KhantayRilbo-seir | 52. | QuvanChuliminji |
| 5. | Gothuroo | 29. | KhantayGosmin | 53. | Fating Chuli |
| 6. | Quvan Narmogargardo | 30. | KhantayKhormachuli | 54. | NosnpoChuli |
| 7. | Lellatilleegargardo | 31. | MunChuliKhantay | 55. | Narmochuli |
| 8. | Karpo-meen | 32. | ShakandhaKhantay | 56. | StonChuli |
| 9. | Rakchay-Karpogargardo | 33. | Chogo-chuliKhantay | 57. | Narmokarpo |
| 10. | Khantay-Geimbo | 34. | Shakandhamangbor | 58. | Shakandhagomakargil |
| 11. | Mamorae | 35. | Chapa-cha Chulikhantay | 59. | Quvan (Margulam) |
| 12. | Peechang-tillegargardo | 36. | PunarKhantay | 60. | Halman MARES |
| 13. | Shakandha farm | 37. | PunarGozi | 61. | Bari-tilee |
| 14. | Quvansanjak | 38. | KhaparickNarmo | 62. | Peechank-tileechulichan |
| 15. | Barquick | 39. | BadanaNarmo | 63. | Lella-tileechulichan |
| 16. | Starga-Chuli | 40. | ZanChuliNarmo | 64. | Nirma-chuli |
| 17. | Tubchi-Chuli | 41. | KhapuckKhantayChuli | 65. | Shipachinmo |
| 18. | KhantayAloo-chuli | 42. | Drongmar | 66. | Margulamchulichan |
| 19. | Khantay Mamore | 43. | Sarquvan | 67. | HalmanChogo |
| 20 | NagpoChuli | 44. | GronChuli | 68. | Tito |
| 21. | Rilbo-chuli | 45. | Khapuck | 69. | Jotholma |
| 22. | Aargoun | 46. | Nirmachuli | 70. | Rachaykarpodarchik |
| 23. | Moti-tileechulichan | 47. | Draymomo | 71. | Samrouth |
| 24. | Aargounchogo | 48. | Rai-juu | 72. | Quvan-chulichogo |

Note: Some unknown types (without name) have not been included in the above list

planted in pairs in order to effect pollination and ensure fruit set. The fruits are yellow orange, rounded or oval, juicy, and sweet with peculiar apricot flavor. Apricots are susceptible to many diseases, such as bacterial canker, crown gall, brown rot, black knot, fruit rot, and powdery mildew.

Apricot germplasm of Ladakh region has been studied earlier also for genetic diversity analysis and physicochemical properties. About 74 apricot genotypes have been studied from the region, showing considerable variation in physical parameters such as fruit shape, size, color, weight, stone weight, diameter, stone/pulp ratio, and chemical characteristics like total soluble solids (TSS), acidity, pH, and sugars (Dwivedi et al. 2002, 2003), indicating immense potential for exploitation of apricot germplasm for breeding programs and development of superior fruit quality cultivars. Sofi et al. (2001) studied the genetic variation and association among fruit weight component characters (shell thickness, kernel breadth, kernel length, kernel weight, stone diameter, fruit diameter, fruit length) in 25 apricot cultivars in district Kargil. Significant variations were found among the cultivars studied. Sharma et al. (2005) evaluated 10 cultivars growing in the arid temperate region of Himachal Pradesh and Jammu and Kashmir, mainly Afghani, Australian, Charmagz, Halman, Nari selection, Nari, Raktsey-Karpo, Shakarpara, and Safeda Parachinar for yield, fruit size, fruit weight, total soluble solids (TSS), acidity, sugars, and ascorbic acid. Cvs. Halman and Shakarpara recorded highest TSS and possessed excellent drying quality, whereas cvs. Safeda, Charmagz, Australian Sweet, and Raktsey-Karpo are the most popular table purpose cultivars. Mir et al. (2012) studied 24 apricot genotypes with different geographic origins comprising indigenous and exotic collections maintained in the germplasm collections of the Central Institute of Temperate Horticulture, Srinagar by using RAPD markers with the main aim to determine the genetic relationship among these genotypes. A high level of polymorphism was observed among different cultivars. The dendrogram based on UPGMA analysis grouped the 24 genotypes into four main clusters. Cluster I represented genotypes from Kashmir region (CITH-1 and CITH-2). All exotic genotypes formed cluster II. Cluster III represented exotic and Ladakh genotypes, whereas cluster IV represented two genotypes from Ladakh and one from China. High degree of polymorphism following RAPD analysis among 12 genotypes from Nubra and Leh of Ladakh region has also been reported by Kumar et al. (2009). Bhat et al. (2013) studied physicochemical characteristics of apricot genotypes from Kashmir. The shape of different apricot genotypes was found as flattish round (Conian Italy, Kaisha) to oval or heart shaped (Australian Sweet, Charmagz). Maximum fruit size was reported in cultivar Conian Italy. The authors also studied 40 apricot cultivars from Kashmir for 28 morphological traits and observed an enormous variation in different fruit traits such as fruit size, shape, fruit volume, flesh, and skin color. Two groups were identified based on fruit size: small fruit (<30 g) and large fruit (>30 g). UPGMA cluster analysis divided apricot cultivars into two groups: cluster I with 33 cultivars and cluster II with six cultivars. Highest fruit weight was recorded for cv. Amb Cher 73.78 g (Wani et al. 2017).

In the J&K State, Ladakh and Kashmir regions have tremendous potential for apricot cultivation. However, due to high economic returns in apple cultivation, apricot cultivation has not received due attention in Kashmir Valley, and there are no concrete apricot orchards in this region except government-controlled nurseries. Despite being one of the primary centers of origin, the lack of cultivation practices of apricot has led to the erosion of genetic diversity of its land races in comparison to apple and other fruit crops. Besides, the apricot trees today in Kashmir Valley are faced with the onslaught of reckless felling for use in bakery and social functions as fuel. This unabated felling has resulted into depletion of its germplasm in the region, with consequent loss of many elite and novel land races which represent natural sources of certain excellent alleles, such as color, flavor, and taste of the fruit, disease resistance, and high yield. A large number of such excellent cultivars are at the brink of extinction in the region. Besides, gummosis, codling moth (*Cydia pomonella*), lack of availability of grafted nursery plants of suitable cultivars, drying, and storage facilities are some of the major constraints to apricot industry in the region (Plates 10.1 and 10.2).

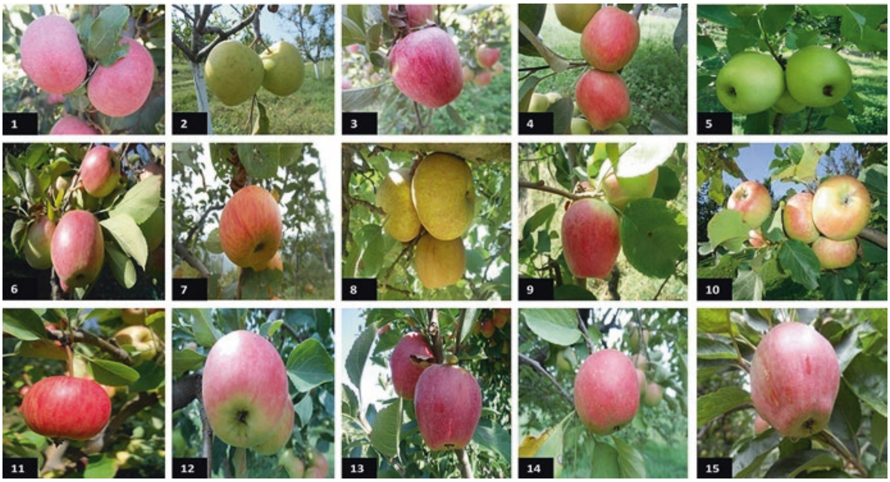

**Plate 10.1** Apple germplasm of Kashmir, India: *1*. American Trel *2*. Bell Gold *3*. Cross Delicous *4*. Dilruba *5*. Golden Delicious *6*. Kashmir Ambri *7*. Kesri *8*. Khuroo *9*. Lal Ambri *10*. Maharaji *11*. Martsewangan Trel *12*. Raj Ambri *13*. Red Delicious *14*. Red Gold *15*. Royal Del icious

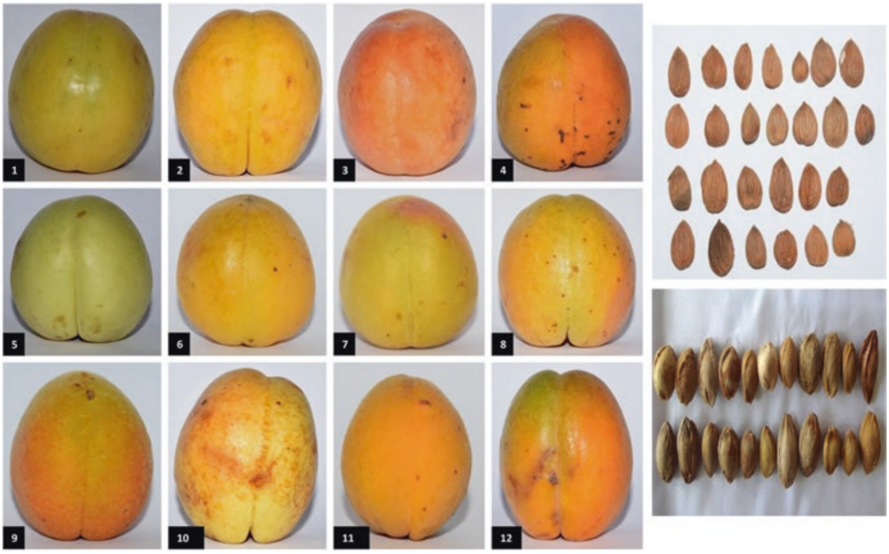

**Plate 10.2** Apricot germplasm of Kashmir, India: *1*. Aghani *2*. Amb Tser (Cher) *3*. Awal Number *4*. Balcota *5*. Irani *6*. Halman *7*. Harcot 8. Khubani *9*. Tilton *10*. Yerwani *11*. Wild 01 *12*. Wild 02

### *10.2.3 Almond (***Prunus amygdalus** *L. Batsch)*

Almond, considered as the king of the dry fruits, is native to Mediterranean region and is one of the major and oldest tree nut crops in the world. It is grown throughout southern Europe, California in the USA, Australia, South Africa, and Asia. The fruit is an edible drupe, with a tough fibrous rind surrounding the stone or shell and seed or nut. The seeds are demulcent and stimulant and act as a nervine tonic. Almond kernels are often eaten fresh or as a dessert. They are extensively used in confectionery and for the preparation of almond milk. Very valuable oil, called Roghan Badam, is also extracted from its kernels. Almond oil is used in pharmaceutical and cosmetic preparations. Major producers include the USA, Spain, Iran, Italy, Morocco, Syria, and Turkey. The world produces 2.00 million tonnes, with the USA alone contributing 80% of the world almond production (Anonymous 2011). In India, almond is grown mainly in the high hilly regions of Uttarakhand, Himachal Pradesh, and Jammu and Kashmir at an altitude of 1500–2500 m amsl. A deep, fertile, well-drained, light loam soil, with a pH range between 5.8 and 6.5, is suitable for its cultivation.

Almond is an important stone fruit of Kashmir and is in fact the first blooming tree in the region. It is cultivated on an area of 15,932 hectares, with an annual production of 8208 metric tonnes (2012–2013) (Table 10.2). Due to continuous exotic introductions and seed-based cultivation, the species has accumulated considerable variability in various characters of commercial value. Being an outbreeding species, each standing tree represents a distinct genotype (Soodan et al. 1988). Most of the almond varieties are exotic in origin. Broadly, there are three types of almonds found in J&K State, viz., sweet hard-shelled, bitter hard-shelled, and paper-shelled. Some important cultivars include Shalimar, Makhdoom, Waris, Nonpareil, Drake, Texas, and Kagzi (see Appendix Table 10.6).

Soodan et al. (1991) studied genetic diversity of almonds in Kashmir Valley based on floral and nut characters. A total of 70 distinct variants were isolated in this study. The shape of almond shell, nut, kernel surface, and taste of kernel have been identified as the most important market value traits. Majority of the Kashmiri almonds have yellowish shade and are oval. The kernels have shining surface and are sweet in taste. These important traits make Kashmiri almonds famous in the Indian and international market. Shell thickness is another important trait of commercial importance. Soodan et al. (1991) have classified almonds of Kashmir into three categories based on shell thickness as follows:

(i) Paper-shelled: shell is <5 mm thick; the nuts can be shelled by hand.
(ii) Thin-shelled: shell is 0.5–1.5 mm thick; the nuts can be shelled by a light hammer.
(iii) Thick-shelled: shell is >1.5 mm thick; the nuts can be shelled only by repeated hammering.

Among the qualitative characters, traits like dull-white flower color, cordate petal shape, and pore type markings on shell surface are found in Kashmiri almonds. Similarly, the quantitative traits like shell thickness, weight and size of nut, and kernel and shelling percentage are promising traits which determine the quality of Kashmiri almonds. Shell thickness determines the effort required in shelling the nuts and the quantity of kernel recovered per unit weight of the nut (Soodan et al. 1987). On the other hand, shelling percentage refers to the relative weight of the edible (kernel) and inedible (shell) parts of the nut. Based on these features, paper-shelled almonds are considered as the best compared to thin-shelled and thick-shelled types. Cytological analysis of different genotypes indicates its diploid nature ($2n = 16$, $n = 8$) (Soodan et al. 1988). Unlike other rosaceous fruits, meiosis in this crop commences in November, which may in some cases continue even up to February (Soodan et al. 1988).

The present-day cultivation of almond in the J&K State is mainly based on some exotic selections. Lack of availability of suitable pollinizer varieties, damage due to spring frost, susceptibility to diseases, and nonavailability of late-blooming varieties for cultivation seem to be the major reasons for low yield in the State. There is an urgent need to expand almond cultivation in the State with the introduction of new low-chilling varieties and identification of cross-compatible groups. Recently, the J&K Government has formulated almond development program for bringing an additional 12,000 hectares of area under its cultivation in a phased manner. These and similar efforts are expected to minimize the demand and supply gap of almond in the country.

## 10.3 Concluding Remarks

The Jammu and Kashmir State has a rich diversity of rosaceous fruits. The fruits from the State are renowned both at national and international levels for unique taste, color, size, and shape. Our recent studies indicate that little work has been done in genetic improvement of rosaceous crops in the State, and even the basic assessment studies are lacking. Only few scattered studies have been conducted in case of apple, apricot, and almond, but a huge gap remains with respect to other rosaceous crops like cherry, plums, and peach. Some of the major problems and concerns in rosaceous fruit industry of Kashmir are loss of indigenous germplasm due to the introduction and monoculture of exotic high-yielding cultivars, susceptibility to pests and diseases, availability of spurious pesticides and fertilizers in the market, and lack of cold chain and cold storage facilities in the State. There is a huge potential of research and development in rosaceous fruits of the State, particularly in the wake of climate change, food crisis, and prevalence of chronic diseases due to changing food habits.

**Acknowledgments** The authors are highly grateful to DBT, Government of India, for providing financial assistance in the project entitled “Creating a Genomics Platform for Apple Research in India” (File No. BT/PR11040/PBD/16/812/2008) and “Characterization and Conservation of Apricot (*Prunus armeniaca* L.) germplasm in Jammu and Kashmir State” (File No. BT/PR11394/PBD/16/1077/2014). Special thanks are due to the Directorate of Horticulture Kashmir, in particular their Pomology expert and Horticulture Officer at Zakura Nursery for necessary field permissions and guidance. We also thank all the owners of apple and apricot orchards for their kind support during field surveys and material collection.

# Appendix

**Table 10.6** List of commercial varieties of almond, apple, and apricot in Jammu and Kashmir State with their salient features

| S. no. | Fruit type | Name of the variety | Salient features |
|---|---|---|---|
| 1. | *Almond* | | |
| | | California paper Shell | Trees upright, medium in vigor, mid-blooming; nuts long, light brown in color, paper-shelled; mid- to late-season maturity |
| | | Drake | Trees low in vigor, spreading, mid-blooming; nuts small to medium in size, bold, roundish with pointed apex, light creamy whitish brown in color, semisoft shelled; mid-season maturity |
| | | Makhdoom | Trees large and spreading, mid-blooming; nuts broad at shoulder with bold and slightly curved apex, nut color brown, soft-shelled; mid- to late-season maturity |
| | | Merced | Trees medium in vigor, upright, mid-blooming; nuts medium, bold, slightly flattened, light brown in color, paper-shelled; mid- to late-season maturity |
| | | Ne-plus ultra | Trees vigorous, spreading, mid-blooming; nuts medium- to large-flattened, bold, light brown in color, paper-shelled; mid-season maturity |
| | | Nonpareil | Trees moderately vigorous, upright to spreading, mid-blooming; nuts medium, bold, light-brown in color, thin-shelled; early-season maturity |
| | | Pranyaj | Trees moderate in vigor, spreading, mid-blooming; nuts medium, brown, flattened to bulge, kernel medium to large, papery-shelled; mid-season maturity |
| | | Shalimar | Trees medium, spreading; nuts long in size, bold with tapering, curved, and pointed apex; nut color creamy brown to slightly whitish, soft-shelled; mid-season maturity |
| | | Primorskij | Trees spreading, moderately vigorous; mid- to late blooming; nuts medium to large, bold, slightly flattened, brown in color; kernel medium to large, soft, paper-shelled; late-season maturity |
| | | Waris | Trees upright in growth, medium vigor, mid-blooming; nuts medium in size, bold, bulged at shoulder, sharply pointed apex; nut color brown to creamy whitish, soft-shelled; mid- to late-season maturity |
| 2. | *Apple* | | |
| | | Ambri | Trees vigorous; fruits oblong, slightly conical toward calyx end; lobes not prominent, red streaks over greenish to yellow ground color; late in maturity (last week of September) |
| | | CITH Lodh Apple-1 | Trees medium in vigor; mid-season flowering, bearing mainly on spurs as well as on shoots; fruit large in size, globosely oblong, conical, smooth lobes, red striped/blushes over yellow ground; early- to mid-season maturity |
| | | Cooper-4 | Trees compact to medium in vigor, good spur development; fruits medium to oblong to conical, with prominently lobed calyx end, solid dark color covering whole fruit skin, very firm texture; maturity in mid-season |

(continued)

**Table 10.6** (continued)

| S. no. | Fruit type | Name of the variety | Salient features |
|---|---|---|---|
| | | Firdous | Trees vigorous; fruits large in size, oblong, conical with prominent calyx end, dark-red blush on yellow ground, resistant to scab; mid- to late-season maturity |
| | | Fuji | Trees medium to high in vigor, develop good spurs; fruits medium to large, round oblong to globose in shape; calyx end smooth, dull-red stripes or blushes on light green-yellow ground; mid in maturity; other strains are red Fuji and Coe red Fuji |
| | | Gala | Trees vigorous, semi-spur type; fruits medium, oval to globose, precocious and regular bearer, solid blush of red color on slightly golden-yellow ground; mid in maturity; various strains of gala are scarlet gala, Royal Gala, galaxy gala, gal gala, and Imperial gala |
| | | Gala must | Trees medium in vigor; fruits large, globosely round; calyx end smooth, red blush/stripes over yellow ground mid in maturity |
| | | Golden delicious | Trees vigorous, roundish oblong; fruit greenish yellow to golden yellow in color; late-season maturity (last week of September); best pollinizer for mid- and late-flowering groups |
| | | Golden spur | Trees compact to medium in vigor, spur type; fruits large, globose to oblong in shape with smooth calyx end; fruit color golden yellow with pink-orange tinge; mid-season maturity |
| | | Granny smith | Trees moderately vigorous; fruits roundish globose to slightly conical; calyx end smooth, bright green in color, sometimes slight yellow tinge appears upon the green blush; mid in maturity; acts as a pollinizer |
| | | Lal Ambri | Trees vigorous; fruits large, oblong to conical with prominent calyx end, dark red blush on yellow ground; mid- to late-season maturity |
| | | Mollies delicious | Trees medium to large in vigor, early blooming; fruits globose to conical; lobes present but not prominent; skin red stripped over greenish-yellow ground; early- to mid-maturity |
| | | Oregon spur | Spur type; fruit oblong to conical; skin completely dark-red blushed; calyx end prominently lobed; maturity second week of august |
| | | Red chief | Trees compact, spur type; spur density very high; fruits slightly oblong to sharp conical; calyx end distinctly lobed; skin solid-stripped dark red covering the whole fruit; maturity ending July to second week of august |
| | | Red delicious | Trees vigorous; fruits oblong to conical; calyx end prominently lobed; skin red stripped over yellow, firm texture; maturity late august; biennial bearing and self-incompatible |
| | | Red gold | Trees medium in vigor; fruits medium in size, round to slightly oblong, dark to dull red in color; maturity mid- to late July to first week of august; very good pollinizer |
| | | Rich-e-red | Trees vigorous; fruits oblong to conical with prominent lobes, red blush over greenish ground; firm texture; maturity third week of august |
| | | Royal Delicious | Trees vigorous; fruit oblong to conical, dark-red stripped, firm texture; maturity mid-august; biennial bearing; self-incompatible |

(continued)

**Table 10.6** (continued)

| S. no. | Fruit type | Name of the variety | Salient features |
|---|---|---|---|
| | | Starkrimson | Trees medium in vigor; fruits prominently conical; calyx end distinctly lobed; skin dark-red stripped; heavy bearing; maturity ending July to second week of august |
| | | Sunhari | Trees vigorous; fruits large, oblong, globose to slightly conical with smooth calyx end, dark golden yellow with orange to pink blush on green ground; mid- to late-season maturity |
| | | Top red | Trees medium to vigorous; fruits medium to large in size, conical with prominent calyx end; striped red-colored skin over greenish ground; mid-season maturity |
| | | Vance delicious | Trees vigorous; fruits medium to large, conical in shape with lobed calyx end; striped red skin on yellow ground; early- to mid-season maturity |
| 3. | *Apricot* | | |
| | | Australian sweet | Ripen in end July to late august; fruit size extra-large and highest among the cold arid cultivars; fruits round in shape, acute apex; mid flavor, medium sweet, acidic; not liked for table purpose but good for processing |
| | | Charmagz | Self-incompatible cultivar, needs a pollinizer; fruits medium in size, roundish flat in shape; skin straw yellow with light-yellow flesh which is very sweet and highly flavored, suitable for dessert and drying purposes |
| | | CITH Apricot-1 | Self-fertile; mid-season blooming; fruits very large (79 g), round, symmetrical smooth distal end, yellowish orange, reddish blemishes; early maturing; tolerant to major pests and diseases |
| | | CITH Apricot-2 | Self-fertile; early- to mid-season blooming; fruits very large in size, oblate, asymmetrical, slightly pointed beak, yellowish orange, reddish on exposed surface; early maturing; tolerant to leaf curl and stigmina blight |
| | | CITH Apricot-3 | Self-fertile; early- to mid-season blooming; fruits medium size, oblate, asymmetrical with slightly pointed beak, yellowish orange with very little reddish tinge; early- to mid-season maturing; tolerant to major pests and diseases |
| | | Halman | Tree spreading and vigorous; fruits large, roundish, skin deep yellow-golden color; kernel sweet, suitable for drying; early- to mid-season maturity in cold arid zone |
| | | Harcot | Trees upright to spreading, vigorous; fruits medium to large with roundish heart shape; skin yellow orange, red blushed; kernel sweet; early- to mid-season maturity |
| | | Kaisha | Trees vigorous, spreading; fruit medium sized, roundish, flattened shape, suture prominent; skin pale lemon yellow with red blush; free stone; early-season maturity |
| | | Nari | A late-ripening variety, available after mid-august; fruits medium in size, oblong, elliptical with truncate base; skin greenish to light yellow with red blush toward the sun-exposed surface; pulp light yellow, sweet/acid ratio is good; pleasant flavor |

(continued)

**Table 10.6** (continued)

| S. no. | Fruit type | Name of the variety | Salient features |
|---|---|---|---|
| | | New Castle | Trees vigorous, spreading; fruits medium to large size, roundish shape; skin lemon/barium yellow; early-season maturity |
| | | Raktsey-Karpo | An early cultivar, ripens in end July to mid-august; fruits medium to large in size, round with compressed pedicel end; pulp light pale, juicy, sweet, mild acidic with pleasant flavor |
| | | Rogan | Fruits small, highly juicy, round shape, glossy skin, straw yellow, very soft, juicy, slightly acidic; sweet pulp; fruit smallest among all cultivated varieties |
| | | Safeda | Fruits large, round; skin glossy, smooth, light-yellow color; flesh soft, maize yellow in color; very sweet, less acidic, pleasing flavor |
| | | Shakar Para | Fruits sweet with pleasant aroma, used for table purposes; ripen late in July to mid-august; fruits medium size, round shape; skin glossy, creamish yellow with rosy blush; pulp soft, light yellow in color; sweet, less acidic, pleasant flavor |
| | | Tokpopa | Fruits ripen late in august, medium size, round shape, compressed with smooth skin, dull-yellow color; juicy, acidic to sweet in taste |
| | | Turkey | Tree vigorous and spreading; fruits medium size, almost round in shape; skin deep yellow, brownish orange with dots; free stone; sweet kernel; mid-season maturity |

Source: Adopted from Singh (2010)

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# Chapter 11
# Varietal Diversity in Cereal Crops of the Jammu and Kashmir State

**N. A. Zeerak**

**Abstract** The precious plant genetic resources existing in the Jammu and Kashmir State hold vast potential for current and future use. These precious resources, however, are now increasingly being threatened, mainly because of human population pressure and changes in climatic and land use pattern and also due to rapid replacement of adapted, indigenous cultivars by the modern high-yielding varieties. Getting impetus from the national and international concerns over the ever-increasing threat to plant biodiversity, it is imperative that a scientific management for conservation of invaluable plant resources is immediately and urgently taken up in this Himalayan region. It is in this context that the present attempt has been made to document, characterize, and enlist the agro-biodiversity of the J&K State with special reference to maize, rice, wheat, and barley crops.

**Keywords** Agro-biodiversity · Himalaya · Variety · Land races

## 11.1 Introduction

Since earlier times, the people residing in the Himalayan State of Jammu and Kashmir (J&K) have been dependent on native biodiversity for their livelihood, food, and shelter. Historical facts stand testimony that biodiversity has always remained intricately associated with the people of the State for providing them with the resources essential for sustaining life. In particular, plant genetic resources have played a pivotal role in development of the societies and cultures of this Himalayan region. The precious plant genetic resources existing in the region hold vast potential for current and future users for the benefit of human kind. These precious resources, however, are now increasingly being threatened, mainly because of human population pressure and changes in climatic and land use pattern and also

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_11

due to rapid replacement of adapted, indigenous cultivars by the modern high-yielding varieties.

Use of plant resources for rapid commercial gains, monocultures, deforestation and land clearing, and use of biohazardous production technologies have also resulted in the loss of many indigenous crop varieties/land races, thereby shrinking the native genetic diversity of important agri-horticultural crops. Realizing this, a National Agricultural Technological Project was launched by the Indian Council of Agricultural Research (ICAR), and all diversity-rich areas of the country, including the J&K State, were brought under it for documentation of agro-biodiversity and its sustainable management and use. Getting impetus from the national and international concerns over the ever-increasing threat to plant biodiversity, it is imperative that a scientific management for conservation of invaluable plant resources is immediately and urgently taken up in this Himalayan region. Accordingly, the present chapter has made an attempt to document, characterize, and enlist the existing biodiversity with respect to plants of agri-horticultural importance growing across the J&K State.

## 11.2 Materials and Methods

Major agro-biodiversity-rich areas of Jammu, Kashmir, and Ladakh regions were surveyed during crop-growing seasons with an objective of exploration, identification, and documentation of agri-horticultural crops, including their wild relatives. The available diversity within major, important crops like cereals, pulses, oilseeds, forage crops, fruit and nuts, vegetables, spices and condiments, medicinal plants, and underutilized plants was recorded. All the crop germplasm, including land races, ecotypes, farmers' varieties, and the introduced high-yielding extant varieties under cultivation, after getting identified in consultation with farmers and agricultural experts, were characterized and enlisted. Indigenous technical knowledge associated with the available diversity, together with phytogeographical information, was also documented. The listed germplasm lines of all the varieties of field crops have been classified on the basis of their habitat and current status of cultivation. Accordingly, the field crop varieties have been designated as widely cultivated (WC), restricted cultivated (RC), and not cultivated (NC).

## 11.3 Results and Discussion

In this chapter, the agro-biodiversity of Jammu, Kashmir and Ladakh regions of J&K State in respect of their major cereal crops is presented.

### *11.3.1* Maize, *Zea mays* L. (Poaceae); Kashmiri Name, *Makayei*

On the basis of total area under maize crop in the J&K State, it ranks as number one cereal crop, but production-wise, it is next to rice. As diet also, maize ranks second after rice, as it is largely being used by *Gujjars* and *Bakarwals* as a routine meal in the form of bread. In villages, however, the mature grains after being roasted over fire are ground to form coarse flour locally known as "sattu," which is consumed with traditional salt tea. Maize cultivation, largely restricted to subtropical and temperate zones of the State due to favorable soil and moisture regimes, is practiced on soils varying from sub-forest slopes to dry plateaus and black peaty soils along the river banks. Area is fragmented, germplasm varied and area specific, and management practices vary from area to area.

Having a number of economic uses, a large number of maize types have been cultivated in the State since centuries. Traditionally, there were mainly two types of maize grown in Kashmir: the early-maturing maize, with soft white grain, and those with hard red grain; however, the latter ones, being sweeter, are preferred over white types. Other types of maize of varied shades of orange, cream, yellow, scarlet, and bluish black shades are also cultivated (Plate 11.1 A, B).

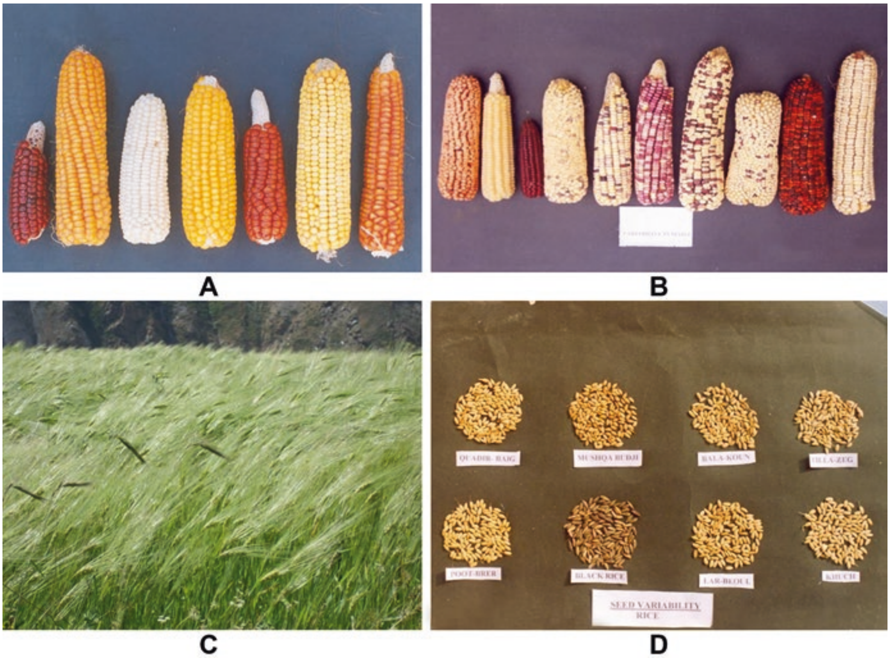


**Plate 11.1** (**A**–**D**): (**A**) Maize types under cultivation in Kashmir region; (**B**) Maize types maintained by Gujjar community of the state; (**C**) 'Ladakh Vishka', a traditional barley variety under cultivation in Drass, Kargil; (**D**) Variation in grain size and shape of some land races of rice

Till recently, presumably due to farmers' own preferences, selection pressure, and geographical isolation, all climatic or agricultural zones of the State used to cultivate their own local maize types, popularly known by their particular places of cultivation and uses. With the introduction of high-yielding varieties in the later part of the twentieth century, however, the traditional cultivars have either been replaced or their genetic purities have hardly remained cent percent. Nevertheless, they possess distinct morphological and quality traits and constitute a valuable germplasm resource of the State. Presently, the principal agricultural groups represented in the Kashmir include large-seeded dent corn, small-seeded flint corn, and sweet corn. All the types are single stalked and 2–3 meters high. The dent and flint types are grown both for table purpose and flour and *sattu* making, and they are also adapted as poultry feedings. Following are the various traditional cultivars/land races, exotic varieties, and recently released high-yielding varieties under cultivation in the State, especially in the Kashmir region.

#### 11.3.1.1 Traditional Farmers Varieties/Land Races

- **Anantnag Makayei**[RC]

The plant is moderately tall (1.2–2.30 m), bearing one to two cobs, yellow seeded, yielding 3.0–3.5 t/ha.

- **Qazigund Makayei** [RC]

It is a local maize type of Kandi maize belt of Qazigund with small seeds of orange type.

- **Pahalgam Makayei** [RC]

It is grown on the hilly terrain of Pahalgam at altitudes of 2500–3000 m amsl. The variety is popular for bread making because of its white flour, and it can adapt to cold conditions. It is early maturing (100–105 days) and has semi-dent gains with yield potential of 20–25 q/ha. It is moderately susceptible to *Turcicum* leaf blight.

- **Gurez Makayei** [RC]

Plant is dwarf with thin stem. It is the traditional maize variety of Gurez and Tilail areas and sown on foothills up to 3500 m amsl. The grains are small, flint, and predominantly white, although yellow lines are also present; it is cold tolerant, with extra early maturity and moderate tolerance to *Turcicum* leaf blight.

- **Niver Makayei** [RC]

It is the commonly grown variety in hilly maize-growing areas of Kashmir and characterized by tall stalks, bold grains, and cobs with higher number of kernel rows. Seeds are either yellow or creamish, accordingly known as *Safed* and *Zared Niver*, respectively. The variety is preferred to other varieties in view of its high yield, early maturity, taste, and long shelf life.

- **Mishre Makayei** [RC]

The sweet corn or sugar corn is grown in some traditional maize belts. Grains are bright yellow to golden and highly shrunken due to soft endosperm. It is popular for consumption as roasted or boiled; it is very early maturing (85–90 days).

- **Aru Makayei** [RC]

It is grown in the high-altitude belts, mostly around Pahalgam up to 3100 m amsl. Plants are medium tall, cobs small, kernel flint, available in different colors of orange, purple, and yellow, early maturing with very high tolerance to cold. Having initially evolved and cultivated by farmers of Aru and Pahalgam, hence the name.

- **Vyaloo Makayei** [RC]

It is moderately flint and light-yellow variety, generally single cobbed and tolerant to cold under altitude range of 2000–3100 m amsl. With yield potential of about 20 q/ha, it is early maturing (100–105 days) but susceptible to *Turcicum* leaf blight. Having been adapted and mostly cultivated in the Vyaloo, Kokernag belt of South Kashmir, hence the name.

- **Poonch Makayei** [RC]

It is a traditional fodder-cum-grain maize variety, mostly grown in the hilly areas of Poonch and adjacent areas. It is a tall variety with medium cob size and small dull whitish semi-dent grains.

- **Paigambri Makayei** [RC]

It is a local maize variety grown in some hilly areas of Poonch and Doda. It has characteristic of large cobs with bold grains of varied shades of dense white and dark purple. The tribal *Gujjars* of these areas cultivate the variety and safeguard its genetic identity with reverence and belief that the cultivar was gifted to them by Prophet Himself, several centuries before!

#### 11.3.1.2 Released Varieties

- **Hybrid Makka-123** [NC]

A Himalayan hybrid developed by the Department of Agriculture, J&K State, and released on all India basis, for hill areas in 1964. The yield is about 55 q/ha and recommended up to an altitude of 2200 m. It has orange-yellow semi-dent grains and matures in about 135–145 days in Kashmir.

- **Composite-1** [NC]

The variety was developed and released by the Department of Agriculture, J&K State, during 1967, for cultivation in temperate regions of the State above 1550 m amsl. Plants are tall with orange-yellow flint grains. The variety matures within 125–130 days and has yield potential of 40–45 q/ha.

- **Composite-2** $^{NC}$

It was developed by the Department of Agriculture, J&K State, in 1968, for cultivation in temperate belts of the State. Grains are bold, yellow, and semi-dent type and ideal for *chapatti* and *sattu* making. It matures within 130–140 days and has a yield potential of 50–55 q/ha.

- **Composite-3** $^{NC}$

It was developed for maize growing belts by the Department of Agriculture, J&K State, during 1970, recommended up to elevation of 2000 m amsl. Grains are yellow and dent type; it matures within 130–135 days and the yield potential is about 55 q/ha.

- **Composite 4** $^{NC}$

It was developed for Himalayan zone as a whole. The variety has bold, white dent grains and is suited for areas like Uri, Poonch, and Rajouri, where there is a preference for white types.

- **Composite-5** $^{RC}$

It was developed by the Department of Agriculture, J&K State, during 1974, for cultivation in sub-Himalayan zones of the State and in plains of Jammu (500–1500 m amsl). Its yield potential is 50–55 q/ha. Grains are orange flint type and bold.

- **Composite-6** $^{WC}$

It was jointly developed and released by the Department of Agriculture, J&K State, and Sher-e-Kashmir University of Agricultural Science and Technology-Kashmir (SKUAST-K) during 1991, for cultivation in the temperate zones of the State at elevations of 1500–1800 m amsl. Plants are medium tall, vigorous with ear placement at reasonable height. Leaves are deep green with narrow apex with strong stilt roots, ears medium thick with compact green husk cover, tassel branched and semi-compact, and silk predominantly light green. Grains are bold, flint type, and orange yellow. The variety is resistant to *Turcicum* blight under field conditions. Yield potential is 45–50 q/ha under suitable management conditions and matures within 155–160 days in the temperate zones and 125–130 days in subtropical zones.

- **Composite-7** $^{RC}$

It was developed and released by the Department of Agriculture, J&K State, in the year 1984, for general cultivation in the hilly maize-growing belts. The plants are tall with lower ear placement, orange-yellow semi-dent to dent grains, medium maturity, and with a yield potential of 35–45 q/ha.

- **Composite-8** $^{WC}$

It was jointly developed by bulk sib-pollination of five $F_{1s}$ produced from exotic material and local materials by the Department of Agriculture, J&K State, and

SKUAST-K and released in 1993 for cultivation in lower and irrigated foothill areas in the Kashmir, higher reaches of the Jammu region (1500–1800 m amsl), and mid elevations (600–1000 m amsl) of Poonch, Rajouri, and Udhampur districts of the Jammu region. Plants are medium tall, vigorous with air placement at reasonable height, leaves dark green with narrow apex with strong stilt roots, ears long and medium thick with compact green husk cover, tassel branched and semi-compact, and silk predominantly light green. Grains are bold, creamy-white, semi-dent, and conical with flat lateral surfaces; it matures within 150–155 days in Kashmir and higher altitudes of Jammu and 110–115 days in mid-elevation zones. The variety is resistant to *Turcicum* blight under field conditions. Yield potential is 40–50 q/ha under suitable management conditions.

- **Composite-14 [RC]**

It was jointly developed and released by the Department of Agriculture, J&K State, and SKUAST-K in 1996 for cultivation in lower and higher altitudes of Kashmir from 2000 to 3100 m amsl. Plants are medium tall (1.5–2 m), leaves narrow and green, tassel lax and medium sized, silk light yellow to purplish, husk cover green, fully covered, cobs medium sized with conical shape, grains bold and orange to orange yellow, predominantly flint which makes them good for *chappati* making, and matures within 135–145 days in Kashmir, 100–110 days in mid-elevation zones, and 95–100 days in Jammu plains. The variety has high level of field resistance to major diseases especially *Turcicum* blight. It has a fair tolerance to stem lodging/breakage, even under high fertility levels. The average yield ranges between 45 and 50 q/ha.

- **Composite-15 [WC]**

It was jointly developed and released by the Department of Agriculture, J&K State, and SKUAST-K in 1993 for cultivation in the hilly maize-growing regions. Plants are tall, vigorous with air placement at reasonable height, leaves deep green with narrow apex, strong stilt roots, ears medium thick with compact green husk cover, silk predominantly light green, and grains bold and orange yellow. The variety is resistant to *Turcicum* blight under field conditions. Yield potential is 45–50q/ha. The plant does not lodge and escapes stem breakage under high fertility conditions. It is early maturing, within 155–160 days in temperate zones and 125–130 days in mid-elevation zones.

- **Composite Super-1 [RC]**

It was developed and released during 1994 by the Department of Agriculture, J&K State, and SKUAST-K for general cultivation in Kashmir and hilly maize-growing regions of Jammu. Plants are tall, vigorous with air placement at reasonable height, and leaves deep green with strong stilt roots which make the plant lodging resistant. Ears are medium thick with compact green husk cover, silk predominantly light green, and grains bold, orange yellow, and semi-flint. The variety is resistant to *Turcicum* blight under field conditions. Yield potential is 50–60 q/ha under suitable management conditions. The plant does not lodge and escapes stem breakage under high fertility conditions. It matures within 155–160 days in temperate zones, 125–130 days in mid-elevation zones, and 110–115 days in Jammu plains.

- **Shalimar Kishan Ganga Maize Composite-1$^{WC}$**

The fodder-cum-grain variety was developed and released by SKUAST-K during 2004 using the exotic International Maize and Wheat Improvement Center (CIMMYT)-Mexico and local land races for cultivation in the maize-growing areas of Gurez and Machil. It is recommended for cold hills of Kashmir (above 2500 m amsl); the plants are medium tall with strong internode, anthocyanin pigmentation, and resistant to lodging. Grains are flint type and uniform light orange with whitish-yellow tip, silk slightly purplish, and cobs medium sized and conical-cylindrical in shape. This variety shows extra early maturing within 120–125 days. It is tolerant to leaf blight and downy mildew and is resistant to stem rot. The variety has yield potential of 45–50 q/ha.

- **Shalimar Kishan Ganga Maize Composite-2 $^{WC}$**

An extra early-maturing maize variety was developed from exotic CIMMYT material and local Gurez maize types and released during 2004 by SKUAST-K for cultivation in the maize-growing belts of Gurez and Machil in Kashmir region. Recommended for cold hills of Kashmir (above 2500 m. amsl), the plants are medium tall with strong tassel and silk with anthocyanin pigmentation. It is resistant to cold, lodging, and shattering with wide leaf angle, grains flint type and uniformly light orange with yellow sides and white-yellowish tip, and cobs medium sized and slightly conical in shape. The variety matures within 120–125 days, is tolerant to leaf blight and downy mildew, and is resistant to stem rot. It is also moderately tolerant to maize stem borer and *Angoumois* grain moth. The variety is dual fodder-cum-grain type and has yield potential of 40–45 q/ha.

- **Shalimar Maize Composite-3 $^{WC}$**

This variety has been developed by SKUAST-K through varietal cross between Pahalgam Yellow, Local Lidroo, C-15, Pop 85, C-4, and C-15, with subsequent selections. It is a yellow-grained variety with early maturity (135–145 days), high yield and higher grain protein, disease resistance, and cold tolerance. It has an average grain yield potential of 48 q/ha and possesses a yield superiority of 20% over standard check C-15, good farmer's acceptability for its early maturity, and good grain/fodder yield, suitable for cultivation in high altitudes of Kashmir region.

- **Shalimar Maize Composite-4 $^{MC}$**

It was developed by SKUAST-K from a varietal cross between the maize genotypes KH-5991, F-7012, SSFX-9199, and C-36 received from the Directorate of Maize Research, Hyderabad (India). The variety has good biomass, timely maturity, and high yield. Grain is flint type with orange-yellow color and high protein content. It has an average yield potential of 63 q/ha and exhibits a yield superiority of

30% over C-6. It is recommended for plains of Kashmir Valley and mid altitudes of Jammu and suitable for poultry industry because of small grain size.

- **Shalimar Maize Hybrid-1** [WC]

A commercial maize hybrid released by SKUAST-K during 2010. It was developed by crossing two inbred lines (CML 349 and CML 354) received from CIMMYT and released for cultivation in high-altitude areas of Kashmir. The variety has flint and white grains, early maturity (135–145 days), very high yield potential, and moderate resistance to *Turcicum* leaf blight, common rust, and stem borer. It has a grain yield potential of 65 q/ha, with a yield superiority of 30% and 50%, respectively, for grain and fodder yield over standard check C-15. The variety has good acceptability for its good yield potential and early maturity.

## *11.3.2* Wheat, *Triticum aestivum* Linn. (Poaceae); Kashmiri Name, *Knakhe*

Wheat is the third most important cereal crop of the State after rice and maize, especially in the subtropical zone. Although grown in Kashmir region as well as in the cold arid zone of Ladakh, its area of cultivation and productivity levels are low in these two regions as compared to subtropical wheat-growing Jammu belt of the State. One of the obvious reasons for this low productivity is that wheat in the Kashmir is largely cultivated as a monocrop, mostly in *Kandi* areas on non-rice lands, under rainfed conditions which are not favorable to improved varieties of wheat. Moreover, its cultivation under double cropping with rice also has limitations; it normally matures by late June, does not completely fit in the wheat-rice cropping sequence, and hence is not cultivated in paddy lands. In the cold arid zone of Ladakh, about 5000 hectares of land are under wheat crop, but the varieties cultivated are used both for grain and fodder purposes. However, due to modernization in agricultural practices and introduction of high-yielding varieties, the area under this crop in different geographical regions of the State has now increased. The commonly cultivated, traditional, introduced, and State-released high-yielding wheat varieties of J&K include the following.

- **Kashmiri Knakhe** [NC]

It is a traditional wheat variety of Kashmir grown in villages of *Kandi* areas of *Dachan parganah.* The plants are short statured (70–105 cm) with amber-reddish grains, yielding about 20–25 q/ha. Having low yield potential, late maturing, and poor food quality, it has been now almost completely replaced by modern varieties.

- **HS-240** [WC]

It was developed by the Indian Agricultural Research Institute (IARI), Shimla, and released for Northern Hill Zone of the country during 1988. Plants are with erect growth habit, erect flag leaf angle, and semi-erect angle of the ear; ear density lax, tapering, and awned; and grains amber colored, hard, and ovate, with medium crease.

- **HS-295** [WC]

It was developed by IARI, Shimla, and released during 1992 for Northern Hill Zone under rainfed conditions. Early growth habit is erect, flag leaf angle is erect, angle of the ear is semi-erect, ears are white and tapering with white awns, and grains are amber colored, semihard, ovate, and with medium crease.

- **VL-738** [WC]

It was developed and released by the Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora, during 1996, for cultivation in the wheat-growing areas of Northern Hill Zone under timely sown, rainfed/irrigated conditions. Early plant growth is semi-erect; flag leaf erect; ear angle erect; ears tapering, white, and awnless; grains amber colored, semihard, ovate, and bold with narrow crease.

- **Mansarover (Sel-195)** [RC]

A popular wheat variety of Ladakh region cultivated both for grain and for fodder purposes. It was released by SKUAST-K in 1999, specifically for cultivation in cold arid wheat-growing areas of Ladakh. It is a semi-tall variety with small amber-colored grains, matures within 115–125 days, and is tolerant to biotic and abiotic stresses; grain yield ranges between 30 and 40 q/ha and fodder yield ranges between 80 and 110 q/ha.

- **Singchen (Swl-8)** [RC]

It was released by SKUAST-K in 1999 for wheat-growing belts of Ladakh region. Plants are tall with thick stem and amber-colored grains. With medium maturity, variety shows resistance to lodging, yellow rust, and ear cockle diseases. Grains are preferred for *chapatti* making and straw palatable to animals. It has shown adaptability to the typical agroclimatic conditions of Ladakh. Yield potential ranges between 35 and 38 q/ha and straw yield 90 and 95 q/ha.

- **Kailash (Sel-194)** [RC]

It was developed and released by SKUAST-K in 2001 for cultivation in the cold arid zone of Ladakh. Plants are medium tall with amber-colored, hard, and bold grains, leaves erect, waxy, and ears compact and awned; it is tolerant to intermittent stress of high temperature, intense solar radiation, and moisture stress. It matures within 120–130 days and has a yield potential of 40–45 q/ha plus straw yield potential of 90–115 q/ha.

- **Shalimar Wheat-1** [WC]

A high-yielding wheat variety developed and released by SKUAST-K in 2004 for cultivation in Northern Hill Zone under rainfed/restricted irrigation and timely sown production conditions. Plants are erect and medium tall (76–115 cm) with tapering ears, bearing deep amber, semihard grains; it is resistant to stripe rust and leaf rust. With a grain yield of about 40 q/ha, it has gained popularity in Kashmir as it matures early and fits well in the wheat-rice cropping sequence.

### *11.3.3* Barley, *Hordeum vulgare* Linn. (Poaceae); Kashmiri Name, *Vishka*

In Kashmir, barley used to be marginally cultivated either separately or along with wheat mostly in hilly tracts as a substitute to wheat. In view of its less preference as a food crop, no special attention has been given to its cultivation. The cultivars grown used to be low yielding and with inferior grain qualities and were often mixed with wheat during milling The crop has now over the years reduced its area under cultivation and has largely been brought under wheat crop. In Ladakh, on the other hand, barley has been an important crop having been used as a staple food and thus has received full attention during its cultivation since decades. Some of the traditional and recently released varieties being largely cultivated in the Ladakh region are as follows:

- **Tibetan Awnless** [RC]

It is a traditional naked barley variety grown in cold arid zone of Ladakh and higher hills of Kashmir up to an attitude of 3400 m amsl. The plants are medium tall with naked grains. The grains have been a staple food for the people residing in Ladakh area since ancient times. Its flour is superior than other barley varieties, similar to wheat and suitable for bread preparation; hence, it is still under cultivation despite introduction of superior varieties.

- **Ladakhi Vishka** [RC]

It is traditionally grown in Ladakh. Plants are tall with weak stem and hence well prone to lodging. Grains are slender, dull, and amber colored, suitable for *sattu* and bread preparation. Traditionally, the extract of the grains was given to patients suffering from renal problems. The grains are not esteemed as a food and are often mixed with wheat by millers (Plate 11.1 C).

- **Nurboo (SBL-4)** [RC]

It is one of the released varieties of naked barley by SKUAST-K in 1999, being cultivated in barley-growing areas of Ladakh under cold arid climatic conditions. The plants are tall with ear neck curved. The grains are smaller, bold and shining, and amber colored, suitable for *sattu* preparation. The variety gives average grain yield of 38 q/ha and straw yield of 65 q/ha. Plants are moderately resistant to yellow rust and pests.

- **Sindhu (NBL-11)** [RC]

It is a naked barley variety developed and released by SKUAST-K in 1999, for cultivation in barley-growing areas of Ladakh. It is popularly grown in Leh and Kargil areas of Ladakh region during normal crop season. The plants are semi-tall, with large droopy leaves. Grains are bold, elliptical, and slightly bluish. Crop duration is from 100 to 110 days. Plants are tolerant to yellow rust but moderately resistant to loose smut. Average yield ranges from 28 to 35 q/ha and straw yield of 50–70 q/ha, and it is suitable for making *sattu* and *chuang*.

### *11.3.4* Rice, *Oryza sativa* Linn. (Poaceae); Kashmiri Name, *Dauni*

Among the three regions of the State, Kashmir is prominently a rice bowl, feeding majority of its inhabitants. Since rice has been the principal food crop of Kashmiris, much attention and importance has been given to its cultivation since earlier times. Moreover, the soil is suitable for its cultivation, and the supply of water has always been sufficient. In fact, the farmers have been cultivating rice even up to an altitude of 2550 m, where the fields are terraced carefully to hold the water and anxiously weeded.

Kashmiris, been great connoisseurs of rice, used to boast of having as many as 150 varieties, each having its special quality in taste, fragrance, and digestibility. Each cultivar could be recognized at various stages of growth, like color of seed, seedling, and adult plant characteristics. Most of these varieties, though having unknown origin and apparently evolved by farmers' own selections (as most of them had names with Kashmiri epithets), had been under cultivation till recently. They showed tremendous diversity, and each agroecological situation in the region had dozens of rice types suited to its ecological niche, thus representing typical land races. According to Lawrence (1895), some villages were famous for their peculiar rice land races. The varieties grown were broadly of two types, the white and the red types, of which the former was the more esteemed by epicures, though the cultivators preferred the latter type as it was less delicate, suffered less from change in climate, and resulted in a higher output (Youngerband 1970). During the governorship of Main Singh (1835–1841), 71 varieties were grown, and the best known among them were *Kinji*, *Dany*, and *Katha Chhan* in red types and *Basmati* and *Chugal* in white types. Rice grown at Nirpur village in district Anantnag was considered to be the finest (Sharma 1986). Despite being quality rice, most of these cultivars were at the same time low yielding and prone to biotic and abiotic stresses (Plate 11.1 D).

Total rice cultivation in the State till first half of the twentieth century was based on the native varieties, after which their low-yield potential and varied response to biotic and abiotic stresses compelled the growers to shift to cultivation of high-yielding and better types. Also, increased food demands and introduction of exotic types accelerated their replacement, and by 1970s, the important rice-producing areas in Kashmir were completely brought under the cultivation of exotic cultivars, which outyielded the local types. Since then, due to getting out of the cycle of cultivation, most of the land races have now become unfamiliar to local growers, except a few types which are still under cultivation at high altitudes, where the exotic and other improved types fail to get proper photoperiodic requirements. Nevertheless, due to conscious efforts of some rice growers to prefer quality rice, some of the local land races are still grown, though in small areas, being thus prevented from extinction. Also, due to consistent efforts of the scientists at SKUAST-K, a good number of local rice types have been collected and characterized and are being maintained as germplasm at the Regional Rice Research Station (RRRS), Khudwani, Anantnag, Kashmir (Parray 2000). The genetic identities of these types are being maintained by breeders at SKUAST-K through ex situ and in situ conservation techniques. Presently, diversity in rice is largely represented by the introduced/locally bred old and new varieties, some land races, and farmers' varieties, as listed hereunder (Plate 11.1 D):

#### 11.3.4.1 Land Races/Farmers' Varieties

- **Aziz Beoul** [NC]

Plants medium tall. Leaf blade and basal leaf sheath green; ligule clefted and white; collar green; auricle pale green; flag leaf angle horizontal. Panicles short and fully awned. Grains bold and slightly aromatic.

- **Begum** [NC]

Plants medium tall. Leaf blade and basal leaf sheath green; drooping leaf angle; ligule clefted and white; collar green; auricle pale green; flag leaf angle descending. Panicles fully awned, with purple awns. Grains bold, nonaromatic, and non-shattering.

- **Bala Koune** [NC]

Plants are short statured. Leaf blade and leaf sheath purple; leaf angle horizontal; flag leaf angle intermediate; ligules white and clefted; collar green; auricle purple. Panicles compact with purple awns. Threshability loose. Grains short, bold, and nonaromatic.

- **Baber** [NC]

Plants medium tall. Leaf blade green with purple leaf sheaths; leaf angle horizontal; ligule white and clefted; collar and auricle purple; flag leaf horizontal. Panicles compact with straw-colored awns. Grains bold and slightly scented. The variety has early maturity and intermediate threshability (Plate 11.2 A).

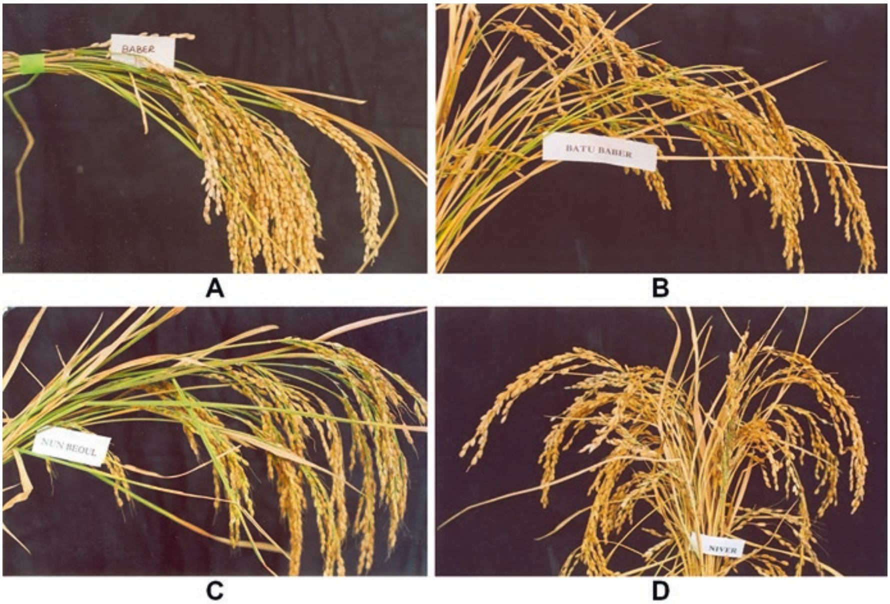


**Plate 11.2** (**A**–**D**) Kashmiri land races of rice: (**A**) Baber; (**B**) Batu Baber; (**C**) Nun Beoul; (**D**) Niver

- **Batu Baber** NC

Plants medium tall. Leaf blade and leaf sheath green; leaf angle erect. Ligule white and clefted; collar green; auricle pale green. Panicles compact and awnless; lemma and palea purple. Grains bold, slightly scented, and non-shattering (Plate 11.2 B).

- **Brez** NC

Plants of medium height. Leaf blade and leaf sheath green; ligule white and clefted; collar green; auricle pale green; flag leaf angle horizontal. Panicles compact and partly awned. The variety matures early and has characteristic bold and slightly scented grains.

- **Barat** NC

Plants tall. Leaf blade and leaf sheath green. Leaf angle horizontal. Ligule white and clefted; collar green; auricle pale green; flag leaf angle horizontal. Panicles compact, with black awns. Grains bold and nonaromatic. Lemma and palea glabrous and brown.

- **Bala-Anzul** NC

Plants of average height. Leaf angle horizontal; leaf blade and basal leaf sheath green. Ligule white and clefted; collar green; auricle purple; flag leaf angle horizontal. Panicles compact and awned; lemma and palea glabrous and of straw color. Grains bold and nonaromatic.

- **Black Rice** [NC]

Plants tall. Leaf angle erect. Leaf blade dark green and pubescent; basal flag and leaf sheath green; leaf angle horizontal; collar and auricle pale green; ligule white with acute tip. Panicles compact and awnless. Lemma and palea brown to black. Grains bold but slender with high length/breadth ratio and scented.

- **Chini Bara** [NC]

Plants characterized by purple-colored foliage. Flag leaf angle horizontal; ligule purple; collar and auricle with purple spots. Panicles compact and fully awned. Grains bold and nonaromatic.

- **Guru-Kaune** [NC]

An early-maturing variety, characterized by compact panicles with black awns. Leaf angle horizontal; leaf blade and leaf sheath green; ligule white and clefted; auricle and collar green. Grains bold and slightly scented.

- **Gulla Bara** [NC]

Plants tall statured, characterized by early maturity and purple awns. Leaf angle horizontal; leaf blade and leaf sheath; ligule white and clefted; auricle purple; collar green. Panicles compact, with long purple awns. Grains bold, slightly scented, and non-shattering.

- **Gulla Zag** [NC]

The variety is characterized by red-colored glumes and purple-awned panicles. Flag leaf angle horizontal; collar green; auricle purple. It is average-yielding and shattering susceptible. Grains bold, with good cooking qualities.

- **Kala Brear** [NC]

Leaf blade and leaf sheath green; ligules white, with purple lines; collar green; auricle pale green. Panicles compact and awnless; flag leaf erect. Grains non-shattering and non-scented. Plants have profuse tillering.

- **Khuch** [NC]

Plants tall. Leaf erect angled; flag leaf inclined. Panicles semi-compact and awnless. Grains bold, shattering type, and slightly scented. Lemma and palea glabrous, with golden furrows on straw.

- **Kawa Krear** [NC]

Plants of medium height and vigorous growth. Medium tillering; culms erect; leaf blade green and pubescent; basal leaf sheath green; flag leaf inclined; auricle pale green; ligule white and clefted; collar green. Panicles partly exerted beyond flag leaf sheath, compact, and fully awned; awns purple. Lemma and palea glabrous, with brown spots on straw. Grains slender, non-shattering, and slightly scented.

- **Kathwari** [NC]

Plants tall with vigorous growth; medium tillering; culms bent; leaves erect; leaf blade green and pubescent; basal leaf-sheath green; flag leaf horizontal; ligule white and clefted; collar green; auricle pale green. Panicles well exerted, compact, and fully awned; lemma and palea with brown spots on straw and hair on lemma bed. Leaf senescence late and slow. Grains bold, non-shattering, and non-scented. This land race is good yielder (3–3.5 t/ha).

- **Kamad** [RC]

Plants of medium height and good vegetative growth. Medium tillering; leaf angle erect; leaf blade green and pubescent; flag leaf angle inclined; ligule white and clefted; collar green; auricle pale green. Panicles well exerted, compact, and awnless; lemma and palea purple and glabrous. Grains reddish, non-shattering, and scented. Early maturity; high mill rice recovery.

- **Larbeoul** [NC]

Plants tall; leaf angle erect; leaf blade green and pubescent; basal leaf sheath green; flag leaf inclined; ligule white and clefted; collar green; auricle pale green. Panicles well exerted, compact, and awnless; lemma and palea white and glabrous. Grains slender, non-scented, and non-shattering. Quality rice with good cooking qualities.

- **Mehwan** [NC]

Plants of medium height and profuse tillering; culms erect; leaf angle erect; blade dark green and pubescent; basal leaf sheath green; flag leaf inclined; ligule with purple lines and clefted; collar and auricle pale green. Panicles long, semi-compact, awnless, and well exerted; lemma and palea with brown spots and glabrous. Grains bold, shattering type, and slightly scented. Leaf senescence late and slow. High yielding.

- **Mughal** [NC]

Plants tall, with medium tillering; culms erect; leaf blade green and leaf angle erect; flag leaf erect; ligule purple and clefted; collar green; auricle pale green. Panicles partly exerted, compact, and awnless. Lemma and palea purple and glabrous. Grains bold, non-shattering, and slightly scented. Early maturing and leaf senescence late.

- **Mushkandi** [NC]

Plants tall, with vigorous growth and poor tillering; leaf blade green and pubescent; leaf angle horizontal; basal leaf sheath green; ligule white and clefted; collar green; auricle pale green; flag leaf horizontal. Panicles just exerted, fully awned, and semi-compact. Lemma and palea white and glabrous. Leaf senescence late and slow. Grains bold, non-shattering, and slightly scented. Cold tolerant and cultivated in hilly areas of the valley. Short maturity period.

- **Meer Zag** NC

Plants of medium height and vigorous growth. Leaf angle erect; leaf blade green and pubescent; basal leaf sheath green; ligule white and truncated; collar green; auricle purple; flag leaf erect; panicles well exerted, awned, and semi-compact. Lemma and palea with purple spots on straw and glabrous. Grains bold, non-shattering, and slightly scented. Early maturity period. High yielding.

- **Mushk Budji** RC

Plants of medium height and medium tillering; flag leaf angle horizontal; leaf blade green and pubescent; basal leaf sheath green; ligule white and clefted; collar green; auricle pale green. Panicles well exerted, awnless, and compact. Lemma and palea white and glabrous. Leaf senescence late and slow. Grains bold, non-shattering, and scented. High mill rice recovery.

- **Mazette** NC

Plants of average height and medium tillering. Leaf angle erect; leaf blade dark green and pubescent; basal leaf sheath green; ligule white and clefted; collar green; auricle pale green; flag leaf erect. Panicles well exerted, compact, and partially awned; awns purple and short; lemma and palea reddish to light purple and with short hairs. Grains bold, non-shattering, and slightly scented. Early maturity period. Average yielding.

- **Nunbeoul** NC

Plants tall, with vigorous growth. Leaf angle erect; leaf blade green and pubescent; basal leaf sheath green; ligule white and truncated. Collar green; auricle purple; flag leaf erect; panicles compact, awned, and fully exerted. Lemma ad palea glabrous and with purple spots on straw. Panicles compact, awned, and non-shattering. Grains bold and slightly scented. High yielding (Plate 11.2 C).

- **Noor-Meri** NC

Plants of medium height; culms erect; leaf angle erect; basal leaf sheath green; leaf blade green and pubescent; ligule white and clefted; collar green; auricle pale green. Flag leaf inclined. Panicles well exerted, compact, and awned. Lemma and palea with brown spots and glabrous. Grains shattering type and non-scented; late leaf senescence. High yielding.

- **Niver Zag** NC

Plant stature short, with erect culms and medium tillering; leaf angle drooping; leaf blade green; basal leaf sheath purple; ligule white and clefted; collar green; auricle pale green. Flag leaf angle descending. Panicles well exerted, compact, and awnless. Grains bold, non-scented, and non-shattering. Early maturing; late leaf senescence.

- **Nick-Cheena** [RC]

Medium tall and with normal growth; medium tillering; culms erect; leaf angle erect. Leaf blade green; basal leaf sheath green; ligule white and clefted; collar green; auricle pale green; flag leaf erect. Panicles compact, exerted, and partially awned. Lemma and palea brown with hairs. Grains bold, non-shattering, and non-scented.

- **Punch-Wall** [NC]

Plants of medium height and vigorous growth; leaf blade pubescent and green; basal leaf sheath green; flag leaf angle erect; ligule white and clefted; auricle purple. Panicles compact and fully awned with long purple awns; medium tillering; threshability loose. Grains bold and non-scented.

- **Prenie Baber** [NC]

Medium tall, with profuse growth; medium tillering; culms erect; leaves horizontal; leaf blade glabrous with purple basal leaf sheath; flag leaf angle erect; ligule white and clefted; collar purple; auricle purple. Panicles compact, well exerted, and fully awned with awns of golden color. Grains bold, slightly scented, and non-shattering. Early maturing.

- **Poot Brear** [NC]

Medium tall variety with profuse tillering; culm stout and erect; leaf angle horizontal; leaf blade green and glabrous; basal leaf sheath green; ligule white and clefted; collar green; auricle pale green; flag leaf descending. Panicles semi-compact, with awns of purple color. Lemma and palea with purple spots and hairs on lemma bed. Grains slender, non-shattering, and non-scented; high-yielding variety (Plate 11.3 A).

- **Niver** [NC]

Plants of short stature with thick culms. Grains bold, reddish, sweet, and nourishing (Plate 11.2 D).

- **Prenie Zager** [NC]

Plants medium tall. Leaf blade pubescence purple; basal leaf sheath purple; flag leaf angle erect; ligule white and clefted; collar and auricle purple. Panicles well exerted, compact, and awnless; lemma and palea glabrous with golden furrows on straw. Leaf senescence late and slow. Grains bold, slightly scented, and non-shattering.

- **Qadir Ganai** [NC]

A farmers' variety with high yield, normal growth, and profuse tillering. Culms erect; leaf blade pubescent and gray; basal leaf sheath green; leaves horizontal; ligule white and clefted; collar green; auricle pale green. Flag leaf horizontal; pani-

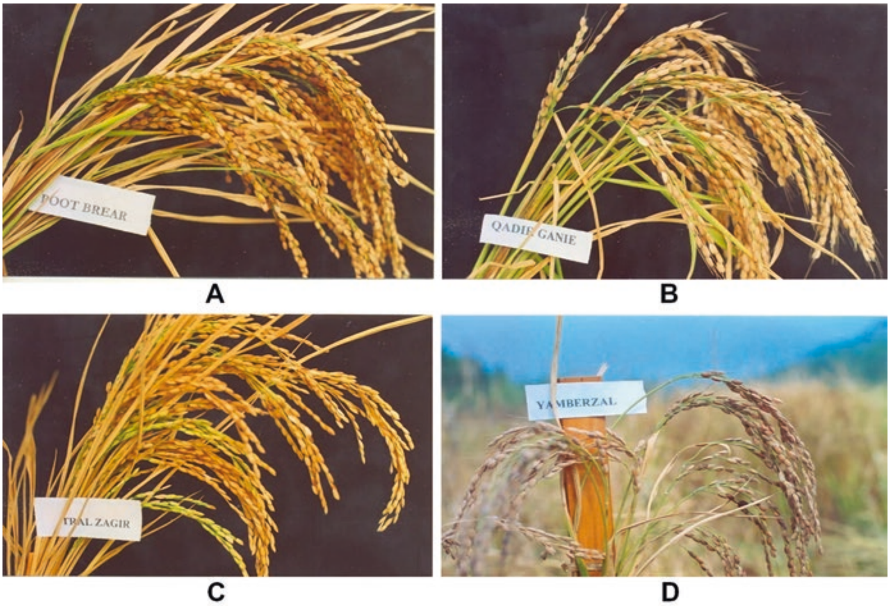


**Plate 11.3** (**A**–**D**) Kashmiri land races of rice contd: (**A**) Poot Brear; (**B**) Qadir Ganai; (**C**) Trel Zager; (**D**) Yimberzuol

cles compact, awnless, and well exerted. Lemma and palea with short hairs. Grains bold, scented, and shattering type (Plate 11.3 B).

- **Qadir Baig** NC

Medium tall. Leaf angle horizontal; leaf blade pale green; basal leaf sheath green; ligule white and clefted; collar green; auricle purple; flag leaf horizontal. Panicles well exerted, compact, and partially awned; awns short and purple; lemma and palea glabrous and purple. Grains bold, shattering prone, and slightly scented. Early maturing and quality rice cultivars.

- **Rama Hall** NC

Tall plant type, with medium tillering. Culm angle erect. Flag leaf angle erect; lemma and palea with golden furrows on straw and with long hairs; panicles compact, well exerted, and partially awned. Grains bold, non-shattering, and non-scented.

- **Rehman Bhatti** RC

**P**lants tall, with culm angle erect; leaf angle horizontal. Flag leaf angle descending. Panicles partially exerted, loose, and fully awned; awns long and purple. Lemma and palea with purple spots on straw and with hairs on lemma bed. Grains bold, shattering prone, and non-scented.

- **Resham** NC

Medium tall plants with extensive tillering. Leaf blade green with purple margins. Flag leaf descending. Panicles long, compact, awnless, and well exerted. Lemma and palea of straw color and with long hairs. Grains slender, non-shattering, and non-scented.

- **Siga** NC

Tall plant type with medium tillering. Culm angle erect. Flag leaf angle erect. Panicles compact, well exerted, and fully awned; awns of straw color. Lemma and palea brown and glabrous. Grains bold, non-shattering, and slightly scented. High yielding; white kernel; late maturity.

- **Shahi** NC

Medium tall; culm angle erect; leaf angle horizontal; flag leaf angle semi-erect. Panicles compact, awnless, and partially exerted. Lemma and palea white and glabrous. Grains bold, shattering prone, and non-scented. Leaf senescence late and slow. Quality rice.

- **Shalla Kew** NC

Medium tall plants with dark-green leaves. Flag leaf angle intermediate between erect and horizontal. Panicles compact, fully awned, long, and of straw color. Lemma and palea with brown spots and glabrous. Leaf senescence slow. Grains bold, shattering prone, and non-scented.

- **Safed Buduj** NC

Plants tall, medium tillering, with vigorous growth. Flag leaf angle erect. Panicles compact, partly exerted, and with awns of straw color. Lemma and palea with golden furrows on straw and short hairs. Grains bold, scented, and non-shattering.

- **Safed Khuch** NC

Plant of medium height and with vigorous growth; leaf blade green; basal leaf sheath dark green. Flag leaf erect. Panicles compact, with short awns of golden color, and partly exerted. Grains bold, non-shattering, and non-scented. High head rice recovery. Late maturing.

- **Tumlahall** NC

Medium tall plants, with profuse tillering. Culms erect. Leaf angle erect; leaf blade purple and pubescent; basal leaf sheath purple. Flag leaf intermediate between descending and erect. Panicles long, semi-compact, and partially awned; awns short and purple. Leaf senescence early. Grains cylindrical, non-shattering, and non-scented.

- **Tilla Zag** [NC]

Plants of medium height with extra vigor and profuse tillering. Leaf blade purple; basal leaf sheath purple; ligule white and clefted; collar purple; auricle purple. Flag leaf erect. Panicles compact, fully awned; and partially exerted from flag leaf sheath. Grains bold, glume dark red, non-shattering type, and scented.

- **Trele Zagir** [NC]

Tall plants with profuse tillering. Leaf blade dark green; basal leaf sheath purple. Ligule white and clefted; collar and auricle pale green. Flag leaf intermediate between erect and horizontal. Panicles compact, partially awned, and well exerted. Lemma and palea with purple spots and glabrous. Grains bold, shattering prone, and non-scented (Plate 11.3 C).

- **Tumla Zag** [NC]

Medium tall plants with profuse tillering. Leaf blade purple with purple basal leaf sheath. Ligule purple and truncated; collar and auricle purple. Flag leaf angle erect. Panicles compact and fully awned with awns of purple color. Lemma and palea purple and glabrous. Leaf senescence early. Grains bold with reddish kernel, non-shattering, and slightly scented.

- **Watazag** [NC]

Plants of medium height and profuse tillering. Leaf angle drooping; leaf blade purple blotched with light purple basal leaf sheath. Ligule with purple lines and cleft; collar and auricle pale green; flag leaf intermediate between erect and horizontal. Panicles well exerted, awnless, and open. Grains bold with red glumes, non-scented, and non-shattering.

- **Yimberzuol** [NC]

Plants tall, with medium tillering. Leaf blade green with light-purple basal leaf sheath. Ligule white and clefted; collar green; auricle pale green. Flag leaf angle erect. Panicles semi-loose, awnless, and well exerted. Lemma and palea reddish to light purple and pubescent. Grains slender, shattering prone, and non-scented (Plate 11.3 D).

#### 11.3.4.2 State-Released Varieties

- **K-39** [WC]

A selection from a cross between China-1039 and IR 580, bred at RRRS, Kashmir. Plants are medium tall, with profuse tillering. Grain bold and longer, translucent, non-glabrous, and non-scented. Released by J&K State Varietal Release Committee (SVRC) in 1978 for commercial cultivation in lower belts of the valley up to 1659 m (amsl), matures in 140–145 days, yields 5.8–6.2 t/ha, photoperiod sensitive, lodging resistant, and resistant to rice blast and cold.

- **K-60** [NC]

K-60 is a selection from a cross between China-47 and Rikku 132, bred at RRRS and released by SVRC in 1962. Grains non-shattering, short and bold, non-scented, and non-glutinous. Suitable for cultivation in Kashmir up to 1700 m, matures in 140–145 days, yields 5–5.5 t/ha. The variety is non-lodging and cold tolerant at early stages of growth.

- **K-65** [NC]

A selection from a cross between Norin 8 and China-47, bred at RRRS and released by SVRC in 1966. Variety is semi-tall and lodging susceptible but with easy threshability. Grains are short and bold, non-scented, non-glutinous, and with low head rice recovery. Suitable for cultivation in the valley up to 1650 m, matures within 140–145 days, yields 5–5.5 t/ha. The variety is cold tolerant at seedling and grain filling stages.

- **Barkat (K-78)** [RC]

A selection from a cross between Shenei and China-971, bred at RRRS and released by SVRC in 1974 for general cultivation especially in the higher belts of J&K State up to 1950 m. Grains are long and bold, and kernel dull white, translucent, and non-scented. Matures in 130–140 days; yields 3.8–4 t/ha with high head rice recovery. The plants are semi-tall, photoperiod sensitive, lodging resistant, and moderately resistant to blast and cold tolerant, both at seedling and grain filling stages.

- **K-332** [NC]

A selection from a cross between Shenei and Norin II, bred at RRRS. It is a medium-tall variety with grains long and bold and kernel dull white, translucent, non-scented, and non-glutinous. It was released by SVRC in 1982 for cultivation in the upper belts of J&K State up to 2196 m amsl, matures in 130–140 days, yields 4–4.5 t/ha, photoperiod sensitive, lodging susceptible, and moderately resistant to blast and cold.

- **China-972** [NC]

The variety was bred at RRRS and released by SVRC in 1956. It is non-shattering but with easy threshability. Grains short and bold, non-scented, and non-glutinous, suitable for cultivation up to 1650 m, matures in 145–150 days, yields 5–5.5 t/ha, non-lodging, and cold tolerant at early stages of growth.

- **China-988** [NC]

The variety was bred at RRRS and released by SVRC in 1956. Being non-shattering with short and bold, non-scented, and non-glutinous grains, it is suitable for lower belts up to 1650 m (amsl), matures in 147–150 days, yields 5–6 t/ha, non-lodging, and cold-tolerant at early stages of growth.

- **China-1007** RC

Bred at RRRS and released by SVRC in 1956, the variety is non-shattering, and grains short and bold, non-scented, and non-glutinous. It is suitable for the lower belts up to 1700 m, matures in 147–152 days, yields 5–6 t/ha, non-lodging, and cold tolerant at early stages of growth.

- **China-1039** WC

A selection from introduced material, bred at RRRS and released by SVRC in 1955. It is a medium-tall variety with intermediate flag leaf angle. Husk-straw colored at maturity, awnless but shattering susceptible. Short and bold grains, and kernel dull white, translucent, non-scented, and non-glutinous. Recommended for lower belts of the valley up to 1650 m under irrigated agro-ecosystem, matures in 136–140 days, yields 5.0–5.5 t/ha, photoperiod sensitive, and lodging susceptible but resistant to cold .

- **Shenei** RC

A selection from introduced material, bred at RRRS and released by SVRC in 1967. It is a medium-tall variety with short and bold grains, which are translucent, non-scented, and non-glutinous. Recommended for commercial cultivation in the higher belts of J&K State up to 1969 m, matures in 130–140 days, yields 3.8–4 t/ha, photoperiod sensitive, non-lodging, moderately resistant to blast, and cold tolerant.

- **Chenab (SKAU-23)** RC

A selection from a cross between K 21–9–10-1 and IR 2053–521–1-1-2, bred at RRRS and released by SVRC in 1993. Medium-tall, erect, and compact plant type, and intermediate flag leaf angle and green apiculus. Panicle is semi-compact, awnless, and straw colored; lemma and palea; medium bold grains; dull white kernel, translucent, and non-scented. It is suitable for lower belts of Kashmir Valley and mid-elevations of Jammu, under irrigated agro-ecosystems. Variety matures in 135–141 days, with yield potential of 6.0–6.5 t/ha.

- **Jhelum (SKAU-27)** WC

A selection from a cross between JAKUKU and IR 1444, bred at RRRS and released by SVRC in 1993. Medium-tall, erect, and compact plant type, with green foliage, erect flag leaf, and green apiculus which turns straw colored at maturity; ligule white and collar green. Panicles straight and awnless. Grains medium bold, translucent, non-scented, whitish, and non-glutinous with good cooking and milling qualities. It is recommended for lower belts of Kashmir up to 1650 m under irrigated agro-ecosystem and fertilizer responsive, matures in 136–141 days, yield potential of 6.0–6.5 t/ha[1]. Plants are photosensitive and non-lodging, resistant to pest damage, moderately resistant to blast and *Helminthosporium* but resistant to cold at seedling and at grain-filling stages.

- **Kohsar (K-429)** WC

Selection from a cross between Shin-el and Ginmasari, bred at RRRS and Sub-Station, Larnoo of SKUAST-K and released in 2001 for general cultivation in Kashmir. Plants semi-tall (75–80 cm) and non-lodging. Flag leaf angle erect, and panicle compact, fully exerted, and partly awned. Apiculus straw colored at maturity. Grains short and bold; kernel dull white and translucent. Recommended for cultivation in high-altitude areas of State, above 1700 m (amsl) under irrigated agro-ecosystem. Fertilizer responsive. Yields 4.0–4.5 t/ha. Matures in 140–145 days. Tolerant to blast, *Helminthosporium* blight, and cold at seedling and grain filling stages.

- **Shalimar Rice-1** WC

It was developed by SKUAST-K and released by SVRC for general cultivation during 2004 in lower belts up to an altitude of 1650 m. The plant is medium tall, extra vigorous, and compact. Flag leaf is erect with purple basal leaf sheath and delayed leaf senescence. The grains are short, slender with non-glutinous endosperm, and nonaromatic. Variety matures in 138–145 days and yields 65–70 q/ha.

## 11.4 Concluding Remarks

The work presented in this chapter is the result of the surveys carried out in the three regions of J&K over the past several years. However, keeping in view the State's vastness and difficult terrain, arriving at a complete picture of the agro-biodiversity of crop plants in this Himalayan region needs much more thoroughness and time. Nevertheless, the results presented here may be considered a good baseline for future studies.

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# Chapter 12
# Genetic Diversity in *Lymnaea acuminata* from Jammu Region, Jammu and Kashmir State

**N. K. Tripathi and Poonam Sharma**

**Abstract** *Lymnaea acuminata* (Pulmonata: Lymnaeidae) is a generalist species with a wide Palaearctic distribution throughout Europe, Asia, and the Far East including Siberia. It is common in shallow water bodies such as ponds, swamps, and floodplains of rivers, which are relatively unstable habitats and show large fluctuations in temperature and water level and occasional desiccation. Phenotypic and genotypic differentiation in pond snail, *Lymnaea acuminata*, was studied by morphometric and RAPD analysis in Jammu region. Morphometric studies indicated that the shell shapes of the subtropical populations of *L. acuminata* were highly differentiated from intermediate and temperate populations. Elongated shells with narrow apertures are present under subtropical conditions, while a more compact shell shape with a wider aperture was present in intermediate and temperate conditions. To understand the genetic cause of two morphs of pond snail among populations, RAPD-PCR analysis was done. The RAPD data showed close linkage between the populations of subtropics, intermediate, and temperate habitats. The high pair-wise similarity and low-distance matrix suggest a limited genetic variation. Examination of genetic relatedness between populations, as determined by RAPD-PCR analysis, revealed that the subtropical, intermediate, and temperate populations appeared to share a common ancestry, and the difference in their shell morphology was attributed to phenotypic plasticity.

**Keywords** *Lymnaea* · Shell · Phenotype · Genotype · RAPD-PCR

## 12.1 Introduction

Biological diversity is the variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystem and the ecological complexes. This includes diversity within species, between species and of ecosystems (Kushwaha and Kumar 1999). In this way, biodiversity includes variety of all forms

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_12

along with their genetic makeup and their all possible assemblages. Species diversity is a property at the population level, while the functional diversity concept is more strongly related to ecosystem stability and stresses and physical and chemical factors for determining population dynamics in the lentic ecosystem. Also, the various organisms including the plankton play a significant role in the dynamics of an ecosystem (Kar and Barbhuiya 2004). India is one of the mega diversity hotspots contributing to the world's biological resources from greater Himalayan range on the northern plain to long stretches of east and Western Ghats in the west.

Although species diversity is the most commonly employed measure of biological diversity, it is not the only measure. Genetic diversity, measured as the level of intraspecific genetic variation, has provided valuable information on levels of genetic variation, gene flow, population subdivision, historical patterns of population fragmentation, and the evolutionary history of populations (Moore et al. 1991; Ball and Avise 1992; Bermingham et al. 1992; Zink and Dittmannn 1993; Zink 1994; Gibbs 1998; Schneider et al. 1998; Gill et al. 1999; Macey et al. 1999; Bates 2000; Patton et al. 2000). However, genetic diversity is not generally measured because appropriate data are considered difficult and expensive to gather. In spite of these potential drawbacks, measuring genetic diversity may be especially important for conservation (Moritz and Faith 1998). Genetic diversity refers to all forms of life on earth, whether microbes, plants, animals, or human beings. Genetic diversity is the sum of genetic information contained in the genes of individual plants, animals, and microorganisms. Each species is the storehouse of an immense amount of genetic information in the form of traits, characteristics, etc. The number of genes ranges from about 1000 in bacteria to more than 400,000 in many flowering plants.

Development of random amplified polymorphic DNA (RAPD) markers, generated by the polymerase chain reaction (PCR), enables estimation of genetic variation between organisms without prior knowledge of sequence information (Williams et al. 1990, 1993; Welsh and Mc-Clelland 1990; Hadrys et al. 1992). Short nucleotide sequences, known as primers, determine the number and size of amplified fragments of DNA. Complimentary sequences result in primary sites randomly distributed throughout the genome, and polymorphisms at such sites result in differing amplification products, indicated by the presence or absence of fragments. Products are run under an electric field on a gel, and the resulting profile is referred to as "DNA fingerprint." This method has been used extensively to detect intraspecific variations (Welsh and Mc-Clelland 1990, 1991; Kambhampati et al. 1992; Procunier et al. 1993) and, more recently, variations between species of aphids (Puterka et al. 1993), parasitic protozoa (Tibayrenc et al. 1993), fish (Bardacki and Skibinski 1994; Nxomani et al. 1994), and intertidal gastropods (Crossland et al. 1993, 1996). The RAPD technique provides an alternative method of analysis of intra- and interspecific genetic variation which is less expensive and time-consuming than RFLP and DNA sequence analysis. The data are obtained from the whole genome, rather than specific genes, and are likely to include both rapidly and slowly evolving segments of DNA. This was not suitable for examining distant evolutionary relationships but can be used for relatively closely related specimens.

RAPD-PCR is one of the potential approaches for identification of molecular genetic markers in various taxa (Hadrys et al. 1992; Stothard and Rolinson 1996). In the present study, the genetic diversity and phenotypic plasticity (morphological components) of *Lymnaea acuminata* were measured in eight geographically populations, using morphometric (Hubendick 1951) and RAPD-PCR studies.

## 12.2 Materials and Methods

### *12.2.1 Sample Collection*

The samples for the present study were collected from eight different districts of Jammu division (Table 12.1).

Each sample was preserved in 70% ethanol. The vials were sealed with paraffin in the field and shifted to Human Genetic Research cum Counselling Centre, University of Jammu, where these samples were stored at −20 °C until DNA was isolated.

### *12.2.2 Procedure*

Chemicals used for the present study were lysis buffer, proteinase-K, phenol:chloroform:isoamyl alchohol, alcohol, TE buffer, 10x loading buffer, ethidium bromide, 50X TAE, and agarose gels. DNA was extracted from the foot muscles of *Lymnaea acuminata* using phenol:chloroform method (Ashburner 1989). The qualitative and quantitative evaluation of the isolated DNA was done by agarose gel electrophoresis and UV spectrophotometry, which is a standard method that separates and identifies DNA fragments according to their molecular weights. For the optimization of RAPD reaction, several modifications in Williams et al.'s (1990) technique were made; oligonucleotide primers from series 1 to 10 RAnC (Bangalore

**Table 12.1** Geographic attributes of the sites of collection of *Lymnaea acuminata* in Jammu region of J&K State

| Name of the district | Longitude | Latitude | Different climatic conditions of Jammu division |
|---|---|---|---|
| Jammu | 74.48° E | 32.39° N | Subtropical |
| Kathua | 75.32° E | 32.22° N | |
| Reasi | 74.83° E | 33.08° N | |
| Samba | 75.08° E | 32.53° N | |
| Rajouri | 74.16° E | 33.23° N | Intermediate |
| Doda | 75.32° E | 32.08° N | Temperate |
| Ramban | 75.25° E | 33.25° N | |
| Kishtwar | 75.77° E | 33.32° N | |

Genei™, India) within and between/among population were used for amplification to standardize the PCR conditions.

### 12.2.3 RAPD Data Analysis

Each RAPD fragment was treated as an independent character. Sizes of the RAPD bands were estimated by comparing with a 100 bp ladder and recorded in a binary matrix to represent the presence (+) or absence (−) of a particular band. The binary matrix was used to estimate Jaccard's coefficient, genetic similarity matrix, and distance matrix (Jaccard 1908). The matrices were subjected to unweighted pair group method of arithmetic averages to construct UPGMA dendrogram (Garcia-Vallve et al. 1999). For individual pair-wise comparisons, the proportion of shared alleles is estimated by calculating the genetic distance based on the proportion of shared alleles (Bowcock et al. 1994), $PSA1 = \Sigma uS/2u$, where the number of shared alleles S was summed overall loci u. Distance between individuals (DSA1) was estimated by $DSA1 = 1 - PSA1$. In order to estimate the genetic variation within and among populations of *L. acuminata*, the Shannon index was calculated using the formula $H_o = -\Sigma pi \log^2 pi$ (Lewontin 1972) where $H_o$ is diversity and pi is the frequency of a particular RAPD band. It must be noted that heterozygous individuals cannot be detected directly by RAPD, since RAPD data was dominant data.

### 12.2.4 Morphometric Analysis of Shell

In the present study, seven morphometric characteristics were studied in the eight populations of pond snail, *Lymnaea acuminata*. Measurements of the shells of specimens of morphs I and II were carried out under a stereomicroscope. Measurements were made according to Hubendick (1951). The shell length (SL) has been measured from the apex along a line through the columella at the level of the columellar fold to the projection of the anterior margin of the shell. The other measures, shell width (SW), aperture length (AL), aperture width (AW), last spire length (LSL), spire length (SpL), and whorl number, were taken parallel to or perpendicular to that of the shell length line. To enable correct measurements, snails were placed on a Petri dish filled with cotton. The appropriateness of the measurements was always assured by verifying, in each specimen, that shell length and width were the same whether taken ventrally or dorsally.

## 12.3 Results

### *12.3.1 Phenotypic Differences*

Shell of pond snail was light brown with relatively obtuse apex and fine growth lines and has only three whorls. The body whorl dominates the shell and is inflated and separated by a deep, well-marked suture. Elongated shells with narrow apertures (i.e., shell length (SL) 1.97–1.98 cm, shell width (SW) 0.91–0.93 cm, aperture length (AL) 1.13 cm, and aperture width (AW) 0.56 cm) were found in pond snails inhabiting rivers and the bay habitats of subtropics (Jammu, Kathua, Reasi, and Samba), whereas a more compact shell shape with a wider aperture (i.e., shell length (SL) 1.63–1.64 cm, shell width (SW) 1.41–1.42 cm, aperture length (AL) 0.86 cm, and aperture width (AW) 0.69 cm) was found in specimens collected from open lakes with strong water currents having intermediate and temperate conditions (Rajouri, Doda, Ramban, and Kishtwar). Morphometric analysis data indicate that the shell shapes vary with the type of climate in which pond snails are present (Fig. 12.1).

### *12.3.2 RAPD-PCR Analysis*

#### 12.3.2.1 Quantification of DNA

DNA was extracted from 40 samples of pond snail. Bands obtained were clearer and bright bands indicating low level of protein and polysaccharide contamination. The yield of DNA was 1000 ± 1.63 μg/ml to 970.66 ± 1.20 μg/ml and the purity (ratio) was 1.821 ± 0.002 to 1.857 ± 0.001 indicating minimal level of contamination (Fig. 12.2).

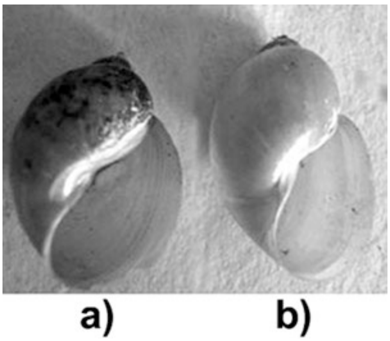


**Fig. 12.1** Two different morphs of *Lymnaea acuminata* analyzed morphometrically during the present study from different geographical regions viz. (**a**) intermediate and temperate conditions; (**b**) subtropical conditions

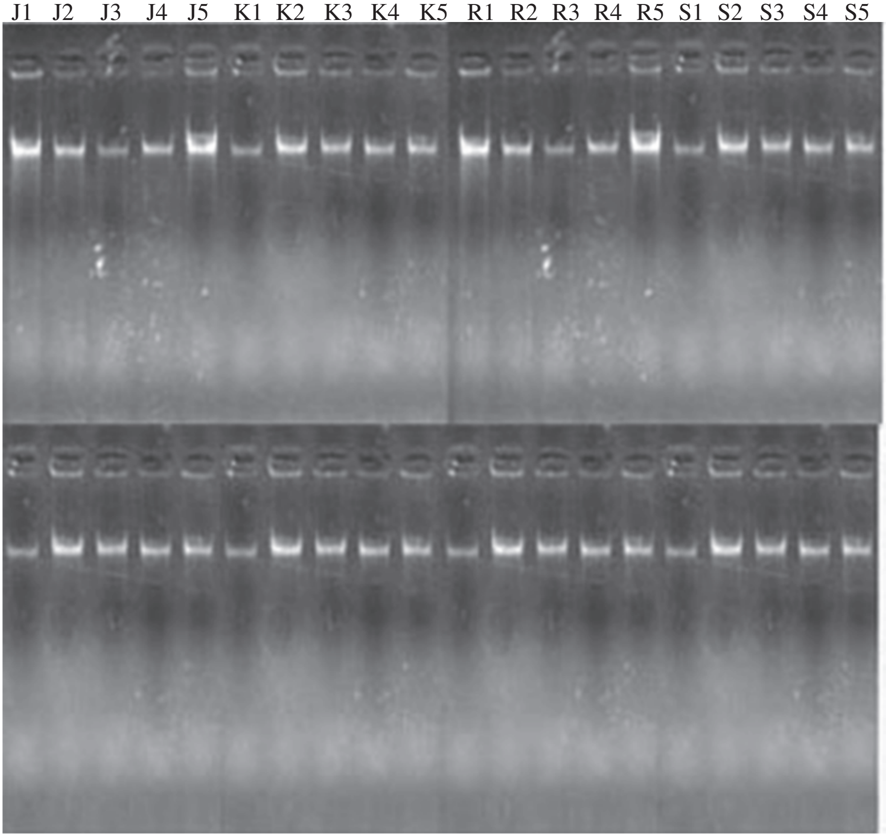


**Fig. 12.2** Electrophoretic pattern (Lane 1-40) showing sharp, distinct bands in the samples isolated from foot muscles of *L. acuminata* from Jammu (J1, J2, J3, J4, J5), Kathua (K1, K2, K3, K4, K5), Reasi (R1, R2, R3, R4, R5), Samba (S1, S2, S3, S4, S5), Ramban (Ra1, Ra2, Ra3, Ra4, Ra5), Kishtwar (Ki1, Ki2, Ki3, Ki4, Ki5), Rajouri (Rj1, Rj2, Rj3, Rj4, Rj5) and Doda (D1, D2, D3, D4,D5), respectively

#### 12.3.2.2 RAPD-PCR Analysis

DNA was extracted using phenol:chloroform:isoamyl method. Ten primers of Bangalore Genei, India (RAnC-1 to RAnC-10), were employed to initially perform the amplification reaction. Four primers (RAnC-3, RAnC-4, RAnC-6, and RAnC-8) generated higher number of bands. All bands were scored as + (present) or - (absent) for the presence or absence of band. Several bands were observed for each primer in the range of 180–1850 bp. These four primers generated a total of 960 bands in all the 40 individuals of which 880 bands were monomorphic and 80 bands polymorphic. Though the percentage of polymorphic bands for each primer ranged from 4.76% to 20%, the average polymorphism was only 8.33%, whereas the percentage

**Table 12.2** Genetic distance and Shannon diversity indices revealed by RAPD analysis using RAnC-3, RAnC-4, RAnC-6, and RAnC-8 primers

| S. No. | Primer name | Genetic distance | Shannon's diversity indices |
|---|---|---|---|
| 1 | RAnC-3 | 0.56 | 0.3534 |
| 2 | RAnC-4 | 0.56 | 0.3550 |
| 3 | RAnC-6 | 0.60 | 0.3458 |
| 4 | RAnC-8 | 0.60 | 0.3490 |
| | **Total** | **0.58 ± 0.02** | **0.3508 ± 0.004** |

of monomorphic bands was 91.67%. Shannon indices ($H_0$) were also calculated to find genetic variation within population. It ranged from 0.3458 to 0.3550, and the mean was 0.3508 with SD of 0.004. Genetic distance ranged from 0.56 to 0.60, and the mean was 0.58 with SD of 0.02 (Table 12.2). The pair-wise Jaccard's coefficient, similarity index, and distance matrices were prepared on the basis of RAPD data.

To understand the genetic relationship among *L. acuminata* populations, Jaccard's matrices were subjected to unweighted pair group method of arithmetic averages to construct UPGMA dendrogram, in which two major clusters were detected. The first cluster contained Jammu, Kathua, Reasi, and Samba and the second Rajouri, Doda, Ramban, and Kishtwar. The UPGMA-based cluster analysis is a good indication of the genetic relationship existing among the population (Fig. 12.3).

## 12.4 Discussion

Morphometric studies indicated that the shell shapes of the subtropical populations of *L. acuminata* were highly differentiated from intermediate and temperate populations. Elongated shells with narrow apertures were associated with subtropical areas, while a more compact shell shape with a wider aperture was associated with the colonized steep, littoral habitat, i.e., of intermediate and temperate region. This would require either strong selection for shell shape or founder effects or a combination of both. The harsh novel environment of wave-exposed conditions could have acted as a strong selection agent on *Lymnaea*. The gastropod shell has been documented as highly subjected to selection from forces such as wave action and current speed. Specific habitats are associated with specific shell shapes in several aquatic gastropod taxa. Shells of *Nucella lapillus* are typically shorter and broader ("more globose") and have a wider aperture on wave-exposed shores as compared on those on sheltered shores (Kitching et al. 1966; Crothers 1981). The shell differences reported in the present study are similar to those studied earlier in *L. peregra* (Lam and Calow 1988; Wullschleger and Ward 1998), *Neritina violacea* (Murty and Rao 1978), and *L. auricularia* (Stift et al. 2004). Further, to study the genetic cause of shell differences among populations, RAPD-PCR analysis was undertaken. The compact shell with a wide aperture enables the expansion of a large foot and thus a

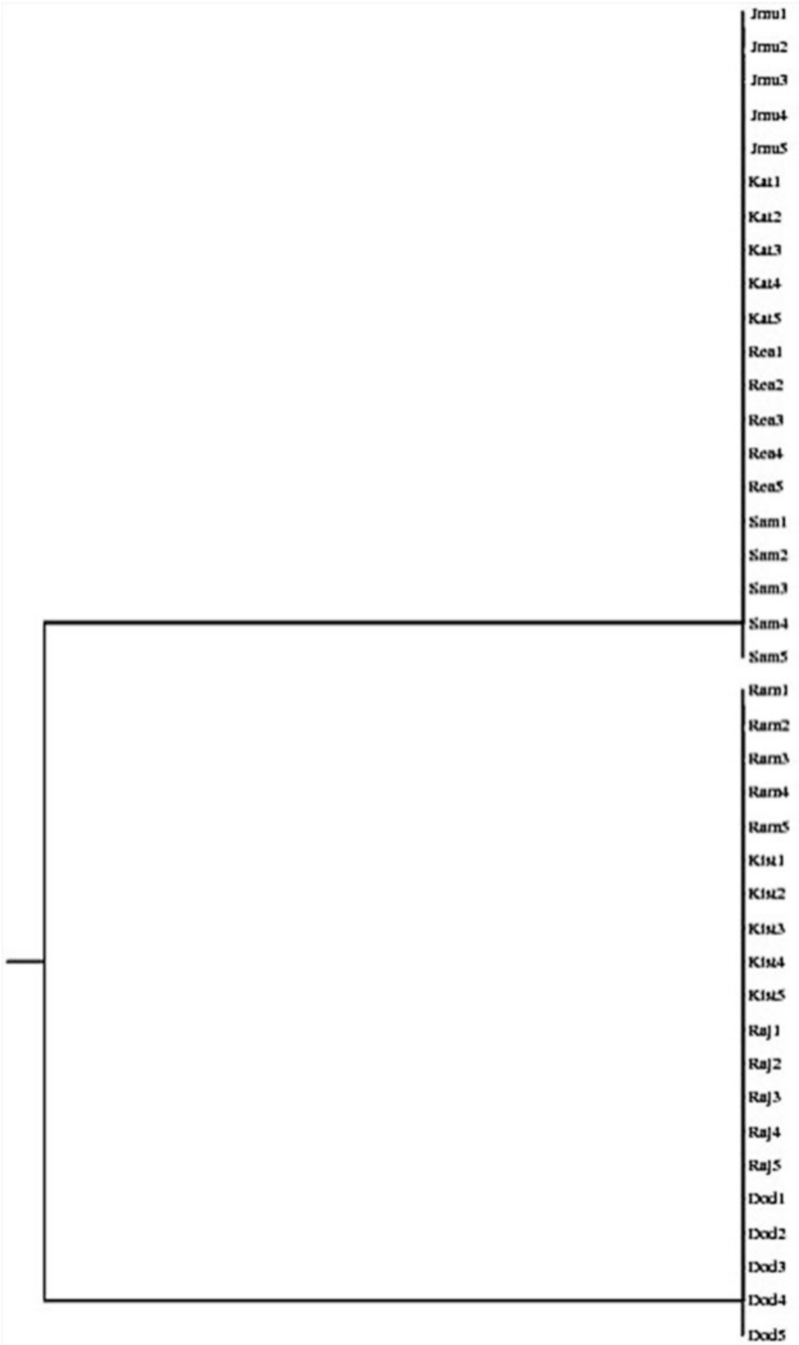


**Fig. 12.3** UPGMA dendrogram constructed from Jaccard's matrix of RAnC- 3, 4, 6 and 8 Primers

firm attachment to the substrate, as shown in several species including *L. peregra* (Dussart 1987). In *L. peregra*, an elongated shell with a narrow aperture is suggested to be advantageous in unstable (i.e., periodically dry) but less wave-exposed habitats, as it would enable snails to easily retreat in the mud during dry periods and lose less water (Eckblad 1973). A study of habitat choice of the two distinct shell shapes found among *L. peregra* populations provides more evidence that shell shape in *L. peregra* is adaptive (Wullschleger and Ward 1998).

The mean percentage polymorphism of 8.33% and the Shannon diversity (Ho) of 0.3508 ± 0.004 indicate a low genetic variation within the population. The observed genetic distance of 0.58 ± 0.02 is low, which further supports the conclusion that genetic variation with the species is low. The banding patterns obtained from the RAPD-PCR studies show greater similarities (number of monomorphic bands was 91.67%) with each other. Genetic relatedness between populations, as determined by RAPD-PCR analysis, revealed that the subtropical, intermediate, and temperate populations appeared to share a common ancestry, and the difference in their shell morphology is attributed to phenotypic plasticity. Consequently, this provides a genetic confirmation that variation in shell morphology and sculpture was mainly due to environmental effects during shell secretion and maturation (phenotypic plasticity). This meant that snails collected from several sites of Jammu division belong to only one species showing intraspecific variation.

## 12.5 Concluding Remarks

Morphometric studies in the present investigation indicated that the shell shapes of the subtropical populations of *L. acuminata* were highly differentiated from intermediate and temperate populations. The RAPD data showed close linkage between the populations of subtropics, intermediate, and temperate habitats. The high pairwise similarity, low Shannon diversity, and low genetic distance suggest a limited genetic variation in the *L. acuminata* population, the difference in their shell morphology being mainly due to phenotypic plasticity.

**Acknowledgments** The authors are grateful to Prof. K. K. Sharma, Ex-Head, Department of Zoology, University of Jammu, for providing necessary lab facilities.

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# Part V
# Biodiversity of Jammu and Kashmir State: Floristic Diversity

# Chapter 13
# Algal Diversity in Jammu and Kashmir State

**Zahoor Ahmad Kaloo and Samar Amin**

**Abstract** The Jammu and Kashmir State possesses a rich diversity of freshwater algae because of the abundance of lakes and wetlands. These algae range from planktonic forms in Cyanophyceae, Bacillariophyceae, Cryptophyceae, and Dinophyceae, to colonial Volvocaceae, to filamentous Zygnemataceae, Ulotrichaceae, and Oedogoniaceae, to complex Chaetophoraceae, Charophyceae, and Rhodophyceae. This chapter has documented a total of 1065 taxa of algae from the State, based on review of literature published so far. In terms of species richness, Bacillariophyceae (with 299 species, 56 varieties, and 8 forma in 45 genera) is the largest class, followed by Chlorophyceae (with 240 species, 39 varieties, and 8 forma in 78 genera), Cyanophyceae (with 216 species, 5 varieties, and 3 forma in 46 genera), Desmidiaceae (with 102 species, 22 varieties, and 2 forma in 21 genera), Euglenophyceae (with 44 species and 2 varieties in 10 genera), Chrysophyceae (with 5 species in 2 genera), Dinophyceae (with 4 species in 4 genera), Xanthophyceae (with 4 species and 1 forma in 3 genera), Charophyceae (with 2 species and 1 variety in 2 genera), and Rhodophyceae and Cryptophyceae (with only 1 species each).

**Keywords** Algae · Diversity · Lakes and wetlands · Himalaya

## 13.1 Introduction

The Jammu and Kashmir (J&K) State is very rich in freshwater algal diversity because of the presence of abundant lakes and wetlands. Reports of studies on algal flora of the J&K State, however, are scanty and scattered (see Dar et al., 2002). The first reports of taxonomic studies on algae from the Kashmir are of Bhatia (1930) and Bharadwaja (1936). The first report of algae (Zygnematales) from Jammu is of Misra (1937), who later on also reported 14 taxa of Zygnemataceae from the Kashmir.

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_13

Subha (1963) reported 46 taxa of algae from the Dal Lake, 14 taxa from Cyanophyta, and 32 from Chlorophyta. Suxena and Venkataswarlu (1968) studied desmids of Kashmir, reporting 42 taxa of them. Das et al. (1969) dealt with planktons of high-altitude lakes in Kashmir, reporting species of *Gonatozygon*, *Cymbella*, *Synedra*, *Pinnularia*, *Navicula*, *Aphanocapsa*, *Closterium*, *Fragilaria*, *Scenedesmus*, *Nostoc*, and *Anabaena*. Kant and Kachroo (1971) studied population dynamics and distribution of phytoplanktons in two adjoining lakes of Srinagar, Dal and Nigeen lakes, and recorded a total of 350 species belonging to 140 genera. They found Chlorophyceae and Bacillariophyceae to be the dominant, followed by Myxophyceae, Dinophyceae, and Euglinineae. The most commonly occurring genera were *Tetraspora*, *Chlorococcum*, *Oocystis*, *Ankistrodesmus*, *Krichneriella*, *Scenedesmus*, *Cladophora*, *Oedogonium*, *Spirogyra*, and *Gloeotrichia*. Fotedar (1981) carried out a study on the vertical distribution of planktons in Dal and Nilnag Lakes of Kashmir, reporting 108 species of these; 58 species belonged to Chlorophyceae, 40 to Bacillariophyceae, 7 to Cyanophyceae, and 3 to Euglenophyceae. Mir and Kachroo (1982) reported 150 species of Chlorophyta from the Dal Lake. These species were spread over 48 genera belonging to orders Zygnematales, Chlorococcales, Volvocales, Chaetophorales, Ulotrichales, Cladophorales, and Oedogonales.

Compere (1983) identified 480 species and infraspecific taxa of algae in several samples from Dal Lake and from some ponds near Srinagar as well as from some localities in Ladakh. Out of these species, 229 were diatoms, 176 green algae (96 desmids and 80 others), and 57 blue-green algae, while 18 taxa were from other classes. He made a qualitative analysis of four samples from the Kashmir valley (Dal Lake and associated ponds) and identified 367 different algae: 163 diatoms, 153 green algae, 36 blue-green algae, and 15 taxa of other algae. From six samples of Ladakh highlands, only 222 algal species were identified; these comprised 137 diatoms, 49 green algae, 31 blue-green algae, and 5 from other algae. Prasad and Jaitly (1985) presented a systematic analysis of the samples collected from a small spring at Puga in Ladakh. They identified 12 taxa of diatoms belonging to 8 genera, viz., *Fragilaria*, *Synedra*, *Navicula*, *Neidium*, *Pinnularia*, *Gomphonema*, *Cymbella*, and *Nitzschia*. Koul (1988) studied the ecology of some mountain streams of Telbal-Dachigam catchment in Srinagar, Kashmir, and identified a total of 179 algal species and subspecies, spread over three taxonomic groups, viz., Bacillariophyceae (129 taxa), Cyanophyceae (28 taxa), and Chlorophyceae (22 taxa). Rather and Mir (1987, 1989) reported 184 algal taxa from various paddy fields in Kashmir. The analysis of these taxa revealed that three algal classes, viz., Chlorophyceae, Bacillariophyceae, and Cyanophyceae, dominated the paddy fields. Chlorophyceae was represented by 13 genera with 59 species, Bacillariophyceae by 16 genera with 50 species, and Cyanophyceae by 18 genera with 55 species.

Kant and Vohra (1991) recorded about 636 species and infraspecific taxa of algae, included in 129 genera, from temperate water bodies of Kashmir and tropical and subtropical aquatic habitats of Jammu, as well as from some localities in high valleys of Ladakh. The algal taxa were studied from diverse habitats like rivers, streams, ponds, pools, lakes, and soils. Kaloo et al. (1995) studied the composition and abundance of phytoplankton in relation to the physical and chemical limnology of Dal Lake in the areas under *Salvinia natans*, an obnoxious weed having characteristic influence on the aquatic vegetation and thermal structure of water beneath it. A total of 27 and 29 taxa of phytoplankton were recorded in the surface and bottom waters, respectively. The dominance of diatoms in the phytoplankton population was related to relatively low temperatures at these sites. Kant and Gupta (1998) carried out taxonomic survey of algae from Leh (Ladakh) and identified a total of 286 genera, 848 species, 155 varieties, 27 forms, and 6 combinations. Statistical analysis of this algal flora revealed that Chlorophyceae (with 143 genera and 440 species) is the largest representative class in the water bodies of this area, followed by Cyanophyceae (with 57 genera and 171 species) and Bacillariophyceae (with 39 genera and 175 species). Xanthophyceae is represented by 15 genera with 15 species, Dinophyceae by 11 genera with 18 species, Euglenineae by 10 genera with 18 species, Chrysophyceae by 8 genera with 8 species, Rhodophyceae by 2 genera with 2 species, and Cryptophyceae by single species. Dar et al. (2002), in their consolidation of algal flora of Kashmir valley, reported 276 species of algae (including phytoplankton) from its lakes and wetlands, 137 species forming the periphytic algal flora, while 184 species occur in paddy fields/soils; some of the overall taxa, however, are said to have been common between these habitat types. Bhat and Pandit (2003) investigated the general ecology of phytoplankton in Anchar Lake, Kashmir. In this study, 143 species and subspecies of algae were reported from the lake basin. Out of these, 31 taxa belonged to Cyanophyceae, 49 to Chlorophyceae, 40 to Bacillariophyceae, 14 to Euglenophyceae, and 3 taxa each to Chrysophyceae, Dinophyceae, and Xanthophyceae. Rashid and Pandit (2006) studied periphytic algal community of seven water bodies of Ladakh region in relation to the physicochemical properties of the water. They found that diatoms were the most abundant periphyton at all the study sites. Overall, they recorded 54 algal taxa from these seven water bodies; out of these, 44 species belonged to Bacillariophyceae, 9 to Chlorophyceae, and 1 species to Cyanophyceae.

Baba et al. (2013) carried out a limnological investigation on Sind nallah flowing through northeast of Srinagar in Kashmir. They identified a total of 49 algal species belonging to Bacillariophyceae (32 spp.), Chlorophyceae (9 spp.), Cyanophyceae (7 spp.), and Xanthophyceae (1 sp.). The taxa belonging to different classes were Cyanophyceae (7 taxa), Chlorophyceae (9), Bacillariophyceae (32), and Xanthophyceae (1). They found that, both qualitatively and quantitatively, Bacillariophyceae was the dominant algal class at all the sites, followed by Chlorophyceae, Cyanophyceae, and Xanthophyceae. Chalotra et al. (2013) studied the morpho-taxonomy of genus *Spirogyra* occurring in freshwater bodies of Jammu, having collected 16 of its species from different habitats in three districts of Jammu province, Samba, Jammu, and Udhampur. They taxonomically determined the species on the basis of vegetative and reproductive structure, reporting *S. calcarea*, *S. rectispire*, *S. submarina*, *S. hollandiae*, and *S. buchetii* for the first time from India. They found all these species to be abundantly growing in both lentic and lotic water bodies. Lone et al. (2013) studied diversity patterns in periphytic algal assemblages in seven springs of Anantnag district in Kashmir. These springs were subjected to different anthropogenic stresses. A total of 23 species was found, belonging to 3 algal classes, Chlorophyceae, Bacillariophyceae, and Cyanophyceae. Chlorophyceae were represented by 6 species, Bacillariophyceae by 12, and Cyanophyceae by 5. The dominant species in the algal community were *Rhizoclonium* spp., *Diatomella balfouriana*, *Navicula* spp., and *Oscillatoria limosa*. Bacillariophyceae were dominant in all these springs, both in terms of density and diversity, followed by Chlorophyceae and Cyanophyceae. Rashid et al. (2013) carried out limnological study on Doodh Ganga and Khansha-Mansha streams of Yusmarg forests. They found that periphytic algal community of these streams was represented by 30 taxa, which belonged to four major classes, namely, Bacillariophyceae (14), Chlorophyceae (11), Cyanophyceae (4), and Euglenophyceae (1). The most common periphytic taxa across all the sites included species of *Zygnema*, *Amphora*, *Cymbella*, *Epithemia*, *Fragilaria*, *Navicula*, *Synedra*, *Tabellaria*, *Lyngbya*, and *Phormidium*.

Pandit et al. (2014) studied the periphytic algal community, in terms of species composition and density, of Dal Lake, Kashmir. They recorded a total of 31 taxa belonging to three major classes, namely, Bacillariophyceae, Chlorophyceae, and Cyanophyceae. The most common periphytic taxa which they encountered across all the study sites were species of *Diatoma*, *Cymbella*, *Synedra*, *Fragilaria*, *Oedogonium*, *Tabellaria*, *Cosmarium*, *Scenedesmus*, and *Oscillatoria.* In terms of species richness, Bacillariophyceae were dominant, followed by Chlorophyceae and Cyanophyceae. Rasool et al. (2014) carried out a study pertaining to taxonomic composition of epiphytic algae of Lidder stream flowing through Pahalgam in Kashmir. They found that this algal community is represented by 144 taxa belonging to 4 classes, namely, Bacillariophyceae (104 spp.), Chlorophyceae (19 spp.), Cyanophyceae (12 spp.), and Euglenophyceae (4 spp.), while Chrysophyceae and Dinophyceae contributed 1 species each. Bacillariophyceae was represented by some dominant forms, like *Navicula* (with 16 species), *Nitzschia* (11 species), *Cymbella* (9 species), and *Gomphonema* (7 species). In Cyanophyceae, *Spirulina* recorded 3 species and *Merismopedia* 2 species. In Chlorophyceae, the highest number of species was documented in genus *Cosmarium* (3 species), while *Closterium*, *Euastrum*, and *Ulothrix* registered 2 species each. Baba et al. (2014) studied the phytoplanktonic populations inhabiting the river Chenab. Phytoplankton collections during 2 years of study on river Chenab and its tributaries recorded 20 species belonging to 3 major groups, Chlorophyceae, Bacillariophyceae, and Cyanophyceae. On the whole, Chlorophyceae were represented by 11 species, Bacillariophyceae by 7, and Cyanophyceae by 2 species. Among Chlorophyceae, the dominant taxa were species of *Volvox*, *Treubaria*, *Spirogyra*, *Uronema*, *Microspora*, and *Pediastrum simplex*. Bacillariophyceae were dominated by *Navicula cuspidata* and species of *Gomphonema*, *Fragilaria*, *Cyclotella*, *Diploneis*, and *Frustulia* and Cyanophyceae by species of *Nostoc* and *Synechocystis*.

This chapter, based on critical review of all the previous research studies, has attempted to provide a consolidated, up-to-date account of the diversity of algae in J&K State.

## 13.2 Results and Discussion

In the present study, a total of 1065 taxa of algae are recorded from J&K State. Based on species richness, Bacillariophyceae (with 299 species, 56 varieties, and 8 forma in 45 genera) is the largest family, followed by Chlorophyceae (with 240 species, 39 varieties, and 8 forma in 78 genera), Cyanophyceae (with 216 species, 5 varieties, and 3 forma in 46 genera), Desmidiaceae (with 102 species, 22 varieties, and 2 forma in 21 genera), Euglenophyceae (with 44 species and 2 varieties in 10 genera), Chrysophyceae (with 5 species in 2 genera), Dinophyceae (with 4 species in 4 genera), Xanthophyceae (with 4 species and 1 forma in 3 genera), Charophyceae (with 2 species and 1 variety in 2 genera), and Rhodophyceae and Cryptophyceae (with only 1 species each).

### *13.2.1 Taxonomic Inventory of Algal Diversity*

The algal species reported so far from J&K State, as grouped under classes, is given in Table 13.1.

## 13.3 Concluding Remarks

Jammu and Kashmir State is an unparalleled repository of rich algal diversity in India. This is because of the abundance of freshwater lakes and wetlands throughout the State. A total of 1065 species and infraspecific taxa of freshwater algae so far reported by various workers in a large number of scattered publications have been inventoried in this chapter. These algae range from planktonic forms in Cyanophyceae, Bacillariophyceae, Cryptophyceae, and Dinophyceae, to colonial Volvocaceae, to filamentous Zygnemataceae, Ulotrichaceae, and Oedogoniaceae, to complex Chaetophoraceae, Charophyceae, and Rhodophyceae. Much of this work, however, is of preliminary nature; many of the algal taxa having been reported from here are not documented by voucher specimens/illustrations (Dar et al., 2002). Need of the time is to collect algae throughout the State and validate their taxonomic identity based on voucher specimens to ensure reliable documentation. This, in turn, will help documenting overall biodiversity of this important region of the Himalayan biodiversity hotspot.

**Table 13.1** Class-wise list of algal species and infraspecific taxa reported from Jammu and Kashmir State

| Name of class | Name of species/infraspecific taxa |
|---|---|
| **1. Cyanophyceae** | *Anabaena affinis* Lemm. |
| | *A. ambigua* C.B.Rao |
| | *A. circinalis* Rabenhorst ex Bornet & Flahault |
| | *A. constricta* (Szafer) Geitler |
| | *A. cylindrica* Lemm. |
| | *A. fertilissima* C.B.Rao |
| | *A. inaequalis* Born. & Flah. |
| | *A. major* (Kutzing) Trevisan |
| | *A. naviculoides* Fritsch |
| | *A. oscillarioides* Bory ex Bornet & Flahault |
| | *A. solitaria* Klebahn |
| | *A. sphaerica* var. *attenuata* Bharadwaja |
| | *A. spiroides* Klebahn |
| | *A. unispora* N.L.Gardner |
| | *A. variabilis* Kutz. ex Born. & Flah. |
| | *Anacystis cyanea* (Kutz.) Drouet & Daily |
| | *Aphanizomenon flosaquae* Ralfs. ex Born. & Flah. |
| | *A. holsaticum* Richter |
| | *Aphanocapsa banaresensis* Bhardwaja |
| | *A. biformis* A. Br. |
| | *A. conferta* (West & G.S. West) Komarkova-Legnerova & Cronberg |
| | *A. elachista* West & G.S. West |
| | *A. grevillei* (Berkeley) Rabenhorst |
| | *A. montana* Cramer |
| | *A. naegelii* Richter |
| | *A. pulchra* (Kutz.) Rabenhorst |
| | *A. roeseana* De Bary |
| | *Aphanotheca castagnei* (Kutz.) Rabh. |
| | *A. nidulans* Richter |
| | *A. pallida* (Kutz.) Rabenh. |
| | *A. stagnina* (Sprengel) A.Braun |
| | *Arthrospira khannae* Drouet & Strickland |
| | *A. massartii* var. *indica* Desikachary |
| | *A. platensis* Gomont |
| | *Aulosira fertilissima* S.L.Ghose |
| | *Calothrix braunii* Born. & Flah. |
| | *C. castellii* Born. & Flah. |
| | *C. fusca* Born. & Flah. |
| | *C. ghosei* Bhardwaja |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *C. javanica* D.Wildeman |
| | *C. thermalis* Hasngirg ex Born. & Flah. |
| | *Chroococcus dispersus* var. *minor* G.M.Smith |
| | *C. giganteus* West |
| | *C. indicus* Zeller |
| | *C. limneticus* Lemm. |
| | *C. macrococous* (Kutz.) Rabenh. |
| | *C. minimus* (Keissler) Lemm. |
| | *C. minutus* (Kutz.) Nageli |
| | *C. montanus* Hansg. |
| | *C. pallidus* Nageli |
| | *C. schizodermaticus* West |
| | *C. spelaeus* Ercegovic |
| | *C. tenax* (Kirch.) Hieron. |
| | *C. turgidis* (Kutz.) Nag. |
| | *C. turgidis* var. *maximus* Nygaard |
| | *C. varius* A. Braun |
| | *Chlorogloea microcystoides* Geitler |
| | *Chroococcidiopsis indica* Desik. |
| | *Coccochloris stagnina* Sprengel |
| | *Coelosphaerium confertum* West & G.S.West |
| | *C. kuetzingianum* Nag. |
| | *C. minutissimum* Lemm. |
| | *C. naegelianum* Unger |
| | *Cyanothece cedrorum* (Sauv.) Kom. |
| | *C. eximia* (Copel.) Kom. |
| | *Cylindrospermum licheniforme* Kutz. ex Born. & Flah. |
| | *C. muscicola* Kutz. ex Born. & Flah. |
| | *C. stagnale* Born. & Flah. |
| | *Dactylococcopsis fasicularis* f. *indica* Desik. |
| | *D. rhaphidioides* Hansg. |
| | *Dermocarpa olivacea* (Reinsch) Tilden |
| | *Eucapsis minuta* Fritsch |
| | *Gloeocapsa atrata* Kutz. |
| | *G. calcarea* Tilden |
| | *G. gelatinosa* Kutz. |
| | *G. granosa* (Berk.) Kutz. |
| | *G. magma* (Breb.) Kutz. |
| | *G. montana* Kutz. |
| | *G. pleurocapsoides* Novacek |
| | *G. polydermatica* Kutz. |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *G. punctata* Nag. |
| | *G. quaternata* Kutz. |
| | *G. stegophila* (Itzigs.) Rabenh. |
| | *Gloeocystis rupestris* Rabenh. |
| | *Gloeotrichia echinulata* Richter |
| | *G. intermedia* (Lemm.) Geitler |
| | *G. longicauda* Schm. |
| | *G. pisum* Thuret ex Born. et Flah. |
| | *G. raciborskii* Woloszynska |
| | *Gomphosphaeria aponina* Kutz. |
| | *G. wichurae* (Hilse) Drouet & Daily |
| | *Homeothrix hansgirgii* (Schm.) Lemm. |
| | *Hydrococcus rivularis* Kutz. |
| | *Katagnymene spiralis* Lemm. |
| | *Lyngbya aestuarii* Liebman ex Gomont |
| | *L. cebennensis* (Gom.) Compere |
| | *L. ceylanica* Wille |
| | *L. contorta* Lemm. |
| | *L. favosa* (Gom.) Ther. & Coute |
| | *L. ferruginea* G.S.West |
| | *L. foveolarum* (Gom.) Hansg. |
| | *L. gardneri* Geitler |
| | *L. hieronymusii* Lemm. |
| | *L. holdenii* Forti |
| | *L. kuetzingii* Schm. |
| | *L. magnifica* Gardner |
| | *L. major* Hansg. |
| | *L. majuscula* Harvey ex Gomont |
| | *L. nigra* Hansg. |
| | *L. orientalis* (G.S.West) Compere |
| | *L. perelegans* Lemm. |
| | *L. retzii* Hansg. |
| | *L. rigidula* (Kutz.) Hansg. |
| | *L. spiralis* Geitler |
| | *L. spirulinoides* Gomont ex Gomont |
| | *L. subtilis* Holden |
| | *L. transvaalensis* Cholnoky |
| | *Merismopedia convoluta* Breb. ex Kutz. |
| | *M. elegans* A. Br. ex Kutz. |
| | *M. glauca* (Ehr.) Kutz. |
| | *M. minima* Beck |
| | *M. punctata* Meyen |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *M. tenuissima* Lemm. |
| | *Microcystis aeruginosa* (Kutz.) Kutz. |
| | *M. densa* G.S.West |
| | *M. elabens* (Breb.) Kutz. |
| | *M. elabentoides* Zal. |
| | *M. elachista* (West & G.S.West) Starmach |
| | *M. flosaquae* (Wittrock) Kirch. |
| | *M. gravillei* (Berk.) Elenk. |
| | *M. holsatica* (Lemm.) Lemm. |
| | *M. incerta* (Lemm.) Lemm. |
| | *M. marginata* (Menegh) Kutz. |
| | *M. orissica* West |
| | *M. protocystis* Crow |
| | *M. robusta* (Clark) Nygaard |
| | *M. stagnalis* (Lemm.) Lemm. |
| | *M. viridis* (A.Br.) Lemm. |
| | *Microspora amoena* (Kutz.) Rabenh. |
| | *Myxosarcina burmensis* Skuja |
| | *M. spectabilis* Geitler |
| | *Nostoc calcicola* Breb. ex Born. & Flah. |
| | *N. linckia* Born. ex Born. & Flah. |
| | *N. pruniformae* Agardh ex Born. & Flah. |
| | *N. spongiaeforme* Ag. ex Born. & Flah. |
| | *N. verrucosum* Vaucher ex Born. & Flah. |
| | *Nodularia laxa* (Born. & Flah.) Compere |
| | *N. spumigena* Mertens ex Born. & Flah. |
| | *Oscillatoria acula* Bruhl & Biswas |
| | *O. acuminata* Gomont |
| | *O. agardhii* Gom. |
| | *O. amoena* Gom. |
| | *O. amphibia* Ag. ex Gom. |
| | *O. angusta* Koppe |
| | *O. angustissima* West & G.S.West |
| | *O. annae* Goor |
| | *O. articulata* Gardner |
| | *O. boryana* Bory ex Gom. |
| | *O. chalybea* Gom. |
| | *O. chlorina* (Kutz) Gom. |
| | *O. chilkensis* Biswas |
| | *O. curviceps* Agardh ex Gom. |
| | *O. curviceps* var. *angusta* Ghose |
| | *O. foreaui* Fremy |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *O. formosa* Bory ex Gom. |
| | *O. granulata* Gardn. |
| | *O. hamelii* Fremy |
| | *O. irrigua* Kutz. ex Gom. |
| | *O. laetevirens* Crouan & Crouan ex Gom. |
| | *O. limnetica* Lemm. |
| | *O. limosa* Ag. ex Gom. |
| | *O. margaritifera* Kutz. ex Gom. |
| | *O. martinii* Fremy |
| | *O. nigra* Vaucher ex Gom. |
| | *O. nigroviridis* Thwaites ex. Gom. |
| | *O. perornata* Skuja |
| | *O. perornata* f. *attenuata* Skuja |
| | *O. princeps* Gom. |
| | *O. proboscidea* Gom. |
| | *O. proteus* Skuja |
| | *O. pseudogeminata* Schmid |
| | *O. putrida* Schmidle |
| | *O. quadripunctulata* Bruhl & Biswas |
| | *O. redekei* Goor |
| | *O. rubescens* DC. ex Gom. |
| | *O. sancta* Kutz. ex Gom. |
| | *O. schroederi* Borge |
| | *O. splendida* Greville ex Gom. |
| | *O. stagnina* Kutz. ex Gom. |
| | *O. subbrevis* Schmidle |
| | *O. tenuis* Ag. ex Gom. |
| | *O. vizagapatensis* Rao |
| | *Phormidium anomalum* Rao |
| | *P. bigranulatum* f. *majus*Vasishta |
| | *P. lucidum* Kutz. ex Gom. |
| | *P. molle* Gom. |
| | *P. retzii* Kutz. ex Gom. |
| | *P. tenue* Gom. |
| | *P. uncinatum* Gom. ex Gom. |
| | *Pseudanabaena catenata* Lauterborn |
| | *P. mucicola* (Naum. & Hub.) Schwabe |
| | *Radiocystis geminata* Skuja |
| | *Raphidiopsis curvata* Fritsch & Rich |
| | *R. indica* Singh |
| | *R. mediterranea* Skuja |
| | *Rivularia aquatica* De Wild. |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *R. minutula* Born. & Flah. |
| | *Schizothrix lacustris* Br. ex Gom. |
| | *Spirulina gigantea* Schmidle |
| | *S. jenneri* (Stizb.ex Gom.) Geitler |
| | *S. labyrinthiformis* Gom. |
| | *S. laxissima* West |
| | *S. major* Kutz. ex Gom. |
| | *S. princeps* West & G.S.West |
| | *S. subsalsa* Oersted ex Gom. |
| | *Stigonema aerugineum* Tilden |
| | *Synechococcus ambiguus* Skuja |
| | *Synechocystis aquatilis* Sauv. |
| | *S. pevalekii* Ercegovic |
| | *Tolypothrix tenuis* Kutz. ex Born. & Flah. |
| | *Trichodesmium erythraeum* Ehr. ex Gom. |
| | *T. iwanoffianu* Nygaard |
| | *T. lacustre* Klebahn |
| | *Xenococcus kerneri* Hansg. |
| | *X. willei* Gardner |
| **2. Chlorophyceae** | *Actinastrum hantzschii* Lagerheim |
| | *Actinotaenium cruciferum* (De Barry) Teiling |
| | *A. cucurbitinum* (Biss.) Teil. |
| | *A. curtum* (Breb. ex Ralfs) Teil. ex Ruzicka & Pouzar |
| | *A. mooreanum* (Arch.) Teil. |
| | *Ankistrodesmus bibraianus* (Reinsch) Korsh. |
| | *A. convolutes* Corda |
| | *A. falcatus* (Corda) Ralfs |
| | *A. falcatus* var. *acicularis* (Braun) G.S.West |
| | *A. falcatus* var. *radiatus* Lemm. |
| | *A. gracilis* (Reinsch) Korsh. |
| | *A. spiralis* (Turn.) Lemm. |
| | *A. spiralis* var. *fasciculatus* Smith |
| | *Arthrodesmus convergens* Ehrenberg ex Ralfs |
| | *Binuclearia tatrana* Wittrock |
| | *B. tectorum* (Kutz.) Beger ex Wichmann |
| | *Botryococcus braunii* Kutz. |
| | *Chaetophora incrassata* Hazen |
| | *Chaetonema irregulare* Nowakowski |
| | *Chodatella quadriseta* Lemm. |
| | *Chlamydocapsa bacillus* (Teil.) Fott |
| | *Chlamydomonas debaryana* Gor. |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *C. gracilis* Snow |
| | *Chlorella vulgaris* Beyer. |
| | *Chlorococcum humicola* (Nag.) Rabenh. |
| | *Cladophora fracta* (Mull. ex Vahl) Kutz. |
| | *C. fracta* var. *intricata* (Lyngb.) Hoek |
| | *C. glomerata* (Linn.) Kutz. |
| | *Closterium acerosum* (Ehr.) ex Ralfs |
| | *C. acerosum* var. *elongatum* Breb. |
| | *C. acutum* Breb. |
| | C. *ehrenbergii* Menegh. ex Ralfs |
| | C. *ehrenbergii* var. *curvatum* Kant & Gupta |
| | *C. lanceolatum* Kutz. ex Ralfs |
| | *C. leibleinii* Kutz. ex Ralfs |
| | *C. libellula* Focke ex Nordst. |
| | *C. lunula* var. *massartii* (Wildeman) Krieger |
| | *C. modesta* Kant & Gupta |
| | *C. moniliferum* Ehr. ex Ralfs |
| | *C. navicula* (Breb.) Lutkem. |
| | *C. parvulum* f. *minor* Nag. |
| | *C. porrectum* Nordst. |
| | *C. pronum* Breb. |
| | *C. pseudodianae* var. *curvatum* Kant & Gupta |
| | *C. pseudolunula* Borge |
| | *C. recurvum* Prescott |
| | *C. setaceum* Ehr. ex Ralfs |
| | *C. strigosum* Breb. |
| | *C. tumidum* Johns. |
| | *C. venus* Kutz. ex Ralfs |
| | *Closteriopsis acicularis* (Chodat) Belch. & Swale |
| | *C. longissima* (Lemm.) Lemm. |
| | *Coelastrum astroideum* De Not. |
| | *C. cambricum* Arch. |
| | *C. cambricum* var. *intermedium* (Bohl.) G.S.West |
| | *C. microporum* Nag. |
| | *C. reticulatum* (Dang.) Senn |
| | *C. sphaericum* Nag. |
| | *Coleochaete scutata* Breb. |
| | *Crucigenia crucifera* (Wolle) Kuntz. |
| | *C. fenestrata* (Schmidle) Schmidle |
| | *C. lauterbornii* (Schmidle) Schmidle |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *C. rectangularis* (Nag.) Gay |
| | *C. tetrapedia* (Kirch) Kuntze |
| | *Cylindrocapsa geminella* Wolle |
| | *Cylindrocystis crassa* var. *elliptica* West & G.S. West |
| | *Dermatophyton radians* Peter |
| | *Desmidium aptogonum* Breb. ex Kutz. |
| | *D. quadrangulatum* var. *acutilobum* f. *protractum* Schroder |
| | *Dictyosphaerium ehrenbergianum* Nag. |
| | *D. indicum* Iyengar & Ramanathan |
| | *D. pulchellum* Wood |
| | *Didymocystis planktonica* Korsh. |
| | *Dimorphococcus lunatus* A.Braun |
| | *Ecballocystis iyengarii* Kant & Gupta |
| | *Elakatothrix bifurcata* Kant & Gupta |
| | *Enteromorpha intestinalis* (Linn.) Nees |
| | *Euastrum dubium* Nag. |
| | *E. gemmatum* Ralfs |
| | *Eudorina elegans* Ehr. |
| | *E. indica* Iyeng. |
| | *Geminella protogenita* (Kutz.) G.S.West |
| | *Gloeotaenium loitlesbergereanum* Hansg. |
| | *Gonatozygon brebissonii* De Barry |
| | *G. monotaenium* De Barry |
| | *G. pilosum* Wolle |
| | *Gonium pectorale* Mull. |
| | *Groenbladia neglecta* (Racib.) Teil. |
| | *Hallasia indica* Kant & Gupta |
| | *Hormidium flaccidum* (Kutz.) A. Br. |
| | *H. subtile* (Kutz.) Heering |
| | *Hydrodictyon indicum* Iyengar |
| | *H. reticulatum* (L.) Bory |
| | *Kirchneriella contorta* (Schmidle) Bohlin |
| | *K. intermedia* Korsh. |
| | *K. lunaris* (Kirch.) Mobius |
| | *K. obesa* (West) West & G.S. West |
| | *Mougeotia bangalorensis* Iyengar |
| | *M. genuflexa* (Roth) Agardh |
| | *M. hirnii* Transeau |
| | *M. jogensis* Iyengar |
| | *M. laetevirens* (Braun) Wittrock |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *M. oblongata* Transeau |
| | *M. scalaris* Hassall |
| | *Mesotaenium macrococcum* (Kutz. ex Kutz.) Roy & Bisset |
| | *Micrasterias radiata* Hass. ex West & G.S.West |
| | *M. pinnatifida* Ralfs |
| | *Micractinium pusillum* Fresenius |
| | *Microspora amoena* (Kutz.) Rabenh. |
| | *Microthamnion strictissimum* Rabh. |
| | *Monoraphidium contortum* (Thur.) Kom.-Legner. |
| | *M. griffithii* (Berk.) Kom.-Legner. |
| | *M. minutum* (Nag.) Kom.-Legner. |
| | *Nephrocytium agardhianum* Nag. |
| | *Netrium digitus* (Breb. ex Ralfs) Itzigs. & Roth. |
| | *Oedocladium operculatum* Tiffany |
| | *Oedogonium brevicingulatum* Jao |
| | *O. capillare* Kutz. ex Hirn |
| | *O. cardiacum* f. *interjectum* Hirn |
| | *O. crassum* Wittr. ex Hirn |
| | *O. crispum* Wittr. ex Hirn |
| | *O. globosum* Nordst. ex Hirn |
| | *O. inversum* Wittr. ex Hirn |
| | *O. paucocostatum* Trans. |
| | *O. tumidulum* Wittr. ex Hirn |
| | *O. varians* Wittr. & Lundell ex Hirn |
| | *Oocystis lacustris* Chodat |
| | *O. parva* West & G.S.West |
| | *O. solitaria* Wittr. |
| | *Pandorina charkowiensis* Korsh. |
| | *P. morum* f. *major* Iyengar |
| | *Pediastrum angulosum* Ehr. ex Menegh. |
| | *P. biradiatum* Meyen |
| | *P. bobyensis* Kant & Gupta |
| | *P. boryanum* (Turp.) Menegh. |
| | *P. boryanum* var. *longicorne* (Reinsch) Hansg. |
| | *P. boryanum* var. *constrictum* Kant & Gupta |
| | *P. duplex* Meyen |
| | *P. duplex* var. *clathratum* (A. Br.) Lager. |
| | *P. duplex* var. *subgranulatum* Racib. |
| | *P. inconspicuum* Kant & Gupta |
| | *P. integrum* Nag. |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *P. lehense* Kant & Gupta |
| | *P. longicorne* Kant & Gupta |
| | *P. ovatum* (Ehr.) A. Braun |
| | *P. ovatum* (Ehr.) var. *simplax* Kant & Gupta |
| | *P. simplex* Meyen |
| | *P. simplex* var. *duodenarium* (Bailey) Rabenh. |
| | *P. spinosum* Kant & Gupta |
| | *P. tetras* (Ehr.) Ralfs |
| | *P. tetras* var. *tetraodon* (Corda) Hansg. |
| | *P. tetras* var. *excisum* (A. Braun) Hansg. |
| | *P. tricornutum* var. *bifidum* Kant & Gupta |
| | *Penium margaritaceum* Breb. |
| | *Pleodorina sphaerica* Iyeng. |
| | *Pleurotaenium minutum* (Ralfs) Hilse |
| | *P. undulatum* Kant & Gupta |
| | *Pseudotetraspora expansum* Kant & Gupta |
| | *Pseudoulvella americana* Will |
| | *Pteromonas aequiciliata* (Gickl.) Chodat |
| | *P. angulosa* (Carter) Lemm. |
| | *Quadrigula quarternata* (West & G.S.West) Printz |
| | *Radiococcus nimbatus* (De Wild.) Schimdle |
| | *Scenedesmus abundans* (Kirch.) Chodat |
| | *S. abundans* var. *brevicauda* Smith |
| | *S. acuminatus* (Lagerh.) Chod. |
| | *S. acutiformis* Schrod. |
| | *S. acutus* Meyen |
| | *S. arcuatus* (Lemm.) Lemm. |
| | *S. arcuatus* var. *capitatus* Smith |
| | *S. armatus* (Chod.) Chod. |
| | *S. armatus* var. *bicaudatus* Hortobagyi |
| | *S. balatonicus* Hortob. |
| | *S. bernardii* Smith |
| | *S. bijuga* (Turp.) Lager. |
| | *S. bijugatus* Kutz. |
| | *S. bijugatus* var. *bicellularis* (Chod.) Philip. |
| | *S. bijugatus* var. *graevenitzii* (Bernard) Philip. |
| | *S. bijugatus* var. *irregularis* (Wille) Smith |
| | *S. bijugatus* f. *parvus* (Smith) Philip. |
| | *S. brasiliensis* Bohlin |
| | *S. budhaensis* Kant & Gupta |
| | *S. carinatus* (Lemm.) Chod. |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *S. communis* Hegew. |
| | *S. decorus* var. *protuberans* Kant & Gupta |
| | *S. denticulatus* var. *linearis* Hansg. |
| | *S. dimorphus* (Turp.) Kutz. |
| | *S. ecornis* (Ehr.) Chod. |
| | *S. graciosus* var. *unipolar* Kant & Gupta |
| | *S. incrassatulus* Bohlin |
| | *S. longus* var. *naegelii* (Breb.) Smith |
| | *S. microspina* Chod. |
| | *S. obliquus* (Turp.) Kutz. |
| | *S. obtusus* Meyen |
| | *S. obtusus* f. *disciformis* (Chod.) Compere |
| | *S. obtusus* f. *ecornis* Compere |
| | *S. opoliensis* Rich. |
| | *S. ovalternus* Chod. |
| | *S. pannonicus* var. *papillatae* Kant & Gupta |
| | *S. pelvis* var. *unispinosus* Kant & Gupta |
| | *S. perforatus* var. *minor* Kant & Gupta |
| | *S. platydiscus* var. *pentarch* Kant & Gupta |
| | *S. prismaticus* Bruhl & Biswas |
| | *S. priyankaii* Kant & Gupta |
| | *S. protuberans* f. *minor* Ley |
| | *S. quadricauda* Chod. |
| | *S. quadricauda* var. *brevispina* Kant & Gupta |
| | *S. serratus* (Corda) Bohlin |
| | *S. varians* Kant & Gupta |
| | *Schroederia setigera* (Sch.) Lemm. |
| | *Selenastrum bibraianum* Reinsch |
| | *S. gracile* Reinsch |
| | *S. westii* Smith |
| | *Sorastrum spinulosum* Nag. |
| | *Sphaerocystis schroeteri* Chod. |
| | *Spirogyra acanthophora* (Skuja) Czurda |
| | *S. amplectens* Skuja |
| | *S. asiatica* Czurda |
| | *S. biformis* Jao |
| | *S. borgeana* Transeau |
| | *S. bullata* Jao |
| | *S. communis* (Hassall) Kutz. |
| | *S. czurdae* Misra |
| | *S. dacimina* (Muller) Kutz. |
| | *S. hyalina* Cleve |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *S. frankliniana* Tiffany |
| | *S. macrospora* (Rao) Krieger |
| | *S. majuscula* Kutz. |
| | *S. parvula* (Trans.) Czurda |
| | *S. polymorpha* Kirch. |
| | *S. pulchrifigurata* Jao |
| | *S. rhizobrachialis* Jao |
| | *S. rivularis* (Hassall) Rabenh. |
| | *S. setiformis* Kutz. |
| | *S. singularis* Nordst. |
| | *S. velata* Nordst. |
| | *S. wabashensis* Tiffany |
| | *Spondylosium desmidiforme* (Borge) G.S.West |
| | *S. pulchrum* (Bailey) Arch. |
| | *Staurastrum cosmarae* Kant & Gupta |
| | *S. curvatum* Turner |
| | *S. dilatatum* Ehr. ex Ralfs |
| | *S. gracile* var. *elegantulum* |
| | *S. gracile* var. *triangularis* Kant & Gupta |
| | *S. lunatum* Ralfs |
| | *S. orbiculare* Meneg. ex Ralfs |
| | *S. pachyrhynchum* Nordst. |
| | *S. protractum* Racib. |
| | *S. furcigerum* (Breb.) Arch. |
| | *Staurodesmus cuspidatus* (Breb.) Teil. |
| | *Stigeoclonium lubricum* (Dillw.) Kutz. |
| | *S. nanum* (Dillw.) Kutz. |
| | *S. tenue* (Ag.) Kutz. |
| | *Temnogametum tirupatiense* Iyengar |
| | *Tetraedron bifidium* (Turner) Wille |
| | *T. caudatum* (Corda) Hansg. |
| | *T. incus* (Teiling) Smith |
| | *T. minimum* (Braun) Hansg. |
| | *T. multispinosum* Kant & Gupta |
| | *T. muticum* (Braun) Hansg. |
| | *T. pusillum* (Wallich) West & G.S.West |
| | *T. regulare* Kutz. |
| | *T. trigonum* (Nag.) Hansg. |
| | *T. trilobulatum* (Reinsch) Hansg. |
| | *Ulothrix rorida* Thuret |
| | *U. tenuissima* Kutz. |
| | *U. zonata* (Weber & Mohr.) Kutz. |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *Uronema elongatum* Hodgetts |
| | *Westella botryoides* (West) De Wilde. |
| | *Zygnema atrocoeruleum* West & G.S.West |
| | *Z. atrocoeruleum* var. *crassa* Misra |
| | *Z. chungii* Li. |
| | *Z. cruciatum* (Vaucher) Agardh |
| | *Z. cylindricum* Transeau |
| | *Z. cylindrosporum* (W. & G.S.West) Krieger |
| | *Z. czurdae* Randhawa |
| | *Z. indicum* Misra |
| | *Z. kashmirense* Misra |
| | *Z. melanosporum* Lagerheim |
| | *Z. misrae* Krieger |
| | *Z. sphaericum* Misra |
| | *Z. sphaericum* f. *crassum* Misra |
| | *Z. srinagarense* Krieger |
| | *Z. stagnale* (Hassal) Kutz. |
| | *Z. subcylindricum* Kriegner |
| | *Z. synadelphum* Skuja |
| | *Z. terrestre* Randhawa |
| | *Zygnemopsis indica* var. *robusta* Kant & Gupta |
| **3. Bacillariophyceae** | *Achnanthes delicatula* Kutz. |
| | *A. elliptica* (Cleve) Cleve-Euler |
| | *A. exigua* Grun. |
| | *A. exilis* Kutz. |
| | *A. flexella* (Kutz.) Brun |
| | *A. hungarica* (Grun.) Grun. |
| | *A. lanceolata* (Breb.ex Kutz.) Grun. |
| | *A. linearis* (Sm.) Grun. |
| | *A. longipes* Ag. |
| | *A. minutissima* Kutz. |
| | *A. parvula* Kutz. |
| | *A. rostrata* Ostr. |
| | *Achnanthidium lanceolatum* Breb. ex Kutz. |
| | *Amphipleura pellucida* (Kutz.) Kutz. |
| | *Amphora bitumida* Prowse |
| | *A. coffeiformis* (Ag.) Kutz. |
| | *A. constricta* (Ehr.) Carru. |
| | *A. normanii* Rabenh. |
| | *A. obtusa* Gregory |
| | *A. ovalis* (Kutz.) Kutz. |
| | *A. ovalis* var. *affinis* (Kutz.) Van Heurck |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *A. veneta* Kutz. |
| | *Anomoeoneis brachysira* (Breb. ex Rabenh.) Cl. |
| | *A. serians* (Breb.) Cl. |
| | *A. serians* var. *brachysira* (Breb. ex Rabenh.) Hust. |
| | *A. sphaerophora* Pfitz. |
| | *Asterionella formosa* Hass. |
| | *Aulacosira granulata* (Ehr.) Sim. |
| | *Bacillaria paradoxa* Gmelin |
| | *Caloneis bacillum* (Grun.) Cl. |
| | *C. clevei* (Lag.) Cl. |
| | *C. limosa* (Kutz.) Patr. |
| | *C. minuta* (Grun.) Oht. & Fuj. |
| | *C. silicula* (Ehr.) Cl. |
| | *C. ventricosa* Meist. |
| | *C. ventricosa* var. *truncatula* (Grun.) Meist. |
| | *Cocconeis pediculus* Ehr. |
| | *C. placentula* Ehr. |
| | *C. placentula* var. *lineata* (Ehr.) Van Heurck |
| | *C. punctata* Ehr. |
| | *Cyclotella comensis* Grun. |
| | *C. comta* Kutz. |
| | *C. meneghiniana* Kutz. |
| | *C. pseudostelligera* Hust. |
| | *C. operculata* (Ag.) Breb. |
| | *Cymatopleura elliptica* (Breb.) Sm. |
| | *C. librile* (Ehr.) Pant. |
| | *C. solea* (Breb) Sm. |
| | *Cymbella aequalis* Sm. |
| | *C. affinis* Kutz. |
| | *C. amphicephala* Naeg. |
| | *C. aspera* (Ehr.) Cl. |
| | *C. cistula* (Ehr.) Kirchn. |
| | *C. cistula* var. *gibbosa* Brun |
| | *C. cuspidata* Kutz. |
| | *C. cymbiformis* var. *curvata* Cl. |
| | *C. cymbiformis* var. *nonpunctata* Font. |
| | *C. diluviana* (Krasske) Florin |
| | *C. ehrenberghii* Kutz. |
| | *C. gaeumannii* Meister |
| | *C. gracilis* (Rabenh.) Cl. |
| | *C. gastroides* (Kutz.) Kutz. |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *C. helvetica* Kutz. |
| | *C. hustedtii* Krasske |
| | *C. inaequalis* (Ehr.) Rabenh. |
| | *C. lanceolata* (Ag.) Kirch. |
| | *C. lata* Grun. |
| | *C. leptoceros* (Ehr.) Kutz. |
| | *C. microcephala* Grun. |
| | *C. minuta* Hilse |
| | *C. minuta* f. *latens* (Krasske) Reimer |
| | *C. minuta* var. *pseudogracilis* (Choln.) Reimer |
| | *C. minuta* var. *silesiaca* (Bleisch) Reimer |
| | *C. muelleri* Hustedt |
| | *C. naviculiformis* Auersw. ex Heib. |
| | *C. prostrata* (Berk.) Cl. |
| | *C. sinuata* Greg. |
| | *C. subaequalis* Grun. |
| | *C. tumida* (Breb.) Van Heurck |
| | *C. turgida* Greg |
| | *C. turgidula* Grun. |
| | *C. undulata* Pero |
| | *C. ventricosa* (Ag.) Ag. |
| | *Denticula elegans* Kutz. |
| | *D. tenuis* Kutz. |
| | *Diatoma elongatum* (Lyngb.) Ag. |
| | *D. hiemale* (Roth) Heib. |
| | *D. hiemale* var. *mesodon* (Ehr.) Kirch. |
| | *D. moniliformis* (Kutz.) Williams |
| | *D. tenuis* Ag. |
| | *D. vulgaris* Bory |
| | *Diatomella balfouriana* Grev. |
| | *Didymosphenia geminata* (Lyngb.) Schm. |
| | *Diploneis elliptica* (Kutz.) Cl. |
| | *D. oblongella* (Nag. ex Kutz.) Cl.-Eul. |
| | *Encyonema caespitosum* Kutz. |
| | *E. prostratum* (Berkeley) Kutz. |
| | *E. ventricosum* (Ag.) Grun. |
| | *Epithemia adnata* (Kutz.) Breb. |
| | *E. adnata* var. *porcellus* (Kutz.) Ross |
| | *E. adnata* var. *proboscidea* (Kutz.) Hendey |
| | *E. argus* (Ehr.) Kutz. |
| | *E. argus* var. *alpestris* (Smith) Grun. |
| | *E. gibba* (Ehr.) Kutz. |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *E. sorex* Kutz. |
| | *E. turgida* (Ehr.) Kutz. |
| | *E. turgida* var. *granulata* (Ehr.) Brun |
| | *E. zebra* (Ehr.) Kutz. |
| | *Eunotia curvata* (Kutz.) Lagerst. |
| | *E. diodon* Ehr. |
| | *E. gracilis* (Ehr.) Rabenh. |
| | *E. major* (Sm.) Rabenh. |
| | *E. minor* (Kutz.) Grun. |
| | *E. pectinalis* (Kutz.) Rabenh. |
| | *E. tenella* (Grun.) Hust. |
| | *E. undulata* Grun. |
| | *Fragilaria arcus* (Ehr.) Cl. |
| | *F. brevistriata* Grun. |
| | *F. capucina* Desm. |
| | *F. capucina* var. *mesolepta* (Rabenh.) Rabenh. |
| | *F. capucina* var. *vaucheriae* (Kutz.) Lange-Bert. |
| | *F. construens* (Ehr.) Grun. |
| | *F. crotonensis* Kitton |
| | *F. intermedia* (Grun.) Grun. |
| | *F. pinnata* Ehr. |
| | *F. ulna* var. *acus* (Kutz.) Lange-Bert. |
| | *F. ulna* var. *amphirhynchus* (Ehr.) Kalin. |
| | *F. ulna* var. *danica* (Kutz.) Kalin. |
| | *F. ulna* var. *longissima* (Sm.) Brun |
| | *F. vaucheriae* (Kutz.) Peterson |
| | *Frustulia rhomboides* (Ehr.) De Toni |
| | *F. rhomboides* var. *crassinervia* (Breb. ex Sm.) Ross |
| | *F. rhomboides* var. *saxonica* (Rabenh.) De Toni |
| | *F. vulgaris* (Thwaites) De Toni |
| | *Gomphonies herculeana* (Ehr.) Cl. |
| | *Gomphonema acuminatum* Ehr. |
| | *G. acuminatum* var. *brebissonii* (Kutz.) Grun. |
| | *G. acuminatum* var. *coronatum* (Ehr.) Rabenh. |
| | *G. africanum* G.S.West |
| | *G. angustatum* (Kutz) Rabenh. |
| | *G. angustatum* var. *citera* (Hohn & Hellerm.) Patr. |
| | *G. angustatum* var. *productum* Grun. |
| | *G. angustatum* var. *sarcophagus* (Greg.) Hust. |
| | *G. augur* Ehr. |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *G. augur* var. *gautieri* Van Heurck |
| | *G. brasiliense* Grun. |
| | *G. clevei* Fricke |
| | *G. constrictum* Ehr. |
| | *G. constrictum* var. *curtum* (Grun.) Van Heurck |
| | *G. dichotomum* Kutz. |
| | *G. elegans* Grun. |
| | *G. geminatum* (Lyngb.) Ag. |
| | *G. ghosea* (Ag.) Abdul Majeed |
| | *G. gracile* Ehr. |
| | *G. instablis* Hohn & Hellerm. |
| | *G. intricatum* Kutz. |
| | *G. lanceolatum f. turris* (Hust.) Hust. |
| | *G. micropus* Kutz. |
| | *G. minutum* (Ag.) Ag. |
| | *G. montanum* (Schu.) Grun. |
| | *G. olivaceum* (Horn.) Breb. |
| | *G. parvulum* (Kutz.) Kutz. |
| | *G. sphaerophorum* Ehr. |
| | *G. subclavatum* (Grun.) Grun. |
| | *G. subclavatum* var. *commutatum* (Grun.) May. |
| | *G. subtile* Ehr. |
| | *G. tenuis* Gandhi |
| | *G. truncatum* Ehr. |
| | *G. truncatum* var. *capitatum* (Ehr.) Woodhead & Tweed |
| | *G. truncatum* var. *turgidum* (Ehr.) Patr. |
| | *G. turris* Ehr. |
| | *Gyrosigma acuminatum* (Kutz.) Rabenh. |
| | *G. attenuatum* (Kutz.) Rabenh. |
| | *G. scalproides* (Rabh.) Cl. |
| | *Hannaea arcus* (Ehr.) Patr. |
| | *Hantzschia amphioxys* (Ehr.) Grun. |
| | *H. amphioxys* f. *brevis* Compere |
| | *H. amphioxys* var. *capitata* Mull. |
| | *Mastogloia elliptica* var. *danseii* (Thw.) Cl. |
| | *M. lanceolata* Thwaites ex Smith |
| | *M. smithii* var. *lacustris* Grun. |
| | *Melosira granulata* (Ehr.) Ralfs |
| | *M. italica* (Ehr.) Kutz. |
| | *M. varians* Ag. |
| | *Meridion circulare* (Grev.) Ag. |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *Navicula advena* Schm. |
| | *N. alpina* (Sm.) Grun. |
| | *N. ambigua* Ehr. |
| | *N. americana* Ehr. |
| | *N. anglica* Ralfs |
| | *N. apiculata* Breb. |
| | *N. bacillum* Ehr. |
| | *N. bengalensis* Grun. |
| | *N. bicapitata* Lagers. |
| | *N. biconfusa* VanLand. |
| | *N. blanda* Schm. |
| | *N. brasilensis* Grun. |
| | *N. cari* Ehr. |
| | *N. cancellata* Donk. |
| | *N. cincta* (Ehr.) Ralfs |
| | *N. cincta* var. *cari* (Ehr.) Cl. |
| | *N. confervacea* (Kutz.) Grun. |
| | *N. crucicula* (Sm.) Donk. |
| | *N. cryptocephala* Kutz. |
| | *N. cryptocephala* var. *exilis* (Kutz.) Grun. |
| | *N. cryptocephala* var. *veneta* (Kutz.) Rabenh. |
| | *N. cuspidata* (Kutz.) Kutz. |
| | *N. cuspidata* var. *heribaudii* Pereg. |
| | *N. dicephala* Ehr. |
| | *N. divergens* (Sm.) Grun. |
| | *N. elegantoides* Hust. |
| | *N. elliptica* var. *oblongella* (Nag.) Grun. |
| | *N. elliptica* var. *ovalis* (Hilse) Cl. & Moll. |
| | *N. exigua* Greg. |
| | *N. gastrum* (Ehr.) Kutz. |
| | *N. graciloides* Mayer |
| | *N. grimmei* Krasske |
| | *N. halophilioides* Hust. |
| | *N. iridis* (Ehr.) Cl. |
| | *N. lanceolata* Ehr. |
| | *N. laterostrata* Hust. |
| | *N. menisculus* Schum. |
| | *N. menisculus* var. *upsaliensis* Grun. |
| | *N. minima* Grun. |
| | *N. mutica* Kutz. |
| | *N. mutica* f. *cohnii* (Hilse) Cl. |
| | *N. nivalis* Ehr. |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *N. oblonga* (Kutz.) Kutz. |
| | *N. perrotetii* (Grun.) Grun. |
| | *N. peregrina* (Ehr.) Kutz. |
| | *N. phyllepta* Kutz. |
| | *N. pinnularia* Cl. |
| | *N. placenta* var. *rostrata* Mayer |
| | *N. placentula* (Ehr.) Kutz. |
| | *N. planna* Hust. |
| | *N. pupula* Kutz. |
| | *N. pygmaea* Kutz. |
| | *N. radiosa* Kutz. |
| | *N. radiosa* var. *tenella* (Breb. ex Kutz.) Van Heurck |
| | *N. rhynocephala* Kutz. |
| | *N. salinarum* var. *intermedia* (Grun.) Cl. |
| | *N. schoenfeldii* Hust |
| | *N. seminulum* var. *intermedia* Hust. |
| | *N. sphaerophora* Kutz. |
| | *N. subhamulata* Grun. |
| | *N. subrhynchocephala* Hust. |
| | *N. subtillisma* Cl. |
| | *N. tantula* Hust. |
| | *N. tripunctata* var. *schizonemoides* Van Heurck |
| | *N. trivialis* Lange-Bert. |
| | *N. vanhoeffeniformes* Gandhi |
| | *N. ventralis* Krasske |
| | *N. viridula* (Kutz.) Ehr. |
| | *N. vitabunda* Hust. |
| | *Neidium affine* (Ehr.) Pfitz. |
| | *N. binodis* (Ehr.) Hust. |
| | *N. bisulcatum* var. *baicalense* (Skv. & Mey.) Reimer |
| | *N. dubium* (Ehr.) Cl. |
| | *N. dubium* f. *constrictum* Hust. |
| | *N. iridis* var. *amphigomphus* (Ehr.) Temp. & Per. |
| | *N. iridis* f. *vernale* (Reich. ex Hust.) Freng. |
| | *N. mirabile* Hust. |
| | *N. productum* (Sm.) Cl. |
| | *Nitzschia acicularis* (Kutz.) Sm. |
| | *N. acidoclinata* Lange-Bert. |
| | *N. alpina* Hust. |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *N. amphibia* Grun. |
| | *N. angularis* Sm. |
| | *N. angustata* (Sm.) Grun. |
| | *N. apiculata* (Greg.) Grun. |
| | *N. capitellata* Hust. |
| | *N. commutata* Grun. |
| | *N. denticulata* Skv. |
| | *N. desertorum* Hust. |
| | *N. dissipata* (Kutz.) Rbenh. |
| | *N. diversa* Hust. |
| | *N. fasciculata* (Grun.) Grun. |
| | *N. frustulum* (Kutz.) Grun. |
| | *N. gandersheimiensis* Krasske |
| | *N. hantzschiana* Rabh. |
| | *N. heufleriana* Grun. |
| | *N. hollerupensis* Fog. |
| | *N. hungarica* Grun. |
| | *N. intermedia* Hantz. |
| | *N. lacunarum* Hust. |
| | *N. levidensis* (Sm.) Grun. |
| | *N. linearis* Sm. |
| | *N. navicularis* (Breb.) Grun. |
| | *N. obtusa* Sm. |
| | *N. ovalis* Arn. |
| | *N. palea* (Kutz.) Sm. |
| | *N. palea* var. *debilis* (Kutz.) Grun. |
| | *N. radicula* Hust. |
| | *N. recta* Hantz. ex Rabenh. |
| | *N. romana* Grun. |
| | *N. sigma* (Kutz.) Sm. |
| | *N. sigmoidea* (Nitz.) Sm. |
| | *N. sinuata* var. *delognei* (Grun.) Lange-Bert. |
| | *N. thermalis* (Kutz.) Grun. |
| | *N. tamnaeana* Guer. |
| | *N. tryblionella* Hantz. |
| | *N. vitrea* Norm. |
| | *Pinnularia appendiculata* (Ag.) Schaarschm. |
| | *P. biceps* Greg. |
| | *P. borealis* Ehr. |
| | *P. brebissonii* (Kutz.) Rabenh. |
| | *P. brevicostata* Cl. |
| | *P. cincta* (Ehr.) Ralfs |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *P. divergentissima* (Grun.) Cl. |
| | *P. gibba* (Ehr.) Ehr. |
| | *P. interrupta* Sm. |
| | *P. major* (Kutz.) Rabenh. |
| | *P. microstauron* (Ehr.) Cl. |
| | *P. nobilis* (Ehr.) Ehr. |
| | *P. subcapitata* Greg. |
| | *P. sudanensis* Zan. |
| | *P. sudetica* (Hilse) Hilse |
| | *P. viridis* (Nitz.) Ehr. |
| | *P. viridis* var. *commutata* (Grun.) Cl. |
| | *Pleurosigma balticum* (Ehr.) Sm. |
| | *P. intermedium* Sm. |
| | *P. macrum* Sm. |
| | *P. marinum* Donk. |
| | *P. obscurum* Sm. |
| | *P. parkeri* Harrison |
| | *P. scalproides* Rabenh. |
| | *P. smithii* Grun. |
| | *P. spencerii* Grun. |
| | *P. strigilis* Sm. |
| | *Rhizosolenia imbricata* Bright. |
| | *Rhoicosphenia curvata* (Kutz.) Grun. |
| | *Rhopalodia acuminata* Kram. |
| | *R. gibba* (Ehr.) Mull. |
| | *R. gibba* var. *ventricosa* (Kutz.) Mayer |
| | *R. operculata* (Ag.) Hak. |
| | *Shizonema smithii* Ag. |
| | *Stauroneis acuta* Sm. |
| | *S. anceps* Ehr. |
| | *S. anceps* f. *gracilis* (Ehr.) Cl. |
| | *S. lauenburgiana* Hust. |
| | *S. muriella* f. *capitata* Lund |
| | *S. palustris* Hust. |
| | *S. phoenicenteron* (Nitz.) Ehr. |
| | *S. thermicola* (Peter.) Lund |
| | *Stenopterobia intermedia* (Lewis) Heurck ex Hanna |
| | *Surirella angusta* Kutz. |
| | *S. biseriata* Breb. |
| | *S. debesii* Hust. |
| | *S. linearis* Sm. |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *S. ovalis* Breb. |
| | *S. ovata* Kutz. |
| | *S. ovata* var. *pianata* (Sm.) Heurck |
| | *S. robusta* Ehr. |
| | *S. robusta* var. *splendida* (Ehr.) Heurck |
| | *S. tenera* var. *nervosa* Schm. |
| | *Synedra acus* Kutz. |
| | *S. affinis* Kutz. |
| | *S. famelica* Kutz. |
| | *S. pulchella* (Ralfs ex Kutz.) Kutz. |
| | *S. ulna* (Nitz.) Ehr. |
| | *S. vaucheriae* (Kutz.) Kutz. |
| | *Tabellaria fenestrata* (Lyngb.) Kutz. |
| | *T. flocculosa* (Roth) Kutz. |
| | *Thalassiosira fluviatilis* Hust. |
| **4. Dinophyceae** | *Ceratium hirundinella* (Mull.) Duj. |
| | *Glenodinium quadridens* (Stein) Schil. |
| | *Gymnodinium aeruginosum* Stein |
| | *Peridinium inconspicuum* Lemm. |
| **5. Euglenophyceae** | *Cryptoglena pigra* Ehr. |
| | *Euglena acus* var. *longissima* Defl. |
| | *E. deses* Ehr. |
| | *E. ehrenbergii* Kleb. |
| | *E. gracilis* Kleb. |
| | *E. limnophila* Lemm. |
| | *E. oxyuris* Schmarda |
| | *E. pedunculata* Goj. |
| | *E. polymorpha* Dang. |
| | *E. proxima* Dang. |
| | *E. tripteris* (Duj.) Klebs |
| | *E. vagans* Defl. |
| | *E. viridis* (Mull.) Ehr. |
| | *Eutreptia viridis* Perty |
| | *Lepocinclis acicularis* France |
| | *L. ovum* (Ehr.) Lemm. |
| | *L. texta* (Duj.) Lemm. |
| | *Petalomomas acuminata* Holl. |
| | *Phacus acuminatus* Stokes |
| | *P. anomalus* Fritsch & Rich |
| | *P. caudata* Hubner |
| | *P. curvicauda* Svirenko |
| | *P. ephipion* Pochm. |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *P. helikoides* Pochm. |
| | *P. indicus* Skv. |
| | *P. lismorensis* Playf. |
| | *P. longicauda* (Ehr.) Duj. |
| | *P. longicauda* var. *rotunda* (Pochm.) Hub. & Pest. |
| | *P. onyx* Pochm. |
| | *P. orbicularis* Hub. |
| | *P. pleuronectes* (Mull.) Nitz. & Duj. |
| | *P. pseudoswirenkoi* Prescott |
| | *P. pyrum* (Ehr.) Arch. |
| | *P. quinquemarginatus* Jahn & Shaw. |
| | *P. sesquitortus* Pochm. |
| | *P. suecica* Lemm. |
| | *Scytomonas pusilla* Stein |
| | *Strombomonas maxima* (Skv.) Defl. |
| | *Trachelomonas abrupta* Svirenko |
| | *T. globularis* (Aver.) Lemm. |
| | *T. hispida* (Perty) Stein. |
| | *T. intermedia* Dang. |
| | *T. planctonica* Svirenko |
| | *T. volvocina* (Ehr.) Ehr. |
| | *T. volvocinopsis* Svir. |
| **6. Chrysophyceae** | *Dinobryon borgei* Lemm. |
| | *D. divergens* Imhof |
| | *D. sertularia* Ehr. |
| | *D. stipitatum* Stein |
| | *Hydrurus foetidus* (Vill.) Trevis. |
| **7. Xanthophyceae** | *Pseudostaurastrum enorme* (Ralfs) Chodat |
| | *Tribonema bombycium* Derb. |
| | *Vaucheria globulifera* West & G.S.West |
| | *V. sessilis* f. *clavata* (Vauch.) Heer. |
| | *V. terrestris* (Vauch.) Lyng. |
| **8. Desmidiaceae** | *Actinotaenium cruciferum* (De Bary) Teil. |
| | *A. cucurbitinum* (Biss.) Teil. |
| | *A. curtum* (Breb. ex Ralfs) Teil. ex Ruzicka & Pouzar |
| | *A. globosum* (Bulnh.) Forst. ex Compere |
| | *A. mooreanum* (Arch.) Teil. |
| | *Bourrellyodesmus sumatranus* Bic. & Compere |
| | *Closterium acerosum* Ehr. ex Ralfs |
| | *C. acerosum* var. *elongatum* Breb. |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *C. cornu* Ehr. ex Ralfs |
| | *C. ehrenbergii* Meneg. ex Ralfs |
| | *C. incurvum* Breb. |
| | *C. leibleinii* Kutz. ex Ralfs |
| | *C. littorale* var. *crassum* W. & G.S.West |
| | *C. moniliferum* (Ehr.) Ralfs |
| | *C. parvulum* Nag. |
| | *C. pseudolunula* Borge |
| | *Cosmarium angulosum* Breb. |
| | *C. auriculatum* Reinsch |
| | *C. awardhense* var. *majus* Kant & Gupta |
| | *C. bicardia* Reinsch |
| | *C. bioculatum* Breb. ex Ralfs |
| | *C. boeckii* Wille |
| | *C. botrytis* Meneg. ex Ralfs |
| | *C. botrytis* var. *subtumidum* Wittr. |
| | *C. candianum* Delp. |
| | *C. circulare* Reinsch |
| | *C. connatum* Breb. ex Ralfs |
| | *C. contractum* var. *ellipsoideum* (Elfv.) West & G.S.West |
| | *C. cucurbita* Breb. ex Ralfs |
| | *C. fictopraemorsum* Forst. |
| | *C. formosulum* Hoff |
| | *C. granatum* Breb. ex Ralfs |
| | *C. granatum* var. *concavum* Lagerh. |
| | *C. hornavanense* Gutw. |
| | *C. hornavanense* var. *dubovianum* (Lutkem.) Ruz. |
| | *C. impressulum* Elfv. |
| | *C. infirmum* Gronbl. |
| | *C. javanicum* Nordst. |
| | *C. laeve* Rabenh. |
| | *C. lundellii* var. *ellipticum* West & G.S.West |
| | *C. minimum* West & G.S.West |
| | *C. moniliforme* Ralfs |
| | *C. monomazum* Lund. |
| | *C. nitidulum* De Not. |
| | *C. obstusatum* (Schmidle) Schmidle |
| | *C. ocellatum* Eich. & Gutwin. |
| | *C. pachydermum* Lund. |
| | *C. pardalis* Cohn |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *C. phaseolus* var. *irregulare* Kant & Gupta |
| | *C. porteanum* Arch. |
| | *C. pseudobroomei* Wolle |
| | *C. pseudogranatum* Nordst. |
| | *C. pseudopyramidatum* Lund. |
| | *C. pseudoquadratulum* Prese. & Scott |
| | *C. punctulatum* var. *pindanum* Skuja |
| | *C. pyramidatum* Breb. ex Ralfs |
| | *C. quadrifarium* var. *oblongum* Kant & Gupta |
| | *C. ralfsii* Breb. ex Ralfs |
| | *C. renellei* Willi |
| | *C. reniforme* (Ralfs) Arch. |
| | *C. repandum* var. *pygmaeum* (Gutw.) Krieg. & Gerl. |
| | *C. speciosissimum* f. *minus* Boldt |
| | *C. subalatum* var. *noncrenatum* Kant & Gupta |
| | *C. subcostatum* Nordst. |
| | *C. subcostatum* f. *minus* W. & G. S. West |
| | *C. subcrenatum* var. *guptae* Kant & Gupta |
| | *C. subcucumis* Schmidle |
| | *C. subimpressulum* Borge |
| | *C. sulcatum* Nordst. |
| | *C. subprotumidum* Nordst. |
| | *C. subtumidum* Nordst. |
| | *C. tetragonum* (Nag.) Arch. |
| | *C. turpinii* Breb. |
| | *C. undulatum* Corda ex Ralfs |
| | *C. vexatum* (Schmidle) Migula |
| | *Cosmocladium pusilum* Hilse |
| | *Cylindrocystis crassa* var. *elliptica* West & G.S.West |
| | *Desmidium aptogonum* Breb. ex Kutz. |
| | *Euastrum bidentatum* var. *oculatum* (Istv.) Krieger |
| | *E. glaziovii* Borges. |
| | *E. insulare* (Wittr.) Roy |
| | *E. spinulosum* Delp. |
| | *Gonatozygon brebissonii* De Bary |
| | *G. monotaenium* De Bary |
| | *G. pilosum* Wolle |
| | *Hyalotheca dissiliens* Breb. ex Ralfs |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| | *Mesotaenium macrococcum* (Kutz.ex Kutz.) Roy & Biss. |
| | *Micrasterias arcuata* var. gracilis West & G.S.West |
| | *M. crux-melitensis* Ralfs |
| | *M. pinnatifida* Ralfs |
| | *M. radiata* Hassl. ex West & G.S.West |
| | *Pleurotaenium clavatum* (Kutz.) De Bary |
| | *Sirocladium kumaoense* Randhawa |
| | *Sirogonium indicum* Singh |
| | *S. reticulatum* Randhawa |
| | *Sphaerozosma filiforme* Ralfs |
| | *S. laeva* (Nordst.) Thom. |
| | *Spondylosium moniliforme* Lund. |
| | *S. nitens* var. *triangulare* Turn. |
| | *Staurastrum acanthocephalum* Skuja |
| | *S. bibrachiatum* Wolle |
| | *S. cyclacanthum* West & G.S.West |
| | *S. furcatum* Breb. |
| | *S. furcigerum* (Breb.) Arch. |
| | *S. furcigerum* var. *armigerum* (Breb.) Nordst. |
| | *S. hexacerum* Wittr. |
| | *S. leptocladum* var. *cornutum* Wille |
| | *S. lunatum* Ralfs |
| | *S. muticum* Breb. ex Ralfs |
| | *S. orbiculare* f. *minus* West & G.S.West |
| | *S. oxyacantha* Arch. |
| | *S. pinnatum* Turn. |
| | *S. quadrangulare* Breb. |
| | *S. setigerum* Cl. |
| | *S. sinense* Lutkern. |
| | *S. tetracerum* Ralfs ex Ralfs |
| | *S. zonatum* Borges. |
| | *Staurodemus convergens* (Ehr. ex Ralfs) Lillier. |
| | *S. cuspidatus* (Breb.) Teil. |
| | *S. dejectus* (Breb.) Teil. |
| | *S. dickiei* Hinode |
| | *S. leptodermus* var. *ikapoae* (Schmidle) Thom. |
| | *Teilingia excavata* (Ralfs ex Ralfs) Bourr. |
| | *T. granulata* (Roy & Biss.) Bourr. |
| | *Xanthidium antilipoeum* var. *leve* Schmidle |

(continued)

**Table 13.1** (continued)

| Name of class | Name of species/infraspecific taxa |
|---|---|
| **9. Charophyceae** | *Chara vulgaris* var. *vulgaris* (L.) Wood |
| | *C. vulgaris* var. *gymnophylla* (Br.) Nym. |
| | *Lychnothamnus barbatus* (Meyen) Leon. |
| **10. Rhodophyceae** | *Compsopogon caeruleus* (Balbis ex Ag.) Mont. |
| **11. Cryptophyceae** | *Cryptomonas erosa* Ehr. |

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# Chapter 14
# Fungal Diversity in the Kashmir Himalaya

**Abdul Hamid Wani, Shauket Ahmed Pala, Rouf H. Boda, and M. Y. Bhat**

**Abstract** The present chapter has documented a total of 548 species of fungi, including 268 species of micro- and 280 species of macro-fungi, from Jammu and Kashmir State, mainly based on review of published literature and studies conducted by the authors during the last decade. *Basidiomycetes* are the dominant group, represented by 182 species, followed by *Ascomycetes* with 25 species. Among the *Basidiomycetes*, dominant families are *Russulaceae* (29 species), *Cortinariaceae* and *Boletaceae* (17 species each), *Coprinaceae* (12 species) and *Tricholomataceae* (11 species), whereas the largest genus is *Russula* (21 species), followed by *Amanita* (11 species). In *Ascomycetes*, *Morchellaceae* (seven species), *Helvellaceae* (six species) and *Pyronemataceae* (five species) are the major families, whereas *Morchella* and *Helvella* are the larger genera (represented by five species each). Nonetheless, overall fungal diversity in the State is still insufficiently known, and there is immediate need to undertake studies required for arriving at a complete authentic inventory of this important group of biota.

**Keywords** Fungal diversity · Kashmir Himalaya · Micro-fungi · Macro-fungi (mushrooms)

## 14.1 Introduction

The fungi form an indispensable biotic component of the biosphere. Most of the recorded fungi (80%) are mycorrhizal or saprophytic in nature. The ability of fungi to form symbiotic relationship with most of the higher plants (mycorrhizal association) for their normal and healthy growth, and to recycle the dead and decaying

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_14

organic matter, is crucial for maintenance of good health of our forest and agroecosystems, thereby enhancing their vigour and farm production.

Fungal kingdom has been estimated to be six times larger than the plant kingdom. The number of existing fungi worldwide has been estimated to be 1.5 million species (Hawksworth 2001). One-third of the global fungal diversity is believed to exist in India, of which only 50% has been characterised till now. More than 15,200 species of fungi have been reported from the country (Singh & Dash 2018). The Jammu and Kashmir (J&K) State has been the cradle for fungi on account of its diverse biogeography, temperate and subtropical climate endorsing copious moist habitats and ample precipitation. The overall species richness of fungi in the State, however, is still not known fully; there is a wide gap in figuring the precise quantitative and qualitative taxonomic diversity due to scanty published literature in this domain of knowledge, besides that all its areas have not been extensively surveyed for documentation of fungal species.

As in other regions of the world, fungi are important in everyday human life in this Himalayan State as well. Macro-fungi, such as species of *Agaricus* (button mushroom) and *Pleurotus* (Dhingri), are highly nutritious and cultivated on commercial scale, thereby contributing to food requirements of rural folk and improving their economy. Species of *Ramaria* (locally called Punze ungji), *Peziza* (Kanpappari), *Heirocium* (Yaade gab), *Coprinus atramentarius* (Sakerbub) and *Auricularia auriculae-judae* (Rudh papad) are collected from forests and prepared into tasty dishes. *Morchella* (Guchi/Kanguch), a highly prized mushroom that costs about Rs. 15,000/kg (dry weight basis), is collected by rural people from coniferous forests and apple orchards and sold for export to other parts of country. Kashmir valley has been a main centre for supply of these morels from ancient times, for both internal consumption and export markets. Many fungi are used on industrial scale for the production of antibiotics, organic acids and vitamins. Penicillin, perhaps the most famous of all antibiotic drugs, is derived from species of a common fungus called *Penicillium*. The members of *Polyporaceae* offer a good opportunity for production of anticancer drugs. Yeasts are used as agents of fermentation in the production of bread, cheese, alcoholic beverage and numerous other food preparations.

From time to time, a number of studies have been conducted on fungi of this region. These include Berkeley (1856), Cooke (1870), Berkeley (1876), Murill (1924), Stewart (1924), Mundkur (1944), Ahmad (1942), Khan (1962), Ghosh and Pathak (1962), Wehmeyer (1963), Kaul and Kachroo (1974), Gupta and Lele (1976), Watling (1978), Kaul (1981), Watling and Abrahim (1986), Abrahim and Kaul (1989), Abrahim (1991), Watling and Abrahim (1992), Dar et al. (2002), Beigh et al. (2008, 2011), Boda (2009), Dar et al. (2009a, b, c, 2010a, b, c), Wani et al. (2010a, b, c) and Pala et al. (2011a, b, c, 2012, 2013). Dar et al. (2002), in their 'Biodiversity of the Kashmir Himalaya', reported 423 species in 185 genera of fungi from various areas in the Kashmir region. These include 01 species of Myxomycetes +23 species in 09 genera of lower fungi (*Phycomycetes*) + 259 species in 105 genera of higher fungi (*Basidiomycetes* 175 species in 61 genera and *Ascomycetes* 84 species in 44 genera), mostly containing their phytopathogenic forms, including the notorious


**Plate 14.1** Thirteen species of mushrooms reported first time from Kashmir

rust and smut-causing parasites. *Deuteromycetes* are also well represented by 140 species in 70 genera, with majority of species occurring as plant parasites.

In the present chapter, an attempt has been made to compile the data based on scattered records available in research works carried out on the fungal flora of the J&K State (Plates 14.1 and 14.2).

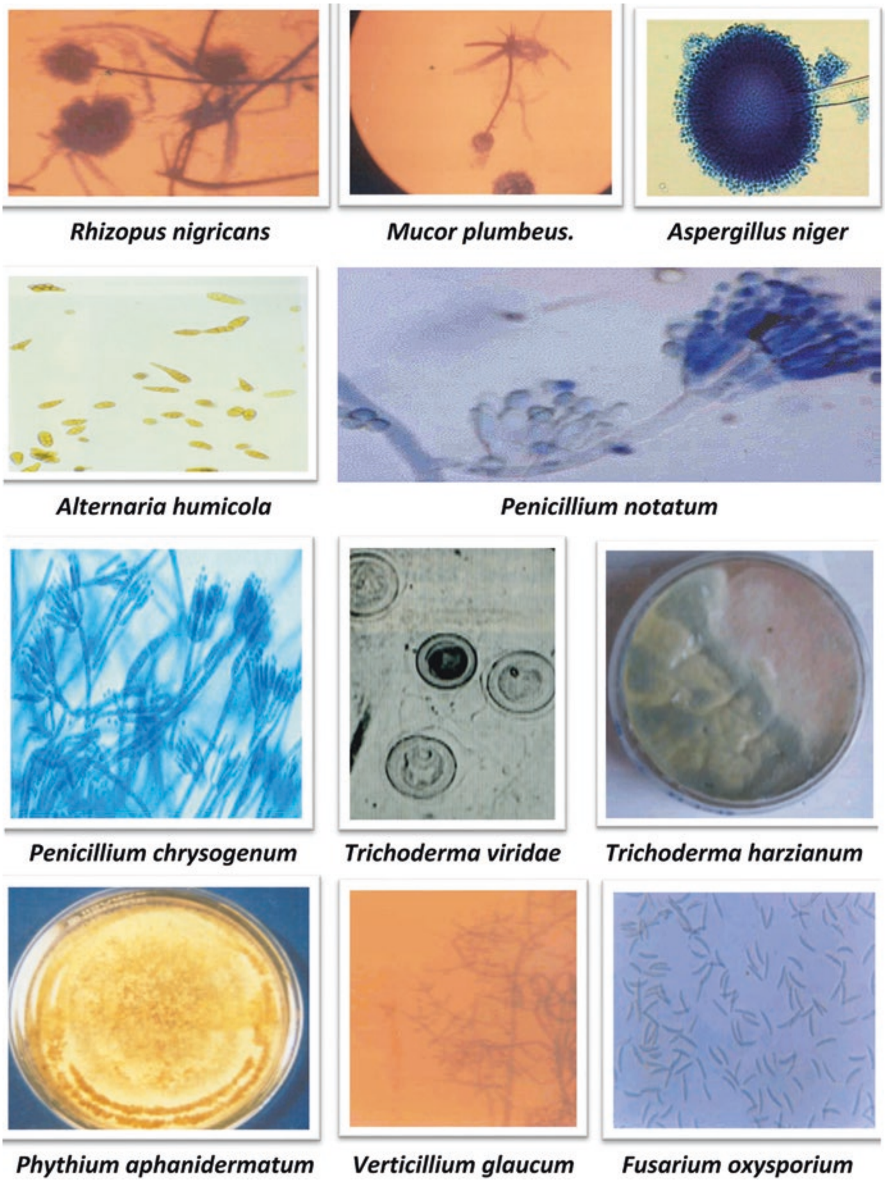


**Plate 14.2** Microfungi from rhizosphere of tomato and brinjal

## 14.2 Materials and Methods

The account of fungal flora presented in this chapter is based on the perusal of literature available on floristic aspects of fungi in J&K State. The fungal taxa dealt with here are arranged under micro- and macro-fungi, although this separation is artificial because micro-fungi and sometimes even macro-fungi are also considered to be microorganisms according to some definitions (Zavarzin 1993, 1995).

Micro-fungi are eukaryotic organisms with fruiting body not readily visible to the naked eye. They are an artificial paraphyletic group, distinguished from macro-fungi only by the presence of a large, multicellular fruiting body. Micro-fungi can also be defined as fungi with either microscopic spore-forming structures or minute fructifications less than a few millimetres in size (not more than 1 cm high) (Hawksworth et al. 1991). These include moulds, mildews, rusts, smuts and yeasts.

Macro-fungi are those fungi that form a readily visible macroscopic (˃1 mm) spore-producing fruiting body. All the mushroom fungi are placed in the category of macro-fungi. Examples of macro-fungi include agarics (mushrooms and toadstools), earthstars, puffballs, stinkhorns, bracket and shelf fungi, coral fungi, disc fungi, cup fungi and morels. Most of the mushrooms belong to class *Ascomycetes* and *Basidiomycetes* of the fungal kingdom (Plates 14.3 and 14.4).

## 14.3 Results and Discussion

Based on the review of all the relevant scientific literature, a total of 548 species of fungi are recorded from J&K State. Among these, 280 species belong to macro-fungi, whereas 268 species represent micro-fungi. *Basidiomycetes* are the dominant group, represented by 182 species, followed by *Ascomycetes* with 25 species.

### *14.3.1 Micro-Fungi*

Micro-fungi are ubiquitous in all terrestrial, freshwater and marine environments. They grow in plants, soil, water, insects, cattle rumens, hair and skin. Most of the fungal body consists of microscopic threads, called hyphae, extending through the substrate in which it grows; some species also exist as soil saprotrophs. Many micro-fungal species occur in lichens, forming symbiotic relationship with algae. Many micro-fungi, like *Penicillium* and *Aspergillus*, discovered first as moulds, cause spoilage of fruit and bread. Many are useful to humans, like *Penicillium* species as source of antibiotic penicillin. Many micro-fungi are harmful, causing diseases in plants, animals and humans.

Most of the fungi are micro-fungi, constituting the dominant group with universal distribution. In the J&K State, little work has been carried out on micro-fungal

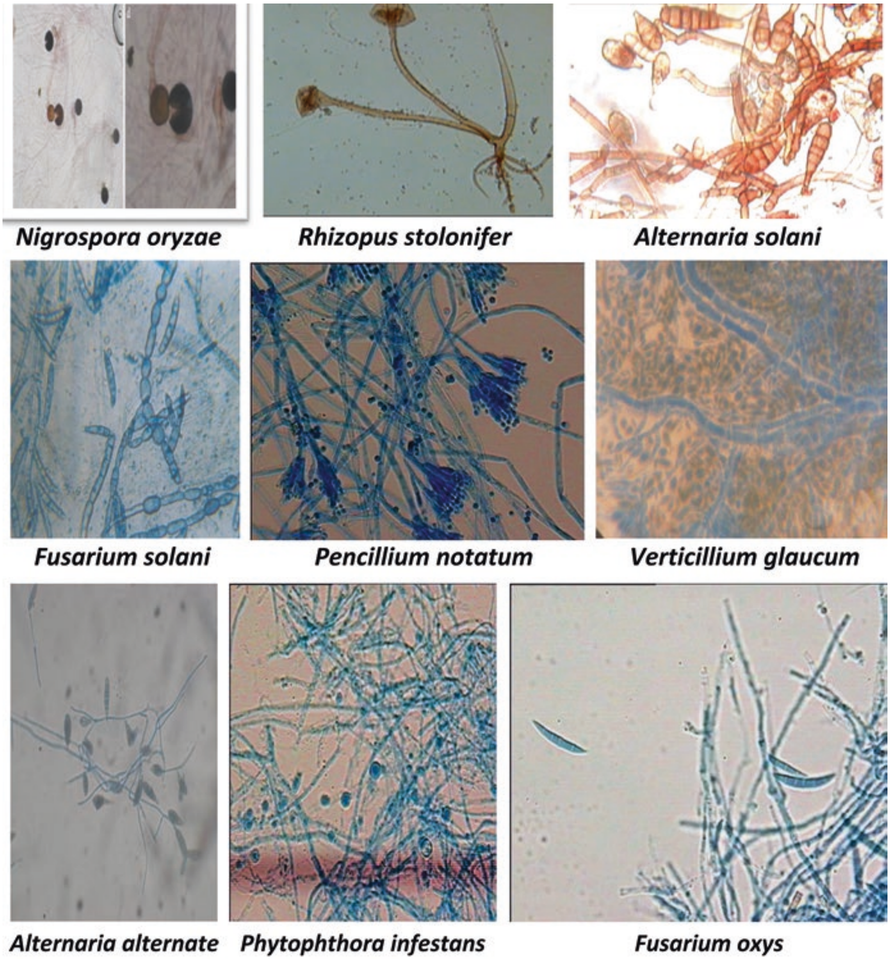


**Plate 14.3** Microfungi from tomato and brinjal in Kashmir (Taskeen-Un Nisa 2009; Wani and Taskeen-Un-Nisa 2011)

diversity, and only a few reports are available. Qasba and Shah (1991), for the first time, compiled the scattered information on fungal flora of J&K, especially micro-fungi. They have reported 17 *Phycomycetes* fungi, 12 species belonging to Peronosporales and 5 species to *Chytridiales*; 54 species *Ascomycetes*, 28 species of Erysiphales +11 species of *Sphaeriales* + 9 species of *Pleosporales* + 1 species of each Taphrinales and *Eurotiales*; 93 *Deuteromycetes*, 55 species of *Sphaeropsidales* + 33 species of *Moniliales* + 5 species of *Melanoconiales*; 88 species of *Uredinales*; and 22 species of *Ustilaginales*. Some other works that attempted to analyse the micro-fungal diversity of J&K from soil, water and plants are as follows.

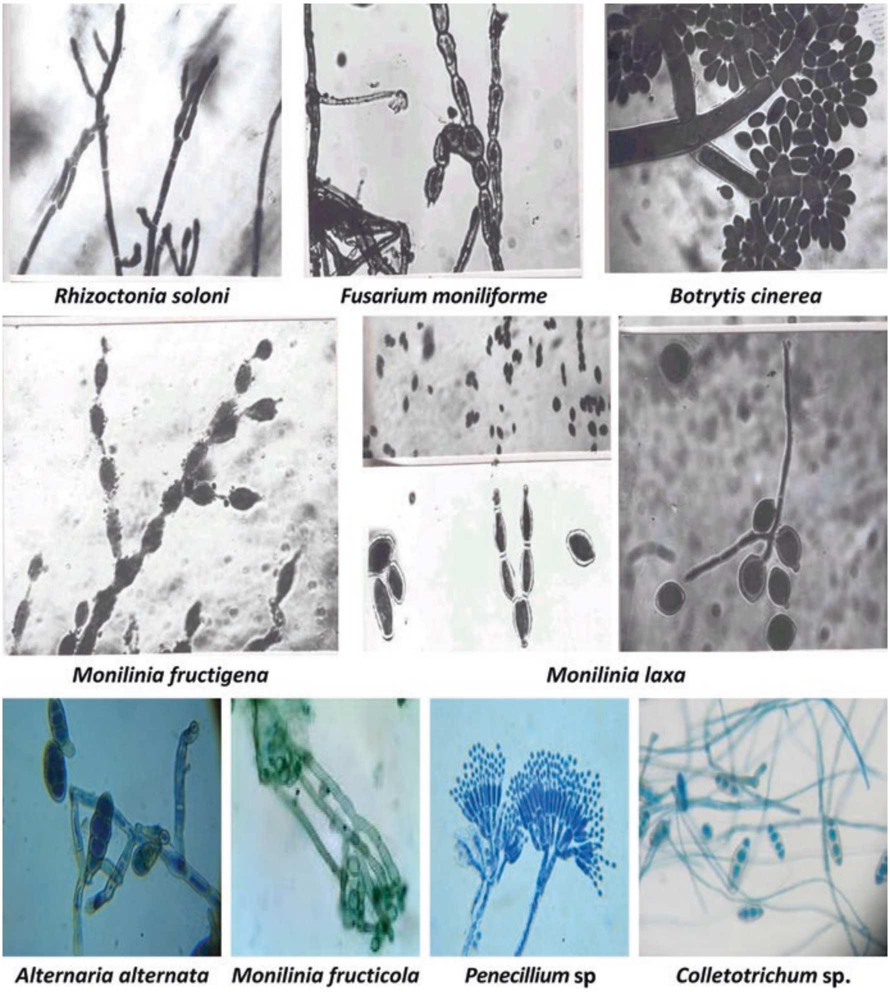


**Plate 14.4** Microfungi on fruits in Kashmir (Wani and Wani 2011)

Bandh et al. (2012) isolated the following 23 species of micro-fungi from Dal Lake:

| | |
|---|---|
| *Penicillium caseicolum* Bainier | *Aspergillus fumigatus* Gorman, Fuller and Dyer |
| *P. commune* Thom | *A. japonicus* Saito |
| *P. chrysogenum* Thom | *A. niger* van Tieghem |
| *P. funiculosum* Thom | *A. terreus* Thom |
| *P. lilacinum* Thom | *A. versicolor* (Vuill.) Tirab. |
| *P. olivicolor* Pitt | *A. wentii* Wehmer |
| *P. dimorphosporum* H.J. swart | *Aspergillus* sp. |

*Penicillium* sp.
*Penicillium* sp. II
*Penicillium* sp. III
*Penicillium* sp. IV
*Aspergillus flavus* link
*Fusarium* sp.
*Rhizopus* sp.
*Acremonium* sp.
*Mucor* sp.

Lone et al. (2011) isolated 26 isolates of fungi from the rhizosphere of walnut (*Juglans regia*) at different sites in Kashmir, as given below:

*Aspergillus niger* van Tieghem
*A. fumigates* Gorman, fuller and dyer
*A. terreus* Thom
*A. terricola* É.J. Marchal
*A. nidulans* G winter
*A. versicolor* (Vuill.) Tirab.
*Capnobotryella renispora* Sugiy.
*Cladophialophora caronii* (Trejos) McGinnis
*Cladosporium sphaerospermum* Penz.
*C. cladosporioides* (Fresen.) G.A. de Vries
*Curvularia lunata* (Wakker) Boedijn
*Curvularia* sp.
*Exophila* sp.
*Fusarium oxysporum* Schltdl.
*F. solani* (Mart.) Sacc.
*Hyaline* sp.
*Mucor himalayansis* Wehm.
*Oospora virabilis* (Lindner) Lindau
*Penicillium aurantiogriseum* Dierckx
*P. camembertii* Thom
*P. notatum* Thom
*Phoma* sp.
*Trichophyton terrestre* Durie and D. Frey
*Trichoderma harzianum* Rifai
*T. koningii* Oudem.
*T. odoratum* Pers.

Many micro-fungi are pathogenic and parasitic in nature, infecting the crops as well as human beings. Apple scab, the most destructive disease in terms of economic loss, is caused by *Venturia inaequalis* (Cooke) G. Winter. It is the most common disease-causing fungi in apple plants and reducing their market value. Rusts and smuts, also common in Kashmir, are caused by species of *Puccinia* and *Ustilago*, respectively. Powdery mildew and downy mildew are also prevalent on some economically important crops. Several micro-fungi are known to cause diseases of vegetables, fruits, cereals, pulses and ornamental and other crops of economic value in Kashmir. Many workers have isolated and identified pathogenic micro-fungi responsible for several plant diseases, such as apple scab, vegetable- and fruit-rot diseases, leaf-spot diseases, powdery mildews, etc. Pushkarnath (1935) was the first to report apple scab from Kashmir. Later, Gupta and Lele (1976, 1980) reported several strains of this fungus from different cultivars and varieties of apple from here. Among various diseases, powdery mildews caused by *Erysiphe cichoracearum* DC. and *Sphaerotheca fuliginea* (Schltdl.) Pollacci are widespread in members of Cucurbitaceae and Asteraceae in Kashmir (Khan and Khan 1970; Khan et al. 1974; Koul 1981; Wani and Ashraf 2003; Mir et al. 2008). Likewise other fungi, such as species of *Erysiphe*, *Sphaerotheca*, *Leveillula*, *Uncinula*, *Podosphaera* and *Phyllactinia*, were found responsible for causing powdery mildew diseases in members of Papilionaceae, Rosaceae and Salicaceae (Wani et al. 2010a, b, c, Mir et al. 2011, 2012).

Micro-fungi have also been found associated with fungal rot of fruits and vegetables. Several studies have been carried out to isolate and identify fungi responsible for postharvest rot of fruits and vegetables in the Kashmir. Many species, such as *Fusarium moniliforme* J. Sheld., *Rhizoctonia soloni* G. Kuhn, *Botrytis cinerea* Pers., *Monilinia fructigena* Honey, *M. laxa* (Aderh. and Ruhland) Honey, *Alternaria alternata* (Fr.) Keissl., *Mucor pyriformis* Scop., *Penicillium expansum* Link, *Aspergillus flavus* Link, *Rhizopus stolonifer* Vuillemin and species of *Colletotrichum* and *Trichoderma*, are known to cause fungal rot of fruits in the Kashmir (Wani and Wani 2011; Wani et al. 2010a, b, c; Parveen et al. 2012, 2013). Similarly, several micro-fungi known to cause fungal rot of vegetables in the Kashmir are *Phytophthora infestans* (Mont.) de Bary, *Fusarium oxysporum* Schltdl., *F. solani* (Mart.) Sacc., *Aspergillus niger* van Tieghem, *Alternaria alternata* (Fr.) Keissl., *A. solani* Sorauer, *Rhizopus stolonifer* Vuillemin, *Mucor plumbeus* Bonord. and *Nigrospora oryzae* (Berk. and Broome) Petch (Taskeen-un-nisa 2009; Taskeen-un-Nisa et al. 2008, 2011a, b; Wani and Taskeen-un-Nisa 2011). Parveen (2014) and Parveen et al. (2014) reported eight species of fungi responsible for causing decay in pears and peaches in the Kashmir valley; these are *Aspergillus niger* van Tieghem, *Penicillium glaucum* Link, *P. expansum* Link, *Alternaria alternata* (Fr.) Keissl., *Drechslera* sp., *Rhizopus stolonifer* Vuillemin, *Mucor piriformis* Scop. and *Aspergillus flavus* Link. Nadia et al. (2016) reported six species of foliicolous fungi which infect different varieties of peaches in the Kashmir valley, viz. *Alternaria alternate* (Fr.) Keissl., *Wilsonomyces carpophilus* (Lev.) Butler, *Entomosporium maculatum* (Lev.), *Monilinia fructicola* (G. Winter) Honey, *Cladosporium carpophilum* Thum. and *Trichothecium roseum* (Pers.) Link. Most of these foliicolous fungi were reported first time from the Kashmir.

### *14.3.2 Macro-Fungi (Mushrooms)*

As per estimated 1.5 million species of fungi existing on the Earth, 1,40,000 species may belong to mushrooms (Hawksworth 2001), but only 14,000 (10%) species are known till now. Of these, about 50% species are considered to possess varying degree of edibility, with more than 3000 species from 31 genera being regarded as the prime edible mushrooms, while about 2000 species are medicinal mushrooms having a variety of health attributes. Although the number of poisonous mushrooms reported is relatively small (approximately 1%), there is an estimate that approximately 10% may have poisonous attributes, with some 30 species being considered to be lethal.

The Kashmir Himalaya forms a prime place for the variety and galaxy of macro-fungi, as it offers congenial ambiances for the luxurious growth of such fungi. However, inventory of macro-fungal flora of this region is far from complete as yet, and many areas are still unexplored. Many workers have reported mushrooms from the Kashmir from time to time. Cooke (1870) was probably the first to describe some edible mushrooms from this region. Berkeley (1876) recorded three taxa: *Russula alutacea* (Pers.) Fr., *Lentinus lecomitis* Fr. and *Hydnum aitchisonii* Berk. from Kashmir. Ahmad (1942) gave an account of *Calvatia gigantea* (Batsch) Lloyd and *Bovista plumbea* Pers. from this region. Khan (1962) described some mushrooms from the Kashmir forests. Ghosh and Pathak (1962) described a number of moral species, including *Helvella crispa* Bull. from coniferous forests of Kashmir. Batra and Batra (1963) recorded *Morchella angusticeps* Peck and *M. esculenta* (L.) Pers. from the valley. Sohi et al. (1965) reported *Helvella lacunosa* Afzel. from the region. Watling (1978) reported the occurrence of some 120 species of large fungi from Kashmir. Kaul (1981) described four species of morels, viz. *Morchella esculenta* (L.) Pers., *M. deliciosa* Fr., *M. hybrida* (Sowerby) Pers. and *M. angusticeps* Peck from Kashmir. He also collected from here a number of mushrooms, viz. *Helvella crispa* Bull., *Cantharellus cibarius* Fr., *Agrocybe cylindracea* (DC.) Maire, *Flammulina velutipes* (Curtis) Singer, *Lactarius deterrimus* Groger, *L. scrobiculatus* (Scop.) Fr., *Russula brevipes* Peck, *Bovista plumbea* Pers., *Lycoperdon pyriforme* Schaeff., *Rhizopogon rubescens* Tul. and C. Tul., *Calvatia elata* Massee, *C. gigantean* (Batsch) Lloyd, *Pholiota nameko* S. Ito and S. Imai and *Agaricus campestris* L. Abrahim et al. (1980) dealt with the fleshy fungi of Gulmarg forest in Kashmir. Atri and Saini (1986) reported five additional taxa of *Russulaceae* from various forests of Kashmir, viz. *Lactarius paradoxus* Beardslee and Burl., *L. pubescens* Hesler and A.H. Sm., *L. scrobiculatus* var. *canadensis* (Scop.) Fr., *L. subisabellinus* var. *murrillianus* Hesler and A.H. Sm. and *Russula rosea* Pers.; the first four of these were new records for India. Abrahim and Kaul (1989) described six species of agarics, viz. *Lentinus lepideus* (Fr.) Fr., *L. strigosus* Fr., *Pleurotus platypus* Sacc., *Clitocbe infundibuliform* Bull., *Conchomyces bursaeformis* (Berk.) E. Horak and *Leucopaxillus albissimus* (Peck) Singer as occurring in Kashmir valley. Watling and Abrahim (1992), while documenting the ectomycorrhizal diversity in Kashmir forests, reported occurrence of about 175 species of mushrooms in Kashmir and surmised 53 of them to be mycorrhizal in nature.

Kaul (1997) has added many other mushroom species to the list that include *Morchella crassipes* (Vent.) Pers., *M. conica* Pers., *Pleurotus platypus* Sacc., *Geopora arenicola* (Lev.) Kers, *Lepiota rhacoides* (Vitt.) Quel., *Lycoperdon pyriforme* Schaeff., *Boletus edulis* Bull., *Clavariadelphus truncates* (Quel.) Donk, *Stropharia semiglobata* (Batsch.) Quel., *Agrocybe cylindrica* (DC.) Maire, *Agaricus controversus* (Pers.) Pers., *Phallus hadrianii* Vent., *Schizophyllum commune* Fr., *Flammulina velutipes* (Curtis) Singer and *Cantharellus cibarius* Fr. Beigh et al. (2008) and Dar et al. (2009a, b, c, 2010a) reported *Clavariadelphus* sp., *Ligula* sp., *Vascellum pratense* (Pers.) Kreisel, *Bovista nigrescens* Pers., *Helvella lacunosa* Afzel., *Aleuria aurantia* (Pers.) Fuckel, *Mitrophora semilibera* DC., *Russula aurea* Pers., *R. atropurpurea* (Krombh.) Britz., *R. delica* Fr., *R. paludosa* Britzelm., *R. lutea* (Huds.) Gray, *Inocybe rimosa* (Bull.) P. Kumm., *Stropharia semiglobata* (Batsch.) Quel., *Hypholoma capnoides* (Fr.) P. Kumm., *Crucibulum leave* (Huds.) Kambly, *Amanita porphyria* Alb. and Schwein., *Sepultaria summeriana* Bull., *Paxina barlae* (Boud.) Seaver, *Peziza exogelatinosa* K. Hansen and Sanda, *Tarzetta catinus* (Holmsk.) Korf and Rogers, *Boletus rhodoxanthus* (Krombh.) Zhao and Yang and *Suillus variegatus* (Sw.) Kuntze from various coniferous forests of Kashmir; these include some hitherto unknown species also. Wani et al. (2010a, b, c) reported nine species of morels and pseudomorels from southern Kashmir Himalaya: *Morchella esculenta* (L.) Pers., *M. conica* Pers., *M. angusticeps* Peck, *M. vulgaris* (Pers.) Bound, *M. hybrida* (Sowerby) Pers., *Verpa bohemica* (Krombh.) J. Schrot., *Helvella crispa* Bull., *H. elastica* Bull. and *Gyromitra esculenta* (Pers.) Fr. Pala et al. (2011a, b, c) reported 11 additional species of mushroom fungi from different regions of the Kashmir valley. Pala et al. (2012) reported 14 species of *Amanita* and *Russula*, viz. *Amanita ceciliae* (Berk. and Br.) Bas, *A. flavoconia* G.F. Atk., *A. muscaria* var. *formosa* Pers., *A. pantherina* (Fr.) Krombh., *A. phalloides* (Fr.) Link., *A. vaginata* (Bull. ex Fr.) Vittd., *A. virosa* (Fr.) Bertillon, *Russula aeruginea* Fr., *R. atropurpurea* (Krombh.) Britz., *R. aurea* Pers., *R. cyanoxantha* (Schaeff.) Fr., *R. delica* Fr., *R. emetica* (Schaeff. Ex Fr.) Gray and *R. nobilis* Velen.; among these *Russula aeruginea* Fr. was the first report from Kashmir. Pala and Wani (2011) reported 72 species of macro-fungi, belonging to *Ascomycetes* and *Basidiomycetes*, from different sites in the western Kashmir Himalaya (Table 14.1).

Wani and Pala (2013) compiled a list of 209 species of macro-fungi, belonging to 85 genera, 43 families and 02 subdivisions (Basidiomycotina and Ascomycotina) (Table 14.2).

A perusal of Table 14.2 reveals that *Basidiomycetes* are the dominant group of fungi in J&K State, represented by 182 species, followed by *Ascomycetes* with 25 species. Among *Basidiomycetes*, the dominant families include *Russulaceae* (with 29 species), *Cortinariaceae* and *Boletaceae* (17 species each), *Coprinaceae* (12 species) and *Tricholomataceae* (11 species), whereas the largest genus is *Russula* (with 21 species), followed by *Amanita* (represented by 11 species). In *Ascomycetes*, *Morchellaceae* (with seven species), *Helvellaceae* (six species) and *Pyronemataceae* (five species) figure as the major families, whereas *Morchella* and *Helvella* are the larger genera (represented by five species each).

## 14.4 Concluding Remarks

The fungal diversity in Jammu and Kashmir is not fully known, though many workers have made attempts on it. Research works on fungi of this region are scanty and scattered. There is lot of scope for mycologists to further survey the little-explored areas in this Himalayan State to document its actual fungal diversity. Both micro- and macro-fungi form significant components of ecosystems in this region and play a vital role in the ecology and economic sustenance. The beneficial fungi to local population are crucial in day-to-day life and need to be thoroughly studied in the State.

**Table 14.1** List of macro-fungal species from Kashmir with information on their edibility, habit, season of occurrence and site(s) of collection (Pala and Wani 2011)

| S. no. | Species | Edibility | Habit | Season of occurrence | Site of collection(s) |
|---|---|---|---|---|---|
| 1 | *Gyromitra esculenta* (Pers.) Fr. | Poisonous | Saprobic | Spring | KLR∗, GUL∗, YUS∗ |
| 2 | *Gyromitra sphaerospora* (Peck) Sacc. | Poisonous | Saprobic | Early Spring | KLR, DODP |
| 3 | *Helvella acetabulum* (L.) Quel. | Inedible but non-poisonous | Saprobic | Summer | YUS |
| 4 | *Helvella crispa* Bull. | Edible | Saprobic | Summer | GUL, FRZ, YUS |
| 5 | *Helvella elastic* Bull. | Edible | Saprobic | Summer | FRZ, GUL |
| 6 | *Helvella macropus* (Pers.) Karst. | Edible | Saprobic | Summer | YUS, DODP |
| 7 | *Humaria hemisphaerica* (Wigg.) Fuckel | Inedible but non-poisonous | Saprobic | Summer | KLR |
| 8 | *Morchella esculenta* (L.) Pers. | Edible | Saprobic | Early spring | GUL, YUS |
| 9 | *Morchella vulgaris* (Pers.) Bound | Edible | Saprobic | Early spring | GUL, YUS |
| 10 | *Scutellinia scutellata* (L.) Lambotte | Inedible but non-poisonous | Saprobic | Spring and summer | YUS, FRZ |
| 11 | *Verpa bohemica* (Krombh.) J. Schrot. | Edible | Saprobic | Early spring | GUL |
| 12 | *Agaricus bisporus* (Lang.) Pilat | Edible | Saprobic | Late spring and summer | KLR, YUS, GUL |
| 13 | *Agaricus campestris* L. | Edible | Saprobic | Summer | GUL, KLR, FRZ |
| 14 | *Agaricus silvicola* (Vittad.) Peck | Edible | Saprobic | Summer | DODP, YUS, FRZ |
| 15 | *Agrocybe molesta* (Lasch) Singer | Edible | Saprobic | Spring and summer | KLR |
| 16 | *Amanita flavoconia* Atk. | Poisonous | Mycorrhizal | Summer and early autumn | FRZ, YUS, GUL |
| 17 | *Amanita muscaria* (L.) Lam. | Poisonous | Mycorrhizal | Summer and early autumn | KLR, GUL, YUS |
| 18 | *Amanita pantherina* (Fr.) Krombh. | Poisonous | Mycorrhizal | Summer and early autumn | YUS |
| 19 | *Amanita phalloides* (Fr.) Link. | Poisonous | Mycorrhizal | Summer | GUL, FRZ, KLR |
| 20 | *Amanita vaginata* (Bull.) Lam. | Edible | Mycorrhizal | Late spring and summer | CHD, CHR |
| 21 | *Auricularia auricula-judae* (Bull.) Quel. | Edible | Saprobic | Summer | CHD, KLR |
| 22 | *Boletus edulis* Bull. | Edible | Mycorrhizal | Late spring and summer | YUS, FRZ |

(continued)

**Table 14.1** (continued)

| S. no. | Species | Edibility | Habit | Season of occurrence | Site of collection(s) |
|---|---|---|---|---|---|
| 23 | *Bovista plumbea* Pers. | Inedible but non-poisonous | Saprobic | Summer | KLR, YUS, GUL |
| 24 | *Calocera viscose* (Pers.) Fr. | Edible | Saprobic | Summer and early autumn | GUL |
| 25 | *Clavariadelphus pistillaris* (L.) Donk | Edible | Mycorrhizal | Summer | FRZ |
| 26 | *Coltricia cinnamomea* (Pers.) Murr. | Inedible but non-poisonous | Mycorrhizal | Summer | KLR |
| 27 | *Coprinus atramentarius* (Bull.) Fr. | Edible | Saprobic | Spring and autumn | CHD, KLR |
| 28 | *Coprinus comatus* (O.F. Mull.) Pers. | Edible | Saprobic | Spring and autumn | YUS |
| 29 | *Coprinus disseminates* (Pers.) Gray | Inedible but non-poisonous | Saprobic | Late spring | CHR, FRZ |
| 30 | *Coprinus micaceus* (Bull.) Fr. | Edible | Saprobic | Spring | FRZ, KLR |
| 31 | *Coprinus plicatilis* (Curt. ex Fr.) Fr. | Edible | Saprobic | Spring and early summer | GUL, YUS |
| 32 | *Cyathus olla* (Batsch) Pers. | Inedible but non-poisonous | Saprobic | Summer and autumn | CHD, YUS |
| 33 | *Flammulina velutipes* (Curtis) Singer | Edible | Saprobic | Late autumn and spring | KLR |
| 34 | *Fomes fomentarius* L. Kickx | Inedible but non-poisonous | Parasitic | Perennial | KLR, CHD, FRZ |
| 35 | *Fomitopsis pinicola* (Sw.) P. Karst | Inedible but non-poisonous | Parasitic | Perennial | YUS, GUL, FRZ |
| 36 | *Ganoderma applanatum* (Pers.) Pat. | Inedible but non-poisonous | Saprobic | Perennial | FRZ, KLR |
| 37 | *Geastrum fimbriatum* Fr. | Inedible but non-poisonous | Saprobic | Summer and autumn | GUL, YUS |
| 38 | *Gloeophyllum sepiarium* (Fr.) P. Karst | Inedible but non-poisonous | Saprobic | Perennial | YUS, FRZ |
| 39 | *Gomphus clavatus* (Pers.) Gray | Poisonous | Mycorrhizal | Summer | GUL, DODP |
| 40 | *Gomphus floccosus* (Shwein.) Singer | Poisonous | Mycorrhizal | Summer and autumn | GUL |
| 41 | *Hericium coralloides* (Scop.) Pers. | Edible | Saprobic | Summer and early autumn | KLR, FRZ |
| 42 | *Hygrocybe conica* (Schaeff. ex Fr.) | Poisonous | Mycorrhizal | Summer | YUS, DODP |
| 43 | *Hypholoma fasciculare* (Huds.) P. Kumm. | Poisonous | Saprobic | Summer | CHD, KLR |
| 44 | *Inonotus hispidus* (Bull.) P. Karst | Inedible but non-poisonous | Parasitic | Summer | KLR |

(continued)

**Table 14.1** (continued)

| S. no. | Species | Edibility | Habit | Season of occurrence | Site of collection(s) |
|---|---|---|---|---|---|
| 45 | *Lactarius controversus* (Pers.) Pers. | Poisonous | Mycorrhizal | Summer | KLR, CHD, FRZ |
| 46 | *Lactarius deliciosus* (L.) Gray | Edible | Mycorrhizal | Summer and autumn | YUS, DODP |
| 47 | *Lentinus tigrinus* (Bull.) Fr. | Edible | Saprobic | Summer and early autumn | CHD, KLR |
| 48 | *Lycoperdon perlatum* Pers. | Edible | Mycorrhizal | Summer | YUS, DODP |
| 49 | *Lycoperdon pyriforme* Schaeff. | Edible | Saprobic | Summer | GUL, YUS, DODP |
| 50 | *Macrolepiota puellaris* (Fr.) Moser | Edible | Saprobic | Spring | DODP |
| 51 | *Macrolepiota rhacodes* (Vitt.) Singer | Edible | Saprobic | Summer | DODP, FRZ |
| 52 | *Mutinus caninus* (Huds.) Fr. | Inedible but non-poisonous | Saprobic | Summer and autumn | YUS |
| 53 | *Panaeolus sphinctrinus* (Fr.) Quel. | Poisonous | Saprobic | Spring | CHD, DODP, KLR |
| 54 | *Panaeolus semiovatus* (Fr.) Lundell and Nannf. | Poisonous | Saprobic | Spring | CHD, YUS |
| 55 | *Paxillus involutus* (Batsch) Fr. | Poisonous | Mycorrhizal | Summer | KLR |
| 56 | *Phallus impudicus* L. | Edible | Saprobic | Summer and autumn | KLR, CHD, YUS |
| 57 | *Pholiota squarrosa* (Mull. ex Fr.) P. Kumm. | Poisonous | Parasitic | Summer | KLR, CHD |
| 58 | *Pleurotus ostreatus* (Jack.) P. Kumm. | Edible | Saprobic | Late spring and summer | KLR |
| 59 | *Psathyrella candolleana* (Fr.) Maire | Edible | Saprobic | Spring and autumn | KLR, FRZ |
| 60 | *Ramaria formosa* (Pers.) Quel. | Edible | Mycorrhizal | Summer | GUL, DODP |
| 61 | *Russula atropurpurea* (Krombh.) Britz. | Poisonous | Mycorrhizal | Summer | GUL |
| 62 | *Russula aurea* Pers. | Edible | Mycorrhizal | Summer and early autumn | DODP, GUL |
| 63 | *Russula emetica* (Schaeff. ex Fr.) Gray | Poisonous | Mycorrhizal | Summer | GUL, YUS |
| 64 | *Russula fragilis* (Pers.) Fr. | Poisonous | Mycorrhizal | Summer | KLR |
| 65 | *Scleroderma citrinum* Pers. | Poisonous | Mycorrhizal | Summer | KLR, CHD |
| 66 | *Schizophyllum commune* Fr. | Inedible but non-poisonous | Saprobic | Autumn | KLR, CHD, FRZ |

(continued)

**Table 14.1** (continued)

| S. no. | Species | Edibility | Habit | Season of occurrence | Site of collection(s) |
|---|---|---|---|---|---|
| 67 | *Stropharia semiglobata* (Batsch.) Quel. | Poisonous | Saprobic | Spring | FRZ, YUS |
| 68 | *Thelephora caryophyllea* (Shaeff.) Pers. | Inedible but non-poisonous | Mycorrhizal | Summer | KLR |
| 69 | *Trametes versicolor* (L) Lloyd | Inedible but non-poisonous | Saprobic | Spring to autumn | CHD, YUS, DODP, KLR |
| 70 | *Tremiscus helvelloides* (DC.) Donk | Edible | Saprobic | Summer | DODP |
| 71 | *Tricholoma aurantium* (Fr.) Ricken | Inedible but non-poisonous | Mycorrhizal | Summer | GUL, YUS |
| 72 | *Volvariella bombycina* (Schaeff.) Singer | Edible | Saprobic | Summer and early autumn | DODP, KLR |

[a]*GUL* Gulmarg, *KLR* Keller, *YUS* Yusmarg, *CHD* Chadoora, *DODP* Doodhpatheri, *FRZ* Ferozpur, *UR* Uri, *CHR* Chrarisharief

**Table 14.2** List of macro-fungal species from Kashmir Himalaya arranged as per their genera, families, orders and subdivisions

| *Subdivision/order/family* | *Genus* | *Species* |
|---|---|---|
| *Basidiomycotina*<br>*Russulales*<br>*Russulaceae* | *Russula* | *Russula uvidus* (Fr.) Fries<br>*Russula veternosa* Fr.<br>*Russula atropurpurea* (Krombh.) Britz.<br>*Russula aurea* Pers.<br>*Russula brevipes* Peck<br>*Russula decolorans* (Fr.) Fr.<br>*Russula delica* Fr.<br>*Russula densifolia* Secr. ex Gillet<br>*Russula emetica* (Schaeff. Ex Fr.) Gray<br>*Russula firmula* Pers.<br>*Russula fragilis* (Pers.) Fr.<br>*Russula fragrantissima* Romagn.<br>*Russula lutea* (Huds.) Gray<br>*Russula maculata* Quel.<br>*Russula naseosa* (Pers.) Fr.<br>*Russula paludosa* Britzelm.<br>*Russula persicina* Krombh.<br>*Russula rubicund* Quel.<br>*Russula sardonia* Fr.<br>*Russula sanguinea* (Bull.) Fr.<br>*Russula xanthophaea* Britzelm. |
| | *Lactarius* | *Lactarius controversus* (Pers.) Pers.<br>*Lactarius deliciosus* (L.) Gray<br>*Lactarius deterrimus* Groger<br>*Lactarius fuliginosus* (Krapf) Fr.<br>*Lactarius lilacinus* (Lasch) Fr.<br>*Lactarius scrobiculatus* (Scop.) Fr.<br>*Lactarius subpurpureus* Peck<br>*Lactarius torminosus* (Schaeff.) Pers. |

(continued)

**Table 14.2** (continued)

| *Subdivision/order/ family* | *Genus* | *Species* |
|---|---|---|
| *Basidiomycotina Russulales Hericiaceae* | *Hericium* | *Hericium coralloides* (Scop.) Pers. |
| *Basidiomycotina Agaricales Amanitaceae* | *Amanita* | *Amanita ceciliae* (Berk. and Br.) Bas<br>*Amanita excelsa* Bas<br>*Amanita flavoconia* Atk.<br>*Amanita franchetii* (Boud.) Fayod<br>*Amanita fritillaria* (Sacc.) Sacc.<br>*Amanita inaurata* Secr. ex Gillet<br>*Amanita muscaria* (L.) Lam.<br>*Amanita pantherina* (Fr.) Krombh.<br>*Amanita phalloides* (Fr.) Link.<br>*Amanita porphyria* Alb. and Schwein.<br>*Amanita vaginata* (Bull.) Lam.<br>*Amanita virosa* (Fr.) Bertillon |
| *Basidiomycotina Agaricales Cortinariaceae* | *Cortinarius* | *Cortinarius argutus* Fr.<br>*Cortinarius decipiens* Fr.<br>*Cortinarius kashmeriensis* Abraham<br>*Cortinarius parafulmineus* Henry<br>*Cortinarius subfulgens* Orton |
| | *Hebeloma* | *Hebeloma cylindorosum* Bull.<br>*Hebeloma crustuliniforme* (Bull.) Quel.<br>*Hebeloma pusillum* Lange |
| | *Inocybe* | *Hebeloma tinctorius* Pers.<br>*Inocybe patouillardi* Bres.<br>*Inocybe appendiculata* Khner<br>*Inocybe fastigiata* (Schaeff.) Quel.<br>*Inocybe friesii* Heim<br>*Inocybe geophylla* (Sowerby) Kumm.<br>*Inocybe hygrophorus* Khner<br>*Inocybe maculata* Boud.<br>*Inocybe rimosa* (Bull.) Kumm. |
| *Basidiomycotina Agaricales Coprinaceae* | *Coprinopsis* | *Coprinopsis macrocephala* (Berk.) Redhead<br>*Coprinus atramentarius* (Bull.) Fr. |
| | *Coprinus* | *Coprinus comatus* (O.F. Mull.) Pers.<br>*Coprinus disseminatus* (Pers.) Gray<br>*Coprinus micaceus* (Bull.) Fr.<br>*Coprinus plicatilis* (Curt. ex Fr.) Fr. |

(continued)

**Table 14.2** (continued)

| *Subdivision/order/ family* | *Genus* | *Species* |
|---|---|---|
| *Basidiomycotina Agaricales Tricholomataceae* | *Tricholoma* | *Tricholoma album* (Schaeff.) Kumm.<br>*Tricholoma aurantium* (Schaeff.) Ricken<br>*Tricholoma portentosum* (Fr.) Quel.<br>*Tricholoma scalpturatum* (Fr.) Quel.<br>*Tricholoma sejunctum* (Sowerby) Quel.<br>*Tricholoma terreum* (Schaeff.) Kumm.<br>*Clitocybe eccentrica* Wang and Liu |
| | *Clitocybe* | *Clitocybe infundibuliformis* Quel.<br>*Clitoybe nuda* Bull.<br>*Clitocybe flaccida* (Sowerby) Vizzini<br>*Clitocybe geotropa* (Bull.) Quel.<br>*Laccaria laccata* (Scop.) Cooke |
| | *Laccaria* | *Laccaria* sp. |
| | *Hygrocybe*<br>*Leucopaxillus*<br>*Conchomyces* | *Hygrocybe conica* (Fr.) Kumm.<br>*Leucopaxillus albissimus* (Peck) Singer<br>*Conchomyces bursaeformis* (Berk.) Horak |
| | *Floccularia* | *Floccularia albolanaripes* (Atk.) Redhead |
| *Basidiomycotina Agaricales Agaricaceae* | *Agaricus* | *Agaricus bisporus* (Lang.) Pilat<br>*Agaricus campestris* L.<br>*Agaricus silvicola* (Vittad.) Peck |
| | *Leucoagaricus* | *Leucoagaricus nympharum* (Kalchbr.) Bon |
| | *Lepiota* | *Lepiota clypeolaria* (Bull.) Kumm.<br>*Lepiota cristata* (Bolton) Kumm. |
| | *Macrolepiota*<br>*Tulostoma* | *Macrolepiota puellaris* (Fr.) Moser<br>*Macrolepiota rhacodes* (Vitt.) Singer<br>*Tulostoma brumale* Pers. |
| *Basidiomycotina Agaricales Strophariaceae* | *Bolbitius*<br>*Panaeolus* | *Bolbitius vitellinus* (Pers.) Fr.<br>*Panaeolus semiovatus* (Fr.) Nannf.<br>*Panaeolus sphinctrinus* (Fr.) Quel.<br>*Panaeolus campanulatus* (Bull.) Quel. |
| | *Agrocybe* | *Agrocybe cylindracea* (DC.) Maire<br>*Agrocybe molesta* (Lasch) Singer |
| | *Stropharia*<br>*Psilocybe*<br>*Pholiota* | *Stropharia semiglobata* (Batsch.) Quel.<br>*Psilocybe subtropicalis* Guzman<br>*Pholiota populnea* (Pers.) Kuyper<br>*Pholiota squarrosa* (Vahl) Kumm. |
| | *Hypholoma* | *Hypholoma fasciculare* (Huds.) Kumm.<br>*Hypholoma capnoides* (Fr.) Kumm. |
| *Basidiomycotina Agaricales Clavariaceae* | *Ramaria* | *Ramaria botrytis* (Pers.) Ricken<br>*Ramaria flava* (Schaeff.) Quel.<br>*Ramaria formosa* (Pers.) Quel.<br>*Ramaria invalii* Cotton and Wakef.<br>*Ramaria rubripermanens* Marr and Stuntz |

(continued)

**Table 14.2** (continued)

| *Subdivision/order/ family* | *Genus* | *Species* |
|---|---|---|
| *Basidiomycotina Agaricales Hygrophoraceae* | *Hygrophorus* | *Hygrophorus camarophyllus* (Alb. and Schwein.) Dumee<br>*Hygrophorus chrysodon* (Batsch) Fr.<br>*Hygrophorus pustulatus* (Pers.) Fr. |
| *Basidiomycotina Agaricales Pleurotaceae* | *Pleurotus* | *Pleurotus ostreatus* (Jack.) Kumm.<br>*Pleurotus platypus* Sacc.<br>*Pleurotus sajor-caju* (Fr.) Singer |
| *Basidiomycotina Agaricales Nidulariaceae* | *Crucibulum* | *Crucibulum leave* (Huds.) Kambly |
| | *Cyathus* | *Cyathus olla* (Batsch) Pers. |
| *Basidiomycotina Agaricales Physalacriaceae* | *Flammulina* | *Flammulina velutipes* (Curtis) Singer |
| *Basidiomycotina Agaricales Psathyrellaceae* | *Psathyrella* | *Psathyrella candolleana* (Peck) A. H. Sm. |
| *Basidiomycotina Agaricales Pluteaceae* | *Volvariella* | *Volvariella bombycina* (Schaeff.) Singer |
| *Basidiomycotina Agaricales Marasmiaceae* | *Marasmius* | *Marasmius androsaceus* (L.) Fr. |
| *Basidiomycotina Agaricales Physalacriaceae* | *Cyptotrama* | *Cyptotrama asprata* (Berk.) Redhead and Ginns |
| *Basidiomycotina Agaricales Schizophyllaceae* | *Schizophyllum* | *Schizophyllum commune* Fr. |
| *Basidiomycotina Boletales* Boletaceae | *Boletus* | *Boletus edulis* Bull.<br>*Boletus formosus* Corner<br>*Boletus granulatus* L.<br>*Boletus luridus* Schaeff.<br>*Boletus rhodoxanthus* (Krombh.) Kuan Zhao and Zhu L. Yang<br>*Boletus versicolor* L. |
| | *Suillus* | *Suillus brevipes* (Peck) Kuntze<br>*Suillus elegans* (Schumach.) Snell<br>*Suillus granulatus* (L.) Roussel<br>*Suillus luteus* (L.) Roussel<br>*Suillus placidus* (Bonord.) Singer<br>*Suillus plorans* (Rolland) Kuntze<br>*Suillus sibiricus* (Singer) Singer<br>*Suillus variegatus* (Sw.) Kuntze |
| | *Leccinum*<br>*Austroboletus*<br>*Strobilomyces* | *Leccinum sp.*<br>*Austroboletus malaccensis* (Pat.) Wolfe<br>*Strobilomyces floccopus* (Vahl) Karst.<br>*Strobilomyces echinocephalus* Gelardi and Vizzini<br>*Strobilomyces mollis* Corner |
| | *Xerocomus* | *Xerocomus bakshii* Singer and B. Singh |

(continued)

**Table 14.2** (continued)

| *Subdivision/order/ family* | *Genus* | *Species* |
|---|---|---|
| *Basidiomycotina Boletales Sclerodremataceae* | *Scleroderma* | *Scleroderma citrinum* Pers.<br>*Scleroderma verrucosum* (Bull.) Pers. |
| | *Pisolithus* | *Pisolithus tinctorius* (Pers.) Coker and Couch |
| *Basidiomycotina Boletales Rhizopogonaceae* | *Rhizopogon* | *Rhizopogon vulgaris* (Vittad.) Lange |
| *Basidiomycotina Boletales Paxillaceae* | *Paxillus* | *Paxillus involutus* (Batsch) Fr.<br>*Paxillus rubicundulus* Orton |
| *Basidiomycotina Boletales Gomphidaceae* | *Chroogomphus* | *Chroogomphus tomentosus* (Murrill)<br>*Chroogomphus vinicolor* (Peck) Mill. |
| *Basidiomycotina Lycoperdales Lycoperdaceae* | *Geastrum* | *Geastrum fimbriatum* Fr.<br>*Geastrum minimum* Schwein.<br>*Geastrum pectinatum* Pers. |
| | *Lycoperdon* | *Lycoperdon perlatum* Pers.<br>*Lycoperdon pyriforme* Schaeff. |
| | *Bovista* | *Bovista nigrescens* Pers.<br>*Bovista plumbea* Pers. |
| | *Langermannia*<br>*Vascellum* | *Langermannia gigantea* (Batsch) Rostk.<br>*Vascellum pratense* Pers. |
| *Basidiomycotina Gomphales Gomphaceae* | *Gomphus* | *Gomphus brunneus* (Heinem.) Corner<br>*Gomphus clavatus* (Pers.) Gray<br>*Gomphus floccosus* (Shwein.) Singer |
| *Basidiomycotina Gomphales Clavariadelphaceae* | *Clavariadelphus* | *Clavariadelphus ligula* (Schaeff.) Donk<br>*Clavariadelphus pistillaris* (L.) Donk<br>*Clavariadelphus truncatus* (Quel.) Donk |
| *Basidiomycotina Polyporales Polyporaceae* | *Lentinus* | *Lentinus lepideus* (Fr.) Fr.<br>*Lentinus strigosus* Fr.<br>*Lentinus tigrinus* Bull.) Fr. |
| | *Fomes*<br>*Trametes* | *Fomes fomentarius* L. Kickx<br>*Trametes versicolor* (Wulfen) Lloyd |
| *Basidiomycotina Polyporales Ganodermataceae* | *Ganoderma* | *Ganoderma applanatum* (Pers.) Pat.<br>*Ganoderma lucidum* (Curtis) P. Karst. |
| *Basidiomycotina Polyporales Fomitopsidaceae* | *Fomitopsis* | *Fomitopsis pinicola* (Sw.) P. Karst |
| *Basidiomycotina Hymenochaetales Hymenochaetaceae* | *Coltricia*<br>*Inonotus* | *Coltricia cinnamomea* (Pers.) Murr.<br>*Inonotus hispidus* (Bull.) P. Karst |
| *Basidiomycotina Thelophorales* Thelephoraceae | *Thelephora* | *Thelephora caryophyllea* (Shaeff.) Pers.<br>*Thelephora terrestris* Ehrh. |
| *Basidiomycotina Thelophorales Gloeophyllaceae* | *Gloeophyllum* | *Gloeophyllum sepiarium* (Fr.) P. Karst |

(continued)

**Table 14.2** (continued)

| *Subdivision/order/ family* | *Genus* | *Species* |
|---|---|---|
| *Basidiomycotina Phallales Phallaceae* | *Phallus* <br> *Mutinus* | *Phallus impudicus* L. <br> *Mutinus caninus* (Huds.) Fr. |
| *Basidiomycotina Cantharellales Cantharellaceae* | *Cantharellus* | *Cantharellus cibarius* Fr. |
| *Basidiomycotina Auriculariales Auriculariaceae* | *Auricularia* | *Auricularia auricula-judae* (Bull.) Quel. |
| *Basidiomycotina Auriculariales Exidiaceae* | *Tremiscus* | *Tremiscus helvelloides* (DC.) Donk |
| *Basidiomycotina Dacrymycetales Dacrymycetaceae* | *Calocera* | *Calocera viscosa* (Pers.) Fr. |
| *Ascomycotina Pezizales Morchellaceae* | *Mitrophora* <br> *Morchella* | *Mitrophora semilibera* (DC.) Lev. <br> *Morchella conica* Pers. <br> *Morchella esculenta* (L.) Pers. <br> *Morchella angusticeps* Peck <br> *Morchella hybrida* (Sowerby) Pers. <br> *Morchella vulgaris* (Pers.) Bound |
| | *Verpa* | *Verpa bohemica* (Krombh.) J. Schrot. |
| *Ascomycotina Pezizales Helvellaceae* | *Helvella* | *Helvella acetabulum* (L.) Quel. <br> *Helvella crispa* Bull. <br> *Helvella elastica* Bull. <br> *Helvella lacunosa* Afzel. <br> *Helvella macropus* (Pers.) Karst. |
| | *Paxina* | *Paxina barlae* (Boud.) Seaver |
| *Ascomycotina Pezizales Pezizaceae* | *Peziza* | *Peziza exogelatinosa* Hansen and Sandal <br> *Peziza repanda* Pers. <br> *Peziza vesiculosa* Pers. |
| *Ascomycotina Pezizales Discinaceae* | *Gyromitra* | *Gyromitra esculenta* (Pers.) Fr. <br> *Gyromitra sphaerospora* (Peck) Sacc. |
| *Ascomycotina Pezizales Sarcoscyphaceae* | *Sarcoscypha* | *Sarcoscypha austriaca* (O. Beck ex Sacc.) Boud. <br> *Sarcoscypha coccinea* (Jacq.) Sacc. |
| *Ascomycotina Pezizales Pyronemataceae* | *Scutellinia* <br> *Sepultaria* <br> *Humaria* <br> *Aleuria* <br> *Tarzetta* | *Scutellinia scutellata* (L.) Lambotte <br> *Sepultaria sumneriana* (Cooke) Massee <br> *Humaria hemisphaerica* (Wigg.) Fuckel <br> *Aleuria aurantia* (Pers.) Fuckel <br> *Tarzetta catinus* (Holmsk.) Korf and Rogers |

Data sources: Abrahim et al. (1980), Dar and Shah (1981), Wattling and Abrahim (1992), Beig et al. (2008, 2011), Dar et al. (2010a, b, c), Wani et al. (2010a, b, c, 2013), Pala et al. (2011a, b, c, 2012)

**Acknowledgements** The authors are highly thankful to the Head, Department of Botany, University of Kashmir, for providing necessary facilities. The first author acknowledges all the research scholars who have helped in compiling this chapter on diversity of fungi in the State.

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# Chapter 15
# Diversity of Lichens in Jammu and Kashmir State

**Roshni Khare, D. K. Upreti, Manzoor Ul Haq, and B. C. Behera**

**Abstract** Lichen survey in Jammu and Kashmir State was initiated during the early 1930s, but detailed explorations started in 1949. The present chapter reports occurrence of 424 species of lichens in the State, belonging to 126 genera in 38 families; these represent ˃ 18% of total lichen species reported so far from India. *Parmeliaceae* is the largest family with 73 species, followed by *Lecanoraceae* with 53 species, *Physciaceae* with 48 species and *Teloschistaceae* with 36 species. *Buellia*, *Caloplaca*, *Cladonia*, *Lecanora*, *Parmotrema*, *Phaeophyscia*, *Physcia*, *Peltigera* and *Ramalina* are the most common genera in the State, while more than 30 genera show restricted occurrence. Equally, there is diversity in growth forms: 178 species being crustose, 159 foliose, 28 fruticose, 23 dimorphic, 32 squamulose and 4 leprose. Most of the species (240) are corticolous (bark inhabiting), followed by 163 saxicolous (rock inhabiting), 46 terricolous (soil inhabiting), 21 muscicolous (moss inhabiting) and a single foliicolous (on leaves) species. Out of 22 districts of the state, Anantnag reveals the maximum (128) lichen species, followed by Doda (with 112 species), Baramulla and Srinagar (with 70 species each), Leh (with 66 species) and Kishtwar (with 36 species), while other districts show lower/poor lichen diversity. Extensive exploration for lichens in little- and unexplored districts will add to the number of lichen taxa reported herein.

**Keywords** Lichens · Diversity · Jammu and Kashmir · Western Himalaya · *Parmeliaceae*

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_15

## 15.1 Introduction

Lichens are strange creatures, being among the most widely distributed and dominant groups of organisms in the world, covering as much as 8% of the Earth's surface (Ahmadjian 1995). The association between the two organisms (mycobiont and photobiont) has been so successful that a large number of fungi have opted for this symbiotic way of life, resulting in recognition of 15,000–20,000 species in the world (Galloway 1992). The symbiotic association in lichens is not just a random mixture of any fungal and algal species, but it is the manifestation of an extremely selective process that has evolved through ages and has developed in many directions. Lichens are cosmopolitan in distribution and have adapted to all possible environmental habitats in the world.

Lichens form important component of any area and have been explored exhaustively from different regions of India including the Himalaya in the second half of the twentieth century. A significant development in taxonomic and floristic studies on Indian lichens was attained, which revealed the occurrence of more than 2343 species with high degree of endemism (Awasthi 2000; Singh et al. 2004; Singh and Sinha 2010). Himalayan habitats, by virtue of their stressed climatology as high environmental lapse rate, high wind velocity, high UV radiation, low atmospheric pressure, low precipitation of rain, high precipitation of snow and delimiting nutrient and exposure regime, support relatively simple ecosystems characterized by limited trophic levels and very few plant growth forms and species (Rai et al. 2010). This stressed climatology of Himalaya supports life forms like lichens, which can tolerate the harsh temperature (longer periods of subzero temperature) and nutrient regimes (very low total carbon and nitrogen in substratum sink pool) produced by steep atmospheric lapse rate. Indian Himalaya comes out as the centre of high-level lichen diversity and symbolizes a hot spot within India (Negi and Gadgil 1996).

The Jammu and Kashmir (J&K) State lies in the lichenogeographic zone, constituting of mountainous to semi-mountainous plains, Shiwalik ranges, mountains of Pir Panjal range, Kashmir valley and mountains of Zanskar, Kargil and Leh. The Himalaya, including J&K State, is often called the 'hot spot' of lichen diversity in India. In conformity with varied climate (tropical, subtropical, temperate to alpine) and altitudinal range, the State provides different kinds of substrates and niches for colonization and growth of lichens. Survey for lichens in the State started during the early 1930s of the last century, when Smith in 1931 identified and published some lichen species collected by Kashyap during 1925. Raghubir in1949 surveyed and collected lichens from Achabal and Pahalgam areas of the Anantnag district. Awasthi and Singh (1970) reported 43 lichen species from J&K. Later on, more meticulous exploration for lichens in the State was started by various workers.

In recent years, Negi and Upreti (2000) conducted an ecological study in Hemis National Park of the Ladakh region, reporting 18 species of lichens from the area. Priyadarshini (2006) reported the occurrence of 30 species from Kalidhar range of the Jammu region. Sheikh et al. (2006a), during their study on lichen diversity of J&K, enumerated 279 species from the State. Sheikh et al. (2006b) reported 48 species of lichens from the Budgam, Pulwama and Jammu districts. Later, Sheikh et al. (2009) reported 30 lichen species from Surinsar-Mansar Wildlife Sanctuary of the Jammu district. After this, Khan et al. (2010) reported 31 species of lichens from Surankote area of the Poonch district, Solan et al. (2010) reported 18 species from the Ramnagar Wildlife Sanctuary, Kumar et al. (2012) accounted for 38 species from the Trans-Himalayan cold desert of Ladakh, Goni et al. (2013) recorded 18 species from Nandini Wildlife Sanctuary in Jammu, and Sheikh et al. (2013) recorded 77 species from Jammu, Kishtwar and Rajouri districts of Jammu. Kumar et al. (2014a, b) reported 24 species from the Zanskar valley, and Rahim et al. (2014) reported 25 species from Kargil and adjoining areas. Recently, Haq et al. (2013), Goni and Sharma (2015) and Bhat et al. (2016) added more species to the State's lichen flora. Lichens of Samba district were dealt with for the first time by Sheikh et al. (2016). More than 70 species have so far been added to the list of lichen flora of the State enumerated by Sheikh et al. (2006a).

In addition to floristics, studies were conducted on various ecological and other aspects. Haq et al. (2012) provided an account on lichen wealth of J&K. Hussan et al. (2013a, b), Bhat et al. (2014) carried out environmental quality assessment in the areas of Anantnag, Rajouri and Srinagar districts. Kumar et al. (2014a, b) studied antioxidant and cytotoxic activities of lichens from the Ladakh region. Pertinently, though lichens are frequently utilized for different purposes in other states of India, no record of their local usage in J&K State is so far available.

## 15.2 Material and Methods

The study is based on the lichen specimens deposited at the Herbarium of Lucknow University, Lucknow (LWU), and Lichen Herbarium of National Botanical Research Institute, Lucknow (LWG), and personal lichen collection of Dr. D.D. Awasthi (AWAS), together with fresh collection of lichens and scrutiny of literature (Singh and Sinha 2010; Rai et al. 2014; Goni et al. 2015). The unidentified lichen specimens were identified with the help of literature on lichens by Awasthi (1988, 1991, 2007), Nayaka (2004) and Divakar and Upreti (2005). The nomenclature of species has been updated by application of outline of *Ascomycota*, 2007, with some additions and corrections. Emphasis has been laid on elucidating the correct and up-to-date systematic position of lichen taxa. All the herbarium specimens studied here have been deposited in LWG.

Overall, about 40 survey and collection explorations for lichens in this region were carried out by various workers since 1949 (Table 15.1). The inventory provided here includes the details of species, family, locality, altitude, substratum and growth form of each lichen taxon, together with name of the collector and year of collection. The lichen taxa mentioned in revisionary, floristic and monographic studies on Indian lichens published in different journals and books are also included in the present chapter.

**Table 15.1** Details regarding lichen collections made in Jammu and Kashmir State

| S. no. | Collector(s) | Year of collection | Locality(ies) of collection |
|---|---|---|---|
| 1 | H. C. Raghubir | 1949 | Achabal, Pahalgam-Anantnag district |
| 2 | K. N. Kaul | 1952 | Kangan-Ganderbal district |
| 3 | D. D. Awasthi | 1953 | Pahalgam, Kokernag-Anantnag district; Shankaracharya Hill-Srinagar district |
| 4 | O. A. Höeg | 1953 | Gulmarg-Baramulla district |
| 5 | K. N. Kaul | 1953 | Baba Rishi, Tangmarg, Gulmarg, Khilanmarg-Baramulla district; Pahalgam-Anantnag district |
| 6 | K. N. Kaul | 1954 | Baba Rishi, Gulmarg-Baramulla district; Achabal-Anantnag district; Banihal-Doda district; Shankaracharya Hill-Srinagar district |
| 7 | T R. Seshadri | 1954 | Gulmarg-Baramulla district; Pahalgam-Anantnag district; Kashmir, locality not mentioned |
| 8 | R. N. Chopra | 1954 | Kashmir, locality not mentioned |
| 9 | L. D. Kapoor | 1955 | Gulmarg-Baramulla district |
| 10 | K. N. Kaul | 1955 | Pahalgam-Anantnag district |
| 11 | G. Saran | 1956 | Kishtwar district; Doda district |
| 12 | K. N. Kaul | 1958 | Khilanmarg, Gulmarg-Baramulla district |
| 13 | B. K. Kaul | 1958 | Gulmarg, Tangmarg-Baramulla district; Shankaracharya Hill, Zaberwan-Srinagar district; Ganderbal-Ganderbal district |
| 14 | K. N. Kaul | 1959 | Baba Rishi-Baramulla district |
| 15 | G. C. Rath | 1960 | Tangmarg, Khilanmarg-Baramulla district; Shankaracharya Hill-Srinagar district; Kashmir, locality not mentioned |
| 16 | D. M. Vean | 1960 | Gilgit, Kashmir |
| 17 | R Gosh | 1963 | Verinag-Anantnag district; Awantipora-Pulwama district |
| 18 | P. Chandra | 1963 | Verinag, Pahalgam-Anantnag district |
| 19 | G.S. Srivastava | 1965 | Kashmir, locality not mentioned |
| 20 | D.D. Awasthi | 1968 | Achabal, Pahalgam, Kokernag-Anantnag district; Khilanmarg, Gulmarg, Tangmarg-Baramulla district; Nandini Hill-Jammu district; Sonamarg-Kangan district; Harwan Garden, Shalimar Garden-Srinagar district |
| 21 | A. Singh and M. Ranjan | 1979 | Kargil district |
| 22 | G. Saran | NA | Achabal, Pahalgam-Anantnag district; Baltal-Ganderbal district |
| 23 | B.N. Bhattacharya | NA | Neh Nar Glacier-Anantnag district |
| 24 | P. D. Dogra | NA | Sonamarg-Ganderbal district |
| 25 | D. K. Upreti | 1982 | Pahalgam-Anantnag district; Gulmarg-Baramulla district; Kangan-Ganderbal district |
| 26 | A. Singh and D.K. Upreti | 1982 | Kangan, Baltal-Ganderbal district; Pahalgam-Anantnag district; Khilanmarg, Gulmarg-Baramulla district |

(continued)

**Table 15.1** (continued)

| S. no. | Collector(s) | Year of collection | Locality(ies) of collection |
|---|---|---|---|
| 27 | H. R. Negi | 1999 | Hemis National Park-Leh district |
| 28 | D.K. Upreti and S. Chatterjee | 2003 | Ladakh-Leh district |
| 29 | H. C. Dutt | 2003 | Chinya Valley, Ramtund forest area, Kaplash-Badharwah, Doda district |
| 30 | M. A. Sheikh | 2004 | Pingalgam, Goosu-Pulwama district; Yusmarg-Budgam district |
| 31 | M.A. Sheikh and A.K. Raina | 2004 | Jammu district |
| 32 | M.A. Sheikh | 2005–2016 | Harwan-Srinagar district; Patnitop-Udhampur district; Jammu district; Kishtwar district; Rajouri district; Samba district |
| 33 | Mamta Bhat | 2008–till date | Poonch and Rajouri districts |
| 34 | Chandra Shekhar | 2010 | Badharwah and Doda districts |
| 35 | Sajaad Iqbal Khan | 2010 | Surankote area-Poonch district |
| 36 | Reema Goni | 2010–2015 | Doda district |
| 37 | Sarika Solan and Khalid Mehta | 2010 | Ramnagar Wildlife Sanctuary-Jammu district |
| 38 | Jatinder Kumar | 2010–2014 | Chang La, Dihar Hill, Ladakh, Nyora valley, Phyang-Leh district; Zanskar-Kargil district |
| 39 | Asma Hussan | 2012 | Harwan area-Srinagar district |
| 40 | Manzoor Ul Haq | 2012–till date | Anantnag district; Budgam district; Ganderbal district; Pulwama district; Dachigam National Park-Srinagar district |

## 15.3 Results and Discussion

A total of 424 species belonging to 126 genera in 38 families of lichens are known from J&K State (Table 15.2; Fig. 15.1), which represents more than 18% of total lichen species reported so far from India. *Parmeliaceae* (with 73 species) is the dominant family in the state, followed by *Lecanoraceae* (53 species), *Physciaceae* (48 species) and *Teloschistaceae* (36 species). Among genera, *Buellia*, *Caloplaca*, *Cladonia*, *Heterodermia*, *Lecanora*, *Parmotrema*, *Peltigera*, *Phaeophyscia* and *Physcia* exhibit dominance in the region, while more than 30 other genera are found to have restricted distribution. Some lichens growing luxuriantly and flourishing in various localities of the State are shown in Plate 15.1.

The area harbours various growth forms of lichens, being represented by 178 species of crustose forms, followed by 159 foliose, 32 squamulose, 28 fruticose, 23 dimorphic and 2 leprose taxa (Fig. 15.1). Tree species such as *Cedrus deodara*, *Abies pindrow*, *Pinus wallichiana*, *Acer* sp. and *Rhododendron* sp. provide varied niches to diverse lichen taxa for their luxuriant growth as epiphytes; the region, therefore, exhibits higher number of bark-inhabiting lichens represented by 197

**Table 15.2** Distribution of lichen taxa in different regions, substrates and growth forms from Jammu and Kashmir state

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Acarosporaceae* | | | | | | | | | | | | | | | | | | | |
| *Acarospora badiofusca* (Nyl.) Th. Fr. | + | – | – | + | – | – | – | – | – | + | – | – | + | – | – | – | – | Sq | S |
| *Acarospora bullata* (Nyl.) Anzi | – | – | – | + | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | S |
| *Acarospora nitrophila* H. Magn. | – | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | Sq | S |
| *Acarospora oxytona* (Ach.) A. Massal. | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | Cr | S |
| *Acarospora strigata* (Nyl.) Jatta | + | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | S |
| *Acarospora tominiana* Magnusson | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Myriospora rufescens* (Ach.) Hepp ex Uloth | – | – | – | + | – | – | – | – | – | + | – | – | – | – | – | – | – | Sq | S |
| *Myriospora smaragdula* (Wahlenb.) Nägeli ex Uloth, in Hepp | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Sq | S |
| *Pleopsidium flavum* (Bell.) Körb | – | – | – | – | – | – | – | – | – | + | – | – | + | – | – | – | – | Cr | S |
| *Sarcogyne privigna* (Ach.) A. Massal | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Agyriaceae* | | | | | | | | | | | | | | | | | | | |
| *Xylographa parallela* (Ach.:Fr.) Behlen and Desberg | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | S |
| *Arthoniaceae* | | | | | | | | | | | | | | | | | | | |
| *Arthonia radiata* (Pers.) Ach. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Caliciaceae* | | | | | | | | | | | | | | | | | | | |
| *Amandinea diorista* (Nyl.) Marbach | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Amandinea montana* (H. Magn.) Marbach | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Cr | S |
| *Amandinea polyspora* (Willey) E. Lay and P. May | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Amandinea punctata* (Hoffm.) Coppins and Scheid. | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Baculifera curtisii* (Tuck.) Marbach | – | + | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Cr | C |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Buellia alboatra* (Hoffm.) Th. Fr. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | S |
| *Buellia alboatrior* (Nyl.) Zahlbr. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C |
| *Buellia betulinoides* R. Schub. and Klem. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | Cr | C |
| *Buellia disciformis* (Fr.) Mudd | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | + | Cr | C |
| *Buellia disjecta* Zahlbr. in hand. Mazz. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Buellia palnienis* S.R. Singh and D.D. Awasthi | – | – | – | + | – | – | – | – | – | - | – | – | – | – | – | – | – | Cr | S |
| *Buellia pharcidia* (Ach.) Malme | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C |
| *Buellia sorediata* (Tuck.) H. Magn. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Buellia subdisciformis* (Leight.) Vain. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C |
| *Buellia substigmea* S.R. Singh and D.D. Awashti | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | – | + | Cr | C |
| *Calicium abietinum* Pers. | – | – | – | – | – | – | – | – | – | – | – | – | – | | – | – | + | Cr | C |
| *Calicium glaucellum* Ach. | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Dimelaena oreina* (Ach.) Norman | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Sq | S |
| *Dirinaria aegialita* (Afzel.) Moore | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Pyxine cocoes* (Sw.) Nyl. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Pyxine petricola* Nyl. | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Pyxine subcinerea* Stirt. | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Candelariaceae* | | | | | | | | | | | | | | | | | | | |
| *Candelaria concolor* (Dicks.) Stein in Cohn | + | – | – | – | – | + | – | + | – | – | – | + | – | – | – | – | + | Fo | C |
| *Candelariella aurella* (Hoffm.) Zahlbr. | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | C |
| *Candelariella grimmiae* Poelt and Reddi | + | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | T |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Candelariella nepalensis* Poelt and Reddi | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | T |
| *Candelariella vitellina* (Ehrh.) Müll. Arg. | + | – | – | + | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | S |
| *Catillariaceae* | | | | | | | | | | | | | | | | | | | |
| *Catillaria erysiboides* (Nyl.) Th. Fr. | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Megalaria pulverea* (Borrer) Hafellner and E. Schreiner | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Chrysothricaceae* | | | | | | | | | | | | | | | | | | | |
| *Chrysothrix candelaris* (L.) J.R. Laundon | – | – | – | + | – | – | – | + | – | – | – | – | – | – | – | – | – | Le | C |
| *Chrysothrix chlorina* (Ach.) J.R. Laundon | – | – | – | + | – | – | – | – | – | – | + | – | – | – | + | – | – | Le | C |
| *Cladoniaceae* | | | | | | | | | | | | | | | | | | | |
| *Cladonia acuminata* (Ach.) Norrl. | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Dm | T |
| *Cladonia awasthiana* Ahti and Upreti | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Dm | C, T |
| *Cladonia cartilaginea* Müll. Arg. | – | – | + | – | – | + | – | – | – | – | – | – | – | – | – | – | – | Dm | C, T |
| *Cladonia cenotea* (Ach.) Schaer. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Dm | T |
| *Cladonia chlorophaea* (Flörke ex Sommerf.) Spreng. | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Dm | C |
| *Cladonia coniocraea* (Flörke) Spreng. | – | + | – | + | – | – | – | – | – | – | – | – | – | – | + | – | – | Dm | C |
| *Cladonia corniculata* Ahti and Kashiw. | + | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Dm | C |
| *Cladonia didyma* (Fée) Vain. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Dm | L |
| *Cladonia farinacea* (Vain.) A. Evans | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Dm | T |
| *Cladonia fimbriata* (L.) Fr. | + | + | + | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Dm | C, T |
| *Cladonia fruticulosa* Kremp. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Dm | T, L |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Cladonia humilis* (With.) J.R. Laundon | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Dm | T |
| *Cladonia macilenta* Hoffm. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | Dm | T |
| *Cladonia mongolica* Ahti | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Dm | T |
| *Cladonia ochrochlora* Flörke | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Dm | C, T |
| *Cladonia pocillum* (Ach.) Grognot | + | + | – | – | – | – | + | – | – | + | – | – | – | – | + | – | – | Dm | T, M |
| *Cladonia pyxidata* (L.) Hoffm. | + | – | – | + | – | – | – | – | – | – | – | – | – | – | + | – | – | Dm | S, M, T |
| *Cladonia ramulosa* (With.) J.R. Laundon | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Dm | T |
| *Cladonia rei* Schaer. | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Dm | C |
| *Cladonia scabriuscula* (Delise) Nyl. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Dm | T |
| *Cladonia subradiata* (Vain.) Sandst. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Dm | T |
| *Cladonia subulata* (L.) F.H. Wigg. | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Dm | T |
| *Lepraria lobificans* Nyl. | – | – | – | – | – | + | – | – | – | – | + | – | + | – | + | – | + | Le | C |
| *Lepraria membranacea* (Dicks.) Vain. | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Le | C |
| *Squamarina cartilaginea* (With.) P. James | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Sq | T |
| *Collemataceae* | | | | | | | | | | | | | | | | | | | |
| *Collema flaccidum* (Ach.) Ach. | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Collema furfuraceum* (Arn.) Du Rietz | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Collema nigrescens* (Huds) DC. in Lam. and DC. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Collema pulcellum Ach.* var. *subnigrescens* (Müll. Arg.) Degel. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Collema rugosum* Kremp. | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Collema subflaccidum* Degel. | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Collema subnigrescens* Degel. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Enchylium limosum* (Ach.) Otálora, P.M. Jørg. and Wedin | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | T |
| *Enchylium polycarpon* (Hoffm.) Otálora, P.M. Jørg. and Wedin | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Fo | C |
| *Leptogium burnetiae* var. *burnetiae* C.W. Dodge | + | + | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | Fo | C, M, S |
| var. *hirsutum* (Sierk.) P.M. Jørg. | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C, M, S |
| *Leptogium cyanescens* (Rabenh.) Körb. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Leptogium denticulatum* Nyl. | – | – | – | + | – | – | – | – | – | – | + | – | – | – | – | – | – | Fo | C |
| *Leptogium pedicellatum* P.M. Jørg. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Leptogium saturninum* (Dicks.) Nyl. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Coniocybaceae* | | | | | | | | | | | | | | | | | | | |
| *Chaenotheca chrysocephala* (Ach.) Th. Fr. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Graphidaceae* | | | | | | | | | | | | | | | | | | | |
| *Graphis arecae* Vain. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Graphis dendrogramma* Nyl. in Cromb. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Graphis epimelaena* Müll. Arg. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Graphis glaucescens* Fée | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Cr | C |
| *Graphis granulata* Fée | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C |
| *Graphis leptocarpa* Fée | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Graphis lineola* Ach. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Graphis longiramea* Müll. Arg. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Graphis scripta* (L.) Ach. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Diploschistes actinostomus* (Pers. ex Ach.) Zahlbr. | + | – | – | + | – | – | – | – | – | + | – | – | – | – | + | – | – | Cr | S |
| *Diploschistes candidissimus* (Kremp.) Zahlbr. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Cr | S |
| *Diploschistes euganeus* (A. Massal.) J. Steiner | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | Cr | S |
| *Diploschistes gypsaceus* (Ach.) Zahlbr. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Diploschistes muscorum* (Scop.) R. Sant. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Cr | S |
| *Diploschistes muscorum* subsp. *bartlettii* Lumbsch | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | S |
| *Diploschistes scruposus* (Schreb.) Norman | – | – | – | + | – | – | – | – | – | – | – | – | + | – | + | – | – | Cr | S |
| *Lecanoraceae* | | | | | | | | | | | | | | | | | | | |
| *Carbonea vitellinaria* (Nyl.) Hertel | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Lecanora achroa* Nyl. in Cromb. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | + | Cr | C |
| *Lecanora alba* Lumbsch | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Cr | C |
| *Lecanora albescens* (Hoffm.) Flörke | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C, S |
| *Lecanora allophana* (Ach.) Nyl. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | + | Cr | C |
| *Lecanora alpigena* (Ach.) Cl. Roux | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Lecanora argentata* (Ach.) Degel. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C |
| *Lecanora campestris* (Schaer.) Hue | + | + | – | – | – | – | – | – | – | + | + | – | – | – | – | – | – | Cr | S |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| subsp. *gulmargia* Upreti | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Lecanora carpinea* (L.) Vain. | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Lecanora chlarotera* Nyl. | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Lecanora cinereofusca* H. Magn. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Lecanora flavidofusca* Müll. Arg. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Lecanora flavidomarginata* de Lesd. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Cr | C |
| *Lecanora frustulosa* (Dicks.) Ach. | + | – | – | + | – | – | + | + | – | + | – | – | – | – | + | – | – | Cr | S |
| *Lecanora hellmichiana* Poelt | – | – | – | – | – | – | + | – | – | – | – | – | + | – | – | – | – | Sq | S |
| *Lecanora helva* Stizenb. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Cr | C |
| *Lecanora himalayae* Poelt | + | – | – | – | – | – | – | – | – | + | – | – | – | – | + | – | – | Sq | T, M |
| *Lecanora imshaugii* Brodo | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Cr | C |
| *Lecanora indica* Zahlbr. | – | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | Sq | S |
| *Lecanora insignis* Degel. | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Lecanora interjecta* Müll. Arg. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | + | Cr | C |
| *Lecanora intricata* (Ach.) Ach. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | S |
| *Lecanora intumescens* (Rebent.) Rabenh. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C |
| *Lecanora iseana* Räsänen | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Lecanora japonica* Müll. Arg. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C |
| *Lecanora kirra* Poelt and Grube | + | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Sq | S |
| *Lecanora meridionalis* H. Magn. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Cr | C |
| *Lecanora praesistens* Nyl. | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Lecanora rugosella* Zahlbr. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C |
| *Lecanora perplexa* Brodo | – | – | – | – | – | + | – | – | – | – | – | – | + | – | – | – | – | Cr | C |
| *Lecanora pseudargentata* Lumbsch | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Lecanora pseudistera* Nyl. | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | Cr | S |
| *Lecanora subpraesistens* Nayaka, Upreti & Lumbsch | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Lecanora subrugosa* Nyl. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C |
| *Lecanora sulphurescens* Fée | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Lecanora tropica* Zahlbr. | – | – | – | – | – | – | + | – | – | – | – | – | + | – | – | – | – | Cr | S |
| *Lecidella alaiensis* (Vain.) Hertel | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C, S, T |
| *Lecidella carpathica* Körb. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | S |
| *Lecidella elaeochroma* (Ach.) Hazsl. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Lecidella enteroleucella* (Nyl.) Hertel | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | S |
| *Lecidella euphorea* (Flörke) Hertel | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C, S, T |
| *Lecidella flavosorediata* (Vìzda) Hertel and Leuckert | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C, S, T |
| *Lecidella stigmatea* (Ach.) Hertel and Leuckert | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Myriolecis dispersa* (Pers.) Śliwa, Zhao Xin and Lumbsch | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | S |
| *Protoparmeliopsis bolcana* (Pollini) Lumbsch | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Sq | S |
| *Protoparmeliopsis garovaglii* (Körb.) Arup, Zhao Xin and Lumbsch | + | – | – | – | – | – | + | + | – | + | – | + | – | – | + | – | – | Sq | S |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Protoparmeliopsis muralis* (Schreb.) M. Choisy | + | + | – | + | – | – | + | + | – | + | + | + | + | – | + | – | – | Sq | S |
| var. *dubyi* (Müll. Arg.) Poelt | + | – | – | – | – | – | + | – | – | + | – | – | – | – | – | – | – | Sq | S |
| *Vainionora warmingii* (Müll. Arg.) Kalb | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C |
| *Rhizoplaca chrysoleuca* (Sm.) Zopf | – | – | – | + | – | – | + | – | – | + | – | – | – | – | + | – | – | Fo | S |
| *Rhizoplaca melanophthalma* (DC.) Leuckert and Poelt | + | – | – | – | + | – | + | – | – | + | – | – | – | – | – | – | – | Fo | S |
| *Rhizoplaca phaedrophthalma* (Poelt) S.D. Leav., Zhao Xin and Lumbsch | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Sq | S |
| *Lecideaceae* | | | | | | | | | | | | | | | | | | | |
| *Lecidea auriculata* Th. Fr. | + | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | S |
| *Lecidea confluens* (Weber) Ach. | – | + | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | S |
| *Lecidea granifera* (Ach.) Vain. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Lecidea plana* (J. Lahm) Nyl. | + | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | S |
| *Lecidea secernens* H. Magn. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | S |
| *Porpidia albocoerulescens* (Wulfen) Hertel and Knoph | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Porpidia crustulata* (Ach.) Hertel and Schwab | – | + | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Porpidia macrocarpa* (DC.) Hertel and Knoph | – | + | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Lichinaceae* | | | | | | | | | | | | | | | | | | | |
| *Lichinella cribellifera* (Nyl.) P.P. Moreno and Egea | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fr | S |
| *Peccania coralloides* (Massal.) Massal. | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Fr | S |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Phylliscum abuense* D.D. Awasthi and S.R. Singh | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Phylliscum indicum* Upreti | – | – | – | – | – | + | – | + | – | – | + | – | + | + | – | – | – | Cr | S |
| *Lobariaceae* | | | | | | | | | | | | | | | | | | | |
| *Sticta praetextata* (Räsänen) D.D. Awasthi | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Megasporaceae* | | | | | | | | | | | | | | | | | | | |
| *Aspicilia almorensis* Räsänen | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | Cr | S |
| *Aspicilia calcarea* (L.) Sommerf. | + | + | – | – | – | – | + | – | – | + | – | – | – | – | – | – | – | Cr | S |
| *Aspicilia dwaliensis* Räsänen | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Aspicilia griseocinerea* Räsänen | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Aspicilia maculata* (H. Magn.) Oksner | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | S |
| *Circinaria contorta* (Hoffm.) A. Nordin, Savić and Tibell | + | – | – | – | – | – | – | – | – | + | + | – | – | – | – | – | – | Cr | S |
| *Circinaria caesiocinerea* (Nyl. ex Malbr.) A. Nordin, Savić and Tibell | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Lobothallia alphoplaca* (Wahlenb. ex Ach.) Hafellner | + | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Sq | S |
| *Lobothallia praeradiosa* (Nyl.) Hafellner | + | + | – | + | – | – | – | + | – | – | – | – | – | – | + | – | – | Sq | S |
| *Melaspileaceae* | | | | | | | | | | | | | | | | | | | |
| *Melaspilea gemella* (Eschw.) Nyl. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | F |
| *Nephromataceae* | | | | | | | | | | | | | | | | | | | |
| *Nephroma expallidum* (Nyl.) Nyl. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Nephroma helveticum* Ach. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Nephroma parile* (Ach.) Ach. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Ochrolechiaceae* | | | | | | | | | | | | | | | | | | | |
| *Ochrolechia pallescens* (L.) A. Massal. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C |
| *Ochrolechia rosella* (Müll. Arg.) Verseghy | – | + | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Cr | C |
| *Opegraphaceae* | | | | | | | | | | | | | | | | | | | |
| *Opegrapha dimidiata* Müll. Arg. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C |
| *Pannariaceae* | | | | | | | | | | | | | | | | | | | |
| *Fuscopannaria subgemmascens* Upreti and Divakar | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Sq | C |
| *Parmeliaceae* | | | | | | | | | | | | | | | | | | | |
| *Austroparmelina pruinata* (Müll. Arg.) A. Crespo, Divakar and Elix | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | Fo | C |
| *Bryoria fuscescens* (Gyeln.) Brodo and D. Hawksw. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fr | C |
| *Bulbothrix setschwanensis* (Zahlbr.) Hale | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | Fo | C |
| *Canoparmelia ecaperata* (Müll. Arg.) Elix and Hale | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Canoparmelia texana* (Tuck.) Elix and Hale | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Cetraria laii* Divakar, A. Crespo and Lumbsch | + | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Fr | C |
| *Cetrelia braunsiana* (Müll. Arg.) W.L. Culb. and C.F. Culb. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Cetrelia cetrarioides* (Delise ex Duby) W.L. Culb. and C.F. Culb. | + | + | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Fo | C |
| *Dolichousnea longissima* (Ach.) Articus | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fr | C |
| *Evernia divaricata* (L.) Ach | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fr | C |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Evernia prunastri* (L.) Ach. | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | Fr | C |
| *Flavoparmelia caperata* (L.) Hale | – | – | – | + | – | – | – | + | – | – | + | – | + | – | – | – | – | Fo | C |
| *Flavopunctelia flaventior* (Stirt.) Hale | + | + | – | + | – | – | – | + | – | – | – | – | + | – | + | – | – | Fo | C |
| *Flavopunctelia soredica* (Nyl.) Hale | + | + | + | – | – | – | – | – | – | – | + | – | + | – | + | – | – | Fo | C |
| *Hypogymnia physodes* (L.) Nyl. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Fo | C |
| *Hypogymnia thomsoniana* (Müll. Arg.) D.D. Awasthi | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Hypogymnia vittata* (Ach.) Gasilien | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Hypotrachyna cirrhata* (Fr.) Divakar, A. Crespo, Sipman, Elix and Lumbsch | – | – | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Lethariella cashmeriana* Krog | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | Fr | C |
| *Melanelixia fuliginosa* (Fr. ex Duby) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Melanelixia glabra* (Schaer.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Melanelixia subargentifera* (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Melanelixia subaurifera* (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | S |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Melanelixia villosella* (Essl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Melanohalea elegantula* (Zahlbr.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch | + | – | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | Fo | C |
| *Melanohalea exasperatula* (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Melanohalea infumata* (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Montanelia disjuncta* (Erichsen) Divakar, A. Crespo, Wedin & Essl. | – | – | – | – | + | – | – | – | – | + | – | – | – | – | – | – | – | Fo | S, C |
| *Montanelia panniformis* (Nyl.) Divakar, A. Crespo, Wedin and Essl. | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Fo | S |
| *Montanelia tominii* (Oxner) Divakar, A. Crespo, Wedin and Essl. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Menegazzia terebrata* (Hoffm.) A. Massal. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Nephromopsis nephromoides* (Nyl.) Ahti and Randlane | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Fo | C |
| *Parmelia saxatilis* (L.) Ach. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | S |
| *Parmelia squarrosa* Hale | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Parmelia sulcata* Taylor in J. Mackay | + | + | + | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Fo | C |
| *Parmelina pastilifera* (Harmand) Hale | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | Fo | C |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Parmelina tiliacea* (Hoffm.) Hale | + | + | – | – | – | – | – | – | – | – | – | – | – | – | + | – | + | Fo | C |
| *Parmelinella wallichiana* (Taylor) Elix and Hale | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Parmelinopsis minarum* (Vain.) Elix and Hale | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Parmotrema austrosinense* (Zahlbr.) Hale | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Parmotrema crinitum* (Ach.) M. Choisy | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Parmotrema cristiferum* (Taylor) Hale | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Parmotrema direagens* (Hale) Hale | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Parmotrema hababianum* (Gyeln.) Hale | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Parmotrema nilgherrense* (Nyl.) Hale | + | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Parmotrema praesorediosum* (Nyl.) Hale | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Parmotrema pseudoreticulatum* (C. Tav.) Hale | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Parmotrema pseudotinctorum* (Abbayes) Hale | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Parmotrema reticulatum* (Taylor) M. Choisy | + | – | – | + | – | – | – | – | – | + | – | – | – | – | – | – | – | Fo | C |
| *Parmotrema sancti-angelii* (Lynge) Hale | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Parmotrema subtinctorium* (Zahlbr.) Hale | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Parmotrema tinctorum* (Despr. ex Nyl.) Hale | + | – | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | Fo | C |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Pleurosticta acetabulum* (Neck.) Elix and Lumbsch | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | + | Fo | C |
| *Pseudevernia furfuracea* (L.) Zopf | − | − | − | + | − | − | − | − | − | − | − | − | − | − | + | − | − | Fr | C |
| *Punctelia borreri* (Sm.) Krog | + | − | − | − | − | − | − | − | − | − | + | − | + | − | + | − | − | Fo | C |
| *Punctelia neutralis* (Hale) Krog | − | − | − | − | − | − | − | + | − | − | + | − | − | − | − | − | − | Fo | C |
| *Punctelia rudecta* (Ach.) Krog | − | − | − | − | − | − | − | − | − | − | − | − | + | − | + | − | − | Fo | C |
| *Punctelia subrudecta* (Nyl.) Krog | + | − | − | + | − | − | − | + | − | − | + | − | + | − | − | − | + | Fo | C |
| *Sulcaria sulcata* (Lév.) Bystrek ex Brodo and D. Hawksw. | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | + | Fr | C |
| *Usnea fulvoreagens* (Räsänen) Räsänen | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | + | Fr | C |
| *Usnea mekista* (Stirt.) G. Awasthi | − | − | − | + | − | − | − | − | − | − | − | − | − | − | − | − | − | Fr | C |
| *Usnea orientalis* Motyka | − | − | − | + | − | − | − | − | − | − | − | − | − | − | − | − | − | Fr | C |
| *Usnea perplexans* Stirt. | + | + | + | − | − | − | − | − | − | − | − | − | − | − | − | − | − | Fr | C |
| *Usnea subfloridana* Stirt. | + | − | + | + | − | − | − | − | − | − | − | − | − | − | − | − | − | Fr | C |
| *Xanthoparmelia antleriformis* (Elix) Elix and J. Johnst. | − | − | − | + | − | − | − | − | − | − | − | − | − | − | − | − | − | Fo | S |
| *Xanthoparmelia australasica* D.J. Galloway | − | − | − | − | − | − | − | − | − | − | − | − | − | − | + | − | − | Fo | S |
| *Xanthoparmelia congensis* (J. Steiner) Hale | − | − | − | − | − | − | − | − | − | − | − | − | + | − | − | − | − | Fo | S |
| *Xanthoparmelia conspersa* (Ach.) Hale | + | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | Fo | S |
| *Xanthoparmelia coreana* (Gyeln.) Hale | + | − | − | − | − | − | − | + | − | + | + | − | − | − | − | − | − | Fo | S |
| *Xanthoparmelia mexicana* (Gyeln.) Hale | − | − | − | − | − | − | − | + | − | + | − | − | − | − | − | − | − | Fo | C, S, T |
| *Xanthoparmelia stenophylla* (Ach.) Ahti and D. Hawksw. | + | − | − | − | − | − | − | − | − | + | − | − | − | − | + | − | − | Fo | S |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Xanthoparmelia tinctina* (Maheu and A. Gillet) Hale | + | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Fo | S |
| *Xanthoparmelia verruculifera* (Nyl.) O. Blanco, A. Crespo, Elix, D. Hawksw. & Lumbsch | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | Fo | S |
| *Peltigeraceae* | | | | | | | | | | | | | | | | | | | |
| *Peltigera canina* (L.) Willd. | + | + | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Fo | S, T, M |
| *Peltigera collina* (Ach.) Schrad. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | T |
| *Peltigera didactyla* (With.) J. R. Laundon | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | T |
| *Peltigera dolichorrhiza* (Nyl.) Nyl. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | T |
| *Peltigera elisabethae* Gyeln. | + | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | T, M |
| *Peltigera horizontalis* (Huds.) Baumg. | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | S, M, T |
| *Peltigera malacea* (Ach.) Funck | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C, S |
| *Peltigera polydactylon* var. *polydactylon* (Neck.) Hoffm. | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | S |
| var. *pruinosa* Gyeln. | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | T |
| *Peltigera praetextata* (Flörke) Zopf | + | + | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C, T, M |
| *Peltigera rufescens* (Weiss) Humb. | + | + | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C, T, M |
| *Solorina bispora* Nyl. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | T |
| *Peltulaceae* | | | | | | | | | | | | | | | | | | | |
| *Peltula euploca* (Ach.) Poelt | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Sq | S |
| *Peltula obscurans* (Nyl.) Gyeln. | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | Sq | S |
| *Peltula patellata* (Bagl.) Swinscow and Krog | – | – | – | – | – | + | – | – | – | – | – | – | – | + | – | – | – | Sq | S |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Pertusariaceae* | | | | | | | | | | | | | | | | | | | |
| *Lepra albescens* (Huds.) Hafellner | – | + | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Lepra tropica* (Vain.) Lendemer and R.C. Harris | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C |
| *Pertusaria leucosorodes* Nyl. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Pertusaria melastomella* Nyl. | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Pertusaria pustulata* (Ach.) Duby | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Pertusaria quassiae* (Fée) Nyl. | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Physciaceae* | | | | | | | | | | | | | | | | | | | |
| *Anaptychia ciliaris* (L.) Körb | + | + | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Fr | C |
| *Anaptychia kaspica* Gyeln. | – | + | + | + | – | – | – | – | – | – | – | – | – | – | + | – | – | Fr | C |
| *Anaptychia pseudoroemeri* Awasthi | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fr | C |
| *Heterodermia diademata* (Taylor) D.D. Awasthi | + | + | – | – | + | – | – | – | – | – | – | + | – | – | + | – | – | Fo | C |
| *Heterodermia galactophylla* (Tuck.) W.L. Culb. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Heterodermia incana* (Stirt.) D.D. Awasthi | – | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | Fo | C |
| *Heterodermia indica* (H. Magn.) D.D. Awasthi | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Heterodermia obscurata* (Nyl.) Trevis. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Heterodermia pseudospeciosa* (Kurok.) W.L. Culb. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Hyperphyscia adglutinata* (Flörke) H. Mayrhofer and Poelt | + | – | – | – | – | + | – | – | – | – | – | + | + | – | – | – | – | Fo | C |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Hyperphyscia granulata* (Poelt) Moberg | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | Fo | C |
| *Hyperphyscia syncolla* (Tuck. ex Nyl.) Kalb | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | Fo | C |
| *Leucodermia boryi* (Fée) Kalb, Singh | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Phaeophyscia ciliata* (Hoffm.) Moberg | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Phaeophyscia constipata* (Norrl. and Nyl.) Moberg | + | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Fo | S |
| *Phaeophyscia endococcina* (Körb.) Moberg | + | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Fo | S |
| *Phaeophyscia hirsuta* (Mereschk.) Essl. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Phaeophyscia hispidula* Ach.) Moberg | + | – | – | – | – | – | – | – | + | – | + | + | + | – | + | – | – | Fo | C |
| var. *exornatula* (Zahlbr.) Moberg | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Phaeophyscia kairamoi* (Vain.) Moberg | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Phaeophyscia nepalensis* (Poelt) D.D. Awasthi | – | – | – | – | – | – | – | – | + | – | – | + | – | – | – | – | – | Fo | C |
| *Phaeophyscia nigricans* (Flörke) Moberg | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | S |
| *Phaeophyscia orbicularis* (Neck.) Moberg | – | – | – | – | – | + | – | – | + | – | + | + | + | – | – | – | + | Fo | S |
| *Phaeophyscia pyrrhophora* (Poelt) D.D. Awasthi and M. Joshi | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Physcia adscendens* (Fr.) H. Olivier | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Physcia aipolia* (Ehrh. ex Humb.) Fürnr. | + | + | – | – | – | – | – | + | – | – | – | – | – | – | + | – | + | Fo | C |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Physcia caesia* (Hoffm.) Fürnr. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Physcia crispa* Nyl. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Fo | C |
| *Physcia dilatata* Nyl. | – | – | – | – | – | – | – | + | – | – | – | – | + | – | – | – | – | Fo | C |
| *Physcia dubia* (Hoffm.) Lettau | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Fo | C |
| *Physcia gomukhensis* D.D. Awasthi and S.R. Singh | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Fo | S |
| *Physcia integrata* Nyl. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Physcia leptalea* (Ach.) DC. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Fo | C |
| *Physcia stellaris* (L.) Nyl. | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Physcia tribacia* (Ach.) Nyl. | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | Fo | C |
| *Physcia tribacoides* Nyl. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Physconia detersa* (Nyl.) Poelt | + | + | – | + | – | – | – | + | – | + | – | – | – | – | – | – | – | Fo | C |
| *Physconia distorta* (With.) J.R. Laundon | + | + | – | – | – | – | – | + | – | – | – | + | – | – | + | – | + | Fo | C |
| *Physconia enteroxantha* (Nyl.) Poelt | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Physconia grisea* (Lam.) Poelt | – | + | – | – | – | – | – | – | – | + | – | – | – | – | + | – | – | Fo | C, S |
| *Physconia muscigena* (Ach.) Poelt | + | – | – | – | – | – | + | – | – | – | – | – | – | – | + | – | – | Fo | M, T |
| *Physconia perisidiosa* (Erichsen) Moberg | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | S |
| *Polyblastidium dendriticum* (Pers.) Kalb | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Polyblastidium hypoleucum* (Ach.) Kalb | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | C |
| *Rinodina badiella* (Nyl.) Th. Fr. | + | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | S |
| *Rinodina sophodes* (Ach.) A. Massal. | – | – | – | – | – | – | – | – | – | – | – | – | + | – | + | – | + | Cr | S |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Rinodina straussii* J. Steiner | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | S |
| *Rinodina turfacea* (Wahlenb.) Körb. | + | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | M, S |
| *Pilocarpaceae* | | | | | | | | | | | | | | | | | | | |
| *Lopadium saxicolum* H. Magn. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Porpidiaceae* | | | | | | | | | | | | | | | | | | | |
| *Mycobilimbia hunana* (Zahlbr.) D.D. Awasthi | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | T |
| *Psoraceae* | | | | | | | | | | | | | | | | | | | |
| *Psora decipiens* (Hedw.) Hoffm. | – | – | – | – | – | + | + | – | – | – | – | – | – | – | – | – | – | Sq | T |
| *Psora himalayana* (C. Bab.) Timdal | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Sq | T |
| *Pyrenulaceae* | | | | | | | | | | | | | | | | | | | |
| *Pyrenula mamillana* (Ach.) Trevis. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Ramalinaceae* | | | | | | | | | | | | | | | | | | | |
| *Bacidia alutacea* (Kremp.) Zahlbr. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Bacidia arnoldiana* Körb. | – | – | – | – | – | – | – | + | – | – | – | – | + | – | – | – | – | Cr | C |
| *Bacidia incongruens* (Stirt.) Zahlbr. | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | Cr | C |
| *Bacidia medialis* (Tuck. ex Nyl.) Zahlbr. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | + | – | – | Cr | C |
| *Bacidia millegrana* (Taylor) Zahlbr. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C |
| *Bacidia phacodes* Körb. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C |
| *Bacidia rubella* (Hoffm.) A. Massal. | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | Cr | C |
| *Bacidia submedialis* (Nyl.) Zahlbr. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Bacidiopsora psorina* (Nyl. ex Hue) Kalb | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Catinaria atropurpurea* (Schaer.) Vì zda and Poelt | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Frutidella caesioatra* (Schaer.) Kalb | + | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | M, T |
| *Lecania fuscella* (Schaer.) A. Massal. | – | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | Cr | C |
| *Ramalina baltica* Lettau | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fr | C |
| *Ramalina conduplicans* Vain. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Fr | C |
| *Ramalina farinacea* (L.) Ach. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fr | C |
| *Ramalina intermedia* (Delise ex Nyl.) Nyl. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fr | C |
| *Ramalina obtusata* (Arnold) Bitter | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fr | C |
| *Ramalina pollinaria* (Westr.) Ach. | + | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fr | C |
| *Ramalina roesleri* (Hochst.) Hue | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fr | C |
| *Ramalina sinensis* Jatta | – | – | – | + | – | – | – | + | – | – | – | – | – | – | – | – | + | Fr | C |
| *Ramalina subampliata* (Nyl.) Fink | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fr | C |
| *Ramalina subfarinacea* (Nyl.) Nyl. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fr | C |
| *Toninia cinereovirens* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Sq | S, T |
| *Toninia tristis* subsp. *asiae-centralis* (H. Magn.) Timdal | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Sq | T |
| *Toninia sedifolia* (Scop.) Timdal | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Sq | M, S |
| *Rhizocarpaceae* | | | | | | | | | | | | | | | | | | | |
| *Rhizocarpon disporum* (Nägeli ex Hepp) Müll. Arg. | – | – | – | – | – | – | – | + | – | + | – | – | – | – | – | – | – | Cr | S |
| *Rhizocarpon geographicum* (L.) DC. in Lam. and DC. | – | – | – | + | – | – | + | – | – | + | – | – | – | – | – | – | – | Cr | S |
| *Rhizocarpon macrosporum* Räsänen | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | S |
| *Rhizocarpon sublucidum* Räsänen | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Stereocaulaceae* | | | | | | | | | | | | | | | | | | | |
| *Stereocaulon glareosum* (Savicz) H. Magn. | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Dm | T |
| *Teloschistaceae* | | | | | | | | | | | | | | | | | | | |
| *Athallia cerinelloides* (Erichsen) Arup, Frödén and Søchting | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Athallia pyracea* (Ach.) Arup, Frödén and Søchting | + | – | – | – | – | – | – | – | – | + | – | + | – | – | + | – | – | Cr | C |
| *Calogaya biatorina* (A. Massal.) Arup, Frödén and Søchting | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C, M, S |
| *Calogaya decipiens* (Arnold) Arup, Frödén and Søchting | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | S |
| *Calogaya saxicola* (Hoffm.) Vondrák | – | – | – | – | – | + | – | – | – | + | – | – | – | – | – | – | – | Cr | S |
| *Caloplaca ahmadiana* Poelt and Hinter. | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | Cr | S |
| *Caloplaca brebissonii* (Fée) J. Sant. ex Hafellner and Poelt | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C, M, S |
| *Caloplaca cerina* var. *muscorum* (A. Massal.) Jatta | – | – | – | – | – | – | – | + | – | – | – | – | – | – | + | – | – | Cr | M |
| var. *chloroleuca* (Sm.) Th. Fr. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Cr | M |
| *Caloplaca diphyodes* (Nyl.) Jatta | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C, M, S |
| *Caloplaca granularis* (Müll. Arg.) Zahlbr. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Caloplaca haematites* (Chaub.) Zwackh | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C, S |
| *Caloplaca himalayana* Y. Joshi and Upreti | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | Cr | C |
| *Caloplaca insularis* Poelt | + | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | F |
| *Caloplaca juniperi* Poelt and Hinter | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | Cr | C |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Caloplaca kashmirensis* Y. Joshi and Upreti | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Caloplaca lithophila* H. Magn. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Caloplaca ochroplaca* Poelt and Hinter. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Caloplaca variabilis* (Pers.) Müll. Arg. | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | S |
| *Flavoplaca citrina* (Hoffm.) Arup, Frödén and Søchting | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | C, M, S |
| *Flavoplaca flavocitrina* (Nyl.) Arup, Frödén and Søchting | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Fulgogasparrea appressa* (Wetmore and Kärnefelt) S.Y. Kondr., Elix, Kärnefelt and A. Thell | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Gallowayella fulva* (Hoffm.) S.Y. Kondr., Fedorenko, S. Stenroos, Kärnefelt, Elix, Hur and A. Thell | + | + | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | Fo | C |
| *Gyalolechia bassiae* (Ach.) Søchting, Frödén and Arup ex Ahti | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | Cr | C |
| *Gyalolechia flavovirescens* (Wulfen) Søchting, Frödén and Arup | – | – | – | – | + | – | – | + | – | – | – | – | – | – | – | + | – | Cr | S |
| *Leproplaca cirrochroa* (Ach.) Arup, Frödén and Søchting | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | S |
| *Leproplaca obliterans* (Nyl.) Arup, Frödén and Søchting | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Cr | S |
| *Polycauliona candelaria* (L.) Frödén, Arup and Søchting | – | + | + | + | – | – | – | – | – | + | + | + | + | – | + | – | + | Fo | C |
| *Polycauliona polycarpa* (Hoffm.) Frödén, Arup and Søchting | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | S |
| *Rusavskia sorediata* (Vain.) S.Y. Kondr. and Kärnefelt | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Fo | S |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Squamulea parviloba* (Wetmore) Arup, Søchting and Frödén | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | Cr | S |
| *Squamulea subsoluta* (Nyl.) Arup, Søchting and Frödén | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Cr | S |
| *Xanthoria elegans* (Link) Th. Fr. | + | + | – | + | – | + | + | + | – | + | – | + | – | – | + | – | – | Fo | S |
| *Xanthoria fallax* (Hepp ex Arnold) Arnold | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | C |
| *Xanthoria parietina* (L.) Th. Fr. | + | – | – | – | – | – | – | + | – | – | – | + | – | – | + | – | + | Fo | C, M, S |
| *Xanthoria ulophyllodes* Räsänen | + | – | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | Fo | C |
| *Trapeliaceae* | | | | | | | | | | | | | | | | | | | |
| *Trapelia coarctata* (Sm. and Sow.) Choisy | – | – | – | + | – | – | – | – | – | – | – | – | + | – | – | – | – | Cr | S |
| *Trapelia placodioides* Coppins and P. James | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Tephromelateceae* | | | | | | | | | | | | | | | | | | | |
| *Tephromela atra* (Huds.) Hafellner | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Cr | S |
| *Umbilicariaceae* | | | | | | | | | | | | | | | | | | | |
| *Lasallia pertusa* (Rassad.) Llano | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | S |
| *Umbilicaria jingralensis* Nagarkar and Patw. | + | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Fo | S |
| *Umbilicaria krascheninnikovii* (Savicz) Zahlbr. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | S |
| *Umbilicaria nepalensis* Poelt | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | S |
| *Umbilicaria vellea* (L.) Ach. | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Fo | S |
| *Umbilicaria virginis* Schaer. | + | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Fo | S |
| *Verrucariaceae* | | | | | | | | | | | | | | | | | | | |
| *Catapyrenium cinereum* (Pers.) Körb. | + | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Sq | T |
| *Catapyrenium squamulosum* (Ach.) Breuss | – | – | – | – | – | + | + | + | – | – | – | – | – | – | – | – | – | Sq | T |

(continued)

**Table 15.2** (continued)

| Name of lichen taxa | Districts surveyed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | GF | SUB |
| *Dermatocarpon meiophyllizum* Vain. | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | Fo | S |
| *Dermatocarpon miniatum* (L.) W. Mann. var. *miniatum* | + | – | – | + | – | + | – | – | – | + | – | – | + | – | – | – | – | Fo | S |
| var. *aetneum* (Tornab.) Zahlbr. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | Fo | S |
| var. *meuselianum* (R. Schub. and Klem.) D.D. Awasthi and Upreti | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | S |
| var. *papillosum* Müll. Arg. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Fo | S |
| *Dermatocarpon vellereum* Zschacke | + | – | – | + | – | + | + | – | – | + | + | – | + | – | + | – | – | Fo | S |
| *Endocarpon nanum* Ajay Singh and Upreti | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | – | Sq | S |
| *Endocarpon pallidulum* (Nyl.) Nyl. | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | Sq | S |
| *Endocarpon rosettum* Ajay Singh and Upreti | – | – | – | – | – | + | – | – | – | – | + | – | + | – | – | – | – | Sq | S |
| *Endocarpon subrosettum* Ajay Singh and Upreti | – | + | – | – | – | + | – | + | – | – | – | – | – | + | – | – | – | Sq | S |
| *Normandina pulchella* (Borrer) Nyl. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Staurothele fissa* (Taylor) Zwackh | – | – | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | Cr | S |
| *Verrucaria acrotella* Ach. | – | – | – | – | – | + | – | – | – | + | + | – | – | – | – | – | – | Cr | S |
| *Verrucaria aethiobola* Wahlb. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | + | – | – | Cr | S |
| *Verrucaria coerulea* (Ramond) DC. in Lam. and DC. | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | Cr | S |
| *Verrucaria laevata* Ach. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |
| *Verrucaria margacea* (Wahlenb.) Wahlenb. | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – | – | Cr | S |

Abbreviations used

Growth forms (*GF*): *Le*- leprose, *Cr*- crustose, *Sq*- squamulose, *Fo*- foliose, *Fr*- fruticose, *Dm*- dimorphic

Substratum (*SUB*): *C*- corticolous, *S*- saxicolous, *T*- terricolous, *F*- foliicolous, *L*- lignicolous, *M* muscicolous

Localities: 1. Anantnag district; 2. Baramulla district; 3. Budgam district; 4. Doda district; 5. Gilgit; 6. Jammu district; 7. Kargil district; 8. Kishtwar district; 9. Kupwara district; 10. Leh district; 11. Poonch district; 12. Pulwama district; 13. Rajouri district; 14. Samba district; 15. Srinagar district; 16. Udhampur district; 17. Kashmir (locality not mentioned)

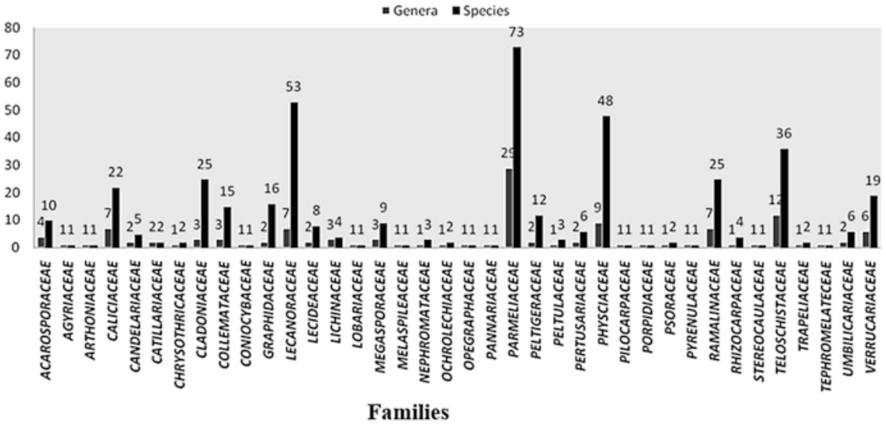


**Fig. 15.1** Family-wise number of genera and species in lichen flora of Jammu and Kashmir State

species, followed by 141 rock-inhabiting, 38 soil-inhabiting, 21 moss-inhabiting and 2 lignicolous species. A single foliicolous (leaf-inhabiting) species, namely, *Melaspilea gemella* (Eschw.) Nyl., has been also recorded from the State.

Out of all districts in the state, Anantnag has the maximum number (128) species of lichens, followed by Doda district with 112 species, Baramulla and Srinagar with 70 species each, Leh with 66 species, Rajouri with 39 species and Kishtwar district with 36 species (Fig. 15.2). Pulwama, Budgam, Gilgit, Kargil, Kupwara, Samba and Udhampur districts are poorly explored for lichens, while many other districts are completely unexplored with reference to lichens.

## 15.4 Concluding Remarks

With wide altitudinal variation from 300 to 6500 m a.s.l., coupled with range in climate from tropical to alpine, Indian Himalayan State of J&K provides suitable habitats for luxuriant growth of lichens. Studies so far conducted have revealed a total of 424 species of lichens from the State. Pertinently, however, this number is less than those for other northwest Himalayan states, like Himachal Pradesh (around 519 species) and Uttarakhand (around 710 species). It may probably be because the State has not so far been thoroughly explored and studied with respect to lichens. In recent years, some universities and research organizations have initiated lichenological investigations pertaining to systematics and bioprospection, in collaboration with CSIR-National Botanical Research Institute, Lucknow, as a result of which the accounts of lichens of Doda, Rajouri, Leh-Ladakh and Kailash regions have become available. A clear picture of the diversity and distribution of


**Plate 15.1** Representative lichens in Jammu and Kashmir: **a**. *Acarospora strigata* (Nyl.) Jatta; **b**. *Bacidia millegrana* (Taylor) Zahlbr.; **c**. *Buellia disciformis* (Fr.) Mudd; **d**. *Cladonia pyxidata* (L.) Hoffm.; **e**. *Endocarpon subrosettum* Ajay Singh & Upreti; **f**. *Flavoparmelia caperata* (L.) Hale; **g**. *Lecanora interjecta* Müll. Arg.; **h**. *Lichinella cribellifera* (Nyl.) P.P. Moreno & Egea; **i**. *Parmotrema reticulatum* (Taylor) M. Choisy; **j**. *Peltigera praetextata* (Flörke) Zopf; **k**. *Peltula euploca* (Ach.) Poelt; **l**. *Toninia sedifolia* (Scop.) Timdal

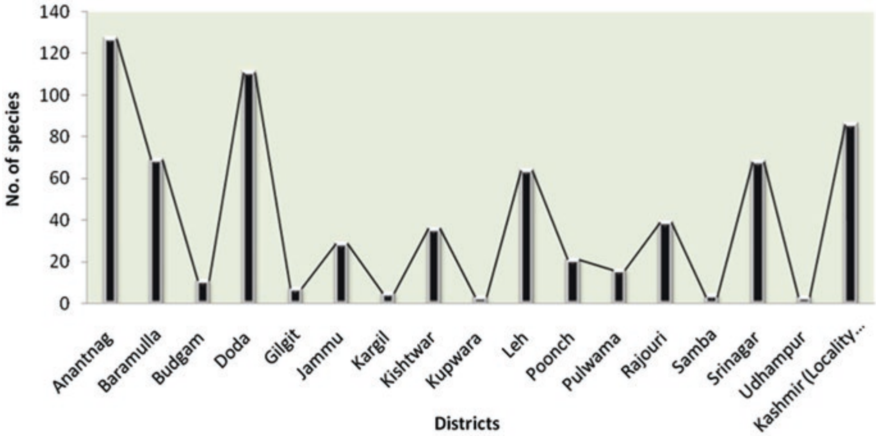


**Fig. 15.2** Number of species of lichens in various districts of Jammu and Kashmir State

lichens in J&K State will, however, be achieved after exhaustive exploration of lichens not only in the easily accessible areas but also in the difficult terrains of all the higher mountain regions. Overall information regarding lichens provides touchstone data which will be useful in conducting future biomonitoring studies and developing conservation strategies in the State. More thorough surveys for the exploration of lichens in little- and unexplored districts will definitely add to the number of lichen species recorded in this chapter from the State.

**Acknowledgements** Authors are grateful to the Director, CSIR-National Botanical Research Institute, Lucknow, for providing necessary laboratory facilities. Thanks are due to the Heads, Department of Botany and Environmental Sciences, Jammu University, and Department of Botany, University of Kashmir, and to Director/Dean, CBS, BGSB University, Rajouri, for providing lichen specimens for the present study. The logistic support of the authorities of J&K Forest Department, during collection of the material, is sincerely acknowledged. The work of Roshni Khare was supported by Science and Engineering Research Board (SERB), Govt. of India, New Delhi (YSS/2014/000883) project grant.

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# Chapter 16
# An Updated Checklist of Bryophytes in Jammu and Kashmir State

**Zeenat Ismail, Anzar A. Khuroo, M. Y. Bhat, Shugufta Rasheed, Rameez Ahmad, and Ghulam Hassan Dar**

**Abstract** The present chapter provides an updated checklist of bryophytes in Jammu and Kashmir State, based on systematic review of scientific literature, herbarium studies in KASH and field observations. The checklist comprises of 420 species, out of which 328 species spread over 117 genera in 32 families belong to mosses, whereas 91 species spread over 40 genera in 23 families belong to liverworts. Interestingly, only one species of hornwort, *Phaeoceros laevis*, is recorded from the State, that too from district Rajouri of the Jammu province. Three larger families in mosses are Pottiaceae (66 spp.), Bryaceae (35 spp.) and Brachytheciaceae (32 spp.), whereas three larger moss genera are *Brachythecium* (24 spp.), *Orthotrichum* (17 spp.) and *Bryum* (13 spp.). Three larger families in liverworts are Aytoniaceae (15 spp.), Porellaceae (11 spp.) and Marchantiaceae (9 spp.), whereas three larger liverwort genera are *Porella* (11 spp.), *Marchantia* (7 spp.) and *Plagiochila* (7 spp.). Hopefully, the present checklist will provide a baseline database for understanding the biodiversity of bryophytes and undertaking their further studies in this Himalayan State.

**Keywords** Checklist · Taxonomy · Bryophytes · Liverworts · Mosses · Jammu and Kashmir

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_16

## 16.1 Introduction

The simplest and the most primitive of land plants, bryophytes occupy a key position in the plant kingdom and mark a pivotal step in the transition of plants from aquatic to terrestrial ecosystems. Although they represent the second largest group of plants after angiosperms (Vanderpoorten and Goffinet 2009), yet they have remained a neglected group in botanical research. This is mainly due to their diminutive stature, few reported economic uses, lack of experts in the field, only a few educational and research institutions with good laboratory facilities, inaccessible literature, lack of awareness towards this group of plants, few sporadic studies and lack of financial support to conduct surveys and taxonomic studies on this group (Sathish et al. 2013).

The term bryophyta is derived from the Greek words *bryon* meaning moss and *phyton* meaning plant. So, essentially it means moss plant. These plants are characterised by a life cycle of alternating haploid and diploid generations, with a dominant gametophyte. It was Robert Brown who first introduced the term bryophyta in 1864 to include algae, fungi, lichens and mosses. Eichler (1883) divided bryophytes into two classes, the Hepaticaceae to include all liverworts and Musci to include all mosses. Engler (1892) divided each of the two classes into three orders: Hepaticaceae into Marchantiales, Jungermanniales and Anthocerotales and Musci into Sphagnales, Andreales and Bryales. The anomalous position of Anthocerotales as an order of the class Hepaticae was pointed out by many workers very early itself. However, it was Howe (Howe 1899) who gave status of class to this order. Generally, bryophytes are now divided into three classes, viz. Hepaticae (liverworts), Anthocerotae (hornworts) and Musci (mosses).

The first ever work dealing exclusively with bryophytes is *Historia Muscorum* (Dillenius 1741) by Dillenius, which also included algae, lichens, lycopods, etc. Linnaeus' *Species Plantarum* (Linnaeus 1753) is considered as the early study on bryophytes, especially *Sphagnum*; it also included some Indian mosses. The first noteworthy contribution to Indian bryology can be found in Griffith's (Griffith 1849a, b) *Notulae* and *Plantae Asiaticae*. Floristic studies on mosses, so richly distributed in the Indian sub-continent, have received little attention throughout the past, probably on account of nonavailability of literature. Even though the Hepaticae have received attention of Indian bryologists since Kashyap (1914), research on Indian mosses began only after a decade or two. However, contribution of scientists from abroad continued even during the early half of the twentieth century. Further, Chopra (1975) published his monumental work *Taxonomy of Indian Mosses*, which includes nearly 2000 species belonging to 329 genera in 56 families.

The role of bryophytes in ecosystem structure and functioning has been well-established. They play an important role in nutrient cycling, soil formation, biomonitoring studies, pollution indicators, climate change adaptation and some other aspects. Bryophytes are used in medicines, household purposes, horticulture, agriculture and fuel industries and as ecological indicators throughout the world.

However, there is also paucity of studies on the ecological functioning of bryophytes in India. Negi and Gadgil (1997) studied the species diversity and community ecology of mosses of Garhwal Himalaya and concluded that the microhabitat and altitude seem to be major ecological factors governing species diversity and composition. Bryophytes are widely used as bioindicators of environment for their unique capacity to absorb the pollutants and exhibit specific responses to even the slightest of environmental changes; some species are extremely sensitive to pollutants and exhibit visible injury symptoms even in the presence of very minute quantities of pollutants (Sahu et al. 2007). They have several biological features making them particularly suited to serve as study organisms in macroevolutionary population genetics and ecological research (Verma and Langer 2014). All workers have insisted that enough focus has not been given to study the bryoflora in India. They have so far been ignored for many reasons, especially because of their relatively less economic value. But recent studies have proven that they can be the resources of many phytochemical and pharmaceutical compounds (Alam 2012). This points to the fact that the conservation of bryophytes is very important in view of their critical role in ecosystem management. Thus, the study of bryoflora should be given due importance and undertaken on the priority basis.

Globally, bryophytes comprise of 20,000 species, belonging to 1050 genera (Oren et al. 2007; Beike and Rensing 2010; Vanderpoorten and Goffinet 2009), and are the second largest group of land plants after angiosperms. Mosses are noticeably more species-rich and widespread than liverworts and hornworts (Shaw and Goffinet 2000). In India, bryoflora is represented by about 2489 taxa, comprising of 1786 species in 355 genera of mosses, 675 species in 121 genera of liverworts and 25 species in 6 genera of hornworts (Dandotiya et al. 2011). Jammu and Kashmir has been equally endowed with rich bryoflora owing to its suitable climatic conditions but remains largely unexplored (Dar et al. 2012). Banday (1997) has explored the bryophytes of Gulmarg and adjacent areas and collected 63 species including 14 liverworts and 49 mosses. Later, Banday et al. (1998) enlisted 48 liverworts from Kashmir, including 25 foliose and 23 thallose forms, and reported absence of hornworts in the region. Dar et al. (2002) dealt with earlier works on liverworts and mosses in the Kashmir and listed 48 species of liverworts distributed over 25 genera in 16 families and 162 species, 2 subspecies and 9 varieties of mosses spread over 70 genera in 25 families from the region. Similarly, there are some preliminary reports on the liverworts of Ladakh region (Dolma and Langer 2012, 2013). Exploration of the Jammu region for bryoflora has revealed rich liverwort diversity, and many rare/threatened/endangered taxa have been reported (Tanwir and Langer 2004; Bhagat et al. 2012; Rashid et al. 2012). Notwithstanding these preliminary studies, information available on the bryophytes of the entire Jammu and Kashmir (J&K) State is insufficient, and whatever available is scattered in different publications which require urgent integration. In view of this fact, the present chapter provides an updated checklist of bryophytes in the J&K State.

## 16.2 Materials and Methods

For the present study, the taxonomic database on bryoflora of J&K State has been generated on the basis of systematic review of relevant scientific literature, herbarium studies in KASH, University of Kashmir, supplemented with field observations. The database has been arranged and authenticated by using an online source: The Plant List (www.plantlist.org). Each record was further authenticated primarily using online sources, such as Catalogue of Life, 2017, (http://www.catalogueoflife.org/col/search/all) and Encyclopedia of Life (http://eol.org/). In the database, the currently valid scientific name of each taxon, with its respective family, is supplemented with crucial information on provincial distribution (Kashmir, Jammu and Ladakh) and source(s) of its record in the State.

## 16.3 Results

The present chapter lists from J&K State a total of 453 taxa (species and infraspecific taxa) of bryophytes on the basis of different published sources (Table 16.1). Of these, 33 taxa are found to be doubtful records (Table 16.2), having been mentioned in literature from time to time but with no authentic record seen in the online source 'The Plant List (www.plantlist.org)' and other such databases. Thus, the checklist of bryophytes of the State comprises of 420 validly published species, out of which 328 species spread over 117 genera in 32 families belong to mosses and 91 species spread over 40 genera in 23 families belong to liverworts (Table 16.1; Fig. 16.1). Interestingly, only one species of hornworts, *Phaeoceros laevis*, is recorded from the State and that too restricted to Rajouri district of Jammu province. Families, such as Pottiaceae (66 spp.), Bryaceae (35 spp.) and Brachytheciaceae (32 spp.), are represented by large number of taxa (Fig. 16.2). Some of the genera of mosses, such as *Brachythecium* (24 spp.), *Orthotrichum* (17 spp.) and *Bryum* (13 spp.), are found to have relatively large number of species (Fig. 16.3). First five dominant families in liverworts, including Aytoniaceae (15 spp.), Porellaceae (11 spp.) and Marchantiaceae (9 spp.) are depicted in Fig. 16.4, whereas genera such as *Porella* (11 spp.), *Marchantia* (7 spp.) and *Plagiochila* (7 spp.) have relatively more number of species as compared to other genera of liverworts (Fig. 16.5). It is hoped that the present checklist will provide a baseline database for understanding the biodiversity of bryophytes in this Himalayan State, kick start the field survey of unexplored areas and undertake much-needed systematic studies on its rich bryoflora (Plate 16.1).

**Table 16.1** An updated checklist of bryophytes recorded from Jammu and Kashmir State

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| *A. Mosses* | | | | |
| 1 | *Atrichum angustatum* (Brid.) Bruch and Schimp. | Polytrichaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 2 | *Atrichum flavisetum* Mitt. Syn: *Atrichum undulatum* var. *haussknechtii* (Jur and Milde) Frye | Polytrichaceae | Jammu, Kashmir | Dar et al. (2002), Banday (2012) and Sharma et al. (2016) |
| 3 | *Atrichum longifolium* Cardot and Dixon ex Gangulee | Polytrichaceae | Jammu | Sharma et al. (2016) |
| 4 | *Atrichum undulatum* (Hedw.) P. Beauv. | Polytrichaceae | Kashmir | Dar et al. (2002) |
| 5 | *Atrichum undulatum* var. *subserratum* (Harv. and Hook.f.) Paris | Polytrichaceae | Kashmir | Dar et al. (2002) |
| 6 | *Catharinea aculeata* (Cardot and P. de la Varde) Broth. Syn: *Atrichum acuelatum* Cardot and P.de la varde | Polytrichaceae | Kashmir | Dandotiya et al. (2011) |
| 7 | *Lyellia bifurcata* Bél. | Polytrichaceae | Kashmir | Dandotiya et al. (2011) |
| 8 | *Pogonatum urnigerum* (Hedw.) P. Beauv. Syn: *Pogonatum himalayanum* Mitt. | Polytrichaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011)and Banday (2012) |
| 9 | *Polytrichum juniperinum* Hedw. | Polytrichaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 10 | *Polytrichum piliferum* Hedw. | Polytrichaceae | Kashmir | Banday (2012) |
| 11 | *Theriotia kashmirensis* H. Rob. | Bauxbaumiaceae | Kashmir | Dandotiya et al. (2011) and Banday (2012) |
| 12 | *Theriotia lorifolia* Cardot | Bauxbaumiaceae | Kashmir | Dandotiya et al. (2011) |
| 13 | *Timmia austriaca* Hedw. | Timmiaceae | Kashmir | Dandotiya et al. (2011) |
| 14 | *Timmia megapolitana* Hedw. | Timmiaceae | Kashmir | Dandotiya et al. (2011) |
| 15 | *Timmia megapolitana* ssp. *bavarica* (Hessl.) Brassard Syn: *Timmia bavarica* Hessl. | Timmiaceae | Kashmir | Dandotiya et al. (2011) |
| 16 | *Encalypta alpina* Sm. | Encalyptaceae | Kashmir | Dandotiya et al. (2011) |
| 17 | *Encalypta ciliata* Hedw. | Encalyptaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 18 | *Encalypta rhabdocarpa* var. *leiomitra* Kindb. | Encalyptaceae | Kashmir | Dandotiya et al. (2011) and Banday (2012) |
| 19 | *Encalypta streptocarpa* Hedw. | Encalyptaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday 2012 |
| 20 | *Encalypta tibetana* Mitt. | Encalyptaceae | Kashmir | Dandotiya et al. (2011) and Banday (2012) |
| 21 | *Encalypta vulgaris* Hedw. | Encalyptaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 22 | *Entosthodon attenuatus* (Dicks.) Bryhn Syn*: Funaria attenuata* (Dicks.) Lindb. | Funariaceae | Kashmir | Banday (2012) |
| 23 | *Entosthodon fascicularis* (Hedw.) Müll. Hal. Syn: *Funaria fascicularis* (Hedw.) Lindb. | Funariaceae | Kashmir | Banday (2012) |
| 24 | *Funaria capillipes* Broth. | Funariaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |
| 25 | *Funaria hygrometrica* Hedw. | Funariaceae | Jammu, Kashmir | Dar et al. (2002), Dandotiya et al. (2011), Banday (2012) and Sharma et al. (2016) |
| 26 | *Funaria koelzei* E.B. Bartram | Funariaceae | Kashmir | Dandotiya et al. (2011) |
| 27 | *Funaria muhlenbergii* Turner Syn: *Funaria mediterranea* Lindb. | Funariaceae | Kashmir | Dandotiya et al. (2011) |
| 28 | *Funaria orthocarpa* Mitt. | Funariaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |
| 29 | *Funaria pilifera* (Mitt.) Broth. | Funariaceae | Kashmir | Dandotiya et al. (2011) |
| 30 | *Funaria pulchella* H. Philib. Syn: *Funaria calcarea* var. *mediterranea* (Lindb.) C.E.O. Jenson and Medelius | Funariaceae | Kashmir | Dar et al. (2002) |
| 31 | *Funaria wijkii* R.S. Chopra | Funariaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 32 | *Physcomitrium pyriforme* (Hedw.) Hampe | Funariaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 33 | *Coscinodon cribrosus* (Hedw.) Spruce | Grimmiaceae | Kashmir | Dandotiya et al. (2011) |
| 34 | *Grimmia alpestris* (F. Weber and D. Mohr) Schleich. | Grimmiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 35 | *Grimmia anodon* Bruch and Schimp. | Grimmiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 36 | *Grimmia elatior* Bruch ex Bals.-criv. and De Not. | Grimmiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 37 | *Grimmia laevigata* (Brid.) Brid. | Grimmiaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 38 | *Grimmia ovalis* (Hedw.) Lindb. | Grimmiaceae | Jammu, Kashmir | Dar et al. (2002), Banday (2012) and Sharma et al. (2016) |
| 39 | *Grimmia poecilostoma* Cardot and Sebille | Grimmiaceae | J&K[a] | Dandotiya et al. (2011) |
| 40 | *Grimmia pulvinata* (Hedw.) Sm. | Grimmiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 41 | *Grimmia trichophylla* Grev. | Grimmiaceae | Kashmir | Banday (2012) |
| 42 | *Grimmia unicolor* Hook. | Grimmiaceae | Kashmir | Dandotiya et al. (2011) and Banday (2012) |
| 43 | *Indusiella thianschanica* Broth. and Müll. Hal. | Grimmiaceae | Kashmir | Dandotiya et al. (2011) |
| 44 | *Schistidium agassizii* Sull. and Lesq. | Grimmiaceae | Kashmir | Banday (2012) |
| 45 | *Schistidium apocarpum* (Hedw.) Bruch and Schimp. | Grimmiaceae | Jammu | Sharma et al. (2016) |
| 46 | *Schistidium apocarpum* ssp. *gracile* (Röhl.) Meyl. | Grimmiaceae | Kashmir | Dandotiya et al. (2011) and Banday (2012) |
| 47 | *Schistidium strictum* (Turner) Loeske ex Martensson | Grimmiaceae | Kashmir | Banday (2012) |
| 48 | *Fissidens diversifolia* Mitt. | Fissidentaceae | Kashmir | Dandotiya et al. (2011) |
| 49 | *Fissidens dubius* P. Beauv. Syn: *Fissidens cristatus* Wilson and Mitt. | Fissidentaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Bandey Banday (2012) |
| 50 | *Fissidens grandifrons* Brid. | Fissidentaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 51 | *Fissidens involutus* Wilson ex Mitt.<br>Syn: *Fissidens plagiochiloides* Besch. | Fissidentaceae | Jammu | Sharma et al. (2016) |
| 52 | *Fissidens robinsonii* Broth. | Fissidentaceae | Jammu | Sharma et al. (2016) |
| 53 | *Fissidens subpalmatus* Müll. Hal. | Fissidentaceae | Jammu | Sharma et al. (2016) |
| 54 | *Fissidens taxifolius* Hedw. | Fissidentaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 55 | *Fissidens zollingeri* Mont.<br>Syn: *Fissidens xiphioides* M. Fleisch. | Fissidentaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 56 | *Ceratodon purpureus* (Hedw.) Brid. | Ditrichaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 57 | *Ceratodon stenocarpus* Bruch and Schimp. | Ditrichaceae | Kashmir | Dandotiya et al. (2011) |
| 58 | *Distichium capillaceum* (Hedw.) Bruch and Schimp. | Ditrichaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 59 | *Distichium inclinatum* (Hedw.) Bruch and Schimp. | Ditrichaceae | Kashmir | Dandotiya et al. (2011) |
| 60 | *Saelania glaucescens* (Hedw.) Broth. | Ditrichaceae | Kashmir | Dandotiya et al. (2011) |
| 61 | *Brothera leana* (Sull.) Müll. Hal. | Dicranaceae | Kashmir | Dandotiya et al. (2011) |
| 62 | *Campylopus recurvis* Mitt.<br>Syn: *Campylopus sedwickii* Dixon | Dicranaceae | Kashmir | Dandotiya et al. (2011) |
| 63 | *Campylopus fragilis* var. *pyriformis* (Schultz) Agst. | Dicranaceae | Kashmir | Dandotiya et al. (2011) and Banday (2012) |
| 64 | *Dicranoweisia cirrata* (Hedw.) Lindb. | Dicranaceae | Kashmir | Dandotiya et al. (2011) |
| 65 | *Dicranoweisia crispula* (Hedw.) Milde | Dicranaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 66 | *Dicranella heteromalla* (Hedw.) Schimp. | Dicranaceae | Kashmir | Banday (2012) |
| 67 | *Dicranella varia* (Hedw.) Schimp. | Dicranaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 68 | *Dicranum Kashmirense* Broth. | Dicranaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 69 | *Dicranum lorifolium* Mitt. | Dicranaceae | Kashmir | Dandotiya et al. (2011) |
| 70 | *Dicranum majus* Turner | Dicranaceae | Kashmir | Banday (2012) |
| 71 | *Dicranum montanum* Hedw. | Dicranaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 72 | *Dicranum scoparium* Hedw. | Dicranaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 73 | *Leucobryum neilgherrense* Müll. Hal. | Dicranaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 74 | *Microdus brasiliensis (*Duby) Thér. | Dicranaceae | Kashmir | Dar et al. (2002) |
| 75 | *Oncophorus virens* (Hedw.) Brid. | Dicranaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 76 | *Oncophorus wahlenbergii* Brid.<br>Syn: *Oncophorus gracillimus* Dixon | Dicranaceae | Kashmir | Dandotiya et al. (2011) |
| 77 | *Oreas martiana* (Hoppe and Hornsch.) Brid. | Dicranaceae | Kashmir | Dandotiya et al. (2011) |
| 78 | *Oroweisia laxifolia* (Hook.f.) Kindb. | Dicranaceae | Kashmir | Dandotiya et al. (2011) |
| 79 | *Orthodicranum montanum* (Hedw.) Loeske | Dicranaceae | Kashmir | Dandotiya et al. (2011) |
| 80 | *Trematodon capillifolius* Müll. Hal. ex G. Roth | Bruchiaceae | Kashmir | Dar et al. (2002) |
| 81 | *Acaulon triquetrum* (Spruce) Müll. Hal. | Pottiaceae | Kashmir | Banday (2012) |
| 82 | *Aloina rigida* (Hedw.) Limpr. | Pottiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 83 | *Barbula amplexifolia* (Mitt.) A. Jaeger | Pottiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 84 | *Barbula canaliculata* (Dixon) R.S Chopra | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 85 | *Barbula constricta* Mitt. | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 86 | *Barbula convoluta* Hedw. | Pottiaceae | Kashmir | Banday (2012) |
| 87 | *Barbula gracilenta* Mitt. | Pottiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 88 | *Barbula indica* (Hook.) Spreng. | Pottiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 89 | *Barbula microstoma* (Dixon and Badhw.) R.S. Chopra | Pottiaceae | Kashmir | Dandotiya et al. (2011) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 90 | *Barbula rigidula* (Hedw.) Mitt. | Pottiaceae | Kashmir | Banday (2012) |
| 91 | *Barbula stewartii* E.B. Bartram | Pottiaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |
| 92 | *Barbula trifaria* (Hedw.)Mitt. | Pottiaceae | Kashmir | Banday (2012) |
| 93 | *Barbula unguiculata* Hedw. | Pottiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 94 | *Bryoerythrophyllum alpigenum* (Vent.) P.C. Chen | Pottiaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 95 | *Bryoerythrophyllum noguchianum* (Gangulee) K. Saito. Syn: *Bryoerythrophyllum yunnanense* var. *noguchianum* Gangulee | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 96 | *Bryoerythrophyllum recurvirostrum* (Hedw.) P.C. Chen | Pottiaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 97 | *Bryoerythrophyllum wallichii* (Mitt.) P.C. Chen | Pottiaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 98 | *Didymodon asperfolius* (Mitt.) H.A. Crum, Steere and L.E. Anderson Syn: *Barbula asperfolia* Mitt. | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 99 | *Didymodon canaliculatus* Dixon | Pottiaceae | Kashmir | Dar et al. (2002) |
| 100 | *Didymodon fallax* Hedw. Syn: *Barbula fallax* Hedw. | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 101 | *Didymodon ferrugineus* (Schimp. ex Besch.) M.O. Hill Syn: *Barbula reflexa* (Brid.) Brid | Pottiaceae | Kashmir | Dar et al. (2002)and Banday (2012) |
| 102 | *Didymodon microstomus* Dixon and Badhw. | Pottiaceae | Kashmir | Dar et al. (2002) |
| 103 | *Didymodon rigidulus* var. *icmadophilus* (Schimp. ex Müll. Hal.) R.H. Zander Syn*: Didymodon icmadophila* (Schimp. ex Müll. Hal.) K. Saito. | Pottiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 104 | *Didymodon tophaceus* (Brid.) Lisa<br>Syn: *Barbula tophacea* (Brid.) Mitt. | Pottiaceae | Kashmir | Banday (2012) |
| 105 | *Didymodon vinealis* (Brid.) R.H. Zander | Pottiaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 106 | *Gymnostomum aeruginosum* Sm. | Pottiaceae | Kashmir | Banday (2012) |
| 107 | *Hydrogonium amplexifolium* (Mitt.) P.C. Chen | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 108 | *Hydrogonium arcuatum* (Griff.) Wijk and Margad. | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 109 | *Hydrogonium gracilentum* (Mitt.) P.C. Chen | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 110 | *Hydrogonium javanicum* (Dozy and Molk.) Hilp. | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 111 | *Hydrogonium pseudoerhenbergii* (M. Fliesch.) P.C. Chen | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 112 | *Hymenostylium filiforme* Dixon | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 113 | *Hymenostylium recurvirostrum* (Hedw.) Dixon<br>Syn: *Gymnostomum recurvirostrum* Hedw. | Pottiaceae | Kashmir | Banday (2012) |
| 114 | *Hyophila involuta* (Hook.) A. Jaeger | Pottiaceae | Jammu | Sharma et al. (2016) |
| 115 | *Microbryum starkeana* (Hedw.) R.H. Zander<br>Syn: *Pottia starkeana* (Hedw.) Müll. Hal. | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 116 | *Molendoa roylei* (Mitt.) Broth. | Pottiaceae | Kashmir | Dar et al. (2002) |
| 117 | *Molendoa sendtneriana* (Bruch and Schimp.) Limpr.<br>Syn: *Anoectangium sendtnerianum* Bruch and Schimp. | Pottiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 118 | *Pleurochaete squarrosa* (Brid.) Lindb | Pottiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 119 | *Pseudocrossidium hornschuchiana* (Schultz) R.H. Zander<br>Syn: *Barbula hornschuchiana* Schultz | Pottiaceae | Kashmir | Banday (2012) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 120 | *Pseudocrossidium revolutum* (Brid.) R.H. Zander<br>Syn: *Barbula revoluta* Brid. | Pottiaceae | Kashmir | Banday (2012) |
| 121 | *Pseudosymblepharis bombayensis* (Müll. Hal.) P. Sollman<br>Syn: *Trichostomum uncinofolium* Dixon | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 122 | *Pterygoneurum ovatum* (Hedw.) Dixon | Pottiaceae | Kashmir | Banday (2012) |
| 123 | *Stegonia latifolia* (Schwägr.) Venturi ex Broth. | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 124 | *Syntrichia brandisii* (Müll. Hal.) R.H. Zander<br>Syn: *Tortula brandisii* (Müll. Hal.) Broth. | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 125 | *Syntrichia montana* Nees<br>Syn: *Tortula intermedia* (Brid.) De Not. | Pottiaceae | Kashmir | Banday (2012) |
| 126 | *Syntrichia norvegica* F. Weber<br>Syn: *Tortula norvegica* (F. Weber) Lindb. | Pottiaceae | Kashmir | Dar et al. (2002) |
| 127 | *Syntrichia ruralis* (Hedw.) F. Weber and D. Mohr<br>Syn: *Tortula ruralis* (Hedw.) P. Gaertn., B. Mey. and Scherb. | Pottiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 128 | *Timmiella anomala* (Bruch and Schimp) Limpr. | Pottiaceae | Jammu, Kashmir | Dar et al. (2002), Dandotiya et al. (2011), Banday (2012) and Sharma et al. (Sharma et al. 2011) |
| 129 | *Timmiella diminuta* (Müll. Hal.) P.C. Chen | Pottiaceae | Jammu | Sharma et al. (2016) |
| 130 | *Timmiella subintegra* Dixon | Pottiaceae | Jammu | Sharma et al. (2016) |
| 131 | *Tortella alpicola* Dixon | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 132 | *Tortella fragilis* (Hook. and Wilson) Limpr. | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 133 | *Tortella tortuosa* (Hedw.) Limpr. | Pottiaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 134 | *Tortula hoppeana* (Schultz ) Ochyra<br>Syn: *Desmatodon latifolius* (Hedw.) Brid. | Pottiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 135 | *Tortula inermis* (Brid.) Mont. | Pottiaceae | Kashmir | Dar et al. (2002) |
| 136 | *Tortula muralis* Hedw. | Pottiaceae | Kashmir | Dandotiya et al. (2011) and Banday (2012) |
| 137 | *Tortula subulata* Hedw. | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 138 | *Tortula norvegica* var. *norvegica* Dixon<br>Syn: *Tortula rubripila* Dixon | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 139 | *Tortula pseudoprinceps* Dixon | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 140 | *Tortula virescens* (De Not.) De Not. | Pottiaceae | Kashmir | Banday (2012) |
| 141 | *Trichostomum brachydontium* Bruch | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 142 | *Trichostomum tenuirostre* (Hook. and Taylor) Lindb.<br>Syn: *Oxystegus cylindricus* (Bruch ex Brid.) Hilp., *O. tenuirostris* (Hook. and Taylor) A. J. E. Sm. | Pottiaceae | Jammu, Kashmir | Dandotiya et al. (2011) and Sharma et al. (2016) |
| 143 | *Weissia brachycarpa* (Nees and Hornsch) Jur.<br>Syn: *Hymenostomum microstomum* (Hedw.) R. Br. | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 144 | *Weissia controversa* Hedw. | Pottiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 145 | *Weissia rutilans* (Hedw.) Lindb | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 146 | *Weissia wimmeriana* (Sendtn.) Bruch and Schimp. | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 147 | *Cinclidotus acutifolius* Broth. | Cinclidotaceae | Kashmir | Dandotiya et al. (2011) |
| 148 | *Tayloria froelichiana* (Hedw.) Mitt. ex Broth. | Splanchaceae | Kashmir | Dandotiya et al. (2011) |
| 149 | *Amblydon dealbatus* (Sw. ex Hedw.) Bruch and Schimp. | Meesiaceae | Kashmir | Dandotiya et al. (2011) |
| 150 | *Anomobryum astorense* (Broth.) Broth. | Bryaceae | Kashmir | Dandotiya et al. (2011) |

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**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 151 | *Anomobryum auratum* (Mitt.) A. Jaeger | Bryaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |
| 152 | *Anomobryum cymbifolium* (Lindb.) Broth. | Bryaceae | Kashmir | Dar et al. (2002) |
| 153 | *Anomobryum julaceum* (Schrad. ex P. Gaertn., B. Mey. and Scherb.) Schimp. | Bryaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 154 | *Anomobryum kashmirense* (Broth.) Broth. | Bryaceae | Kashmir | Dandotiya et al. (2011) |
| 155 | *Anomobryum parvifolium* E.B. Bartram | Bryaceae | Kashmir | Dandotiya et al. (2011) |
| 156 | *Anomobryum pellucidium* Dixon and Badhw. | Bryaceae | Kashmir | Dandotiya et al. (2011) |
| 157 | *Bryum alpinum* Huds. ex With. | Bryaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 158 | *Bryum argentum* Hedw. Syn: *Bryum argentum* var. *lanatum* (P. Beauv.) Hampe | Bryaceae | Kashmir | Dar et al. (2002) |
| 159 | *Bryum caespiticium* Hedw. | Bryaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 160 | *Bryum evanidinerve* Broth. Syn: *Bryum gamblei* Broth. | Bryaceae | Kashmir | Dar et al. (2002) |
| 161 | *Bryum inclinatum* (Hedw.) Dicks. ex With. | Bryaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 162 | *Bryum mildeanum* (Jur.) Podp. Syn: *Bryum alpinum* var. *mildeanum* (Jur.) Podp. | Bryaceae | Kashmir | Dar et al. (2002) |
| 163 | *Bryum muchlenbeckii* Bruch and Schimp. | Bryaceae | Kashmir | Banday (2012) |
| 164 | *Bryum pallens* Sw. | Bryaceae | Kashmir | Banday (2012) |
| 165 | *Bryum paradoxum* Schwägr. Syn: *Bryum teretuisculum* Hook. ex Harv. | Bryaceae | Kashmir | Dar et al. (2002) |
| 166 | *Bryum pseudotriquetrum* (Hedw.) P. Gaertn., B. Mey. and Scherb. | Bryaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 167 | *Bryum schleicheri* Schwägr. | Bryaceae | Kashmir | Dar et al. (2002) and Banday (2012) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 168 | *Bryum uliginosum* (Brid.) Bruch and Schimp. | Bryaceae | Kashmir | Dandotiya et al. (2011) |
| 169 | *Bryum weigelii* Spreng. | Bryaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 170 | *Haplodontium fabroniodes* Cardot | Bryaceae | Kashmir | Dandotiya et al. (2011) |
| 171 | *Leptobryum pyriforme* (Hedw.) Wilson | Bryaceae | Kashmir | Dandotiya et al. (2011) |
| 172 | *Mielichhoferia badhwarii* Dixon | Bryaceae | Kashmir | Dandotiya et al. (2011) |
| 173 | *Mielichhoferia himalayana* Mitt. | Bryaceae | Kashmir | Dandotiya et al. (2011) |
| 174 | *Mniobryum wahlenbergii* (F. Weber and D. Mohr) Jenn. | Bryaceae | Kashmir | Dandotiya et al. (2011) |
| 175 | *Pohlia cruda* (Hedw.) Lindb. | Bryaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 176 | *Pohlia elongata* Hedw. | Bryaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 177 | *Pohlia longicolla* (Hedw.) Lindb. | Bryaceae | Kashmir | Dandotiya et al. (2011) |
| 178 | *Pohlia ludwigii* (Spreng. ex Schwägr.) Broth.<br>Syn*: Mniobryum ludwigii* (Spreng. ex Schwägr.) Loeske | Bryaceae | Kashmir | Dandotiya et al. (2011) |
| 179 | *Pohlia melanodon* (Brid.) A.J. Shaw.<br>Syn: *Mniobryum delicatulum* (Hedw.) Dixon | Bryaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 180 | *Pohlia minor* Schleich. ex Schwägr. | Bryaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 181 | *Pohlia nutans* (Hedw.) Lindb. | Bryaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 182 | *Ptychostomum capillare* (Hedw.) D.T. Holyoak and N. Pedersen<br>Syn: *Bryum capillare* Hedw. | Bryaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 183 | *Rhodobryum ontariense* (Kindb.) Paris | Bryaceae | Kashmir | Dandotiya et al. (2011) |
| 184 | *Rhodobryum roseum* (Hedw.) Limpr. | Bryaceae | Jammu | Sharma et al. (2016) |
| 185 | *Mnium integrum* Bosch and Sande Lac. | Mniaceae | Kashmir | Kour et al. (2015a) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 186 | *Mnium lycopodioides* Schwägr. | Mniaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |
| 187 | *Mnium marginatum* (Dicks. ex With.) P. Beauv. | Mniaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 188 | *Mnium spinulosum* Bruch and Schimp. | Mniaceae | Jammu | Sharma et al. (2016) |
| 189 | *Mnium spinosum* (Volt) Schwägr. | Mniaceae | Kashmir | Banday (2012) |
| 190 | *Mnium succulentum* Mitt. | Mniaceae | Kashmir | Kour et al. (2015a) |
| 191 | *Mnium thomsonii* Schimp. | Mniaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 192 | *Plagiomnium affine* (Blandow ex Funck) T.J. Kop. Syn: *Mnium affine* Blandow ex Funck | Mniaceae | Kashmir | Dandotiya et al. (2011) |
| 193 | *Plagiomnium confertidens* (Lindb. and Arnell) T.J. Kop Syn: *Mnium conferitidens* (Lindb. and Arnell) Kindb. | Mniaceae | Kashmir | Kour et al. (2015a) |
| 194 | *Plagiomnium cuspidatum* (Hedw.) T.J. Kop. Syn: *Mnium cuspidatum* Hedw. | Mniaceae | Kashmir | Dandotiya et al. (2011) and Kour et al. (2015a) |
| 195 | *Plagiomnium elatum* (Bruch and Schimp.) T.J. Kop. | Mniaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 196 | *Plagiomnium ellipticum* (Brid) T.J. Kop. | Mniaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 197 | *Plagiomnium medium* (Bruch and Schimp.) T.J. Kop. | Mniaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 198 | *Plagiomnium rostratum* (Schrad.) T.J. Kop. Syn: *Mnium rostratum* Schrad. | Mniaceae | Kashmir | Dandotiya et al. (2011) and Kour et al. (2015a) |
| 199 | *Rhizomnium punctatum* (Hedw.) T.J. Kop. | Mniaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 200 | *Bartramia halleriana* Hedw. | Bartramaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 201 | *Bartramia ithphylla* Brid. | Bartramaceae | Kashmir | Dandotiya et al. (2011) and Banday (2012) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 202 | *Conostomum tetragonum* (Hedw.) Lindb. | Bartramaceae | Kashmir | Dandotiya et al. (2011) |
| 203 | *Philonotis calcarea* (Bruch and Schimp.) Schimp. | Bartramaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 204 | *Philonotis falcata* (Hook.) Mitt. | Bartramaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Kour et al. ( 2015a, b) |
| 205 | *Philonotis fontana* (Hedw.) Brid. | Bartramaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 206 | *Philonotis fontana* var. *pumila* (Turner) Brid. | Bartramaceae | Kashmir | Dar et al. (2002) |
| 207 | *Philonotis seriata* Mitt. | Bartramaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 208 | *Philonotis turneriana* (Schwägr.) Mitt. | Bartramaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |
| 209 | *Plagiopus oederianus* (Sw.) H.A. Crum and L.E. Anderson<br>Syn: *Plagiopus oederi* (Brid.) Limpr. | Bartramaceae | Kashmir | Dandotiya et al. (2011) |
| 210 | *Amphidium lapponicum* (Hedw.) Schimp. | Orthotrichaceae | Kashmir | Dar et al. (2002) |
| 211 | *Orthotrichum affine* Schrad. ex Brid. | Orthotrichaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 212 | *Orthotrichum alpestre* Hornsch. ex B.S.G.<br>Syn: *Orthotrichum duthiei* Venturi<br>Syn: *O. venustum* Venturi | Orthotrichaceae | Kashmir | Dandotiya et al. (2011) |
| 213 | *Orthotrichum anomalum* Hedw. | Orthotrichaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 214 | *Orthotrichum crenulatum* Mitt.<br>Syn: *Orthotrichum virens* Venturi | Orthotrichaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 215 | *Orthotrichum cupulatum* Hoffm. ex Brid. | Orthotrichaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 216 | *Orthotrichum griffithii* Mitt. ex Dixon | Orthotrichaceae | Kashmir | Dandotiya et al. (2011) |
| 217 | *Orthotrichum hispanicum* F. Lara, Garilleti and Mazimpaka | Orthotrichaceae | Kashmir | Dandotiya et al. (2011) |
| 218 | *Orthotrichum laevigatum* J.E. Zetterst. | Orthotrichaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 219 | *Orthotrichum macounii* Austin | Orthotrichaceae | Kashmir | Dandotiya et al. (2011) |
| 220 | *Orthotrichum obtusifolium* Brid. | Orthotrichaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 221 | *Orthotrichum pumilum* Sw. | Orthotrichaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 222 | *Orthotrichum rupestre* Schleich ex Schwägr. | Orthotrichaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 223 | *Orthotrichum rupestre* ssp. *sturmii* (Hoppe and Hornsch.) Boulay Syn: *Orthotrichum sturmii* Hoppe. and Hornsch. | Orthotrichaceae | Kashmir | Dandotiya et al. (2011) |
| 224 | *Orthotrichum speciosum* Nees | Orthotrichaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 225 | *Orthotrichum stramineum* Hornsh. | Orthotrichaceae | Kashmir | Banday (2012) |
| 226 | *Orthotrichum striatum* Hedw. | Orthotrichaceae | Kashmir | Dandotiya et al. (2011) and Banday (2012) |
| 227 | *Orthotrichum urnigerum* Myrin | Orthotrichaceae | Kashmir | Dandotiya et al. (2011) and Banday (2012) |
| 228 | *Zygodon rupestris* Schimp. ex Lorentz Syn: *Zygodon baumgartneri* Malta | Orthotrichaceae | Kashmir | Banday (2012) |
| 229 | *Zygodon viridissimus* (Dicks.) Brid. | Orthotrichaceae | Kashmir | Banday (2012) |
| 230 | *Braunia attenuata* (Mitt.) A. Jaeger | Hedwigiaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 231 | *Hedwigia ciliata* (Hedw.) P. Beauv. | Hedwigiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 232 | *Aulacominium androgynum* (Hedw.) Schwägr. | Aulacomniaceae | Kashmir | Dandotiya et al. (2011) |
| 233 | *Aulacomnium palustre* (Hedw.) Schwägr. | Aulacomniaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 234 | *Aulacomnium turgidum* (Wahelnb.) Schwägr. | Aulacomniaceae | Kashmir | Dandotiya et al. (2011) |
| 235 | *Amblystegium humile* (P. Beauv.) Crundw. | Amblystegiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 236 | *Amblystegium riparium* (Hedw.) Schimp. | Amblystegiaceae | Kashmir | Banday (2012) |
| 237 | *Amblystegium serpens* (Hedw.) Schimp. | Amblystegiaceae | Jammu, Kashmir | Dandotiya et al. (2011), Banday (2012) and Sharma et al. (2016) |
| 238 | *Campylium hispidulum* (Brid.) Mitt. | Amblystegiaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |
| 239 | *Cratoneuron commutatum* (Hedw.) G. Roth | Amblystegiaceae | Kashmir | Dar et al. (2002), Banday (2012) and Kour et al. (2015a, b) |
| 240 | *Cratoneuron commutatum* var. *falcatum* (Brid.) Mönk. | Amblystegiaceae | Kashmir | Dar et al. (2002) |
| 241 | *Cratoneuron filicinum* (Hedw.) Spruce | Amblystegiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 242 | *Cratoneuron filicinum* var. *fallax* (Brid.) G. Roth | Amblystegiaceae | Kashmir | Dar et al. (2002) |
| 243 | *Drepanocladus aduncus* (Hedw.) Warnst. | Amblystegiaceae | Kashmir | Dar et al. (2002), Banday (2012) and Kour et al. (2015a, b) |
| 244 | *Drepanocladus exannulatus* (Schimp.) Warnst. | Amblystegiaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 245 | *Drepanocladus uncinatus* (Hedw.) Warnst. | Amblystegiaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 246 | *Hygrohypnum duriusculum* (De Not.) D.W. Jamieson Syn: *Hygrohypnum dilatatum* (Wilson) Loeske | Amblystegiaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 247 | *Hygrohypnum luridum* (Hedw.) Jenn. | Amblystegiaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 248 | *Platydictya subtilis* (Hedw.) H.A. Crum | Amblystegiaceae | Kashmir | Dandotiya et al. (2011) |
| 249 | *Abietinella abietina* (Hedw.) M. Fleisch. | Thuidiaceae | J&K[a] | Dandotiya et al. (2011) |
| 250 | *Anomodon acutifolius* Mitt. | Thuidiaceae | Kashmir | Dandotiya et al. (2011) |
| 251 | *Anomodon attenuatus* (Hedw.) Huebner | Thuidiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 252 | *Anomodon viticulosus* (Hedw.) Hook. and Taylor | Thuidiaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 253 | *Claopodium assurgens* (Sull. and Lesq.) Cardot | Thuidiaceae | Jammu | Sharma et al. (2016) |
| 254 | *Claopodium pellucinerve* (Mitt.) Best | Thuidiaceae | Kashmir | Dar et al. (2002); Banday (2012) |
| 255 | *Haplocladium microphyllum* (Hedw.) Broth. | Thuidiaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011), Banday (2012) and Kour et al. (2015a, b) |
| 256 | *Haplocladium microphyllum* ssp. *capillatum* (Mitt.) Reimers | Thuidiaceae | Kashmir | Dandotiya et al. (2011) |
| 257 | *Thuidium meyenianum* (Hampe.) Dozy and Molk. | Thuidiaceae | Jammu | Dandotiya et al. (2011) |
| 258 | *Thuidium recognitum* ssp. *philibertii* (Limpr.) Dixon Syn: *Thuidium philibertii* Limpr. | Thuidiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 259 | *Habrodon kashmiriensis* Vohra | Leskeaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 260 | *Lescuraea incurvata* (Hedw.) E. Lawton | Leskeaceae | Kashmir | Dar et al. (2002) |
| 261 | *Lescuraea laevifolia* (Mitt.) R.S. Chopra | Leskeaceae | Kashmir | Dar et al. (2002) |
| 262 | *Lescuraea mutabilis* (Brid.) Lindb. | Leskeaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 263 | *Lescuraea saxicola* (Schimp.) Molendo | Leskeaceae | Kashmir | Dar et al. (2002) and Banday (2012) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 264 | *Leskea hyaloapiculata* Dixon | Leskeaceae | Kashmir | Dandotiya et al. (2011) |
| 265 | *Leskeella incrassata* (Lindb. ex Broth.) Broth. | Leskeaceae | Kashmir | Dandotiya et al. (2011) |
| 266 | *Leskeella nervosa* (Brid.) Loeske | Leskeaceae | Kashmir | Dandotiya et al. (2011) |
| 267 | *Lindbergia duthiei* (Broth.) Broth. | Leskeaceae | Kashmir | Banday (2012) |
| 268 | *Pseudoleskea laevifolia* (Mitt.) A. Jaeger | Leskeaceae | Kashmir | Banday (2012) |
| 269 | *Pseudoleskea incurvata* (Hedw.) Loeske | Leskeaceae | Kashmir | Banday (2012) |
| 270 | *Pseudoleskeella catenulata* (Brid. ex Schrad.) Kindb. | Leskeaceae | Kashmir | Dandotiya et al. (2011) |
| 271 | *Brachythecium brachycladum* Paris | Brachytheciaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 272 | *Brachythecium buchananii* (Hook.) A. Jaeger | Brachytheciaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 273 | *Brachythecium cirrosum* (Schwägr.) Schimp. | Brachytheciaceae | Kashmir | Dandotiya et al. (2011) |
| 274 | *Brachythecium collinum* (Schleich. ex Müll. Hal.) Schimp.<br>Syn: *Brachythecium myurelliforme* Dixon | Brachytheciaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 275 | *Brachythecium curvatulum* (Broth.) Paris | Brachytheciaceae | Kashmir | Banday (2012) |
| 276 | *Brachythecium falcatum* (Grout) H. A. Crum | Brachytheciaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 277 | *Brachythecium glabratum* (Broth.) Paris | Brachytheciaceae | Kashmir | Dar et al. (2002) |
| 278 | *Brachythecium glaciale* Schimp. | Brachytheciaceae | Kashmir | Banday (2012) |
| 279 | *Brachythecium glareosum* (Bruch ex Spruce) Schimp. | Brachytheciaceae | Kashmir | Dar et al. (2002) |
| 280 | *Brachythecium indicopopuleum* Dixon | Brachytheciaceae | Kashmir | Banday (2012) |
| 281 | *Brachythecium kamounense* (Harv.) A. Jaeger | Brachytheciaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011), Banday (2012) and Kour et al. (2015a, b) |
| 282 | *Brachythecium kashmirense* (Broth.) Paris | Brachytheciaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 283 | *Brachythecium longicuspidatum* (Mitt.) A. Jaeger | Brachytheciaceae | Kashmir | Dandotiya et al. (2011) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 284 | *Brachythecium mildeanum* (Schimp.) Schimp. | Brachytheciaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 285 | *Brachythecium obsoletinerve* Dixon | Brachytheciaceae | Kashmir | Banday (2012) |
| 286 | *Brachythecium plumosum* (Hedw.) Schimp. | Brachytheciaceae | Kashmir | Dar et al. (2002), Banday (2012) and Kour et al. (2015a, b) |
| 287 | *Brachythecium populeum* (Hedw.) Schimp. | Brachytheciaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 288 | *Brachythecium procumbens* (Mitt.) A. Jaeger | Brachytheciaceae | J&K[a] | Dandotiya et al. (2011) |
| 289 | *Brachythecium reflexum* (Starke) Schimp. | Brachytheciaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 290 | *Brachythecium rivulare* Schimp. | Brachytheciaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 291 | *Brachythecium rutabulum* (Hedw.) Schimp. | Brachytheciaceae | Kashmir | Dar et al. (2002), Banday (2012) and Kour et al. (2015a, b) |
| 292 | *Brachythecium salebrosum* (Hoffm. ex F. Weber and D. Mohr.) Schimp. | Brachytheciaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 293 | *Brachythecium velutinum* (Hedw.) Schimp. | Brachytheciaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 294 | *Brachythecium waziriense* Dixon | Brachytheciaceae | Kashmir | Banday (2012) |
| 295 | *Eurhynchium Pulchellum* (Hedw.) Jenn. | Brachytheciaceae | Kashmir | Dandotiya et al. (2011) |
| 296 | *Eurhynchium ripariodes* (Hedw.) P.W. Richards | Brachytheciaceae | Kashmir | Dandotiya et al. (2011) |
| 297 | *Homalothecium sericeum* (Hedw.) Schimp. | Brachytheciaceae | Kashmir | Dandotiya et al. (2011) |
| 298 | *Oxyrrhynchium vagans* (A. Jaeger) Ignatov and Huttunen Syn: *Rhynchostegium vagans* A. Jaeger | Brachytheciaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 299 | *Platyhypnidium muelleri* (A. Jaeger) M. Fleisch. | Brachytheciaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 300 | *Platyhypnidium ripariodes* (Hedw.) Dixon | Brachytheciaceae | Kashmir | Dar et al. (2002) |
| 301 | *Rhynchostegiella menadensis* (Sande Lac.) E.B. Bartram | Brachytheciaceae | Jammu | Sharma et al. (2016) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 302 | *Rhynchostegium riparoides* (Hedw.) Cardot | Brachytheciaceae | Kashmir | Banday (2012) |
| 303 | *Ectropothecium manii* Broth | Hypnaceae | Jammu | Sharma et al. (2016) |
| 304 | *Homomallium incurvatum* (Schrad. ex Brid.) Loeske | Hypnaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |
| 305 | *Homomallium shimlaense* (Mitt.) Broth. | Hypnaceae | Kashmir | Dandotiya et al. (2011) |
| 306 | *Hypnum cupressiforme* Hedw. | Hypnaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011), Banday (2012); Kour et al. (2015a, b) |
| 307 | *Hypnum revolutum* (Mitt.) Lindb. | Hypnaceae | Kashmir | Banday (2012) |
| 308 | *Isopterygiopsis pulchella* (Hedw.) Z. Iwats. Syn: *Isoptergium pulchellum* (Hedw.) A. Jaeger | Hypnaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 309 | *Orthothecium intricatum* (Hartm.) Schimp. | Hypnaceae | Kashmir | Dandotiya et al. (2011) |
| 310 | *Orthothecium strictum* Lorentz. | Hypnaceae | Kashmir | Dar et al. (2002) |
| 311 | *Pylasia polyantha* (Hedw.) Schimp. | Hypnaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 312 | *Taxiphyllum taxirameum* (Mitt.) M. Fleisch Syn: *Taxiphyllum maniae* (Renauld and Paris) M. Fleisch | Hypnaceae | Jammu | Sharma et al. (2016) |
| 313 | *Rhytidiadelphus triquetrus* (Hedw.) Warnst. | Hylocomiaceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| 314 | *Pterigynandrum filiforme* Hedw. | Pterigynandraceae | Kashmir | Dar et al. (2002) |
| 315 | *Plagiothecium denticulatum* (Hedw.) Schimp. | Plagiotheciaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 316 | *Plagiothecium denticulatum* var. *obtusifolium* (Turner) Moore | Plagiotheciaceae | Kashmir | Dar et al. (2002) |
| 317 | *Plagiothecium nemorale* (Mitt.) A. Jaeger | Plagiotheciaceae | Kashmir | Dandotiya et al. (2011) |
| 318 | *Plagiothecium perminutum* Dixon | Plagiotheciaceae | Kashmir | Dandotiya et al. (2011) |

(continued)

Table 16.1 (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 319 | *Plagiothecium piliferum* (Sw.) Schimp. | Plagiotheciaceae | Kashmir | Banday (2012) |
| 320 | *Plagiothecium platyphyllum* Mönk. | Plagiotheciaceae | Kashmir | Dar et al. (2002) |
| 321 | *Plagiothecium roseanum* Schimp. | Plagiotheciaceae | Kashmir | Dar et al. (2002) |
| 322 | *Plagiothecium sylvaticum* (Brid.) Schimp. | Plagiotheciaceae | Kashmir | Dandotiya et al. (2011) |
| 323 | *Heterophyllium haldanianum* (Grev.) M. Fleisch. | Sematophyllaceae | Kashmir | Dandotiya et al. (2011) |
| 324 | *Leucodon sciuroides* (Hedw.) Schwägr. | Leucodontaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 325 | *Leucodon secundus* (Harv.) Mitt. | Leucodontaceae | Kashmir | Dandotiya et al. (2011) |
| 326 | *Cryptoleptodon rigidulus* (Wilson ex Mitt.) Broth. | Pterobryaceae | Kashmir | Dandotiya et al. (2011) |
| 327 | *Neckera pennata* Hedw. | Neckeraceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011) and Banday (2012) |
| 328 | *Thamnobryum alopercurum* (Hedw.) Nieuwl. ex Gangulee | Neckeraceae | Kashmir | Dar et al. (2002) and Banday (2012) |
| B. Liverworts | | | | |
| 1 | *Dumortiera hirsuta* (Sw.) Nees | Marchantiaceae | Jammu | Rashid et al. (2012) |
| 2 | *Marchantia kashypii* Udar and Shaheen | Marchantiaceae | Jammu | Rashid et al. (2012) |
| 3 | *Marchantia nepalensis* Lehm. and Lindenb. | Marchantiaceae | Jammu, Kashmir, Ladakh | Dar et al. (2002), Dandotiya et al. (2011), Rashid et al. (2012) and Dolma and Langer (2012) |
| 4 | *Marchantia paleacea* Bertol. | Marchantiaceae | Kashmir | Dar et al. (2002) |
| 5 | *Marchantia palmata* Reinw., Nees and Blume | Marchantiaceae | Jammu, Kashmir, Ladakh | Dar et al. (2002), Dandotiya et al. (2011), Rashid et al. (2012) and Dolma and Langer (2012) |
| 6 | *Marchantia papillata* ssp. *grossibarba* (Stephani) Bischl. | Marchantiaceae | J&K[a] | Dandotiya et al. (2011) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 7 | *Marchantia polymorpha* L. | Marchantiaceae | Jammu, Kashmir, Ladakh | Dar et al. (2002), Dandotiya et al. (2011),Rashid et al. (2012) and Dolma and Langer (2012) |
| 8 | *Marchantia subintegra* Mitt. | Marchantiaceae | Jammu | Rashid et al. (2012) |
| 9 | *Preissia quadrata* (Scop.) Nees | Marchantiaceae | Jammu, Kashmir, Ladakh | Dar et al. (2002), Dandotiya et al. (2011) and Dolma and Langer (2012) |
| 10 | *Asterella wallichiana* (Lehm.) Grolle | Aytoniaceae | Jammu | Tanwir and Langer (2004) |
| 11 | *Asterella pathankotensis* (Kashyap) Verd. | Aytoniaceae | Jammu | Tanwir and Langer (2004) |
| 12 | *Asterella mussuriensis*(Kashyap) Kashyap | Aytoniaceae | Jammu | Tanwir and Langer (2004) |
| 13 | *Asterella angusta* (Stephani) Pandé, K.P. Srivast. and Sultan Khan | Aytoniaceae | Jammu | Rashid et al. (2012) |
| 14 | *Asterella blumeana* (Nees) Pandé, K.P. Srivast. and Sultan Khan | Aytoniaceae | Jammu | Rashid et al. (2012) |
| 15 | *Asterella reticulata* (Kashyap) Pandé, K.P. Srivast. and Sultan Khan | Aytoniaceae | Jammu, Kashmir | Dar et al. (2002) and Rashid et al. (2012) |
| 16 | *Fimbraria parvipora* Stephani | Aytoniaceae | Kashmir | Dandotiya et al. (2011) |
| 17 | *Fimbraria reticulata* Kashyap | Aytoniaceae | Kashmir | Dandotiya et al. (2011) |
| 18 | *Mannia androgyna* (L.) A. Evans | Aytoniaceae | J&K[a] | Dandotiya et al. (2011) |
| 19 | *Mannia foreaui* Udar and V. Chandra | Aytoniaceae | Jammu | Rashid et al. (2012) |
| 20 | *Mannia indica* Kachroo | Aytoniaceae | Jammu | Tanwir and Langer (2004) |
| 21 | *Plagiochasma appendiculatum* Lehm. and Lindb. | Aytoniaceae | Jammu, Kashmir, Ladakh | Dar et al. (2002), Dandotiya et al. (2011), Rashid et al. (2012) and Dolma and Langer (2012) |
| 22 | *Plagiochasma articulatum* Kashyap | Aytoniaceae | Jammu, Ladakh | Rashid et al. (2012) and Dolma and Langer (2012) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 23 | *Plagiochasma intermedium* Lindb. and Gottsche | Aytoniaceae | Jammu, Ladakh | Rashid et al. (2012) and Dolma and Langer (2012) |
| 24 | *Reboulia hemisphaerica* (L.) Raddi | Aytoniaceae | Jammu, Kashmir, Ladakh | Dar et al. (2002), Dandotiya et al. (2011), Rashid et al. (2012) and Dolma and Langer (2012) |
| 25 | *Athalamia pinguis* Falc. | Cleveaceae | Jammu | Rashid et al. (2012) |
| 26 | *Clevea pusilla* (Stephani) Rubasinghe, Sumudu C.K. and D.G. Long Syn: *Athalamia pusilla* (Stephani) Kashyap | Cleveaceae | Jammu | Rashid et al. (2012) |
| 27 | *Sauteria alpina* (Nees and Bisch.) Nees | Cleveaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |
| 28 | *Sauteria spongiosa* (Kashyap) S. Hatt. Syn: *Sauchia spongiosa* Kashyap | Cleveaceae | Ladakh | Dolma and Langer (2012) |
| 29 | *Conocephalum conicum* (L.) Underw. | Conocephalaceae | Jammu, Kashmir, Ladakh | Dar et al. (2002), Dandotiya et al. (2011), Rashid et al. (2012) and Dolma and Langer (2012) |
| 30 | *Riccia aravalliensis* Pandé and Udar | Ricciaceae | Jammu | Rashid et al. (2012) |
| 31 | *Riccia discolor* Lehm. and Lindenb. | Ricciaceae | Jammu | Rashid et al. (2012) |
| 32 | *Riccia fluitans* L. | Ricciaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |
| 33 | *Riccia frostii* Austin | Ricciaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |
| 34 | *Riccia warnstorfii* Limpr. | Ricciaceae | Jammu | Rashid et al. (2012) |
| 35 | *Riccia crystallina* L. | Ricciaceae | Jammu | Tanwir and Langer (2004) |
| 36 | *Ricciocarpus natans* (L.) Corda | Ricciaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |
| 37 | *Targionia hypophylla* L. | Targioniaceae | Jammu | Rashid et al. (2012) |
| 38 | *Targionia indica* Udar and A. Gupta | Targioniaceae | Jammu | Tanwir and Langer (2004) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 39 | *Cyathodium aureonitens* (Griff.) Mitt. | Targioniaceae | Jammu | Tanwir and Langer (2004) |
| 40 | *Cyathodium cavernarum* Kunze | Targioniaceae | Jammu | Tanwir and Langer (2004) |
| 41 | *Pellia endiviifolia* (Dicks.) Dumort. | Pelliaceae | Jammu, Kashmir | Dar et al. (2002) and Rashid et al. (2012) |
| 42 | *Pellia epiphylla* (L.) Corda | Pelliaceae | Kashmir | Dar et al. (2002) |
| 43 | *Apometzgeria pubescens* (Schrank) Kuwah. | Metzgeriaceae | Kashmir | Dar et al. (2002) |
| 44 | *Metzgeria conjugata* Lindb. | Metzgeriaceae | Kashmir | Dar et al. (2002) |
| 45 | *Metzgeria furcata* (L.) Corda | Metzgeriaceae | Kashmir | Dandotiya et al. (2011) |
| 46 | *Metzgeria himalayensis* Kashyap | Metzgeriaceae | Kashmir | Dar et al. (2002) |
| 47 | *Aneura pinguis* (L.) Dumort. | Aneuraceae | Kashmir, Ladakh | Dar et al. (2002) and Dolma and Langer (2012) |
| 48 | *Riccardia multifida* (L.) Gray | Aneuraceae | Jammu | Rashid et al. (2012) |
| 49 | *Riccardia pinguis* (L.) Gray | Aneuraceae | Kashmir | Banday et al. (1998) |
| 50 | *Porella acutifolia* (Lehm. and Lindenb.) Trevis. | Porellaceae | Jammu | Rashid et al. (2012) |
| 51 | *Porella caespitans* (Stephani) S. Hatt. | Porellaceae | Jammu | Rashid et al. (2012) |
| 52 | *Porella campylophylla* (Lehm. and Lindenb.) Trevis. | Porellaceae | Jammu | Rashid et al. (2012) |
| 53 | *Porella chinensis* (Stephani) S. Hatt. | Porellaceae | Jammu | Rashid et al. (2012) |
| 54 | *Porella chinensis* var. *decurrens* (Stephani) S. Hatt Syn: *Porella decurrens* (Stephani) S. Hatt. | Porellaceae | J&K[a] | Dandotiya et al. (2011) |
| 55 | *Porella densifolia* var. *appendiculata* (Stephani) S. Hatt. Syn: *Porella appendiculata* (Stephani) S. Hatt. | Porellaceae | Kashmir | Dar et al. (2002) |
| 56 | *Porella gracillima* Mitt. | Porellaceae | J&K[a] | Dandotiya et al. (2011) |
| 57 | *Porella madagascariensis* (Nees and Mont.) Trevis. | Porellaceae | J&K[a] | Dandotiya et al. (2011) |
| 58 | *Porella obtusata* var. *macroloba* (Stephani) S. Hatt. and M.X. Zhang | Porellaceae | J&K[a] | Dandotiya et al. (2011) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 59 | *Porella ovalis* (Gottsche ex Stephani) S. Hatt. and G.C. Zhang<br>Syn: *Madotheca ovalis* Gottsche ex Stephani | Porellaceae | Ladakh | Dolma and Langer (2012) |
| 60 | *Porella platyphylla* (L.) Pfeiff. | Porellaceae | Jammu, Kashmir | Dar et al. (2002) and Rashid et al. (2012) |
| 61 | *Radula campanulata* Lindenb. and Gottsche | Radulaceae | Kashmir | Dar et al. (2002) |
| 62 | *Radula complanata* (L.) Dumort. | Radulaceae | Jammu, Kashmir | Dar et al. (2002) and Rashid et al. (2012) |
| 63 | *Radula lindenbergiana* Gottsche ex Hartm. | Radulaceae | Kashmir | Dar et al. (2002) |
| 64 | *Frullania gaudichaudii* (Nees and Mont.) Nees and Mont. | Jubulaceae | Jammu | Rashid et al. (2012) |
| 65 | *Frullania muscicola* Stephani | Jubulaceae | Jammu, Kashmir | Dar et al. (2002), Rashid et al. (2012) and Banday et al. (1998) |
| 66 | *Frullania neurota* Taylor | Jubulaceae | Jammu | Rashid et al. (2012) |
| 67 | *Rectolejeunea aloba* (Sande Lac.) Stephani<br>Syn: *Lejeunea aloba* Sande Lac. | Lejeuneaceae | Jammu | Rashid et al. (2012) |
| 68 | *Trocholejeunea sandvicensis* Mizut. | Lejeuneaceae | Jammu | Rashid et al. (2012) |
| 69 | *Tuzibeanthus Chinensis* (Stephani) Mizut. | Lejeuneaceae | Jammu | Rashid et al. (2012) |
| 70 | *Blepharostoma trichophyllum* (L.) Dumort. | Pseudolepicoleaceae | Jammu, Kashmir, Ladakh | Dar et al. (2002), Dandotiya et al. (2011)and Dolma and Langer (2012) |
| 71 | *Lepidozia reptans* (L.) Dumort. | Lepidoziaceae | Kashmir | Dar et al. (2002), Dandotiya et al. (2011)and Banday et al. (1998) |
| 72 | *Chiloscyphus himalayensis* (A. Srivast. and S.C. Srivast.) J.J. Engel | Lophocoleaceae | J&K[a] | Dandotiya et al. (2011) |
| 73 | *Chiloscyphus polyanthus* (L.) Corda | Lophocoleaceae | Kashmir | Dar et al. (2002) |
| 74 | *Lophocolea bidentata* (L.) Dumort. | Lophocoleaceae | Kashmir | Dar et al. (2002) |

(continued)

**Table 16.1** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 75 | *Lophocolea minor* Nees | Lophocoleaceae | Kashmir | Dar et al. (2002) |
| 76 | *Plagiochila asplenioides* (L.) Dumort. | Plagiochilaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |
| 77 | *Plagiochila chinensis* Stephani | Plagiochilaceae | Jammu | Rashid et al. (2012) |
| 78 | *Plagiochila duthiana* Stephani | Plagiochilaceae | Kashmir | Dar et al. (2002) |
| 79 | *Plagiochila himalayana* Schiffner | Plagiochilaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |
| 80 | *Plagiochila parvifolia* Lindenb. | Plagiochilaceae | Jammu | Rashid et al. (2012) |
| 81 | *Plagiochila sciophila* Nees | Plagiochilaceae | J&K[a] | Dandotiya et al. (2011) |
| 82 | *Plagiochila spinulosa* (Dicks.) Dumort. | Plagiochilaceae | Kashmir | Banday et al. (1998) |
| 83 | *Jungermannia confertissima* Nees | Jungermanniaceae | Kashmir | Dandotiya et al. (2011) |
| 84 | *Jungermannia lanceolata* L. | Jungermanniaceae | Jammu | Rashid et al. (2012) |
| 85 | *Lophozia incisa* (Schrad.) Dumort. | Jungermanniaceae | Ladakh | Dolma and Langer (2012) |
| 86 | *Solenostoma duthianum* (Stephani) C. Gao Syn: *Jungermannia duthiana* Stephani | Jungermanniaceae | Kashmir | Dandotiya et al. (2011) |
| 87 | *Scapania verrucosa* Heeg Syn: *Scapania parva Stephani* | Scapaniaceae | Kashmir | Dar et al. (2002) |
| 88 | *Gymnocolea inflata* (Huds.) Dumort. | Anastrophyllaceae | Jammu | Rashid et al. (2012) |
| 89 | *Anthelia julacea* (L.) Dumort. | Antheliaceae | Ladakh | Dolma and Langer (2012) |
| 90 | *Weisnerella denuta* (Mitt.) Stephani | Wiesnerellaceae | Jammu | Tanwir and Langer (2004) |
| 91 | *Exormotheca brevipedunculata* (Kashyap) D.G. Long, Crand. Syn: *Stephensoniella brevipedunculata* Kash. | Exormothecaceae | Jammu | Tanwir and Langer (2004) |
| C. Hornwort | | | | |
| 1 | *Phaeoceros laevis* (L.) Prosk. | Anthocerotaceae | Jammu | Rashid et al. (2012) |

[a]Exact information about the regional distribution is not available
*Syn* synonym

**Table 16.2** List of doubtful records which have been excluded from the checklist of bryophytes from Jammu and Kashmir State

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 1 | *Distichium carillaceum* | Ditrichaceae | Kashmir | Dandotiya et al. (2011) |
| 2 | *Hymenostylium recurvirostre* | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 3 | *Hymenostylium recurvirostre* var. *aurantiacum* | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 4 | *Molendoa himalayana* | Pottiaceae | Kashmir | Dandotiya et al. (2011) |
| 5 | *Bryum muehlenbeckii* ssp. *evanidinerve* (Broth.) Podp. | Bryaceae | Kashmir | Dar et al. (2002) |
| 6 | *Bryum pseudotriquetrum* var. *pallescens* (Schleich. ex Schwägr.) Dixon | Bryaceae | Kashmir | Dandotiya et al. (2011) |
| 7 | *Amblystegium subdilatatum* Broth. | Amblystegiaceae | Kashmir | Dandotiya et al. (2011) |
| 8 | *Campyliadelphus brevisetum* | Amblystegiaceae | Kashmir | Dandotiya et al. (2011) |
| 9 | *Campylium pellucinerve* | Amblystegiaceae | Kashmir | Banday (2012) |
| 10 | *Hygrohypnum subdilatatum* | Amblystegiaceae | Kashmir | Dandotiya et al. (2011) |
| 11 | *Lescuraea incrassate* | Leskeaceae | Kashmir | Dandotiya et al. (2011) |
| 12 | *Lescuraea nervosa* | Leskeaceae | Kashmir | Dandotiya et al. (2011) |
| 13 | *Eurhynchium deltoideum* | Brachytheciaceae | Kashmir | Dandotiya et al. (2011) |
| 14 | *Asterella calciatii* | Aytoniaceae | Kashmir | Dar et al. (2002) |
| 15 | *Riccia himalayensis* Steph. ex Kashyap | Ricciaceae | Kashmir | Dar et al. (2002) |
| 16 | *Riccia melanospora* Kashyap | Ricciaceae | Jammu | Tanwir and Langer (2004) |
| 17 | *Ricciopsis natans* Corda, in Opiz Beiter | Ricciaceae | Kashmir | Banday et al. (1998) |
| 18 | *Porella borellii* (Gola) Parihar | Porellaceae | Kashmir | Banday et al. (1998) |
| 19 | *Porella obtusifolia* (Kashyap) Parihar | Porellaceae | Kashmir | Banday et al. (1998) |
| 20 | *Porella trigonifolia* (Steph.) Parihar | Porellaceae | Kashmir | Dar et al. (2002) |
| 21 | *Radula lindbergii* | Radulaceae | Kashmir | Dandotiya et al. (2011) |
| 22 | *Frullania pyriflora* | Jubulaceae | Kashmir | Dar et al. (2002) and Banday et al. (1998) |

(continued)

**Table 16.2** (continued)

| S. no. | Scientific name | Family | Regional distribution | Literature source (s) |
|---|---|---|---|---|
| 23 | *Chiloscyphus campanulatus* Stephani | Lophocoleaceae | J&K[a] | Dandotiya et al. (2011) |
| 24 | *Plagiochila accedens* Stephani | Plagiochilaceae | Jammu | Rashid et al. (2012) |
| 25 | *Plagiochila cavifolia* | Plagiochilaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |
| 26 | *Plagiochila ferruginea* Stephani | Plagiochilaceae | Kashmir | Dar et al. (2002) |
| 27 | *Plagiochila mittenii* | Plagiochilaceae | Kashmir | Dar et al. (2002) |
| 28 | *Plagiochila phalangea* Taylor | Plagiochilaceae | Jammu | Rashid et al. (2012) |
| 29 | *Plagiochila wornoffii* St. | Plagiochilaceae | Jammu | Rashid et al. (2012) |
| 30 | *Lophozia alpestris* (Schleich.) A. Evans | Jungermanniaceae | Jammu, Kashmir, Ladakh | Dar et al. (2002) and Dolma and Langer (2012) |
| 31 | *Lophozia piacenzai* Gola | Jungermanniaceae | Kashmir | Dar et al. (2002) and Dandotiya et al. (2011) |
| 32 | *Cephalozia* sp. *Dumort.* | Cephaloziaceae | Ladakh | Dolma and Langer (2012) |
| 33 | *Schistidium alpicola* | Grimmiaceae | Kashmir | Dandotiya et al. (2011) and Banday (2012) |

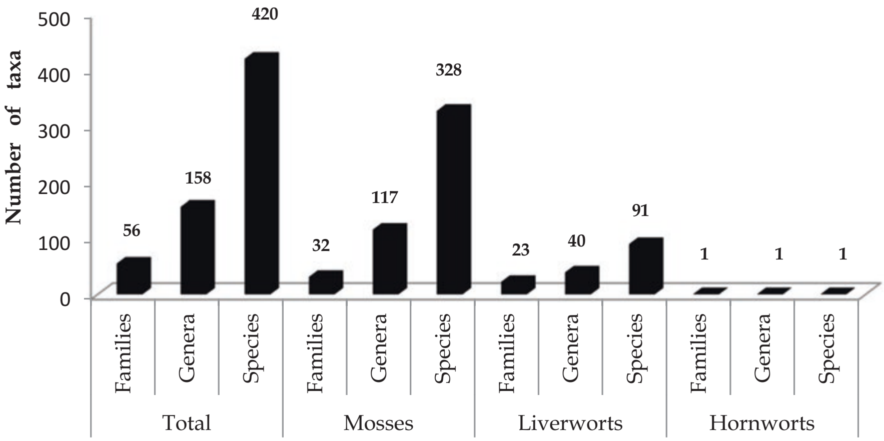


**Fig. 16.1** Taxonomic conspectus of bryophytes recorded from Jammu and Kashmir State

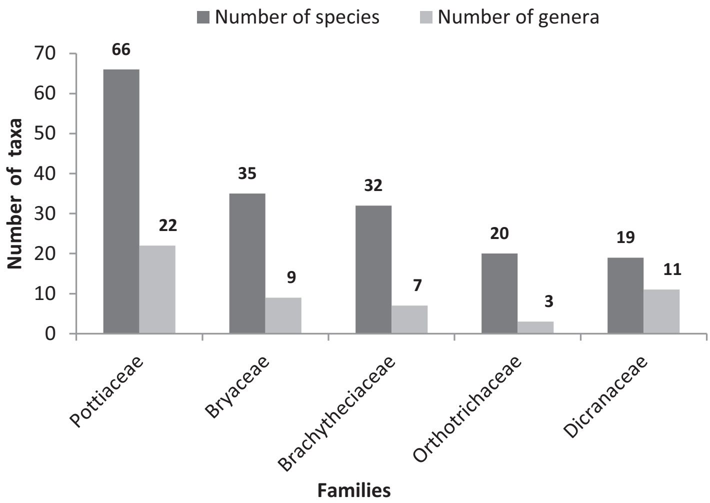


**Fig. 16.2** First five dominant families of mosses along with their number of genera and species in Jammu and Kashmir State

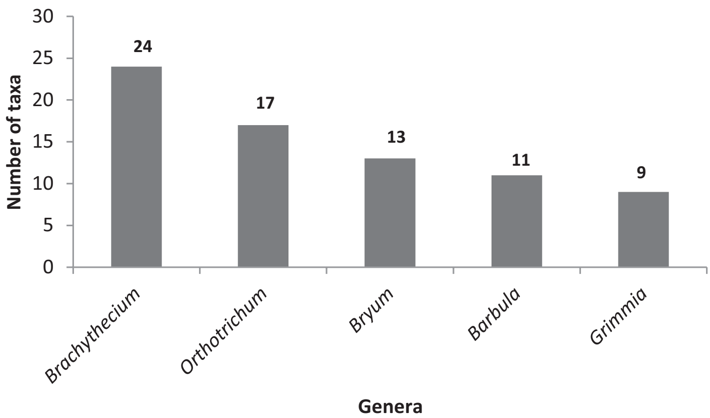


**Fig. 16.3** First five dominant genera in mosses growing in Jammu and Kashmir State

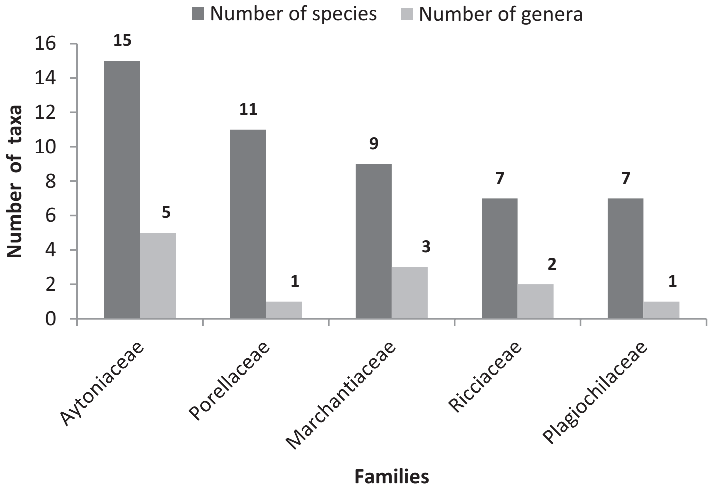


**Fig. 16.4** First five dominant families of liverworts along with their number of genera and species in Jammu and Kashmir State

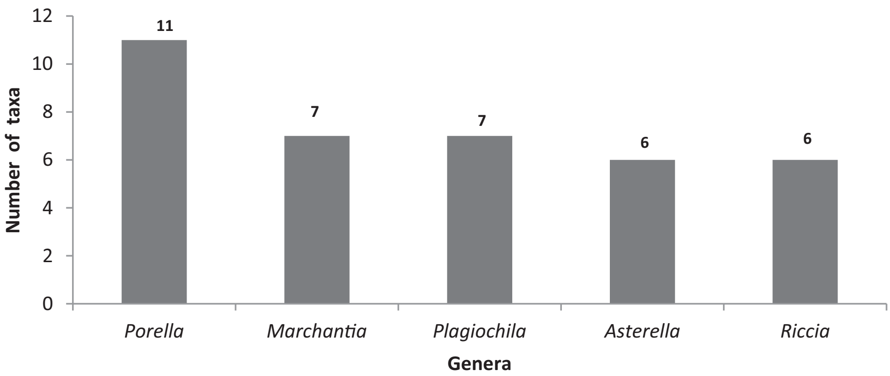


**Fig. 16.5** First five dominant genera of liverworts recorded from Jammu and Kashmir State

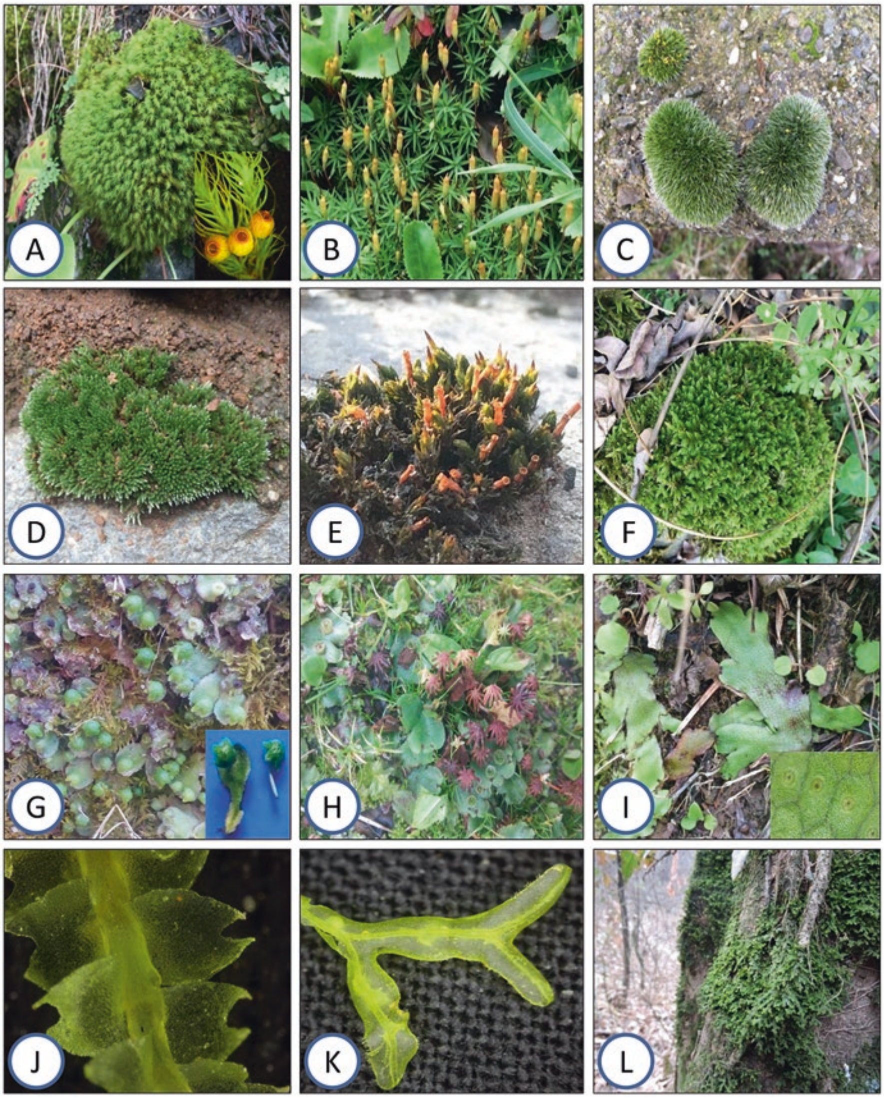


**Plate 16.1** Mosses: (**a**). *Bartramia halleriana* (**b**). *Polytrichum juniperinum* (**c**). *Grimmia pulvinata* (**d**). *Bryum argenteum* (**e**). *Orthotrichum affine* (**f**). *Hypnum cupressiforme;* Liverworts (**g**). *Reboulia hemispherica* (**h**). *Marchantia polymorpha* (**i**). *Conocephalum conicum* (**j**). *Lophocolea bidentata* (**k**). *Metzgeria furcata* (**l**). *Porella platyphylla*

## 16.4 Concluding Remarks

The Jammu and Kashmir State has been regarded as a biological paradise on Earth and is a part of Himalayan biodiversity hotspot (Dar and Khuroo 2013). The State harbours rich floristic diversity, which ranges from lower groups (i.e. algae, bryophytes and pteridophytes) to higher forms (i.e. gymnosperms and angiosperms). Till date, much of the research studies have been more focussed towards angiosperms and gymnosperms (Singh et al. 2002; Dar and Dar 2006), and the lower groups of plants, including bryophytes, have received little attention.

The present study reports 420 taxa of bryophytes from Jammu and Kashmir State. Mosses (328 taxa) are found to be overwhelmingly dominant as compared to liverworts (91 taxa). Since this group of plants has been largely neglected as compared to other groups and since the role of bryophytes in ecosystem structure and functioning has been well-established, therefore, the comprehensive database generated during the present study can provide baseline information regarding this group and can also be of immense help in undertaking their conservation. The first and foremost requirement for effective management of bryophytes is their correct taxonomic identification because bryophytes are difficult to identify due to their inconspicuous morphological characters. The information generated herein can be utilised by the policymakers in formulating successful management plan for the conservation, sustainable use and public awareness of bryophytes.

**Acknowledgements** We are highly thankful to the Head, Department of Botany, University of Kashmir, for providing necessary facilities. The sincere support and help rendered by the staff at the Centre for Biodiversity and Taxonomy, University of Kashmir, is greatly acknowledged. Zeenat Ismail acknowledges the funding received under CSIR-UGC NET-JRF during the course of present study.

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# Chapter 17
# Pteridophytic Flora of Jammu and Kashmir State: A New Sketch

**Brijesh Kumar, H. C. Pande, and Pushpesh Joshi**

**Abstract** The chapter provides an updated account of pteridophytic flora of Jammu and Kashmir state. As a part of northwestern Himalaya, the state represents an abode of pteridophytic wealth, totalling 200 species belonging to 44 genera under 19 families; these include 189 taxa of ferns and 11 of fern allies. Among ferns, the largest family is Dryopteridaceae (with 44 taxa), followed by Pteridaceae (41 taxa), Woodsiaceae (33 taxa), Aspleniaceae (22 taxa), Thelypteridaceae (17 taxa) and Polypodiaceae (13 taxa), while Ophioglossaceae and Dennstaedtiaceae (with 5 taxa each) and Osmundaceae with 2 taxa are smaller families. Lygodiaceae, Marsileaceae, Oleandraceae, Davalliaceae, Blechnaceae, Azollaceae and Salviniaceae are monotypic families, each having a single representative type. The larger families among fern allies are Selaginellaceae (with six taxa) and Equisetaceae (four taxa), while Lycopodiaceae is a monotypic family. The families and genera are arranged as in Fraser-Jenkins (2008a, 2010b). All the taxa are provided with brief ecological notes and distribution in the state. In addition, 29 doubtful reports published by earlier workers have been excluded in the present work.

**Keywords** Vascular plants · Pteridophytes · Ferns · Northwest Himalaya

## 17.1 Introduction

Known as botanical snakes of plant kingdom, the pteridophytes are the oldest land plants, having flourished so well in the past and dominated the Earth's vegetation about 280–230 million years ago. Although they are now replaced by seed-bearing vascular plants of the present-day vegetation, still they are considered as a connecting link between nonvascular and vascular plants. Presently, pteridophytes do not form dominant vegetation anywhere in the world flora. They are further grouped into two broad groups – ferns and 'fern allies'. Among these, the ferns constitute a major element of the pteridophytic flora. Ferns are the most dominating and diverse

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_17

group of pteridophytes throughout the world and include ca. 300 genera and 12,000 known species (Chandra 2000). Most of the fern species are distributed in tropical and subtropical areas, with limited distribution in temperate regions. They prefer growing in cool, moist and shady places. In monsoon season, they luxuriously grow in varied habitats: on trees, boulders, rocks, walls, forest floors, open and dry slopes, rock crevices, deep ravines and aquatic habitats also.

India depicts significant diversity in pteridophytic flora. The Eastern Himalaya and the North-eastern India, with ca. 845 species in 179 genera, is the richest region representing approximately 60% pteridophytes known from the country; this is followed by the South India, including Eastern and Western Ghats with 345 species in 117 genera, and the North India, including Western Himalaya with 340 species in 101 genera. Seventeen percent of the total pteridophytic species are endemic to India (Sharma and Singh 2001). However, Khullar (1994, 2000) maintains that though not so rich in pteridophytes as the Eastern Himalaya, the Western Himalaya exhibits uniqueness due to its diverse topographical, pedological and climatic conditions, harbouring ca. 361 fern taxa out of the 1265 taxa in India; this represents >28% of the Indian pteridophytes (Singh et al. 2011).

Jammu and Kashmir State, due to its unique geographical position and varied topography, has very rich and much diverse floristic composition. The earlier contributions to the pteridophytic flora of this State include those of Beddome (1876, 1883), Clarke (1880) and Hope (1899–1904). Several scientists of Botanical Survey of India, like T.A. Rao, M.A. Rao, N.C. Nair, U.C. Bhattacharyya, B.M. Wadhawa, J.N. Vohra, R.R. Rao, M.V. Vishwanathan and D.K. Singh, have added some fragmented collections from different parts of the State. However, noteworthy contributions to the pteridophytic flora in the State were made by Stewart (1937, 1945, 1951, 1957, 1972), Javeid (1965), Kapoor and Sarin (1977), Dhir (1980), Kapur (1985), Fraser-Jenkins (1992, 1993, 1997, 2008a, b, 2010a, b, 2012), Khullar (1994, 2000), Singh and Pande (2002) and Wani et al. (2012). Singh et al. (1999) recorded 168 species of pteridophytes under 54 genera in 31 families. Kirn (2000) enumerated 94 taxa under 33 genera in 20 families from the Poonch district. Dar et al. (2002) listed 90 species of pteridophytes from the Kashmir region. Singh and Pande (2002) added more information, which resulted in 207 taxa in 57 genera and 31 families. Wani et al. (2012) reported 113 taxa in 38 genera under 23 families from the Kashmir Valley, of which 47 taxa (ca. 42%) are said to be rare or endangered.

## 17.2 Materials and Methods

The present work is based on the study of herbarium specimens deposited in various herbaria, viz. FRI, Dehradun Herbarium (DD); BSI, NRC Herbarium (BSD); RRL, Jammu Herbarium (RRLH); and the University of Kashmir Herbarium (KASH). Besides, some plant taxa that are included in the present study are based on earlier published literature, including those of Stewart (1937, 1945, 1951, 1972, 1979, 1982, 1984), Javied (1965, 1971), Kapur and Sarin (1977), Dhir (1980), Dixit

(1984), Kapur (1985), Khullar (1984, 1994, 2000), Chandra (2000), Kirn (2000), Kirn and Kapahi (2001), Singh and Pande (2002), Fraser-Jenkins (2008a), Wani et al. (2012), Mir et al. (2013, 2014), Anjum et al. (2014) and Fraser-Jenkins et al. (2017). Nomenclature of all the taxa has been updated. The families and genera are arranged as per classification suggested by Fraser-Jenkins (2008a, 2010b). Brief ecological notes and distribution in the State are appended with each species.

## 17.3 Results and Discussion

The present study enumerates 200 pteridophytic taxa, belonging to 44 genera under 19 families, which include 189 ferns and 11 fern allies (Plates 17.1–17.3). Among ferns the largest families are Dryopteridaceae (with 44 taxa in 4 genera) followed by Pteridaceae (41:9), Woodsiaceae (33:7), Aspleniaceae (22:1), Thelypteridaceae (17:1) and Polypodiaceae (13:6), while Ophioglossaceae (5:2), Dennstaedtiaceae (5:3) and Osmundaceae (2:1) are the smaller families. Families Lygodiaceae, Marsileaceae, Oleandraceae, Davalliaceae, Blechnaceae, Azollaceae and Salviniaceae are monotypic (i.e. have a single representative type each), indicating narrow genetic base of these families. The larger families among fern allies are Selaginellaceae (6:1) and Equisetaceae (4:1), while Lycopodiaceae is a monotypic family. In addition, 29 doubtful species, under 20 genera and 10 families, reported by earlier workers are also appended.

### *17.3.1 Enumeration of Species*

**Lycopodiaceae**

*Huperzia selago* (L.) Bernh. ex Schrank &Mart. subsp. *appressa* (Bach. Pyl. ex Desv.) D. Löve, Botanisk. Notis. 109: 164. 1956.

Rare, grows on shady moist and mossy rocks in subalpine-alpine zone, alt. 4000–4500 m.

Distribution: Kashmir: Baramulla (Gulmarg), Ganderbal (Kangan, Sonamarg).

**Selaginellaceae**

*Selaginella aitchisonii* Hieron., in Nat. Pflanzenfam. [Engler and Prantl] 1(4): 674. 1901.

Frequent, grows on rocky and shady hill slopes in subalpine-alpine zone, alt. 2200–3400 m.

Distribution: Kashmir: Anantnag (Pahalgam), Ganderbal (Kangan, Baltal, Sonamarg).

*Selaginella chrysocaulos* (Hook. & Grev.) Spring, Bull. Acad. Roy. Sci. Bruxelles 10 (1): 232, t. 141. 1843. (Plate 17.1a).

Abundant, grows in open shady places, alt. 1000–2000 m.


**Plate 17.1** (**a**) *Selaginella chrysocaulos* (Hook. & Grev.) Spring; (**b**) *Equisetum diffusum* D. Don; (**c**) *Ophioglossum polyphyllum* A. Braun ex Schub.; (**d**) *Osmunda claytoniana* subsp. *vestita* (Wall. ex Milde) Á. Löve & D. Löve; (**e**) *Loxogramme involuta* (D. Don) C. Presl; (**f**) *Pyrrosia flocculosa* (D. Don) Ching; (**g**) *Pteridium revolutum* (Blume) Nakai.; (**h**) *Adiantum philippense* L.

Distribution: Jammu: Reasi (Katra), Udhampur.

*Selaginella jacquemontii* Spring, Bull. Acad. Roy. Sci. Bruxelles 10: 226. 1843.

Common, grows on rock cliffs and in crevices, alt. 1000–3000 m.

Distribution: Kashmir: Anantnag (Pahalgam), Ganderbal (Kangan, Sonamarg, Sind valley).

*Selaginella reticulata* (Hook. & Grev.) Spring, Bull. Acad. Roy. Sci. Bruxelles 10: 233. 1843.

Rare, grows in moist shaded places, alt. 400–1400 m.

Distribution: Jammu: Jammu (Akhnoor), Poonch, Rajouri.

*Selaginella subdiaphana* (Wall. ex Hook et Grev.) Spring, Bull. Acad. Roy. Sci. Bruxelles 10: 232. 1843.

Common, grows on open mossy boulders, moist surfaces, walls, roadsides, forest margins, alt. 600–1500 m.

Distribution: Jammu: Kathua (Basholi).

*Selaginella vaginata* Spring, Mém. Acad. Roy. Sci. Belgique 24: 87. 1850.

Rare, grows in moist and shady places, alt. 2000–4000 m.

Distribution: Jammu: Kathua (Painal).

**Equisetaceae**

*Equisetum arvense* L., Sp. Pl. 2: 1061. 1753.

Common, grows in marshy places along the streams, alt. 2000–4000 m.

Distribution: Kashmir: Anantnag (Kungwatan), Bandipore (Kishenganga Valley), Ganderbal (Kangan, Sonamarg, Thajiwas), Srinagar, Kulgam (Yarikah), ; Ladakh: Gilgit, Kargil (Dras).

*Equisetum diffusum* D. Don, Prodr. Fl. Nepal 19. 1825. (Plate 17.1b).

Common, grows in open shady and waterlogged sandy places along streams, alt. 500–3000 m.

Distribution: Jammu: Kathua (Kot-Banjal); Kashmir: Kupwara (Kalaroos forest), Jhelum Valley; Ladakh: Kargil (Sankoo).

*Equisetum palustre* L., Sp. Pl. 2: 1061. 1753.

Rare, grows on stony moist soil, near the streams, alt. 1800–3000 m.

Distribution: Kashmir: Srinagar (Dachigam).

*Equisetum ramosissimum* Desf., Fl. Atlant. 2: 398–399. 1799.

Frequent, grows in marshy habitats, along water channels in sandy soils, alt. 1000–3000 m.

Distribution: Kashmir: Anantnag (Pahalgam), Bandipore (Kishenganga Valley), Srinagar (Dachigam); Ladakh: Kargil (Dras), Sabunala, Leh, Indus Valley.

**Ophioglossaceae**

*Botrychium lunaria* (L.) Sw., J. Bot. (Schrader) 1800(2): 110. 1801.

Rare, grows among grasses in moist shady places, alt. 2800–330 m.

Distribution: Kashmir: Anantnag (Pahalgam), Baramulla (Gulmarg, Mt. Apharwat), Ganderbal (Kangan, Sonamarg); Ladakh: Gilgit.

*Botrychium virginianum* (L.) Sw., J. Bot. (Schrader) 1800 (2): 111. 1800.

Rare, grows on humus-rich shady, grassy slopes, alt. 1700–2500 m.

Distribution: Jammu: Kishtwar, Poonch; Kashmir: Anantnag (Pahalgam), Kupwara (Lolab Valley).

*Ophioglossum petiolatum* Hook., Exot. Fl. 1: 56, t. 56. 1823.

Occasional, grows in moist grassy places, alt. up to 1200 m.

Distribution: Jammu: Poonch.

*Ophioglossum polyphyllum* A. Braun ex Schub., Fl. Azor. 17. 1844.

Frequent, grows on grassy hilly slopes, alt. 600–2400 m.

Distribution: Jammu: Jammu, Poonch.

*Ophioglossum reticulatum* L., Sp. Pl. 2: 1063.1753. (Plate 17.1c).

Common, grows on grassy slopes, alt. 400–1800 m.

Distribution: Jammu: Kathua, Rajouri, Udhampur; Kashmir: Srinagar (Dachigam).

**Osmundaceae**

*Osmunda claytoniana* L. subsp. *vestita* (Wall. ex Milde) Á. Löve and D. Löve, Taxon 26(2/3): 324. 1977. (Plate 17.1d).

Common, grows in patches on open slopes in subalpine-alpine meadows, alt. 3000–4200 m.

Distribution: Jammu: Ramban, Udhampur (Patnitop, Sanasar); Kashmir: Anantnag (Lidderwat), Baramulla (Bagtore, Gulmarg, Khilanmarg), Muzaffarabad, Srinagar (Dagwan).

*Osmunda japonica* Thunb., Nova Acta Regiae Soc. Sci. Upsal. 2: 209. 1780.

Rare, grows among shady and moist rocks near waterfalls, alt. 1400–2200 m.

Distribution: Jammu: Kathua (Kadol).

**Lygodiaceae**

*Lygodium japonicum* (Thunb.) Sw., J. Bot. (Schrader) 1800 (2): 106. 1801.

Rare, grows along forest edges, hilly slopes, scandent on neighbouring bushes; alt. 800–1500 m.

Distribution: Jammu: Jammu (Tawi Valley), Poonch (Pir-kalanjar, Kotli); Kashmir: Muzaffarabad (Jhelum Valley).

**Marsileaceae**

*Marsilea minuta* L., Mant. Pl. Altera 308. 1771.

Common, grows in ditches, ponds, rice fields, along lake banks, alt. 600–2000 m.

Distribution: Jammu: Kathua (Basholi), Poonch, Udhampur; Kashmir: Baramulla (Wagoora), Muzaffarabad, Srinagar (Dal Lake).

**Polypodiaceae**

*Lepisorus clathratus* (C. B. Clarke) Ching, Bull. Fan Mem. Inst. Biol. 4(3): 71–72. 1933.

Occasional, grows in moist, mossy rock crevices and on tree trunks, alt. 2500–3600 m.

Distribution: Jammu: Poonch (Bimbar Gali); Kashmir: Anantnag (Aru, Pahalgam, Lidder Valley), Bandipore (Barnai, Gurez, Kishenganga Valley), Baramulla (Aliabad), Budgam (Fras-nag), Ganderbal (Sonamarg), Rajdhiangan; Ladakh: Gilgit, Kargil (Batalik, Darchik).

*Lepisorus morrisonensis* (Hayata) H. Ito, J. Jap. Bot. 11: 92. 1935.

Occasional, grows on mossy rocks and tree trunk, alt. 2000–3000 m.

Distribution: Kashmir: Anantnag (Mount Kolahoi, Pahalgam), Ganderbal (Kangan, Sonamarg), North Kashmir Valley (Kachil Peak).

*Lepisorus nudus* (Hook.) Ching, Bull. Fan Mem. Inst. Biol. 4(3): 83. 1933.

Occasional, grows as lithophyte and epiphyte in moist and shady places, alt. 700–2000 m.

Distribution: Jammu: Poonch (Nakyal near Kotli).

*Lepisorus scolopendrium* (Ching) Mehra & Bir, Res. Bull. Panjab Univ. Sci. 15: 168. 1964.

Rare, grows as lithophyte and epiphyte in moist and shady places, alt. 1500–3000 m.

Distribution: Kashmir: Anantnag (Lidderwat, Pahalgam), Budgam (Fras-nag), Kishtwar (Batkot-purfuzal), Pir Panjal.

*Lepisorus thunbergianus* (Kaulf.) Ching, Bull. Fan Mem. Inst. Biol. 4(3): 88–89. 1933.

Occasional, grows as lithophyte and epiphyte in moist and shady places, alt. 1500–2000 m.

Distribution: Kashmir: Anantnag (Daksum, Mount Kolahoi, Lidderwat), Baramulla (Ferozpur Nallah, Tangmarg), Budgam (Fras-nag), Ganderbal (Kangan, Sonamarg), Pir Panjal Range.

*Loxogramme involuta* (D. Don) C. Presl, Tent. Pterid. 215. 1836. (Plate 17.1e).

Rare, grows as lithophyte and epiphyte, alt. 1700–2300 m.

Distribution: Jammu: Kathua (Kadol).

*Microsorum membranaceum* (D. Don) Ching, Bull. Fan Mem. Inst. Biol. 4: 309. 1933.

Frequent, grows as epiphyte or rarely lithophytic in shady places, alt. 1400–2300 m.

Distribution: Jammu: Jammu (Tawi Valley).

*Pichisermollodes quasidivaricata* (Hayata) Fraser-Jenk., Indian Fern J. 26(1-2): 123. 2010.

Rare, grows as epiphyte or lithophytic in rock crevices, alt. 2000–3200 m.

Distribution: Kashmir: Anantnag (Pahalgam), Kashmir Valley.

*Polypodiodes amoena* (Wall. ex Mett.) Ching, Acta Phytotax. Sin. 16 (4): 27. 1978.

Common, grows as epiphyte or lithophyte in humus-rich moist places, alt. 1600–2200 m.

Distribution: Jammu: Poonch (Bafliaz), Udhampur (Patnitop, Nathatop to Sanasar).

*Polypodiodes lachnopus* (Wall. ex Hook.) Ching, Acta Phytotax. Sin. 16(4): 27. 1978.

Occasional, grows as epiphyte or lithophyte on mossy tree trunks and rocks, alt. 1700–2200 m.

Distribution: Jammu: Udhampur (Patnitop, Nathatop to Sanasar).

*Polypodiodes microrhizoma* (C.B. Clarke) Ching, Acta Phytotax. Sin. 16(4): 27. 1978.

Frequent, grows as an epiphyte or lithophyte on mossy tree trunks and rocks, alt. 1600–2000 m.

Distribution: Jammu: Reasi (Bhairon forest, Vaishno Devi), Udhampur (Nathatop to Sanasar).

*Pyrrosia flocculosa* (D. Don) Ching, Bull. Chin. Bot. Soc. 1: 66. 1935. (Plate 17.1f).

Occasional, grows on mossy tree trunks in shady forests, alt. 600–2000 m.

Distribution: Kashmir: Anantnag (Verinag).

*Pyrrosia porosa* (C. Presl) Hovenkamp, Blumea 30(1): 208. 1984.

Occasional, grows as an epiphyte/lithophyte on mossy tree trunks or rocks, alt. 1500–2000 m.

Distribution: Jammu: Kathua (Kadol), Poonch (Bimbar Gali, Bafliaz, Serimarg) .

**Dennstaedtiaceae**

*Dennstaedtia wilfordii* (T. Moore) Christ, Geogr. Farne 192, 195. 1910.

Rare, grows in moist and shady places near streams and water channels, alt. 1350–1800 m.

Distribution: Kashmir: Baramulla (Rampur), Jhelum Valley.

*Dennstaedtia zeylanica* (Sw.) Zink ex Fraser-Jenk. & Kandel, Ferns and Fern Allies of Nepal. 1: 161. 2015.

Occasional, grows in semiopen places, slopes, shaded roadsides, alt. 1800–3000 m.

Distribution: Jammu and Kashmir (Fraser-Jenkins et. al. 2017).

*Hypolepis polypodioides* (Blume) Hook., Sp. Fil. 2: 63. 1852.

Common, grows along the streams or in swampy forest, alt. 1200–2000 m.

Distribution: Jammu: Doda (Ramsu), Kathua (Bani), Kishtwar, Udhampur (Patnitop).

*Pteridium brownseyi* Fraser-Jenk., New Sp. Syndr. Indian Pteridol. 219. 1997.

Rare, grows in open forests or on grassy hilly slopes, alt. 1800–2500 m.

Distribution: Kashmir: Muzaffarabad.(Jhelum Valley)

*Pteridium revolutum* (Blume) Nakai, Bot. Mag. (Tokyo) 39(461): 109. 1925. (Plate 17.1g).

Common, forms patches in open forest or on grassy hilly slopes, alt. 1800–2500 m.

Distribution: Jammu: Kathua (Bhund), Kishtwar, Poonch (Bimbar Gali), Ramban (Banihal), Udhampur (Patnitop, Sanasar),; Kashmir: Anantnag (Pahalgam, Pahalgam-Chandanwari), Bandipore (Chorwan, Dawar, Gurez, Kishenganga Valley, Nagmarg), Baramulla (Gulmarg, Khilanmarg), Ganderbal (Kangan, Sonamarg), Muzaffarabad (Leepa Valley); Ladakh: Gilgit.

**Pteridaceae**

*Adiantum capillus-veneris* L., Sp. Pl. 2: 1096.

Common, grows in moist and humus-rich places along water channels, alt. 700–2000 m.

Distribution: Jammu: Doda (Batote, Kud), Jammu (Samba-Mansar Lake), Kathua (Basholi), Kishtwar (Chatru, Didhpur, Shalimar Nallah), Poonch, Reasi (Katra), Udhampur (Patnitop), ; Kashmir: Anantnag (Pahalgam), Baramulla (Babareshi, Buniyar, Jhelum Valley Road to Uri, Shrenz, Wagoora), Srinagar (Dachigam, Nishat Bagh), Sudhmahadev, ; Ladakh: Ladakh.

*Adiantum edgeworthii* Hook., Sp. Fil. 2: 14. 1851.

Occasional, grows in humid, shady situations, in rock crevices, alt. 1200–1800 m.

Distribution: Jammu: Kathua (Bani), Rajouri.

*Adiantum incisum* Forssk., Fl. Aegypt. -Arab. 187. 1775.

Common, grows on shady slopes, road edges and walls, alt. 700–1500 m.

Distribution: Jammu: Doda (Sudhmahadev), Jammu, Kathua (Bani, Jasorta forest), Poonch, Ramban, Reasi (Katra), Udhampur; Kashmir: Baramulla (Jhelum Valley Road to Uri, Rampur), Muzaffarabad; Ladakh: Kargil (Zanskar).

*Adiantum pedatum* L., Sp. Pl. 2: 1095. 1753.

Rare, grows as lithophyte on shaded walls or slopes, alt. 2500–3300 m.

Distribution: Jammu: Kishtwar (Podar); Kashmir: Anantnag (Aru, Munda to Banihal, Pahalgam, Tragbal), Baramulla (Gulmarg, Kishenganga Valley), Bandipore (Bagtore, Burzil Nallah, Gurez, Kanzalwal).

*Adiantum philippense* L., Sp. Pl. 2: 1094. 1753 (Plate 17.1h).

Common, grows as a lithophyte on shaded walls at humid places, alt. 800–1500 m.

Distribution: Jammu: Jammu (Jammu-Udhampur Road), Kathua.

*Adiantum tibeticum* Ching, Acta Phytotax. Sin. 18(1): 104, pl. 1, f. 12–15. 1980.

Rare, grows along coniferous forest slopes, forming dense patches, alt. 2000–3000 m.

Distribution: Kashmir: Anantnag (Amarnath, Aru, Pahalgam), Bandipore (Barnai, Gurez), Baramulla (Babareshi, Buniyar, Gulmarg, Shrenz, Wagoora), Srinagar (Bhampur, Dachigam).

*Adiantum venustum* D. Don, Prodr. Fl. Nepal. 17.1825 (Plate 17.2a).

Common, grows in densely shaded humus-rich soils, alt. 2000–4000 m.

Distribution: Jammu: Doda (Kud), Kathua, Kishtwar, Reasi (Vaishno Devi), Udhampur (Nathatop, Sanasar); Kashmir: Anantnag (Pahalgam, Pissoo Ghati), Baramulla (Gulmarg), Kupwara (Lolab Valley).

*Aleuritopteris albomarginata* (C.B. Clarke) Ching, Hong Kong Naturalist 10: 109. 1941 (Plate 17.2b).

Common, grows on moist humus-rich exposed slopes or walls, alt. 1500–2500 m.

Distribution: Jammu: Doda (Sudhmahadev), Kathua (Basholi), Poonch (Bimbar Gali), Reasi (Vaishno Devi), Udhampur (Patnitop).

*Aleuritopteris anceps* (Blanford) Panigrahi, Bull. Bot. Surv. India 2: 321. 1961.

Rare, grows on exposed rocks along roadsides, alt. 800–1800 m.

Distribution: Jammu: Doda (Kud), Kathua (Basholi), Poonch, Udhampur (Patnitop); Kashmir: Muzaffarabad.

*Aleuritopteris bicolor* (Roxb.) Fraser-Jenk., Fern Gaz. 18(5): 223. 2009.

Common, grows on walls, roadside slopes or forest floors in shady places, alt. 600–1500 m.

Distribution: Jammu: Jammu (Tawi Valley), Kathua (Mansar Lake), Poonch, Udhampur (Jammu-Udhampur Road); Kashmir: Muzaffarabad.

*Aleuritopteris dubia* (Hope) Ching, Hong Kong Naturalist 10: 200. 1941.

Occasional, grows in shady and moist places, alt. 1200 m.


**Plate 17.2** (**a**) *Adiantum venustum* D. Don; (**b**) *Aleuritopteris subvillosa* (Hook.) Ching; (**c**) *Chelianthes nitidula* Wall ex Hook. subsp. *nitidula* Fraser-Jenk.; (**d**) *Cheilanthes pteridioides* subsp. *acrostica* (Balb.) O. Bolòs; (**e**) *Cryptogramma brunoniana* Wall. ex Hook. & Grev.; (**f**) *Pteris terminalis* Wall. ex J. Agardh; (**g**) *Asplenium yoshinagae* subsp. *indicum* (Sledge) Fraser-Jenk.; (**h**) *Thelypteris erubescens* (Wall. ex Hook.) Ching

Distribution: Jammu: Poonch (Kolai), Reasi (Vaishno Devi, Adhkumari).

*Aleuritopteris formosana* (Hayata) Tagawa, Acta Phytotax. Geobot. 14: 191. 1952.

Abundant, grows on exposed rocky hill slopes or in shady places, alt.1500–1800 m.

Distribution: Jammu: Doda (Kud, Sudhmahadev), Udhampur (Patnitop).

*Aleuritopteris grisea* (Blanf.) Panigrahi, Bull. Bot. Surv. India 2(3/4): 321. 1961.

Rare, grows among shady rocks, alt. 2600–3000 m.

Distribution: Ladakh: Kargil (Batalik, near Mulbekh), Leh (Darchik), Rabi La.

*Aleuritopteris leptolepis* (Fraser-Jenk.) Fraser-Jenk., Taxon. Revis. Indian Subcontinental

Pteridophytes 127. 2008.

Occasional, grows in damp moist and shady places in forests, alt. 1600–2500 m.

Distribution: Ladakh: Leh (Darchik).

*Aleuritopteris rufa* (D. Don) Ching, Hong Kong Naturalist 10(3–4): 200–201. 1941.

Frequent, grows in limestone rock crevices, alt. 1000–1500 m.

Distribution: Jammu: Reasi (Vaishno Devi, Ardhkumari).

*Aleuritopteris subvillosa* (Hook.) Ching, Hong Kong Naturalist 10(3–4):203. 1941**.**

Rare, grows on rocks and walls, alt. 2100–3000 m.

Distribution: Jammu: Poonch (Chittapani, Rattan Pir); Kashmir: Muzaffarabad.

*Aleuritopteris* × *pangteyi* Fraser-Jenk. & E. Wollenw., Taxon. Revis. Three Hundred Indian Subcont. Pterid. 130. 2008.

Grows in similar condition of parentage.

Distribution: Jammu and Kashmir (Fraser-Jenkins et. al. 2017).

*Aleuritopteris* × *vermae* (Fraser-Jenk. & Viane) Fraser-Jenk. & Khullar, Taxon. Revis. Three Hundred Indian Subcont. Pterid. 130. 2008.

Grows in similar condition of parentage.

Distribution: Jammu and Kashmir (Fraser-Jenkins et. al. 2017).

*Ceratopteris thalictroides* (L.) Brongn. subsp. *gaudichaudii* (Brongn.) Fraser-Jenk. & Pariyar, Ferns Fern-Allies Nepal 1: 257. 2015.

Occasional, grows in ponds, ditches or marshy places, alt. up to 1000 m.

Distribution: Jammu and Kashmir (Fraser-Jenkins et. al. 2017).

*Cheilanthes nitidula* subsp. *nitidula* Wall. ex Hook., Sp. Fil. 2: 112. 1852. (Plate 17.2c).

Frequent, grows in rock crevices along roadsides, alt. 1500–2400 m.

Distribution: Jammu: Kathua (Bani), Kishtwar (Shalimar Nallah, Chatru, Didhpur); Kashmir: Kangan (Baltal Pass), Pir Panjal Range.

*Cheilanthes persica* (Bory) Mett ex Kuhn, Filic. Afr. 73. 1868.

Distribution: Jammu: Kathua, Kishtwar, Poonch, Ramban; Kashmir: Baramulla (Ghanta-mula, Rampur, Wagoora), Bandipore (Kishenganga Valley), Srinagar (Harwan, Takht-i-Suleman), Jhelum Valley; Ladakh: Gilgit (Jutial).

*Cheilanthes pteridioides* (Reichard) C. Chr. subsp**.** *acrostica* (Balb.) O. Bolòs, Vigo, Masalles & Ninot, Fl. Man. Països Catalans 1213. 1990. (Plate 17.2d). Occasional, grows as lithophyte in shady moist rock crevices, alt. 700–1800 m.

Distribution: Jammu: Doda (Puldoda, Kandani), Kishtwar (Shalimar Nallah, Chatru, Didhpur), Poonch (Rattan Pir), Ramban; Kashmir: Bandipore (Kishenganga Valley), Baramulla (Wagoora), Srinagar (Harwan, Takht-i-Suleman), Jhelum Valley.

*Coniogramme affinis* (Wall.) Hieron., Hedwigia 57. 297. 1916.
Occasional, grows in shady moist forest slopes, alt. 2200–3000 m.
Distribution: Jammu: Doda (Batote), Udhampur (Patnitop, Nathatop-Sanasar).
*Coniogramme intermedia* Hieron., Hedwigia 57. 301. 1916.
Frequent, grows in shady moist forest or rock crevices, alt. 2000–3000 m.
Distribution: Jammu: Udhampur (Patnitop); Kashmir: Anantnag (Pahalgam).
*Coniogramme pubescens* Hieron., Hedwigia 57: 314. 1916.
Occasional, grows in moist and shady humus floor or slopes, alt. 1500–3000 m.
Distribution: Kashmir: Kashmir Himalaya (Fraser-Jenkins *pers. comm.*).
*Coniogramme serrulata* (Blume) Fée, Mém. Foug. 5.Gen. Fil.: 167,t. 14 B, f. 2. 1852.
Occasional, grows in moist, shady humus-rich forest floor or slopes, alt. 1500–3000 m.
Distribution: Kashmir: Bandipore (Kishanganga Valley); Ladakh: Gilgit (Nanga Parbat).
*Cryptogramma brunoniana* Wall. ex Hook.& Grev., Icon. Filic. 2(8): pl. 158. 1830. (Plate 17.2e).
Frequent, grows in rock crevices or at the base of boulders, alt. 3000 m and above.
Distribution: Jammu: Doda (Seoj-Kailash); Kashmir: Anantnag (Kolahoi Glacier, Lidder Valley, Marbal Pass, Zur Nallah), Baramulla (Gulmarg, Khilanmarg, Mitchal area) Ladakh: Baltistan (Deosai, Skardu), Gilgit.
*Cryptogramma stelleri* (S.G. Gmel.) Prantl, Bot. Jahrb. Syst. 3(5): 413. 1882.
Occasional, grows in moist shady rock crevices of alpine region, alt. 3100–4300 m.
Distribution: Jammu: Poonch (Naltar, Chunagund); Kashmir: Bandipora (Koragbal, Kamri, Gurais), Baramulla (Aliabad), Ganderbal (Kangan, Sonamarg, near Gangabal lakes); Ladakh: Gilgit-Baltistan (Hunza), Karakorum mountains.
*Notholaena lanuginosa* Desv. ex Poir. subsp. *bivalens* Reichst., Willdenowia 13(2): 364. 1984.
Rare, grows on exposed rocks, alt. 900–3600 m.
Distribution: Kashmir: Kashmir Himalaya (*c.f.* Stewart 1957; Khullar 1994; Fraser-Jenkins et. al. 2017).
*Onychium cryptogrammoides* Christ, Notul. Syst. (Paris) 1: 52. 1909.
Common, grows on forest floor in shady and moist places, alt. 1200–2700 m.
Distribution: Jammu: Doda (Doda to Bhadawah, Batote, Kud), Kathua (Kadol),Kishtwar (Chatru, Shalimar Nallah), Poonch (Bimbar Gali, Suden Gali), Reasi (Vaishno Devi, Bhairon Temple Forest), Udhampur (Patnitop, Nathatop, Sanasar), ; Kashmir: Anantnag (Pahalgam), Baramulla (Gulmarg).
*Onychium kholianum* Fraser-Jenk. & S. Matsumoto, Ferns Fern-Allies Nepal 1: 292–294.
Occasional, grows on moist and shady side of hill slope, alt. ± 1500 m.
Distribution: Jammu and Kashmir (Fraser-Jenkins et. al. 2017).
*Onychium lucidum* (D. Don) Spreng., Linnaeus Syst. Veg., ed. 16, 4(1): 66. 1827.
Occasional, grows along hilly slopes amidst with grasses, alt. 1200–2000 m.

Distribution: Jammu: Kathua (Bhund), Kishtwar (Chatru, Didhpur, Mughal Mazar, Shalimar Nallah,) Poonch (Serimarg); Kashmir: Baramulla (Jhelum Valley Road, near Rampur), Muzaffarabad (Chikar).

*Onychium vermae* Fraser-Jenk. & Khullar, Ferns Fern-Allies Nepal 1: 300-302. 2015.

Common, grows in semiexposed moist places, alt. 1500–2200 m.

Distribution: Jammu and Kashmir (Fraser-Jenkins et. al. 2017).

*Pteris aspericaulis* Wall. ex J. Agardh, Recens. Spec. Pter. 22. 1839.

Frequent, grows in humus-rich forest edges, alt. 1500–2400 m.

Distribution: Jammu: Poonch (Rattan Pir); Kashmir: Muzaffarabad.

*Pteris cretica* subsp**.** *cretica* L., Mant. Pl. 1: 130. 1767.

Common, grows in open and dry places, alt. 1400–2300 m.

Distribution: Jammu: Doda (Batote), Kathua (Kadol); Kishtwar (Chatru, Didhpur, Saarthal, Shalimar Nallah), Ramban, Reasi (Vaishno Devi); Udhampur (Patnitop, Nathatop to Sanasar); Kashmir: Anantnag (Pahalgam); Baramulla (Buniyar, Chandigam, Wagoora), Srinagar (Dachigam).

*Pteris cretica* L. subsp. *laeta* (Wall. ex Ettingsh.) Fraser-Jenk., Taxon. Revis. Indian Subcontinental Pteridophytes 100. 2008.

Rare, grows with *Pteris cretica* in similar conditions.

Distribution: Kashmir: Kashmir Himalaya (Fraser-Jenkins et. al. 2017).

*Pteris terminalis* Wall. ex J. Agardh, Recens. Spec. Pter. 20. 1839 (Plate 17.2f).

Rare, grows in deep stream valley and shady damp places, alt. 1600–2000 m.

Distribution: Jammu: Poonch (Bafliaz); Kashmir: Anantnag (Pahalgam).

*Pteris vittata* subsp. *vittata* L., Sp. Pl. 2: 1074. 1753.

Abundant, grows on open roadsides, ditches and walls or along river and canal banks, alt. above 600 m.

Distribution: Jammu: Jammu, Kathua(Basholi), Kishtwar (Chatru, Didhpur), Poonch, Ramban, Reasi (Katra, Vaishno Devi), Udhampur; Kashmir: Muzaffarabad.

*Pteris vittata* L. subsp. *emodi* Fraser-Jenk., Taxon. Revis. Indian Subcontinental Pteridophytes 96 97, f. 77–81. 2008.

Common, grows on dry and exposed slopes or moist/densely shaded places, alt. 600–1500 m.

Distribution: Jammu: Kathua (Basholi), Kishtwar, Reasi (Vaishno Devi); Kashmir: Baramulla (Jhelum Valley Road, Uri).

*Pteris vittata* L. subsp. *vermae* Fraser-Jenk., New Sp. Syndr. Indian Pteridol. 229. 1997.

Occasional, grows in exposed slopes or moist shady places, alt. 600–1500 m.

Distribution: Jammu and Kashmir (Fraser-Jankins et. al. 2017).

*Pteris wallichiana* J. Agardh, Recens. Spec. Pter. 69. 1839.

Frequent, grows in forests or on beds of dry streamlets, alt. 1800–2400 m.

Distribution: Jammu and Kashmir (Fraser-Jenkins et. al. 2017).

**Aspleniaceae**

*Asplenium adiantum-nigrum* L., Sp. Pl. 2: 1081. 1753.

Common, grows among rocks in forest, along stream sides, on walls, alt. 1800–3200 m.

Distribution: Jammu: Doda (Batote, Bhaderwah, Sudhmahadev), Kishtwar (Chatru, Didhpur, Mughal Mazar, Shallimar Nallah), Poonch, Ramban, Udhampur (Patnitop); Kashmir: Anantnag (Aru, Kokernag, Pahalgam), Bandipore (Kishenganga Valley), Baramulla (Ghantamula, Gulmarg, Jhelum Valley Road near Rampur, Shrez, Tangmarg, Thyan, Wagoora), Ganderbal (Sind valley), Srinagar (Harwan), Kupwara (Lolab Valley).

*Asplenium amoenum* C. Presl ex Mett., Abhandl. Senckenb. Naturf. Ges.3: 131, t. 4, f. 11. 1859.

Rare, grows on moist and wet rocks, alt. 1500–2400 m.

Distribution**:** Jammu: Kathua (Kardon).

*Asplenium ceterach* L., Sp. Pl. 2: 1080. 1753.

Abundant, grows on dry exposed rocks or walls, alt. 900–2500 m.

Distribution: Jammu: Doda (Bhaderwah), Kishtwar, Poonch; Kashmir: Baramulla (Babareshi, Buniyar, Ghantamula, Jhelum Valley, Shrenz, Wagoora), Ganderbal (Kangan, Naranag), Srinagar (Dachigam, Harwan, near Dal Lake, near Shankaracharya Mandir, Nishat Garden, Srinagar Hills, Vanpora); Ladakh: Baltistan, Gilgit.

*Asplenium daghestanicum* Christ subsp. *aitchisonii* (Fraser-Jenk. & R. Reichst.) Fraser-Jenk., Indian Fern J. 27(1–2): 190, f. 14, 15. 2010.

Rare, grows in rock crevices and on cliffs, alt. 2500–4200 m.

Distribution: Kashmir: Anantnag (near Chatpontsal Nallah, Lidder Valley, Pahalgam); Ladakh: Baltistan (Swarna Nallah, Shingo).

*Asplenium dalhousiae* Hook., Icon. Pl. 2: pl. 105. 1837.

Common, grows in moist shady places, forest floor, alt. 500–2500 m.

Distribution: Jammu: Doda (Bhaderwah), Jammu, Kathua (Kadol), Poonch, Reasi (Katra, Vaishno Devi), Udhampur (Mantalai); Kashmir: Anantnag (Pahalgam), Bandipore (Kishenganga Valley), Baramulla (Babareshi, Buniyar, Jhelum Valley Road, Shrenz, Wagoora), Muzaffarabad, Pir Panjal, Srinagar (Dachigam, Harwan, Vanpora); Ladakh: Gilgit.

*Asplenium fontanum* (L.) Bernh. subsp. *pseudofontanum* (Kossinsky) Reichst. & Schneller, Candollea 37(1): 124. 1982.

Common, grows on calcareous shady rocks, among boulders, alt. 2000–3000 m.

Distribution: Jammu: Poonch (Mandi-Loran); Kashmir: Anantnag (Aru to Nafran, Pahalgam, Kintmala Nallah, Kalahoi Glacier, Lidder Valley), Baramulla (Ferozpur Nallah, Rampur, Tangmarg), Bandipore (Chorwan, Gurez, Kishenganga Valley), Ganderbal (Sind Valley, Sonamarg), Kungwatan (Aharbal-Kungwatan); Ladakh: Baltistan, Gilgit, Kargil (Zanskar), Ladakh to Kang, Shingo Valley.

*Asplenium khullarii* Reichst. & Rasbach ex Fraser-Jenk., Taxon. Revis. Indian Subcontinental Pteridophytes 171, f. 207. 2008.

Occasional, grows in shaded, humid and mossy rock crevices, alt. 2500–3500 m.

Distribution: Jammu: Udhampur (Patnitop, Sanasar).

*Asplenium laciniatum* D. Don subsp. *kukkonenii* (Viane & Reichst.) Fraser-Jenk., Taxon. Revis. Indian Subcontinental Pteridophytes 169. 2008.

Occasional, grows among moist shady rocks, in forests, alt. 1600–2500 m

Distribution: Kashmir: Anantnag (Lidder Valley, Pahalgam), Bandipore (Tragbal), Baramulla (Gulmarg, Wagoora), Ganderbal (Kangan, Gund, Sonamarg), Srinagar.

*Asplenium laciniatum* subsp. *laciniatum* D. Don, Prodr. Fl. Nepal. 8. 1825.

Abundant, grows among moist shady rocks, alt. 1600–3000 m.

Distribution: Jammu: Doda (Batote), Poonch (Baltistan Pass, Chittapani), Reasi (Vaishno Devi), Udhampur (Patnitop, Sanasar), ; Kashmir: Anantnag (Aru, Lidder Valley, Naubug, Pahalgam).

*Asplenium laciniatum* D. Don subsp. *tenuicaule* (Hayata) Fraser-Jenk., Taxon. Revis. Indian Subcontinental Pteridophytes 169, f. 1, 2. 2008**.**

Occasional, grows in shady rock crevices, alt. 1000–1800 m.

Distribution: Jammu: Kathua (Kadol), Poonch, Rajouri, Reasi (Bhairon Temple, Vaishno Devi), Udhampur (Patnitop); Kashmir: Muzaffarabad, Jhelum Valley.

*Asplenium punjabense* Bir, Fraser-Jenk. & Lovis, Fern Gaz. 13(1): 55. 1985.

Occasional, grows along stream banks, on walls and rocky slopes, alt. 900–2000 m.

Distribution: Jammu: Doda (Bhaderwah), Kishtwar; Kashmir: Muzaffarabad, Srinagar.

*Asplenium ruta-muraria* L., Sp. Pl. 2: 1081. 1753.

Occasional, grows in calcareous rock crevices; alt. 2100–3600 m.

Distribution: Kashmir: Anantnag (Badwan, Kalahoi Glacier, Lidder Valley, Pahalgam), Bandipore (Barnai, Dawar, Gurais), Baramulla, Ganderbal (Kangan, Sonamarg), Muzaffarabad (Rattigali); Ladakh: Baltistan (near Skardu), Kargil (Batalik), Kangi Nallah.

*Asplenium sarelii* Hook. subsp. *pekinense* (Hance) Fraser-Jenk., Pangtey & Khullar, Indian Fern J. 27(1-2): 194. 2011.

Rare, grows on walls and rocks, alt. 600–2500 m.

Distribution: Kashmir: Anantnag (Pahalgam), Baramulla (Jhelum Valley Road, Rampur to Uri).

*Asplenium septentrionale* (L.) Hoffm. subsp. *caucasicum* Fraser-Jenkins & Lovis, Notes Roy. Bot. Gard. Edinburgh 38(2): 281. 1980.

Occasional, grows in dry rock crevices, on cliffs in open places, alt. above 2400 m.

Distribution: Jammu and Kashmir (Fraser-Jenkins et. al. 2017).

*Asplenium septentrionale* subsp. *septentrionale* (L.) Hoffm., Deutschl. Fl. 2: 12–13. 1795.

Common, grows in dry rock crevices, on cliffs in open places, alt. 2100–4200 m.

Distribution: Jammu: Poonch, Ramban (Banihal); Kashmir: Anantnag (Lidderwat, Kolahoi Glacier), Bandipore (Gurez, Kanzalwan, Kishenganga Valley, Nagmarg), Baramulla (Ferozpur Nallah, Gulmarg, Tangmarg), Ganderbal (Kangan, Sonamarg, Thajwas); Ladakh: Baltistan, Gilgit.

*Asplenium trichomanes* L. subsp. *quadrivalens* D. E. Mey., in Ber. Deutsch. Bot. Ges. 74: 456. 1962.

Abundant, grows in shady rock crevices (limestone and silicates) and walls on banks and cliffs, alt. 1500–3000 m.

Distribution: Jammu and Kashmir (Fraser-Jenkins et. al. 2017).

*Asplenium trichomanes* subsp. *trichomanes* L., Sp. Pl. 2: 1080. 1753.

Occasional, grows in shady rock (silicate) crevices, unmortarted walls, cliffs, roadsides; alt. 1500–3000 m.

Distribution: Jammu and Kashmir (Fraser-Jenkins et. al. 2017).

*Asplenium viride* Huds., Fl. Angl. 385. 1762.

Common, grows on calcareous rocks, in shady rock crevices, forest cliffs; alt. 2300–4000 m.

Distribution: Jammu: Poonch; Kashmir: Anantnag (Amarnath Cave, Lidder Valley, Sheeshnag), Bandipore (Barnai, Chorwan, Gurez, Kamri Pass, Tilel Range), Baramulla (Gulmarg, Khilanmarg), Ganderbal (Kangan, Baltal to Amarnath, Sonamarg), Muzaffarabad; Ladakh: Baltistan, Gilgit, Minimarg, Kargil, Panikhar.

*Asplenium yoshinagae* Makino subsp. *indicum* (Sledge) Fraser-Jenk., Pakistan Syst. 5: 97. 1991 (Plate 17.2g).

Rare, grows as epiphyte on mossy tree and lithophyte on shady and moist rocks, alt.1400–2000 m.

Distribution: Jammu: Kathua (Bani, Kardol).

*Asplenium* × *alternifolium* Wulfen, Misc. Austriac. 2. 51 t. 5 f. 2. 1782.

Rare, grows in rock crevices, where the parental species grow together on acidic rocks, alt. 2100–2400 m.

Distribution: Jammu: Kathua (Sarthal, Chatra Gala Pass, Basholi to Bhaderwah); Kashmir: Anantnag (Pahalgam).

*Asplenium* x *chingii* Fraser-Jenk., Taxon. Revis. Three Hundred Indian Subcont. Pterid. 158–159. 2008.

Rare, grows in rocks cliffs, alt. above 2000 m.

Distribution: Jammu: Kathua (Sarthal, N. of Basholi).

*Asplenium* × *sobtianum* Fraser-Jenk., Pangtey & Khullar, Indian Fern J. 27(1–2): 211, f. 35. 2011.

Rare, grows as lithophyte on shady, mossy and moist rocks.

Distribution: Jammu: Doda (Batote).

**Thelypteridaceae**

*Thelypteris arida* (D. Don) C.V. Morton, Amer. Fern J. 49 (3): 113. 1959.

Rare, grows in marshy places along streams, alt. 1000–1600 m.

Distribution: Jammu: Kathua (West of Dhar); Kashmir: Wular Lake area.

*Thelypteris cana* (Baker) Ching, Bull. Fan Mem. Inst. Biol. 6(5): 291. 1936.

Frequent, grows in forest, near streams, in damp places, alt. 1000–1800 m.

Distribution: Jammu: Poonch (Bimbar Gali), Kathua (Bhandar).

*Thelypteris dentata* (Forssk.) E. P. St. John, Amer. Fern J. 26(2): 44. 1936.

Abundant, grows along ravines, streams and moist places, alt. 600–1500 m.

Distribution: Jammu: Kathua, Kishtwar (Bhandar Koot, Didhpur, Mughal Mazar, Sarthal), Poonch, Ramban, Reasi (Katra); Kashmir: Baramulla (Buniyar).

*Thelypteris erubescens* (Wall. ex Hook.) Ching, Bull. Fan Mem. Inst. Biol., Bot. 6(5): 293–295. 1936 (Plate 17.2h).

Common, grows near streams, ravines in shady conditions, alt. 1000–2400 m.

Distribution: Jammu: Doda (Kud, Sudhmahadev), Kathua, Kishtwar (Bhandar Koot, Didhpur, Mughal Mazar), Poonch (Goorah, Nawalnadi, Serimarg), Ramban (Banihal), Udhampur (Patnitop); Kashmir: Bandipore (Dhani, Titwal, Kishenganga Valley), Jhelum Valley.

*Thelypteris levingei* (C.B. Clarke) Ching, Bull. Fan Mem. Inst. Biol., Bot. 6(5): 273–274. 1936.

Common, grows along moist and wet places, alt. 1200–2600 m.

Distribution: Kashmir: Anantnag (Lidder Valley, en route to Amarnath), Bandipore, Baramulla (Gulmarg, Gurez, Tangmarg, Wagoora), Ganderbal (Kangan, Sind Valley), Kupwara (Lolab Valley), Srinagar (Harwan), Jhelum Valley, Pir Panjal Range.

*Thelypteris microstegia* (Hook.) Fraser-Jenk. subsp. *laterepens* (E.W. Trotter) Fraser-Jenk., Annot. Checkl. Ind. Pterid. 1: 454. 2016.

Rare, grows in wet places near streams in forests, alt. 2000–2700 m.

Distribution: Kashmir: Anantnag (Aru, Pahalgam), Baramulla (Gulmarg, Tangmarg).

*Thelypteris microstegia* subsp. *microstegia* (Hook.) Fraser-Jenk., Annot. Checkl. Ind. Pterid. 1: 454. 2016.

Occasional, grows in wet places along stream banks in forests, alt. 1500–2400 m.

Distribution: Jammu: Kathua (Kadol).

*Thelypteris mollissima* (Kunze) Thapa, Pterid. Nepal 95. 2002.

Occasional, grows in shady and marshy places, alt. 1500–2400 m.

Distribution: Jammu: Kathua (Banjal, Kadol); Kashmir: Kupwara (Lolab Valley).

*Thelypteris nudata* (Roxb.) C.V. Morton, Contr. U.S. Natl. Herb. 38(7): 352. 1974.

Rare, grows on moist rocky slopes, near the streams, alt. 1400–1600 m.

Distribution: Jammu: Kathua (Ramkot to Dhar), Poonch.

*Thelypteris palustris* (A. Gray) Schott, Gen. Fil. pl. 10. 1834.

Common, grows in marshy places, near lake banks, alt. 1500–2000 m.

Distribution: Kashmir: Bandipore, Baramulla (Gulmarg), Ganderbal (Sind Valley), Srinagar (Srinagar, Harwan), Kupwara (Lolab Valley).

*Thelypteris papilio* (C. Hope) K. Iwats., Mem. Coll. Sci. Kyoto Imp. Univ., Ser. B, Biol. 31(3): 175. 1965.

Occasional, grows in moist places, along streams banks, alt. 1600 m.

Distribution: Jammu: Kathua (Bhund).

*Thelypteris penangiana* (Hook.) C. F. Reed, Phytologia 17(4): 303. 1968.

Rare, grows in moist shady rocks, near waterfalls, alt. 1200–1600 m.

Distribution: Jammu: Jammu (Tawi Valley), Kathua (Kadol, Domel), Poonch (Nawal Nadi), Rajouri (Manjakote); Kashmir: Jhelum Valley.

*Thelypteris phegopteris* (L.) Sloss. ex Rydb., Fl. Rocky Mts. 1043. 1917.

Common, grows in moist, marshy places, near streams, alt. 2500–3000 m.

Distribution: Kashmir: Anantnag (Pahalgam), Bandipore (Burzil Nallah, Gurez, Izmarg, Razdan Pass), Baramulla (Gulmarg, Khilanmarg), Budgam (Fras Nag, Nil Nag), Ganderbal (Sonamarg), Muzaffarabad.


**Plate 17.3** (**a**) *Thelypteris prolifera* (Retz.) C.F. Reed; (**b**) *Hypodematium crenatum* Kuhn & Decken subsp. *loyalii* Fraser-Jenk. & Khullar; (**c**) *Woodsia alpina* (Bolton) Gray; (**d**) *Dryopteris barbigera* (T. Moore ex Hook.) Kuntze; (**e**) *Dryopteris caroli-hopei* Fraser-Jenk.; (**f**) *Polystichum mehrae* Fraser-Jenk. & Khullar; (**g**) *Polystichum thomsonii* (Hook. F.) Bedd.; (**h**) *Woodwardia unigemmata* (Makino) Nakai

*Thelypteris prolifera* (Retz.) C. F. Reed, Phytologia 17(4): 306. 1968 (Plate 17.3a).
Abundant, grows near river banks, water channels, alt. 500–1500 m.
Distribution: Jammu: Jammu, Kathua, Poonch, Rajouri, Reasi (Katra), Udhampur.
*Thelypteris punethae* Fraser-Jenk., Annot. Checkl. Ind. Pterid. 481.2017.
Rare, grows in similar condition of *T. dentata*.
Distribution: Jammu: Kathua (Bhund, Basholi).
*Thelypteris tylodes* (Kunze) Ching, Bull. Fan Mem. Inst. Biol., Bot. 6 (5): 296–298. 1936.
Occasional, grows in moist rocky places, along streams, alt. 1000–1600 m.
Distribution: Jammu: Kathua (Bhund, Kadol).
*Thelypteris* × *kashmiriana* Fraser-Jenk., Taxon. Revis. Indian Subcontinental Pteridophytes 200. 2008**.**
Occasional, grows in moist rocky places, along streams, alt. 1000–1600 m.
Distribution: Jammu: Doda (Bhaderwah, Nalthi).

**Woodsiaceae**
*Athyrium atkinsonii* Bedd., Suppl. Ferns S. Ind. 11, pl. 359. 1876.
Rare, grows in shady, humus-rich forest floor, alt. 3000–3700 m.
Distribution: Jammu: Kathua (Chatra Gala Pass); Kashmir: Anantnag (Lidder Valley, Pahalgam), Bandipore (Kishenganga Valley), Baramulla (Gulmarg, Khilanmarg), Budgam (Fras-Nag), Ganderbal (Kangan, Sonamarg).
*Athyrium attenuatum* (Wall. ex C.B. Clarke) Tagawa, Acta Phytotax. Geobot. 16(6): 177–178. 1956.
Common, grows in forest floor, alt. 2400–3000 m.
Distribution: Jammu: Doda (Marbal Pass), Kishtwar, Udhampur (Patnitop); Kashmir: Anantnag (Lidder Valley, Kolahoi Glacier, Pahalgam), Bandipore (Gurez, Izmarg Kishenganga Valley), Baramulla (Gulmarg), Srinagar (Dagwan), Pir Panjal.
*Athyrium distans* (D. Don) T. Moore in Index Fil. (T. Moore) 125, 181. 1860;
Occasional, grows in forests, on banks of streams, alt. 1500–2500 m.
Distribution: Kashmir: Ganderbal (Sind Valley).
*Athyrium mackinnoniorum* (C. Hope) C. Chr., Index Filic. 143. 1905.
Common, grows in shady moist and humus-rich soil, alt. 2200–3000 m.
Distribution: Jammu: Poonch (Serimarg), Kishtwar (Chenab Valley), Reasi (Vaishno Devi), Udhampur (Patnitop); Kashmir: Anantnag (Amarnath, Pahalgam, Tangmarg), Bandipore (Gurez, Kishenganga Valley), Baramulla (Babareshi, Gulmarg, Mt. Apharwat)..
*Athyrium pectinatum* (Wall. ex Mett.) T. Moore, Index Fil. (T. Moore) 2: 186. 1860.
Common, grows on grassy hill slopes, alt. 1500–2000 m.
Distribution: Jammu: Kathua.
*Athyrium rubricaule* (Edgew. ex C.B. Clarke) Bir, Nova Hedwigia 4: 169, t. 54. 1962.
Occasional, grows under shady forest slopes, alt. 2000–2800 m.

Distribution: Jammu: Doda (Bhaderwah); Kashmir: Anantnag (Lidder Valley, Pahalgam, Sekiwas, Zur-nar), Bandipore (Gurez), Baramulla (Gulmarg), Budgam (Fras-Nag), N. Kashmir Valley (Sarpat).

*Athyrium rupicola* (Edgew. ex C. Hope) C. Chr., Index Filic. 3: 145. 1905.

Common, grows in rock crevices, along roadsides, alt. 2500–3500 m.

Distribution: Jammu: Kathua (Chatra Gala Pass), Udhampur (Patnitop, Nathatop-Sanasar); Kashmir: Anantnag (Sheshnag), Pir Panjal.

*Athyrium schimperi* Moug. ex Fee subsp**.** *biserrulatum* (Christ) Fraser-Jenk., New Sp. Syndr. Indian Pteridol. 60. 1997.

Rare, grows in damp shady places, alt. 1800–3000 m.

Distribution: Jammu: Kathua, Poonch (Rattan Pir), Reasi (Vaishno Devi), Udhampur (Patnitop, Sanasar); Kashmir: Baramulla (Gulmarg).

*Athyrium strigillosum* (T. Moore ex E.J. Lowe) Salomon, Nomencl. Gefässkrypt. 112. 1883.

Rare, grows on the banks of streams and shaded ravines and on moist rocks, alt. 1500–2100 m.

Distribution: Jammu: Doda (Bhaderwah), Kishtwar, Poonch (Bagh, Rawalkot, Banjosa), Udhampur (Patnitop, Nathatop-Sanasar); Kashmir: Bandipora ( Gurez, Kanzalwan), Muzaffarabad (Chikar).

*Athyrium wallichianum* Ching, in Bull. Fan Mem. Inst. Biol. Bot. 8: 497. 1938.

Common, grows on hill slopes, alt. 3200–4000 m.

Distribution: Kashmir: Anantnag (Amarnath, Mount Kolahoi, Lidderwat), Bandipore (Razdan meadows, Gurez, Kamri Pass), Baramulla (Gulmarg, above Khilanmarg), Burzil Pass, Ganderbal (Gangabal Lake).

*Cystopteris fragilis* (L.) Bernh subsp. *diaphana* (Bory) Litard., Bull. Soc. Bot. Deux-Sevres 23: 88. 1912.

Occasional, grows among bushes and rocks, alt. 2400–3000 m.

Distribution: Jammu: Doda (Bhaderwah), Kathua (Chatr Gala Pass); Ladakh: Chang La.

*Cystopteris fragilis* (L.) Bernh subsp. *dickieana* (R. Sim) Hyl., Uppsala Univ. Arsskr. 1945(7): 59. 1945.

Common, grows on rocky hill slopes and in crevices, alt. 2300–4000 m.

Distribution: Jammu: Kishtwar, Udhampur (Patnitop, Sanasar); Kashmir: Anantnag (Amarnath, Aru, Mount Kolahoi, Pahalgam, Lidderwat), Bandipore (Gurez), Baramulla (Babareshi, Nambalnar, Shrenz, Wagoora), Ganderbal (Baltal, Baltal-Matayan); Ladakh: Hemis National Park, Leh (Leh-Khaotse), Kargil (Dras-Kargil Road), Khardong La.

*Cystopteris fragilis* subsp**.** *fragilis* (L.) Bernh., Neues J. Bot. 1(2): 27. 1806.

Common, grows on open rocky hill slopes and in crevices, alt. 2000–4500 m.

Distribution: Jammu: Kathua, Kishtwar, Udhampur (Patnitop, Sanasar); Kashmir: Anantnag (Amarnath, Aru, Mount Kolahoi, Pahalgam, Lidderwat), Bandipore (Barnai, Gurez), Baramulla (Babareshi, Nambalnar, Shrenz, Wagoora), Srinagar (Jasker-Dagwan), Tilel Range; Jammu, Ganglas; Ladakh, Khardung La, Thanglang La.

*Cystopteris montana* (Lam.) Bernh. ex Desv., Neues J. Bot. 1(2): 26. 1806.

Occasional, grows in rock crevices in birch forests, alt. 3000–4000 m

Distribution: Kashmir: Baramulla (Gulmarg), Ganderbal (Sonamarg), Kupwara (Bangas).

*Cystopteris fragilis* (L.) Bernh. nothosubsp. × *montserratii* (Prada and Salvo) Fraser-Jenk., New Sp. Syndr. Indian Pteridol. 100. 1997.

Occasional, grows on open rocky hill slopes and in crevices, alt. 2000–4500 m.

Distribution: Jammu: Udhampur (Patnitop, Sanasar); Kashmir: Bandipore (Kishenganga Valley), Baramulla (Gulmarg).

*Deparia allantodioides* (Bedd.) M. Kato, J. Fac. Sci. Univ. Tokyo, Sect. 3, Bot. 13(4): 393. 1984.

Common, grows on hill slopes and forest, alt. 2300–3000 m.

Distribution: Jammu: Kathua, Kishtwar (Mughal Mazar), Poonch, Udhampur (Patnitop, Nathatop-Sanasar); Kashmir: Anantnag (Pahalgam, Kolahoi Glacier, Lidder Valley), Bandipore (Barnai, Gurez), Baramulla (Gulmarg), Ganderbal (Sind valley), Muzaffarabad.

*Deparia boryana* (Willd.) M. Kato, Bot. Mag. (Tokyo) 90(1017): 36. 1977.

Occasional, grows along streams, in moist places, alt. 1800–2400 m.

Distribution: Jammu: Kathua (Basholi, Silodi Mandir from Bhund to Bani).

*Deparia japonica* (Thunb.) M. Kato, Bot. Mag. (Tokyo) 90(1017): 37. 1977.

Occasional, grows in moist shady places along streams, alt. 1200–2000 m.

Distribution: Jammu: Kishtwar, Udhampur (Patnitop); Kashmir: Bandipore (Kishenganga Valley), Kupwara (Keran), Pir Panjal, Muzaffarabad (Jula), Nilishang.

*Deparia macdonellii* (Bedd.) M. Kato, J. Fac. Sci. Univ. Tokyo, Sect. 3, Bot. 13(4): 391. 1984.

Rare, grows in very wet situations along streamlets, alt. 1200–1800 m.

Distribution: Kashmir: Bandipore (Gurez, Kanzalwan, Kishenganga Valley), Baramulla (Buniar, Harpat Rai Nallah near Rampur), Budgam (Nilnag), Jhelum Valley, Kupwara (Keran, Lolab Valley), Muzaffarabad (Sharda, Leepa).

*Deparia petersenii* (Kunze) M. Kato, Bot. Mag. (Tokyo) 90(1017): 37. 1977.

Common, grows on forest floor in damp situations in shady places, alt. 1500–2000 m.

Distribution: Jammu: Kathua (Bani), Poonch (Banjosa, Rawalkot), Udhampur (Patnitop); Kashmir: Muzaffarabad (Neelam Valley), Taubat.

*Deparia subsimilis* (Christ) Fraser-Jenk., Taxon. Revis. Indian Subcontinental Pteridophytes 239. 2008.

Common, grows on hill slopes in rocky places near the streams, alt. 2300–3800 m.

Distribution: Kashmir: Anantnag (Chandanwari, Pahalgam, Mount Kolahoi), Baramulla (Gulmarg-Tangmarg Nallah).

*Diplazium esculentum* (Retz.) Sw., J. Bot. (Schrader) 1801(2): 312. 1803.

Abundant, grows along ditches, streams, alt. up to 1600 m.

Distribution: Jammu: Kathua (Perol, Kathua city, Kadol), Poonch.

*Diplazium laxifrons* Rosenst., Hedwigia 56. 337. 1915.

Occasional, grows in moist places, alt. 300–1500 m.

Distribution: Jammu: Kathua (Kadol), Poonch (Bufliaz).

*Diplazium longifolium* T. Moore, Index Fil. 141. 332. 1859.

Occasional, grows along ravines, waterfalls and wet rocks, alt. 1200–2400 m.

Distribution: Jammu: Kathua (Kadol).

*Diplazium maximum* (D. Don) C. Chr., Index Filic. fasc. 4: 235. 1905.

Abundant, grows in shady, moist places along streambeds, alt. 1200–2500 m.

Distribution: Jammu: Doda (Bhaderwah), Kishtwar (Chetru, Shalimar Nallah), Poonch, Udhampur (Patnitop, Sanasar); Kashmir: Anantnag (Pahalgam), Ganderbal (Sonamarg).

*Diplazium sibiricum* subsp. *himalaicum* Fraser-Jenk., Taxon. Revis. Indian Subcontinental Pteridophytes 277. 2008.

Rare, grows in deep-shaded, moist places along streams, alt. 2300–3000 m.

Distribution: Kashmir: Anantnag (Chandanwari, Pahalgam), Bandipore (Gurez, Kishenganga Valley), Baramulla (Gulmarg-Tangmarg trek), Donari Nallah, Kupwara (Keran Nallah), Muzaffarabad.

*Diplazium spectabile* (Wall. ex Mett.) Ching, Lingnan Sci. J. 15(2): 278–279. 1936.

Occasional, grows in wet places, alt. 900–2000 m.

Distribution: Jammu: Kathua (Sibdi Mandir, North of Bhund and Basholi).

*Diplazium* × *kashmirianum* Fraser-Jenk., Bot. Helv. 102(2): 154. 1992.

Rare, grows in deep forested stream gully, alt. 1500 m.

Distribution: Jammu: Doda (Bhaderwah), Kathua (Bani, Basholi, Kadol).

*Gymnocarpium fedtschenkoanum* Pojark., Soobshch. Tadzh. Fil. Akad. Nauk SSSR. 22: 9. 1950.

Common, grows in deep, moist and sheltered ravines along streams, alt. 2000–3000 m.

Distribution: Jammu: Kishtwar, Udhampur (Patnitop, Sanasar); Kashmir: Anantnag (Pahalgam, Sheshnag, en route to Amarnath), Bandipore (Gurez, Barnai, Chorwan, Kishanganga Valley), Baramulla (Ferozpur Nallah, Gulmarg, Tangmarg), Budgam (Nilnag), Ganderbal (Kangan, Sonamarg); Ladakh: Baltistan-Gilgit (Jutial Nala, Balti, Katsura).

*Hypodematium crenatum* subsp. *crenatum* (Forssk.) Kuhn, Disk. Reis. Bot. 3(3): 37, f. a. 1879.

Common, grows in crevices of dry rocks, alt. 800–1800 m.

Distribution: Jammu: Kathua (Kot-Banjal), Kishtwar (Chatru), Poonch (Kolai, Tuti Pir, Hila Kotli), Ramban, Reasi (Katra, Bhairon Temple), Udhampur (Chenani); Kashmir: Muzaffarabad, Pir Chinasi.

*Hypodematium crenatum* Kuhn &Decken subsp. *loyalii* Fraser-Jenk. & Khullar, Bot. Helv. 102(2): 146. 1992. (Plate 17.3b).

Common, grows in crevices of dry rocks, alt. 800–1800 m.

Distribution: Throughout Himalayan range of subsp. *crenatum* (Fraser-Jenkins et. al. 2017).

*Woodsia alpina* (Bolton) Gray in Nat. Arr. Brit. Pl. 2. 17.1821. (Plate 17.3c).

Frequent, grows in dry rock crevices, alt. 2700–4000 m.

Distribution: Kashmir: Anantnag (Lidder Valley, Kolahoi Glacier, Pahalgam), Budgam (above Fras-Nag), Baramulla (Mt. Apharwat, Gulmarg), Ganderbal (Kangan, Sind Valley, Sonamarg), Sonsal Nallah, Kainmul.

*Woodsia glabella* R. Br. ex Richardson, Narr. Journey Polar Sea 754. 1823.
Rare, lithophytic, grows in moist rock crevices, alt. 4000 m.
Distribution: Ladakh: Dras to W. Ladakh.

**Dryopteridaceae**
**Subfam. Dryopteridoideae**

*Dryopteris acutodentata* Ching, Bull. Fan Mem. Inst. Biol., Bot. 8(6): 432–433. 1938.
Rare, grows among rocks, above the forest zone, alt. 3000–4000m.
Distribution: Kashmir: Bandipore (Tragbal Pass).

*Dryopteris barbigera* (T. Moore ex Hook.) Kuntze, Revis. Gen. Pl. 2: 812. 1891 (Plate 17.3d).
Common, grows on open slopes among bushes, alt. 3100–4500 m.
Distribution: Jammu: Kathua, Poonch (near Mirpur), Reasi; Kashmir: Anantnag (Aharwat, Chandanwari, Chatponsal Nallah, near Bajipath, N-E of Pahalgam, Harnag, Lidder Valley); Bandipore (Razdan Pass, Gurez, Kamri Pass), Baramulla (Donari Pass), Ganderbal (Kangan, Sonamarg), Jhelum Valley, Muzaffarabad (Mitsahoi); Ladakh: Gilgit, Kargil (Zanskar).

*Dryopteris blanfordii* (C. Hope) C. Chr., Index Filic. fasc. 4: 254. 1905.
Occasional, grows in forest floor or among rocks, alt. 2000–3500 m.
Distribution: Jammu: Kathua, Poonch, Udhampur (Patnitop), Ramban (Banihal Pass), Pir Panjal Range; Kashmir: Anantnag ( Chatponsal Nallah, near Bajipath, Lidder Valley, Pahalgam), Bandipore (Gurez, Koragbal, Kishenganga Valley), Baramulla (Mt.Apharwat, Gulmarg), Kupwara (Keran), Ganderbal (Baltal, Kangan, Gund, Sonamarg to Ganderbal, Sind Valley), Muzaffarabad (Keran); Ladakh: Kargil (Zanskar), Gilgit-Baltistan.

*Dryopteris caroli-hopei* Fraser-Jenk., Bull. Brit. Mus. (Nat. Hist.), Bot. 18(5): 422–425, f. 50. 1989. (Plate 17.3e).
Occasional, grows along open hill slopes, alt. 1500–2200 m.
Distribution: Jammu: Udhampur (Vaishno Devi), Kathua (Kadol).

*Dryopteris chrysocoma* (Christ) C. Chr., Index Filic. fasc. 5: 257. 1905.
Occasional, grows in open places among boulders, in rock crevices along roads; alt. 1900–3500 m.
Distribution: Jammu: Poonch (Rattan Pir); Kashmir: Anantnag (Pahalgam), Pir Panjal Range; Ladakh: Kargil (Zanskar).

*Dryopteris cochleata* (D. Don) C. Chr., Index Filic. 5: 258. 1905.
Common, grows on forest slopes, alt. 700–1200 m.
Distribution: Jammu: Jammu, Poonch (Rattan Pir), Kathua.

*Dryopteris dickinsii* (Franch. and Sav.) C. Chr., Index Filic. fasc. 5: 262. 1905.
Rare, grows on shady coniferous forest slopes, alt. 1700–2500 m.
Distribution: Jammu: Poonch (Tangdur Forest), Rajouri; Kashmir: Baramulla (Gantamulla), Kupwara
(Lolab Valley).

*Dryopteris edwardsii* Fraser-Jenk., New Sp. Syndr. Indian Pteridol. 138. 1997.
Rare, grows in the upper-level forest zone on ground, alt. 2500–3000 m.

Distribution: Jammu: Kathua (Sarthal); Kashmir: Anantnag (Pahalgam), Baramulla (Ferozepur Nallah, Gulmarg, Tangmarg), Muzaffarabad (Taubat, Neelam Valley).

*Dryopteris filix-mas* (L.) Schott, Gen. Fil., sub pl. 9. 1834.

Occasional, grows on open rocky slopes, roadsides, above forest zone, alt. 2700–3900 m.

Distribution: Kashmir: Bandipore (Razdan Pass, Kishanganga Valley), Baramulla (Gulmarg), Ganderbal (Sonamarg); Ladakh: Baltistan-Gilgit (Nanga Parbat), Kargil (Meenamarg near Zoji La),.

*Dryopteris juxtaposita* Christ, Bull. Acad. Int. Géogr. Bot. 17(212): 138. 1907.

Frequent, grows in open forests, along the side of rocks, alt. 1500–3000 m.

Distribution: Jammu: Doda (Bhaderwah, Nalthi), Poonch (Mandi-Loran), Kathua (Sarthal), Ramban (Banihal), Udhampur (Patnitop); Kashmir: Muzaffarabad (Sharda, Neelam Valley).

*Dryopteris komarovii* Kossinsky, Bot. Mater. Gerb. Glavn. Bot. Sada R.S.F.S.R.2: 1–2. 1921.

Occasional, grows on rocky hill slopes, in rock crevices, alt. 3000–4500 m.

Distribution: Kashmir: Anantnag (on way to Kolhai, Pahalgam), Bandipore (Kamri Pass, Kishenganga Valley), Budgam (Fras-nag), Ganderbal (Baltal, Kangan, Sind Valley, Sonamarg to Kargil), Muzaffarabad (Naltar), Daman pass, Pir Panjal Range; Ladakh: Baltistan-Gilgit (Nanga Parbat), Kargil (Meenamarg near Zoji La).

*Dryopteris lepidopoda* Hayata, Icon. Pl. Formosan. 4: 161–162, f. 101. 1914.

Rare, grows on the ground, along streams, alt. 1300–3000 m.

Distribution: Jammu: Kathua (Sarthal); Kashmir: Baramulla (Wagoora).

*Dryopteris nigropaleacea* (Fraser-Jenk.) Fraser-Jenk., Bol. Soc. Brot., sér. 2, 55: 238. 1982.

Common, grows on ground in mid-level forest zone, along open situations, alt. 1300–2700 m.

Distribution: Jammu: Doda (Batote, Bhaderwah), Kathua (Banjal), Kishtwar, Poonch, Udhampur (Patnitop, Sanasar), Rajouri, Reasi (Vaishno Devi); Kashmir: Anantnag (Aru, Pahalgam), Bandipore (Kishenganga Valley, Titwal to Surkhala), Baramulla (Babareshi, Gulmarg, Shrenz, Uri, Wagoora), Ganderbal (Gund, Sonamarg, Sind Valley).

*Dryopteris panda* (C. B. Clarke) Christ, Bull. Acad. Int. Géogr. Bot. 20(1): 176. 1909.

Occasional, grows on open hill slopes, alt. 2700–3000 m.

Distribution: Kashmir: Muzaffarabad**.**

*Dryopteris ramosa* (C. Hope) C. Chr., Index Filic. 5: 287. 1905.

Frequent, grows on moist, humus-rich forest floor, along roads, alt. 2000–4000 m.

Distribution: Jammu: Doda (Batote, Furfuzal), Poonch (Rattan Pir), Ramban (Banihal Pass); Kashmir: Anantnag (Amarnath, Kolahoi, Pahalgam, ), Bandipore (Barnai, Gurez, Kishenganga Valley), Baramulla (Babareshi, Gulmarg, Khilanmarg, Shrenz, Wagoora), Ganderbal (Gund, Sonamarg), Kupwara (Andrbug, Lolab Valley); Ladakh: Kargil (Sukh Nallah, Drass); Gilgit, N. Batistan (Shan Valley).

*Dryopteris redactopinnata* S. K. Basu & Panigrahi, Indian J. Forest. 3(3): 270. 1980.

Frequent, grows on open, shady hill slopes or forest floor, alt. 2000–3000 m.

Distribution: Jammu: Kathua (Chatra Gala Pass, Sarthal), Udhampur (Upper Chenab North), Pir Panjal; Kashmir: Anantnag (Pahalgam), Bandipore (Kishenganga Valley), Baramulla (Gulmarg), Budgam (Fras-nag), Kupwara (Andrbug, Lolab Valley, Keran), Muzaffarabad.

*Dryopteris serratodentata* (Bedd.) Hayata, Icon. Pl. Formosan. 4: 179, f. 116. 1914.

Rare, grows on shady hilly slopes, alt. 2700–3000 m.

Distribution: Kashmir: Anantnag (Chatponsal Nallah, near Bajipath, Sekiwas near Yamhar Pass, upper Lidder Valley), Ganderbal (Baltal, Sind Valley).

*Dryopteris stewartii* Fraser-Jenk., Kalikasan 7: 272. 1979.

Common, grows on forest slopes, alt. 2000–3000 m.

Distribution: Jammu: Kathua, Poonch (Toli Pir), Udhampur (Patnitop), Ramban (Banihal); Kashmir: Anantnag (Pahalgam), Kulgam (Aharbal), Bandipore (Chorwan, Gurez), Baramulla (Mt. Apharwat, Babareshi, Gulmarg, Khilanmarg, Shrenz, Wagoora), Ganderbal (Gund, Prang near Sonamarg), Muzaffarabad, Sri nagar (Dachigam), ; Ladakh: Baltistan-Gilgit (Birik, Hunza, Wazarat).

*Dryopteris subimpressa* Loyal, Nova Hedwigia 16: 467, t. 177, 178, f. 9-16. 1969.

Rare, grows on forest floor along streams, alt. 2200–3000 m.

Distribution: Jammu: Rajouri.

*Dryopteris xanthomelas* (Christ) C. Chr., Index Filic., Suppl. 1, 41. 1913.

Frequent, grows on shady places in open forest slopes, alt. 2700–4000 m.

Distribution: Jammu: Kathua, Kishtwar, Ramban (Banihal); Kashmir: Anantnag (Pahalgam, Lidder Valley), Baramulla (Gulmarg, Kalantra), Ganderbal (Kangan , Sind Valley, Sonamarg), Muzaffarabad, Kupwara (Andrbug, Lolab); ; Ladakh: Kargil (Meenamarg near Zoji La), Baltistan-Gilgit.

*Dryopteris yigongensis* Ching, Fl. Xizang. 1: 253. 1983.

Occasional, grows in forests, alt. 2500–3000 m.

Distribution: Jammu: Kathua (Sarthal); Kashmir: Anantnag (Pahalgam), Baramulla (Gulmarg, Ferozpur Nallah, Tangmarg), Muzaffarabad (Taubat, Neelam Valley).

*Dryopteris zayuensis* Ching & S.K. Wu, Fl. Xizang.1: 255–256. 1983.

Rare, grows in forest, alt. above 2000 m.

Distribution: Jammu: Kathua; Kashmir: Baramulla (Ferozpur Nallah, Tangmarg), Muzaffarabad (Taubat, Neelam Valley).

*Dryopteris* × *liddarensis* Fraser-Jenk., Bull. Brit. Mus. (Nat. Hist.), Bot. 18(5): 460. 1989.

Rare, grows in rock crevices of noncalcareous rocks, on west facing cliffs, alt. 3000 m.

Distribution: Kashmir: Anantnag (Pahalgam, Lidder Valley near Bajipath, Upper Chatponsal Nallah).

*Dryopteris* × *macdonellii* Fraser-Jenk., Bull. Brit. Mus. (Nat. Hist.), Bot. 18(5): 464. 1989.

Rare, grows in open places among low bushes, alt. 2130 m.

Distribution: Kashmir: Bandipore (Chorwan, Donari, Gurez, North Kashmir Valley).

**Subfam. Polystichoideae**

*Cyrtomium anomophyllum* (Zenker) Fraser-Jenk., Taxon. Revis. Indian Subcontinental Pteridophytes 330. 2008.

Rare, grows in moist, well-shaded places, in forests and ravines, alt. 1500–2500 m.

Distribution: Jammu: Kathua (Kadol), Poonch (Bagh, Serimarg); Kashmir: Muzaffarabad (Chikar).

*Cyrtomium caryotideum* C. Presl, Tent. Pterid. 86, t. 2, f. 26. 1836.

Occasional, grows on moist shady rocks, alt. 1200–2000 m.

Distribution: Jammu: Doda, Kathua, Poonch (Toli Pir, Bagh, Rawalkot, Kotli, Mirpur, Serimarg), Rajouri, Udhampur (Patnitop, Jakher Forest); Kashmir: Bandipore (Titwal, Lower Kishenganga Valley), Muzaffarabad (Cihikar), Jhelum Valley, Srinagar.

*Cyrtomium macrophyllum* (Makino) Tagawa, Acta Phytotax. Geobot. 3: 62. f. 3(5–7). 1934.

Occasional, grows on shady, moist forest slopes, alt. 2000–3500 m.

Distribution: Jammu: Kathua (Kadol), Ramban (Banihal); Kashmir: Muzaffarabad (Chikar, Leepa Valley, Pir Chinasi,).

*Polystichum bakerianum* (Atk. ex C.B. Clarke) Diels, in Nat. Pflanzenfam. 1(4): 191. 1899.

Rare, grows on alpine hill slopes and in meadows, alt. 3000–4200 m.

Distribution: Jammu: Kathua (Chatra Gala Pass), Udhampur; Kashmir: Anantnag, Baramulla, Ganderbal (Gangabal Lake, Sind Valley), Muzaffarabad, Pir Panjal.

*Polystichum discretum* (D. Don) J. Sm., J. Bot. (Hooker) 3: 413. 1841.

Frequent, grows on shady forest slopes or in ravines, alt. 2000–3000 m.

Distribution: Jammu: Doda (Kud), Kathua, Kishtwar (Mughal Mazar), Poonch (Serimarg, Chittapani Valley), Reasi (Katra, Vaishno Devi, Bhairon Temple), Udhampur (Patnitop); Kashmir: Baramulla (Babareshi, Rampur, Shrenz, Tangmarg, Wagoora, Uri), Muzaffarabad (Pattika, Rathra, Nawal Nadi).

*Polystichum lachenense* (Hook.) Bedd., Ferns Brit. India pl. 32. 1865.

Occasional, grows among rocks on rocky hill slopes, alt. above 3000 m.

Distribution: Jammu: Poonch (Bimbar Gali); Kashmir: Anantnag (Kolahoi Glacier, Lidder Valley), Bandipore (Kishenganga Valley), Baramulla (Mt. Apharwat, Gulmarg), Ganderbal (Gangabal lake, Sind Valley); Ladakh: Baltistan-Gilgit, Kargil (Zanskar). .

*Polystichum lentum* (D. Don) T. Moore, Index Fil. 86, 95. 1858.

Occasional, grows on shady rocks and in rock crevices at damp places, alt. 1200–2400 m.

Distribution: Jammu: Kathua (Kadol, Basholi).

*Polystichum lonchitis* (L.) Roth, Tent. Fl. Germ. 3(1): 71. 1800.

Common, grows in rock crevices in meadows, along dry stream courses, alt. 2700–3000 m.

Distribution: Jammu: Poonch, Udhampur; Kashmir: Anantnag (Pahalgam, Mt. Kolahoi), Bandipore (Kanzalwan, Gurez, Kishenganga Valley), Baramulla (Barnai, Gulmarg, Khilanmarg, Ningal Nallah), Ganderbal (Sonamarg), Kupwara (Razdan Pass), Muzaffarabad; Ladakh: Baltistan-Gilgit.

*Polystichum luctuosum* (Kunze) T. Moore, Index Fil. 95. 1858.

Occasional, grows along moist shady places in drier valleys, alt. 1300–2400 m.

Distribution: Jammu: Poonch (Chittapani Valley, Dhuli, Nawal Nadi, Serimarg); Kashmir: Bandipore (Kishenganga Valley, Titwal), Baramulla (Jhelum Valley Road near Rampur), Muzaffarabad (Chikar, Sanaji, Kotli).

*Polystichum mehrae* Fraser-Jenk. & Khullar, Indian Fern J. 2(1–2): 10, f. 7–8.1985. (Plate 17.3f).

Occasional, grows in shady rock crevices, alt. 1500–2400 m.

Distribution: Jammu: Kathua; Kashmir: Muzaffarabad.

*Polystichum obliquum* (D. Don) T. Moore, Index Fil. 87, 98. 1858.

Occasional, grows on deep-shaded, moist dripping rocks, alt. 1200–2100 m.

Distribution: Jammu: Kathua (Kadol, North of Basholi).

*Polystichum piceopaleaceum* Tagawa, Acta Phytotax. Geobot. 5(4): 255–256. 1936.

Frequent, grows on moist forest floor, alt. 2000–3000 m.

Distribution: Jammu: Kathua (Banjal), Kishtwar, Poonch, Reasi (Vaishno Devi), Udhampur (Patnitop); Kashmir: Anantnag (Pahalgam), Bandipore (Kishenganga Valley), Baramulla (Gulmarg, Babareshi, Shrenz, Tangmarg, Wagoora); Ladakh: Kargil (on Ladakh Road, Drass).

*Polystichum prescottianum* (Wall. ex Mett.) T. Moore, Index Fil. 101. 1858.

Common, grows in open alpine meadows, alt. 3000–4000 m.

Distribution: Jammu: Kathua, Poonch; Kashmir: Anantnag (Pahalgam), Bandipore (Razdan margs), Baramulla (Mt Apharwat, Gulmarg, Khilanmarg), Muzaffarabad, Pir Panjal; Ladakh: Baltistan-Gilgit, Kargil (Drass, Sioj-Kailash), .

*Polystichum shensiense* Christ, Bull. Acad. Int. Géogr. Bot. 16(199–200–201): 113.1906.

Rare, grows in the drier inner ranges only, alt. 4000–4500 m.

Distribution: Kashmir: North Kashmir; Ladakh: Baltistan-Gilgit, Ladakh.

*Polystichum sinense* (Christ) Christ, Bull. Soc. Bot. France: Mem. 1: 30. 1905.

Rare, grows on dry alpine slopes among rocks, alt. 3500–4500 m.

Distribution: Kashmir: Srinagar (Dagwan); Ladakh: Baltistan-Gilgit.

*Polystichum squarrosum* (D. Don) Fée, Mém. Foug. 5: 278. 1852.

Common, grows as undergrowth on shady forest slopes, forest sides, alt. 1300–2700 m.

Distribution: Jammu: Kathua (Kot-Banjal), Poonch, Reasi (Katra, Vaishno Devi), Udhampur (Patnitop); Kashmir: Anantnag (Pahalgam), Baramulla (Uri to Aliabad).

*Polystichum thomsonii* (Hook. f.) Bedd., Ferns Brit. India 1: 126, pl. 126. 1866. (Plate 17.3g).

Occasional, grows in moist, shaded rock crevices, alt. 17000–3000 m.

Distribution: Jammu: Kathua, Kishtwar (Mughal Mazar), Poonch (Chittapani, Pushana), Udhampur (Patnitop); Kashmir: Anantnag (Harnag, Chandanwari, Pahalgam, Kolahoi Glacier, Lidder Valley), Baramulla (Gulmarg); Ladakh: Baltistan (Bagicha olding, Indus Valley, Shyok).

*Polystichum yunnanense* Christ, Notul. Syst. (Paris) 1(2): 34–35. 1909.

Occasional, grows on moist forest slopes, along moist stream courses, alt. 1800–2300 m.

Distribution: Jammu: Kathua (Kote-Banjal, Kadol), Poonch, Reasi (Vaishno Devi), Udhampur (Jakher Forest); Kashmir: Baramulla (Gulmarg, Uri, Jhelum Valley Road near Rampur), Muzaffarabad. Ladakh: Gilgit.

*Polystichum* × *flemingii* Fraser-Jenk., Aspects Plant Sciences 1: 277. 1991.

Rare, grows on moist forest slopes, along moist stream courses, alt. 1800–2300 m.

Distribution: Jammu: Kathua (Kadol), Poonch, Reasi (Vaishno Devi).

**Subfam. Tectarioideae**

*Tectaria coadunata* (Wall. ex Hook. & Grev.) C. Chr., Contr. U.S. Natl. Herb. 26(6): 331. 1931.

Occasional, grows among shady rocks, in rock crevices and cliffs, alt. 1200–1700 m.

Distribution: Jammu: Jammu, Kathua, Poonch, Rajouri.

**Oleandraceae**

*Nephrolepis cordifolia* (L.) C. Presl, Tent. Pterid. 79. 1836.

Cultivated as an ornamented plant in gardens and parks.

**Davalliaceae**

*Araiostegia pulchra* (D. Don) Copel., Philipp. J. Sci. 34(3): 241. 1927.

Occasional, grows as an epiphyte on trees and rocks, alt. 1700–2600 m

Distribution: Jammu: Poonch, Kathua, Reasi (Vaishno Devi); Kashmir: Kashmir Valley.

**Blechnaceae**

*Woodwardia unigemmata* (Makino) Nakai, Bot. Mag. (Tokyo) 39(461): 103. 1925. (Plate 17.3h).

Occasional, grows on moist, shaded and humus-rich hill slopes, alt. 1400–2500 m.

Distribution: Jammu: Doda (Bhadarwah), Poonch (Mandi-Loran), Kathua (Basholi, Kot-Banjal), Kishtwar (Chatru), Udhampur (Patnitop); Kashmir: Bandipore (Lower Kishenganga Valley), Baramulla (Jhelum Valley Road near Rampur), Muzaffarabad (Chikar).

**Azollaceae**

*Azolla pinnata* subsp**.** *asiatica* R.M.K. Saunders & K. Fowler, Bot. J. Linn. Soc. 109(3): 349–351. 1992.

Occasional, grows in waterbodies: ponds, ditches and lakes, alt. 1400–1800 m.

Distribution: Jammu: Kathua; Kashmir: Bandipora (Sonawari), Baramulla (Narbal on way to Gulmarg), Srinagar (Dal Lake, Nigeen Lake) .

**Salviniaceae**

*Salvinia natans* (L.) All., Fl. Pedem. 2: 289. 1785.

Common, grows in ponds, paddy fields and lakes, alt. 1400–1800 m.

Distribution: Kashmir: Muzaffarabad (Sarran), Srinagar (Dal, Nigeen and Anchar Lakes, Hokersar).

### 17.3.2 Excluded/Doubtful Taxa

**Selaginellaceae**

*Selaginella nepalensis* Spring, Bull. Acad. Roy. Sci. Bruxelles 10: 234. 1843.

**Ophioglossaceae**

*Ophioglossum nudicaule* L. f., Suppl. Pl. 443. 1781.

*O. petiolatum* Hook., Exot. Fl.1: 56, pl. 56. 1823.

**Lygodiaceae**

*Lygodium flexuosum* (L.) Sw., J. Bot. (Schrader) 1800(2): 106. 1801.

**Polypodiaceae**

*Lepisorus loriformis* (Wall. ex Mett.) Ching, Bull. Fan Mem. Inst. Biol. 4(3): 81–82. 1933.

*Loxogramme porcata* M.G. Price, Amer. Fern J. 80(1): 6, f. 3. 1990.

*Phymatopteris erythrocarpa* (Mett. ex Kuhn) Pic. Serm., Webbia 28(2): 462. 1973.

*Polypodiastrum argutum* (Wall. ex Hook.) Ching, Acta Phytotax. Sin. 16(4): 28 1978.

*Pyrrosia mollis* (Kunze) Ching, Bull. Chin. Bot. Soc. 1(1): 53–54. 1935.

**Pteridaceae**

*Ceratopteris thalictroides* (L.) Brongn., Bull. Sci. Soc. Philom. Paris 8: 186.1822.

*Gymnopteris vestita* (Hook.) Underw., Bull. Torrey Bot. Club 29(11): 627. 1902.

*Onychium fragile* Verma, S.C. & Khullar, Nova Hedw. 9(1-4): 85. 1965.

*O. japonicum* (Thunb.) Kunze, Bot. Zeitung (Berlin) 6: 507. 1848.

*O. siliculosum* (Desv.) C. Chr., Index Filic. fasc. 8: 469. 1906.

*Notholaena marantae* (L.) R. Br., Prodr. 145. 1810.

*Pteris stenophylla* Wall. ex Hook. & Grev., Icon. Filic. 2(7): pl. 130. 1829.

**Aspleniaceae**

*Asplenium cheilosporum* Kunze ex Mett., Abh. Senckenb. Naturf. Ges.6: 133, t. 5, f. 12–13. 1859.

*A. ensiforme* Wall. ex Hook. & Grev., Icon. Filic. 1(4): pl. 71.1828.

*A. nesii* Christ in Nuovo Giorn., Bot. Ital., n.s., 4(1): 90. 1897.

*A. paucivenosum* (Ching) Bir, Bull. Bot. Surv. India 4: 3. 1962.

**Thelypteridaceae**

*Trigonospora ciliata* (Wall. ex Benth.) Holttum, Blumea 19(1): 29. 1971.

**Woodsiaceae**

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*A. foliolosum* T. Moore ex R. Sim, Priced Cat. Ferns 6: 22. 1859.

*A. nigripes* (Blume) T. Moore, Index Fil. 49. 1857.

*A. setiferum* C. Chr., Index Filic.3: 146. 1905.

*Woodsia hancockii* Baker, Ann. Bot. (Oxford) 5(18): 196–197. 1891.

**Dryopteridaceae**

**subfam. Dryopteridoideae**
*Dryopteris wallichiana* (Spreng.) Hyl., Bot. Not. 1953(3): 352. 1953.
**subfam. Polystichoideae**
*Cyrtomium falcatum* (L. f.) C. Presl, Tent. Pterid. 86. 1836.
**Salviniaceae**
*Salvinia molesta* D.S. Mitch., Brit. Fern Gaz.10(5): 251–252. 1972.

## 17.4 Concluding Remarks

The present chapter has enumerated 200 pteridophyte species from the Indian Himalayan state of Jammu and Kashmir. This number is reasonably expected to be more considering many unexplored areas in the state. Most of this flora (ca. 75%) comprises Sino-Himalayan elements, followed by Euro-mediterranean (ca. 15%) and South-East Asian (ca. 8%) elements. Proportion of Euro-mediterranean elements is considerably higher than that in the rest of Indian pteridophytic flora. This is due to the unique phytogeographical position of the State which serves as the gateway for European, Mediterranean and Central Asian elements into the Indian Flora.

Endemic and threatened plants of an area reflect its importance and unique topography at a global platform. Chandra et al. (2008) and Fraser-Jenkins (2008b, 2010b, 2012) revised the list of endemic and threatened pteridophytes of India, reporting ca. 20 threatened taxa from the state. An unpublished report on threatened pteridophytes of the Western Himalaya prepared by researchers of Botanical Survey of India, NRC, Dehradun, as per the IUCN categories and criteria's version 9.0 (IUCN 2011, 2012) (website: http://www.iucnredlist.org/) includes 17 regionally threatened pteridophytes from the state. Among these five species – *Selaginella aitchisonii*, *Equisetum palustre*, *Notholaena lanuginosa* subsp. *bivalens*, *Dennstaedtia wilfordii* and *Deparia macdonellii* – are critically endangered; three species, *Botrychium virginianum*, *Woodsia glabella* and *Dryopteris dicknsii*, are endangered; four species, *Asplenium khullarii*, *Asplenium sarelii* subsp. *pekinense*, *Diplazium sibiricum* subsp. *himalaicum* and *Dryopteris filix-mas*, are vulnerable; while five species, *Asplenium punjabense*, *Athyrium rubricaule*, *Cystopteris montana*, *Huperzia selago* subsp. *appressa* and *Woodsia alpina*, are near-threatened.

The depletion and change in composition dynamics of pteridophytes in J&K State can be attributed to several factors, biotic and abiotic. These include clearing of vegetation cover for road construction, disposal of debris downside roads, construction of dams (it directly hampers natural growth of vegetation of an area, thereby affecting the shade and moisture loving ferns), increasing population pressure (it is directly proportional to agricultural extension and acceleration of forest clearing for colonization), overexploitation of natural resources, deforestation (leading to the drying up of water bodies and removal of shades, so important for ideal habitats of pteridophytes) and landslides. Ferns are very sensitive and highly susceptible to forest fire as it changes the soil dynamics of a given area, making it prone to erosion and reducing its capacity to absorb moisture and rainfall. Grazing in grasslands in the hills is a serious cause of depletion of fern flora, since it affects the higher plants whereon epiphytic species flourish.

**Acknowledgements** Authors are grateful to the Director, Botanical Survey of India, Kolkata, and Scientist In-charge, Botanical Survey of India, Northern Regional Centre, Dehradun, for providing necessary working facilities and encouragement. One of us, late Dr. H.C. Pande, who passed away in September 2013, has wished to be thankful to Mr. C. R. Fraser-Jenkins, Kathmandu, for his valuable suggestions during the preparation of this manuscript.

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# Chapter 18
# Diversity of Gymnosperms in Jammu and Kashmir State

**A. R. Dar and Ghulam Hassan Dar**

**Abstract** The chapter reveals diversity of gymnosperms in the state of Jammu and Kashmir. Both wild and cultivated taxa of gymnosperms growing in the state, along with taxonomic complexity in *Abies, Juniperus* and *Ephedra* have been described. A total of 41 species, distributed over 18 genera in 10 families under 5 orders, are reported based on all available information and extensive fieldwork. Twenty, out of all these species occur wild in the state, while the other 21 species are grown in cultivation. Coniferales is the dominant order, comprising 5 families, 13 genera and 31 species. Cupressaceae is the largest family with 4 genera and 16 species. *Juniperus* is the largest genus with 8 species (6 wild +2 cultivated), followed by *Ephedra* with 6 species (all wild); in both these genera, however, the occurrence of some species in the state needs to be ascertained. *Abies* is also a complex, represented here by 2 species: *A. pindrow* and *A. spectabilis*, with hybrid swarms between the two. In all, 26 species are reported from the Jammu region, 28 species from Kashmir and only 10 species from the Ladakh region. In habit, 31 species are trees and 10 species shrubs/sub-shrubs. Species such as *Taxus wallichiana* and *Juniperus semiglobosa* are rare and threatened.

**Keywords** Gymnosperms · Floristic diversity · Wild and cultivated species · Jammu and Kashmir state

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_18

## 18.1 Introduction

Gymnosperms form an important group of plants because of their immense ecological, socio-economic and evolutionary value. They are distributed throughout the world, with extensive latitudinal and longitudinal ranges. In comparison to other plant groups, extant gymnosperms are less in number; there are only about 1079 species in total, distributed over 12 families in about 83 genera (Christenhusz and Byng 2016). The three 'non-conifer' groups comprise about 337 species of cycads in 10 genera, one extant ginkgophyte and 111 species of gnetophytes in 3 genera (Christenhusz and Byng 2016). According to Farjon (2010), there are about 615 species of conifers in 70 accepted genera; but according to Christenhusz and Byng (2016), their number is 629 species in 69 genera and 6 families. Although much lesser in number, gymnosperms still constitute a dominant component of forests of the world in temperate areas of both the Northern and Southern Hemispheres. They occur in all the continents except Antarctica, and form the outstanding feature of natural landscape in the Himalayas as well. From taxonomic standpoint, the existing gymnosperms belong to 6 orders: Cycadales, Ginkgoales, Coniferales, Gnetales, Welwitschiales and Ephedrales.

Despite their immense ecological and socio-economic values, as also their preponderance in forest ecosystems, the taxonomy of gymnosperms has received little attention in the Indian subcontinent, more so in the state of Jammu and Kashmir (J&K). Even though Hooker (1888) gave the first taxonomic treatment of gymnosperms of the erstwhile British India, he has cited very little plant material from this Himalayan state. Since then, some local workers have attempted to deal with floristics of gymnosperms in this region (Dhar 1966, 1975; Javeid 1970, 1979; Singh and Kachroo 1976, 1994; Dar et al. 2002; Dar and Christenson 2003; Dar 2004), but, as yet, the overall picture of the taxonomic complexity of gymnosperms in the Indian subcontinent as a whole is far from complete, especially in more taxonomically intricate genera such as *Ephedra* and *Juniperus*. The present chapter provides floristic diversity of gymnosperms in J&K as is known currently.

## 18.2 Materials and Methods

Besides extensive field observations and collections, accompanied with studying relevant herbarium specimens at the University of Kashmir Herbarium (KASH), exhaustive literature survey from varied sources (Brandis 1874; Hooker 1888; Gamble 1902; Bailey 1933; Lambert 1933; Raizada and Sahni 1960; Dallimore and Jackson 1966; Mehra 1975; Singh and Kachroo 1976; Mehra 1988; Sahni 1990; Dar and Christenson 2003; Dar 2004; Dar and Dar 2005, 2006, 2011, 2017) formed the basis for compilation of this conspectus of gymnosperms of J&K. Standard taxonomic methodology has been followed to process the specimens collected during field studies with special treatment (Page 1979) for some taxa (e.g. species of

*Abies, Picea* and *Cedrus*) where all the leaves (needles) fell down the twigs a few days after direct pressing. Nomenclature has been updated wherever necessary. Information on the status of the species (wild, cultivated), habit, common/local names, altitude, distribution and conspicuous uses is tabulated to achieve brevity.

## 18.3 Results and Discussion

### *18.3.1 Diversity and Distribution of Gymnosperms*

In the present study, a total of 41 species of gymnosperms are recorded from the state of J&K. These are spread over 18 genera in 10 families and 5 orders. Only about half of the overall species, however, occur as wild, whereas others are found in cultivation (Table 18.1; Plate 18.1).

#### 18.3.1.1 Wild Gymnosperms

Among all the gymnosperm taxa occurring in J&K, 20 species belonging to 7 genera in 4 families and 3 orders occur in the wild (Table 18.2; Plate 18.1). The conifers, with 13 species in 5 genera and 2 families form the dominant group. Among families, Pinaceae with 7 species in 4 genera is richly represented, while Taxaceae with 1 species is the least represented. *Juniperus* and *Ephedra* are the largest genera in wild, each represented by 6 species; those of the latter being distributed mostly in Ladakh region of the state (Table 18.3).

*Pinus* is the most prominent genus in wild, being represented by 3 species: *P. wallichiana*, *P. roxburghii* and *P. gerardiana. P. wallichiana* is the most common gymnosperm species growing wild in the Kashmir Valley. It forms pure and

**Table 18.1** Diversity of gymnosperm flora in Jammu and Kashmir State

| | Number of genera | | | Number of species | | |
|---|---|---|---|---|---|---|
| Name of family | Total | In wild | In cultivation | Total | In wild | In cultivation |
| Cycadaceae | 01 | - | 01 | 01 | - | 01 |
| Zamiaceae | 01 | - | 01 | 01 | - | 01 |
| Pinaceae | 04 | 04 | 01 | 10 | 07 | 03 |
| Podocarpaceae | 01 | - | 01 | 01 | - | 01 |
| Araucariaceae | 01 | - | 01 | 01 | - | 01 |
| Cupressaceae | 04 | 01 | 04 | 16 | 06 | 10 |
| Taxodiaceae | 03 | - | 03 | 03 | - | 03 |
| Taxaceae | 01 | 01 | - | 01 | 01 | - |
| Ephedraceae | 01 | 01 | - | 06 | 06 | - |
| Ginkgoaceae | 01 | - | 01 | 01 | - | 01 |
| *Total: 10* | *18* | *07* | *13* | *41* | *20* | *21* |


**Plate 18.1** Representative images of gymnosperms from Jammu and Kashmir State

**Table 18.2** Gymnosperms growing as wild in Jammu and Kashmir State

| Name of | | | |
|---|---|---|---|
| Order | Family | Genus | Species |
| Coniferales | Pinaceae | *Pinus* | 1. *P. gerardiana* |
| | | | 2. *P. roxburghii* |
| | | | 3. *P. wallichiana* |
| | | *Cedrus* | 1. *C. deodara* |
| | | *Picea* | 1. *P. smithiana* |
| | | *Abies* | 1. *A. pindrow* |
| | | | 2. *A. spectabilis* |
| | Cupressaceae | *Juniperus* | *1. J. communis* |
| | | | *2. J. polycarpos* |
| | | | *3. J. pseudosabina* |
| | | | *4. J. semiglobosa* |
| | | | *5. J. squamata* |
| | | | *6. J. wallichiana* (*J. indica*) |
| Taxales | Taxaceae | *Taxus* | 1. *T. wallichiana* |
| Ephedrales | Ephedraceae | *Ephedra* | 1. *E. gerardiana* |
| | | | 2. *E. intermedia* |
| | | | 3. *E. major* Subsp. *procera* (*E. nebrodensis* var. *procera*; *E. procera*) |
| | | | 4. *E. pachyclada* |
| | | | 5. *E. przewalskii* |
| | | | 6. *E. regeliana* |
| *Total: 3* | *4* | *7* | *20* |

dominant forest stands at many places (e.g. Pahalgam, 2134 m; Naranag, 1900 m; Boniyar (Uri), 1540 m), and mixed communities with *Picea, Cedrus* and *Taxus* at most other places. It is also spread across some forests in hilly districts of the Jammu region (Kishtwar, Doda, Ramban, Poonch and Rajouri). *Pinus roxburghii* is very restricted in its distribution in the Kashmir Valley. It occurs at only a few places (e.g. Lalpul (Uri), 1250 m); some planted trees exist at Shankaracharya Hill (1650 m) and Kashmir University Botanical Garden (1580 m) in Srinagar. However, it is well represented in the Jammu region and forms the dominant tree element in all subtropical forests of this province. *Pinus gerardiana* is restricted in distribution to only a few drier pockets in the Jammu region (Kishtwar, Padder). None of these three wild-growing species of *Pinus* is represented in the Ladakh region (see Table 18.3).

*Picea smithiana* is fairly common in the forest vegetation at some places in Kashmir (e.g. Yusmarg, 2400 m; Gulmarg, 2400 m), while at some other places it is associated with *Pinus wallichiana*, *Cedrus deodara* and species of *Abies*. It is also present in montane forests of the Jammu region, but has not been reported from Ladakh region.

*Cedrus deodara,* once widely distributed and dominating many forest divisions in the Kashmir region, has now mostly been restricted to some of its forest compart-

**Table 18.3** Inventory of species of gymnosperms in Jammu and Kashmir

| 1.S. No. | Species name | Common/Local name | Habit | Provincial distribution | | |
|---|---|---|---|---|---|---|
| | | | | J[a] | K[b] | L[c] |
| 1. | *Cycas revoluta* Thunb. | Sago cycad/Japanese sago palm | Tree | √ | x | x |
| 2. | *Zamia furfuracea* L. f. | Cardboard sago/Jamaican sago | Sub-shrub | √ | x | x |
| 3. | *Pinus canariensis* C. Sm. | Canary Island pine | Tree | × | √ | × |
| 4. | *Pinus gerardiana* Wallich ex D. Don | Chilgoza pine | Tree | √ | × | × |
| 5. | *Pinus halepensis* Miller | Aleppo pine | Tree | × | √ | × |
| 6. | *Pinus radiata* D. Don | Monterey pine | Tree | × | √ | × |
| 7. | *Pinus roxburghii* Sargent | Chir pine/*Chaero* | Tree | √ | √ | × |
| 8. | *Pinus wallichiana* A.B Jackson | Blue pine/*Kaeur* | Tree | √ | √ | × |
| 9. | *Picea smithiana* (Wall.) Boiss. | Spruce/*Kachul* | Tree | √ | √ | × |
| 10. | *Cedrus deodara* (Lamb.) G. Don | Himalayan cedar/*Deodor* | Tree | √ | √ | × |
| 11. | *Abies pindrow* Royle | West Himalayan low level fir/*Budul* | Tree | √ | √ | × |
| 12. | *Abies spectabilis* (D. Don) Spach. | Web fir, upper Himalayan fir/*Reia Budul* | Tree | √ | √ | × |
| 13. | *Podocarpus neriifolius* D. Don | Brown pine | Tree | √ | × | × |
| 14. | *Araucaria cunninghamii* Aiton ex A. Cunn. | Hoop pine/colonial pine | Tree | √ | × | × |
| 15. | *Cryptomeria japonica* D. Don | Japanese cedar/*Cryptomeria* | Tree | √ | √ | × |
| 16. | *Sequoiadendron giganteum* (Lindley) J. Buchholz | Giant sequoia/*Sequoia* | Tree | × | √ | × |
| 17. | *Taxodium distichum* (Linn.) Richard. | Common bald cypress/*Taxodium* | Tree | × | √ | × |
| 18. | *Cupressus arizonica* Greene | Arizona cypress | Tree | √ | √ | × |
| 19. | *Cupressus cashmeriana* Royle ex Carriere | Bhutan or Kashmir cypress/*Cupressus, Cypress* | Tree | × | √ | × |
| 20. | *Cupressus gigantea* W. C. Cheng & L. K. Fu | Tibetan cypress, King cypress, Ju bai | Tree | × | √ | × |
| 21. | *Cupressus guadalupensis* S. Watson | Guadalupe cypress | Tree | √ | √ | × |
| 22. | *Cupressus sempervirens* L. | Mediterranean cypress/*Cupressus, Cypress* | Tree | √ | √ | × |
| 23. | *Cupressus torulosa* D. Don | Himalayan cypress/*Cupressus, Cypress* | Tree | √ | √ | × |
| 24. | *Juniperus chinensis* L. | Chinese juniper/*Juniper* | Small tree | × | √ | × |

(continued)

**Table 18.3** (continued)

| 1.S. No. | Species name | Common/Local name | Habit | Provincial distribution | | |
|---|---|---|---|---|---|---|
| | | | | J[a] | K[b] | L[c] |
| 25. | *Juniperus communis* L. | Common juniper or ground juniper/*Yathur* | Shrub | √ | √ | × |
| 26. | *Juniperus horizontalis* Moench | Creeping juniper/*Juniper* | Shrub | √ | √ | × |
| 27. | *Juniperus polycarpos* K. Koch | Eastern juniper | Tree (shrub) | √ | × | √ |
| 28. | *Juniperus pseudosabina* Fisch. & C. A. Mey. | Turkestan juniper or dwarf black juniper | Tree (shrub) | × | × | √ |
| 29. | *Juniperus semiglobosa* regel | Common pencil juniper or cedar/*Shir, Challai, Dhup* | Small tree | × | √ | √ |
| 30. | *Juniperus squamata* Buch-Han ex D. Don | Single seeded Juniper/*Yathur* | Shrub | √ | √ | √ |
| 31. | *Juniperus wallichiana* Hook. f. & Thomson ex Brandis | Black juniper | Tree (-Shrub) | √ | × | × |
| 32. | *Platycladus orientalis (*L.) Franco | Chinese arborvitae/Sarva | Small tree | √ | √ | × |
| 33. | *Thuja occidentalis* L. | Northern white-cedar/*Sarva* | Small tree | √ | √ | × |
| 34. | [d]*Taxus wallichiana* Zucc. | Himalayan yew/*Pastul* | Tree | √ | √ | × |
| 35. | [e]*Ephedra gerardiana* Wall. ex C. A. Meyer | Tse, *Somlata/Asmani bhuti* | Sub-shrub | √ | √ | √ |
| 36. | *Ephedra intermedia* Schrenk & C. A. Meyer | Zhong Ma Huang | Sub-shrub (shrub) | × | × | √ |
| 37. | *Ephedra major* subsp. *procera* Fisch. & C. A. Meyer (*E. nebrodensis* Tineo var. *procera*; *E. procera*) | – | Sub-shrub | × | × | √ |
| 38. | *E. pachyclada* Boiss. | – | Shrub | × | × | √ |
| 39. | *E. przewalskii* Stapf | – | Shrub | × | × | √ |
| 40. | *E. regeliana* Florin | – | Sub-shrub | × | × | √ |
| 41. | *Ginkgo biloba* L. | Maiden hair tree/Ginkgo | Tree | √ | √ | × |

[a]Jammu
[b]Kashmir
[c]Ladakh
[d]*Taxus baccata* reported previously to occur in cultivation in Kashmir University Botanical Garden and a few nurseries of Kashmir Valley has not been found in these locations in the present study
[e]Off late, various populations of *Ephedra gerardiana* have been found to vary considerably in the Kashmir Valley at different locations, namely Noorkhah (Uri), Shankaracharya (Srinagar), etc.

ments (e.g. Chandanwari (Uri) 1500 m; Wangat (Sind Valley), 2300 m) because of indiscriminate cutting. In some other forests of Kashmir, *Cedrus deodara* occurs in mixed communities with other conifers, although less frequently as compared to *Pinus wallichiana, Picea smithiana,* and other components. Deodar also occurs in some montane forests of the Jammu region, but not in Ladakh (Table 18.3).

*Abies* complex in the state comprises 2 species: *A. pindrow* and *A. spectabilis. A. pindrow* generally occurs higher up on mountains, forming dominant component of the forest vegetation at some places (e.g. Thajwas (Sind Valley), 2900 m; Naranag, 1900 m; Gulmarg, 2400 m; Pahalgam, 2200 m), while at many other places it exists as a part of mixed forests of *Picea smithiana, Pinus wallichiana, Abies* hybrids and *Taxus wallichiana. Abies spectabilis* forms the highest conifer forests in the Kashmir region. During the course of our studies, we found that, besides the two parent species, *A. pindrow* and *A. spectabilis*, there exist a swarm of hybrids between them. These hybrids show various degree of intermediacy in characters, such as bark, leaves (length, arrangement, apex notching, margin curving and groove prominence) and cone characteristics (axis length, thickness, swollen or pointed tips). Both these *Abies* species and their hybrids also occur in montane areas of the Jammu region, especially along slopes of the Pir Panjal range in the Himalayas. None of the two fir species or their hybrids, however, occurs in Ladakh (Table 18.3).

*Taxus wallichiana* is less frequent in forests of the Kashmir Valley, rare in mountainous areas along Pir Panjal in the Jammu region, and absent in the Ladakh region. It occurs at some places (e.g. Gulmarg, 2400 m; Yusmarg 2400 m; Naranag 1900 m) with usually less number of trees in mixed communities with other conifers (species of *Pinus*, *Picea* and *Abies*). Slow growth rate, dioecious nature, spatial isolation of opposite sexes and less abundance of pollen grains per male cone as compared to other gymnosperms are probably the factors responsible for rarity of *Taxus wallichiana.* It yields taxol, an alkaloid used to treat cancer, and is often exploited for this purpose.

The genus *Juniperus* comprises 6 wild species in the state: *J. communis*, *J. polycarpos*, *J. pseudosabina, J. semiglobosa*, *J. squamata* and *J. wallichiana* (Table 18.2). *Juniperus communis* is distributed throughout subalpine-alpine zone in the Kashmir region, the Pir Panjal Himalayan tract in the Jammu region, up to lower reaches of Greater Himalayan montane range in Zanskar and Ladakh, dominating the open-slope vegetation. It is a variable species, occurring usually isolated (Sonamarg, 2800 m), in association with *J. squamata*, *Betula utilis* and *Rhododendron campanulatum* (Apharwat, 3000 m), or amongst other conifers, namely *Cedrus deodara* and *Pinus wallichiana* (Fourbay, Ganderbal, 1850 m). *Juniperus squamata* forms the most dominant gymnospermous component of alpine vegetation in the Kashmir region, along upper Pir Panjal Himalayan tract in the Jammu region, up to the Greater Himalayan montane range in Ladakh. It occurs as mats, narrow or quite broad, in the alpine zone, dotting most of the upper montane terrain in the state (e.g. Apharwat, 3000 m; Sheshnag 3300 m; Pir Ki Gali, 3500 m; Simthan Pass, 3100 m; Zoji La, 3500 m). Occasionally, it is associated with *J. communis, Betula utilis* and

*Rhododendron* spp. (e.g. Apharwat, 3000 m; Aaram Pathri, 3600 m). *Juniperus semiglobosa* occurs in Ladakh (e.g. Drass), some areas along open mountain slopes in the Kashmir Valley (e.g. Gagangir, 2100 m; Baltal and Hari Pora in Sind Valley). *Juniperus polycarpos* has been reported from Ladakh and Kargil in the Ladakh region, and from Chenab Valley and Kishtwar in the Jammu region, but not from Kashmir, so far. *Juniperus wallichiana* is reported from Kishtwar in Jammu region; its usual distribution appears to be east of Kashmir. Another species, *Juniperus pseudosabina*, is reported to occur beyond Nanga Parbat in Baltistan (Gilgit, Hunza, Astor and Skardu), the areas under present administration of Pakistan, but it has not been collected from Indian side of the study area, although listed with our flora by many previous workers (Hooker 1888; Gamble 1902; Lambert 1933; Gaussen 1968; Mehra 1988).

In the case of *Juniperus* complex, it has been found that *J. recurva* reported by previous workers from our area (e.g. Hooker 1888; Gamble 1902; Gaussen 1968; Singh and Kachroo 1976; Sahni 1990) is actually *Juniperus squamata.* Furthermore, *J. macropoda* reported from the north-west Himalayas under various names (e.g. *J. excelsa, J. polycarpos*) by various workers (Lambert 1933; Raizada and Sahni 1960; Sahni 1990) has been found to be actually *J. semiglobosa*, an entirely distinct species (see Dar and Christensen 2003).

*Ephedra* is a complex genus, having been a challenge for satisfactory taxonomic delimitation. Six species are mostly reported from the erstwhile undivided territory of J&K State: *Ephedra gerardiana*, *E. intermedia*, *E. major* subsp. *procera* (*E. nebrodensis* var. *procera*; *E. procera*), *E. pachyclada, E. przewalskii* and *E. regeliana*. All these species are sub-shrubs or shrubs, being distributed far and wide in the cold desert of Ladakh; in fact, the entire Ladakh region is the home of ephedras. Out of these six species, only one – *Ephedra gerardiana,* occurs in some hilly/montane areas of the Kashmir region and along upper reaches of the Pir Panjal Himalayan tract in the Jammu region. In both Kashmir and Jammu hills, however, its occurrence is only sporadic. It occurs in small patches, usually at high altitudes (e.g. Uri, 1450 m; Zoji La, 2800 m, Shankaracharya, 1650 m). Among other five species, two species, namely *Ephedra intermedia* and *E. regeliana* occur frequently in the whole of Ladakh and are well represented in our collections and herbaria. The other three species, *E. major* subsp. *procera, E. pachyclada* and *Ephedra przewalskii*, on the other hand, could not be deciphered in our collections from the state and are not satisfactorily represented in our herbaria. *E. przewalskii*, a rare species, has been reported from Nanga Parbat (Carl Troll 1939) and Baltistan, near Saling in bed of Shyok River (Stewart 1972: 23); however, both localities are now in Pakistan-administered Kashmir; *E. nebrodensis* var. *procera* (*E. procera*) from Gilgit (Baltistan) and Kishtwar (Stewart 1972: 23), whereas *E. pachyclada* has been reported from Ladakh – Minu Pureng Valley, 3800 m, UC Bhattacharyya 41,485 (BSD) (fide Sahni 1990). The occurrence of all the three latter species in the territories of J&K needs to be authentically checked.

**Table 18.4** Gymnosperms existing in cultivation in Jammu and Kashmir

| Name of Order | Family | Genus | Species |
|---|---|---|---|
| Cycadales | Cycadaceae | *Cycas* | 1. *C. revolute* |
| | Zamiaceae | *Zamia* | 1. *Z. furfuracea* |
| Coniferales | Pinaceae | *Pinus* | 1. *P. canariensis* |
| | | | 2. *P. halepensis* |
| | | | 3. *P. radiata* |
| | Podocarpaceae | *Podocarpus* | 1. *Podocarpus neriifolius* |
| | Araucariaceae | *Araucaria* | 1. *Araucaria cunninghamii* |
| | Cupressaceae | *Cupressus* | 1. *C. arizonica* |
| | | | 2. *C. cashmeriana* |
| | | | 3. *C. gigantea* |
| | | | 4. *C. guadalupensis* |
| | | | 5. *C. sempervirens* |
| | | | 6. *C. torulosa* |
| | | *Juniperus* | 1. *J. chinensis* |
| | | | 2. *J. horizontalis* |
| | | *Platycladus* | 1. *P. orientalis* |
| | | *Thuja* | 1. *T. occidentalis* |
| | Taxodiaceae | *Cryptomeria* | 1. *C. japonica* |
| | | *Sequoiadendron* | 1. *S. giganteum* |
| | | *Taxodium* | 1. *T. distichum* |
| Ginkgoales | Ginkgoaceae | *Ginkgo* | 1. *G. biloba* |
| *Total: 3* | *8* | *13* | *21* |

#### 18.3.1.2 Cultivated Gymnosperms

Over the years, several species of gymnosperms have been introduced and cultivated in gardens, parks, bare rocky slopes and roadsides in the state. Out of the total gymnosperms in our state, 21 species distributed over 13 genera in 8 families and 3 orders occur in cultivation only (Table 18.4; Plate 18.1). Out of these, order Coniferales shares the maximum proportion with 18 species in 10 genera and 5 families, while Ginkgoales is represented by only one species. Cupressaceae is the largest family, with 10 species in 4 genera, while the families Cycadaceae, Zamiaceae and Ginkgoaceae are the least represented, with only one species each (Table 18.4).

Besides, wild-growing species of *Pinus* – a few exotic species, *P. canariensis, P. halepensis* and *P. radiata*, have been introduced for cultivation purpose in many gardens, parks and small hills of both Jammu and Kashmir regions of the state (Fig. 18.1, Plates 18.2 and 18.3).

None of the *Cupressus* species exists in wild in the state; however, *C. arizonica*, *C. cashmeriana, C. guadalupensis*, *C. sempervirens* and *C. torulosa* are widely cultivated in varied habitats, especially in some bare rocky slopes where other gymno-

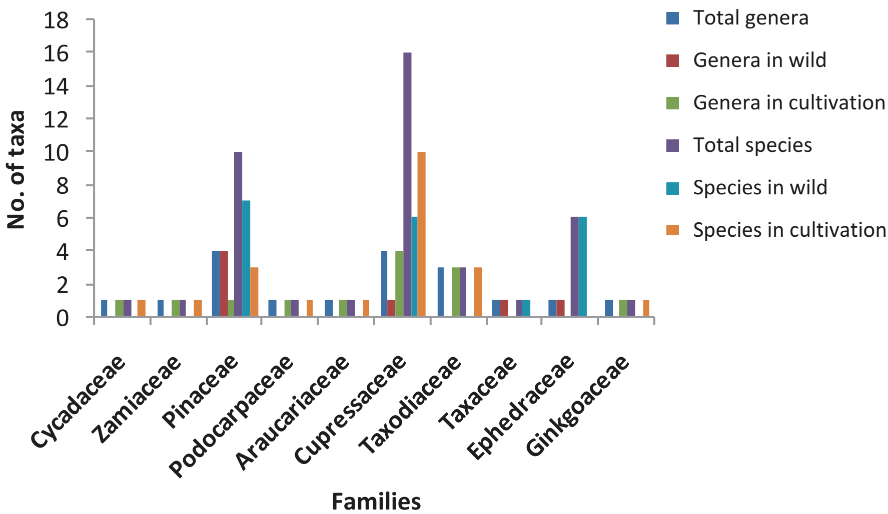


**Fig. 18.1** Diversity of gymnosperm flora in Jammu and Kashmir

sperm species find it difficult to establish in the Kashmir Valley, and some areas in the Jammu region. *C. cashmeriana* is a graceful tree, which although named after Kashmir, exists here only under cultivation, that too in some specific botanical gardens of the Kashmir Valley.

Two species of *Juniperus*, namely *J. chinensis* and *J. horizontalis* (*J. prostrata*), have been introduced and are cultivated in major gardens and parks in the Kashmir Valley and Jammu region. One species of *Platycladus*, *P. orientalis*, is grown commonly in gardens and parks of Kashmir and Jammu. In addition, *Thuja occidentalis* exists in cultivation in some gardens and parks of both these regions.

Species such as *Cryptomeria japonica*, *Sequoiadendron giganteum* and *Taxodium distichum* occur as cultivated specimens in our state. Only one tree of *Sequoiadendron giganteum* is present in Tangmarg area of the Kashmir Valley, a second specimen is said to have dried up now!

The living fossil – *Ginkgo biloba* – is cultivated in most of the gardens and parks of the state. Moreover, we had some big trees of this species established in some floriculture gardens in Srinagar; however, their condition has been deteriorating and the biggest specimen tree in the floriculture garden at Lalmandi is now dead. Some young trees are growing in the Kashmir University Botanical Garden and elsewhere in Kashmir as well as Jammu.

Furthermore, many gymnosperm species, *Cycas revoluta, Podocarpus neriifolius, Zamia furfuracea* and *Araucaria cunninghamii,* etc., exist in cultivation in many gardens and parks of the Jammu region and the last one is also grown in the Kashmir Valley.


**Plate 18.2** Field photographs of gymnosperms growing in Jammu and Kashmir State

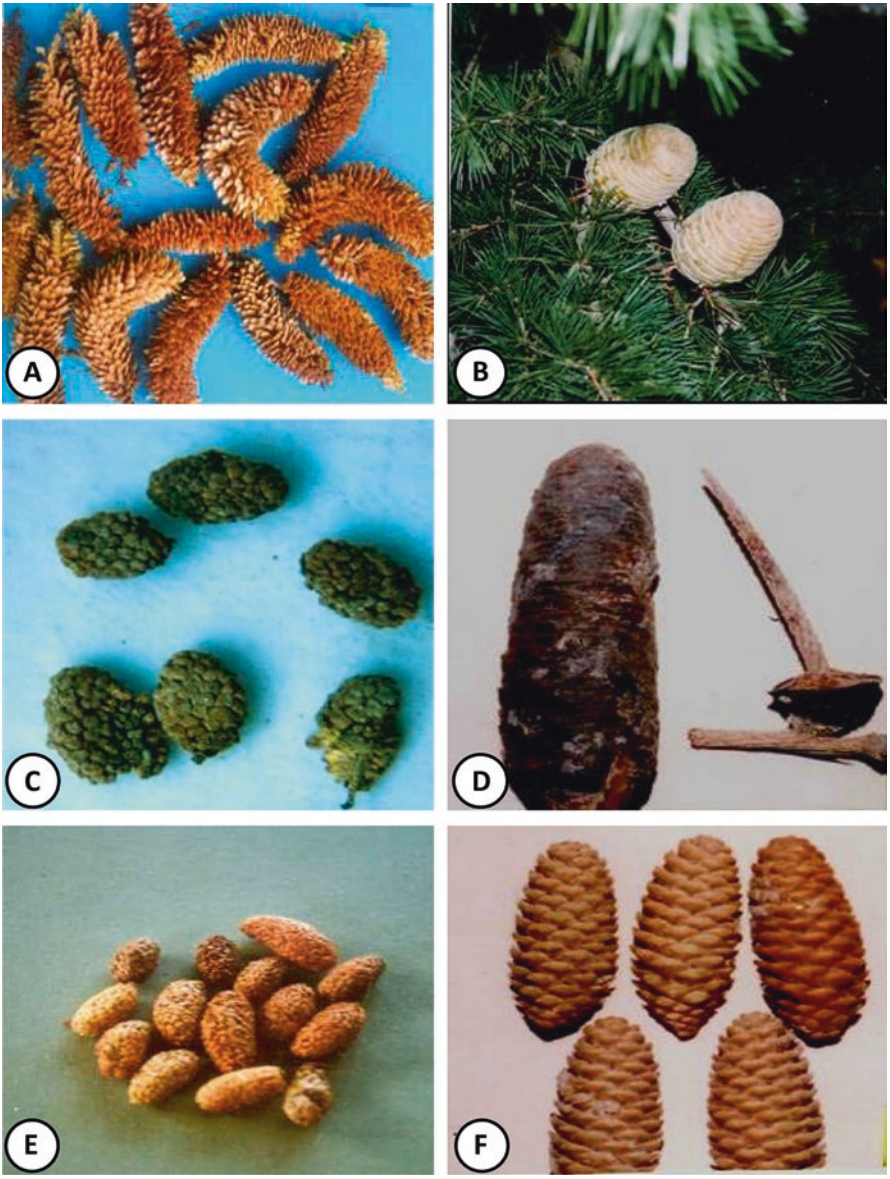


**Plate 18.3** Male and females cones of some gymnosperm species of Jammu and Kashmir: (**a**). Male cones of *Cedrus deodara* (**b**). Female cones of *Cedrus deodara* (**c**). Male cones of *Abies pindrow* (**d**). Female cone of *Abies pindrow* (**e**)**.** Males cones of *Picea smithiana* (**f**). Female cones of *Picea smithiana*

### *18.3.2 Economic Importance of Gymnosperms*

Gymnosperms, being the dominant component of our forests, are of diverse economic importance, providing timber, fuel, resins, gum, medicine and many more useful products. Most of the timber used in construction of buildings is derived from conifers (species of *Pinus, Cedrus, Abies*) because of their straight-grain wood and its ease of manipulation. Deodar is the strongest of the Himalayan coniferous woods; the blue pine is much used in the house construction and light furniture (Table 18.5). Notable as a source of pulpwood for paper manufacture are pines, firs and spruces. Conifers are effective windbreakers, especially the evergreen species. They are important for soil erosion control and protection of watersheds. The species of *Juniperus*, *Taxus*, *Ephedra* and *Ginkgo* have diverse medicinal properties (Table 18.5).

**Table 18.5** Economic importance of gymnosperms of Jammu and Kashmir State

| *Species name* | *Importance* |
|---|---|
| *Cycas revoluta* | 1. Used as ornamental and is popular as bonsai plant. |
| | 2. Its pith contains edible starch and is used for making sago. |
| *Zamia furfuracea* | 1. Plants are salt and drought tolerant. |
| | 2. Popular for cultivation purpose. |
| *Pinus canariensis* | 1. The aromatic wood is hard, strong and durable. |
| | 2. Used as ornamental plant. |
| *Pinus gerardiana* | 1. Seeds edible. |
| *Pinus halepensis* | 1. Used for ornamental and avenue plantation. |
| *Pinus radiata* | 1. Most valued pine for rapid growth and desirable lumber and pulp qualities. |
| | 2. Most common species of Christmas tree in Australia and New Zealand. |
| *Pinus roxburghii* | 1. As timber for construction purposes but quality is inferior. |
| | 2. The thick, soft bark is used for tanning. |
| | 3. Most important resin yielding pine. |
| | 4. Charred leaves used as dye. |
| *Pinus wallichiana* | 1. As timber for construction purposes. |
| | 2. Oleoresin on distillation furnish turpentine and rosin. |
| | 3. Residue of wood used as charcoal. |
| | 4. The water used in the reduction of leaves used for medicinal purposes. |
| | 5. A dark-brown, viscous and sticky substance *killam* is used by farmers in paddy fields to protect them from *khase*. |

(continued)

**Table 18.5** (continued)

| *Species name* | *Importance* |
|---|---|
| *Picea smithiana* | 1. Used for pulpwood. |
| | 2. Wood used for framing material, general millwork, crafts etc. |
| *Cedrus deodara* | 1. Strongest of Indian coniferous woods. |
| | 2. Used for second-grade pencils. |
| | 3. The wood on distillation yields reddish-brown oil with balsamic odour. |
| | 4. Tribal people use extract of boiled deodar wood to protect their cattle from lice, mosquito etc. |
| | 5. Wood is used in *hawans* and pollen as *pitham*. |
| *Abies pindrow* | 1. Wood is used for indoor joinery, matchwood, paper pulp. |
| | 2. Wood is shock resistant and nail withdrawal resistant. |
| *Abies spectabilis* | 1. Wood is used for framing, decking, panelling, millwork, furniture parts, fruit and vegetable containers. |
| *Podocarpus neriifolius* | 1. Yellowish wood useful for construction purposes. |
| | 2. Cultivated for ornamental purpose because of its beautiful shape. |
| *Araucaria cunninghamii* | 1. Used as timber and ornamental plant. |
| *Cryptomeria japonica* | 1. Wood is used for staves, buildings, tea boxes and furniture. |
| | 2. Wood after chemical treatment can be exploited for bottle corks and crown liners making. |
| | 3. Satisfactory material for paper pulp. |
| *Sequoiadendron giganteum* | Used as ornamental and avenue tree. |
| *Taxodium distichum* | 1. Wood is used for construction of water tanks, water pipes, furniture, fencing, ventilators etc. |
| | 2. Resin from cones used as healing application to wounds. |
| | 3. Used as ornamental plant. |
| *Cupressus arizonica* | 1. Cultivated as ornamental tree. |
| *Cupressus cashmeriana* | 1. Used as ornamental plant because of its graceful look. |
| *Cupressus gigantea* | 1. Exploited for timber and firewood. |
| | 2. Cultivated as ornamental tree. |
| *Cupressus guadalupensis* | 1. Cultivated as ornamental tree. |
| *Cupressus sempervirens* | 1. Fragrant wood is obnoxious to insects, hence used for cloth chests. |
| | 2. Used as ornamental plants. |
| *Cupressus torulosa* | 1. Wood is considered strongest after that of deodar and is used for sleepers, temples, images, poles, etc. |
| | 2. Used for pencil making, battery separators. |

(continued)

**Table 18.5** (continued)

| *Species name* | *Importance* |
|---|---|
| *Juniperus chinensis* | 1. Used as ornamental and avenue plantation. |
| *Juniperus communis* | 1. Female cones beneficial in treating urinary tract, bladder, kidneys and prostrate infections. |
| | 2. These also help in increasing digestive fluids, eliminating gases and stomach cramps. |
| | 3. Juniper berries relieve pain and inflammation in rheumatism and arthritis. |
| | 4. Twigs and leaves are used as incense. |
| | 5. Decoction of branches is used as anti-dandruff shampoo. |
| *Juniperus horizontalis* | 1. Used as ornamental in gardens and parks. |
| *Juniperus polycarpos* | Not available |
| *Juniperus pseudosabina* | Not available |
| *Juniperus semiglobosa* | 1. Wood is used for furniture, pencil making, fuel and charcoal. |
| | 2. Female cone is medicinal. |
| *Juniperus squamata* | 1. Wood is used as fuel in alpines. |
| | 2. Foliage burnt as incense in monasteries. |
| | 3. Female cone is medicinal. |
| *Juniperus wallichiana* | Not available |
| *Platycladus orientalis* | 1. Used as ornamental in gardens and parks. |
| | 2. Wood used in Buddhist temples for construction work and chipped for incense burning. |
| *Thuja occidentalis* | 1. Used as ornamental in gardens and parks. |
| | 2. Commercially used for fencing and posts, lumber, poles and shingles. |
| *Taxus wallichiana* | 1. Wood is elastic and is used in making bows, arrows and also burnt as incense. |
| | 2. Young twigs and leaves could be used to semi-synthesise *taxol*. |
| | 3. Aril (but not poisonous seeds) is edible. |
| *Ephedra gerardiana, E. intermedia E. major* subsp. *procera, E. pachyclada, E. regeliana* | 1. Source of ephedrine (though in varied quantities), which is used for treating allergy, asthma, cold, rheumatism, flu etc. |
| *Ginkgo biloba* | 1. Wood is used for class blackboards, chessboards, chopping blocks and firewood. |
| | 2. A tea of leaves occasionally used for elderly persons experiencing memory loss. |
| | 3. Leaf extract is used to relieve asthma and urination related problems. |
| | 4. Seeds eaten roasted and credited with prompting digestion and diminishing the effect of drinking wine. |

## 18.4 Concluding Remarks

Presently, one would find many of the forest belts presenting a deserted look due to indiscriminate "slaughtering" of gymnosperm species for the last many decades. As revealed by field surveys and botanical forays, some of our gymnosperm species are now evidently rare and threatened. These include *Taxus wallichiana* and *Juniperus semiglobosa*; the former is included in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); the species listed in the said appendix could become endangered if their trade is not controlled. Some other species of junipers and ephedras, owing to their occurring in harsh habitats, are also sensitively rare in nature. So much needs to be done by public in general and administrators in particular, besides the scientific community and other stakeholders, to protect and manage this goldmine of this Himalayan state for future prosperity.

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# Chapter 19
# An Updated Taxonomic Checklist of Angiosperms in Jammu and Kashmir State

**Ghulam Hassan Dar and Anzar A. Khuroo**

**Abstract** The chapter provides an updated account of angiosperm flora of the state of Jammu & Kashmir (J&K). A total of 5056 taxa, comprising 4778 species plus 278 subspecies/varieties, belonging to 1306 genera in 180 families are recorded from the state. Asteraceae with 613 species and 50 subspecies/varieties in 130 genera is the largest family, followed by Poaceae, Fabaceae, Brassicaceae, Rosaceae, Cyperaceae, Lamiaceae, Ranunculaceae, Caryophyllaceae, Boraginaceae, Apiaceae and Polygonaceae. The larger genera in the angiosperm flora include *Taraxacum* with 83 species and infra-specific taxa (mostly apomicts), followed by *Carex* (78 species), *Potentilla*, *Astragalus*, *Artemisia*, *Ranunculus*, *Saussurea*, *Polygonum, Nepeta*, *Corydalis*, *Silene*, *Poa*, *Gentiana*, *Draba*, *Euphorbia*, *Berberis*, *Cyperus*, *Saxifraga*, *Allium*, *Salix*, *Geranium*, *Veronica*, *Persicaria*, *Androsace* and *Primula.* The consolidated taxonomic checklist of angiosperms presented here reveals that the species plus infra-specific taxa recorded from J&K constitute 27.28% of all the angiosperm species in India, and 58.11% of the angiosperm flora of the Indian Himalayan region. Furthermore, many families and genera in the state contain 50% or more of their total species occurring in India. These results reveal that J&K is a mega-biodiversity state of India, rich in endemics and arboreal, aquatic, medicinal and crop plants. A good proportion of the flora, however, comprises exotic weeds, some of which have become invasive.

**Keywords** Floristics · Angiosperm Flora · Taxonomic Checklist · Endemic Taxa · Jammu & Kashmir · Floristic Elements

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_19

## 19.1 Introduction

The flora of Jammu and Kashmir (J&K) has attracted the attention of botanists/naturalists for the last two centuries. As per written records, floristic studies in J&K date back to first collection of plants from Ladakh and Kashmir by Dr. William Moorcroft, a British veterinary surgeon, in 1820–22 (Moorcroft and Trebeck 1841). This was followed by other western explorers, namely Victor Jacquemont in 1831 (Jacquemont 1834), Royle (1833–1840), Vigne in 1835–39 (Vigne 1842) and von Huegel (1836). Royle, for the first time, published illustrations and taxonomic diagnoses of many plants from Kashmir. Hooker, in his monumental work, *Flora of British India* (1872–1897), cited plant specimens from this Himalayan region with a large number of taxa. This was followed by some important contributions to the flora of J&K, including reports of the botanical tours of Duthie (1893–1894), Meebold (1909) and Rao (1960, 1961); and the useful floristic treatises of Stewart (*Flora of Ladakh*, 1916–1917), Coventry (*Wild Flowers of Kashmir,* 1923–1930), Blatter (*Beautiful Flowers of Kashmir,* 1928–1929) and Lambert (*List of Trees and Shrubs in Forests of Jammu and Kashmir*, 1933).

The floristic studies in this region received a great boost with the establishment of Jammu & Kashmir University at Srinagar in 1961 and Jammu University in 1969. Many local students started research on various floristic aspects of this state, and with the plant specimens collected during the course of these studies was established a herbarium – the KASH – at University of Kashmir in 1972. These studies were also triggered by the publication of Stewart's helpful *An Annotated Catalogue of Vascular Plants of West Pakistan and Kashmir* (1972). The establishment of the Centre of Plant Taxonomy (COPT), now renamed as Centre for Biodiversity & Taxonomy (CBT), in the University of Kashmir in 1981 was a very important milestone in the onward progress of floristic research in this state. Subsequent to this, numerous research papers and some important books dealing with floristic aspects in different areas/regions of the state were published by the local and other workers. These publications include those of Wali and Tiku (1964), Javeid (1966, 1968), Kapoor (1968), Ahmad and Durani (1970), Javeid and Naqshi (1973), Singh and Kachroo (1976), Kachroo et al. (1977), Javeid (1978, 1979), Sharma and Kachroo (1981, 1983), Dar and Kachroo (1982, 1983, 1992), Dar et al. (1983, 1995), Dhar and Kachroo (1983), Dar and Naqshi (1984, 1990, 2001), Naqshi et al. (1984, 1988, 1989), Kak and Durani (1986), Kaul (1986), Munshi and Javeid (1986), Dhar et al. (1987), Koul and Naqshi (1988), Sharma and Jamwal (1988, 1998), Kak (1990), Kapur and Sarin (1990), Ara and Naqshi (1993), Singh and Kachroo (1994), Ara et al. (1995, 1996), Navchoo and Kachroo (1995), Chaurasia and Singh (1996–2001), Naqshi and Ara (1996), Awasti (1997), Kaul (1997), Swami and Gupta (1998), Dar (1999), Dar and Christensen (1999), Bhat (2002), Dar et al. (2002), Aman and Dar (2003, 2007), Aman et al. (2003), Khan et al. (2006), Chaurasia et al. (2007), Dar et al. (2007), Dar (2008), Khuroo et al. (2007a, 2010, 2011), Reshi et al. (2009), Malik et al. (2010), Shabana et al. (2010, 2013), Sharma (2010), Akhter et al. (2011), Bhellum et al. (2013), Dar and Khuroo (2013), Dar and Nordenstam (2014), Dar et al. (2014), Haq et al. (2016) and Dar and Malik (2017).

Insights into the flora of J&K are also provided in the series of volumes and fascicles of *Flora of India*, published by the Botanical Survey of India, as well as in the fascicles of the *Flora of Pakistan,* published in Pakistan under the editorship of Nasir and Ali/Ali and Nasir/Ali and Qaiser (1970 onwards). Many plants of the state, especially those growing in montane regions, are included in the *Flowers of the Himalaya* by Polunin and Stainton (1984), as also in its supplement by Stainton (1988). Recently, the Botanical Survey of India published *Flora of Jammu & Kashmir*, Vol. 1 (Singh et al. 2002), which deals with pteridophytes, gymnosperms and angiosperms. In angiosperms, 51 families (Ranunculaceae – Moringaceae) have been included.

The information provided in the aforementioned publications is, however, scattered and has not been authentically consolidated into a complete, up-to-date flora of the state as a whole. Whereas Singh and Kachroo (1976) have reported a total of 2915 species and Vir Jee et al. (1989) reported 3054 species of angiosperms from the Kashmir Himalaya, Kachroo (1993) reported 880 species from the Ladakh region, Dar et al. (2002) reported 2000 species from the Kashmir Valley, while Sharma (2010) reported 780 species from the Jammu region. Singh et al. (1999), however, reported 4439 taxa of angiosperms, comprising 4252 species in 1220 genera and 189 families from J&K. To bring clarity, the present chapter provides a consolidated and updated account of the angiosperm flora of the J&K state.

## 19.2 Materials and Methods

J&K state holds a pivotal position in the Indian subcontinent, representing a unique biogeographic region in the northwest- and trans-Himalayas (Rodgers and Panwar 1988). The state is partitioned by the high Himalayan mountain ranges into three regions: Jammu, Kashmir and Ladakh, which differ conspicuously in geography, geology, climate, culture and ethnicity. The greatly varied topography, altitude and climate across subtropical Jammu, through temperate Kashmir to the cold-arid Ladakh, result in a vast array of habitats, supporting a correspondingly rich biodiversity.

The present study is based on the database compiled by the authors after thorough perusal of all the available floristic literature dealing with angiosperms of J&K and the information gathered from the field surveys conducted in the state during the last four decades. In the absence of complete and updated list of flora of the state, the information was gleaned out from the original publications to ensure authentic scientific identification. The overall information so obtained has been collated, resulting in the present updated checklist of the angiosperm flora of the state. The arrangement of species into genera and of genera into families follows that in *Mabberley's Plant-Book* (Mabberley 2017) which, in turn, generally follows that in K. Kubitzki's *The Families and Genera of Vascular Plants* (1990– ), modified as per the system of Angiosperm Phylogeny Group (APG) (Angiosperm Phylogeny Group 1998, 2003, 2016). Nonetheless, for convenience, families are arranged alphabetically under monocots and dicots; the genera within families are also placed in alphabetical sequence. The nomenclature of all taxa has been thoroughly updated.

## 19.3 Results and Discussion

In the present work, 5056 taxa (species, subspecies/varieties) are reported from the three regions of J&K state – Jammu, Kashmir and Ladakh. These taxa include 4778 species and 278 subspecies/varieties belonging to 1306 genera in 180 families (Table 19.1).

The 12 larger families, represented by more than 100 species each, are given in Table 19.2; of these 2 belong to monocotyledons and 10 to dicotyledons.

**Table 19.1** Number of taxa recorded in angiosperm flora of Jammu & Kashmir State

| Angiosperm group | Number of | | | | |
|---|---|---|---|---|---|
| | Families | Genera | Species (spp.) | Subspecies/ varieties (sspp./ vars.) | Species+subspecies/ varieties (spp + sspp./vars.) |
| Monocotyledons | 40 | 259 | 900 | 13 | 913 |
| Dicotyledons | 140 | 1047 | 3878 | 265 | 4143 |
| **Total** | **180** | **1306** | **4778** | **278** | **5056** |

**Table 19.2** Twelve larger families in angiosperm flora of Jammu & Kashmir state with number of genera, species and subspecies/varieties

| S. No. | Name of family | Number of | | | |
|---|---|---|---|---|---|
| | | Genera | Species (spp.) | Subspecies/varieties (sspp./vars.) | Species +sspp./vars. |
| 1. | Asteraceae | 130 | 613 | 50 | 663 |
| 2. | Poaceae[a] | 120 | 395 | 06 | 401 |
| 3. | Fabaceae (Papilionoideae)[b] | 90 | 342 | 32 | 374 |
| 4. | Brassicaceae | 64 | 225 | 41 | 266 |
| 5. | Rosaceae | 23 | 184 | 07 | 191 |
| 6. | Cyperaceae[a] | 16 | 185 | 05 | 190 |
| 7. | Lamiaceae | 55 | 185 | 03 | 188 |
| 8. | Ranunculaceae | 20 | 141 | 12 | 153 |
| 9. | Caryophyllaceae | 20 | 133 | 17 | 150 |
| 10. | Boraginaceae | 29 | 110 | 17 | 127 |
| 11. | Apiaceae | 45 | 104 | 12 | 116 |
| 12. | Polygonaceae | 09 | 103 | 04 | 107 |

[a]Monocots

[b]If taken as Fabaceae (*Nom. Alt.* Leguminosae) *sensu lato*, that is including 3 subfamilies: Caesalpinioideae, Mimosoideae and Papilionoideae, it ranks as second largest family in terms of number of species plus subspecies/varieties (111 genera with 404 species plus 33 subspecies/ varieties); for further details see Table 19.4

The 25 larger genera, represented by 23 or more taxa each, are given in Table 19.3; and of these 4 belong to monocotyledons and 21 to dicotyledons.

On taking into consideration the first 10 larger angiosperm families in Jammu, Kashmir and Ladakh, the floristic variation among these three geographic regions of the state becomes evident. The temperate families predominate in Kashmir and Ladakh, namely Asteraceae, Brassicaceae, Lamiaceae and Ranunculaceae; however, Rosaceae and Apiaceae, amongst the dominant families of Kashmir, are replaced by Boraginaceae and Caryophyllaceae in Ladakh. In the larger genera also, both Kashmir and Ladakh show dominance of northern temperate elements. On the other hand, the angiosperm flora of the Jammu region is strikingly different from that of other two regions (Kashmir and Ladakh) of the state. In Jammu, Asteraceae ranks as the third largest family, the first rank being occupied by the predominantly

**Table 19.3** The 25 larger genera with respect to number of species plus subspecies/varieties in the angiosperm flora of Jammu & Kashmir; (number given in parenthesis denotes number of subspecies/varieties).

| S. No. | Name of genus | Family belonging to | Number of species (plus subspecies/varieties) in J&K |
|---|---|---|---|
| 1. | *Taraxacum* | Asteraceae | 80 (03) = 83[b] |
| 2. | *Carex*[a] | Cyperaceae | 78 |
| 3. | *Potentilla* | Rosaceae | 64 (06) = 70 |
| 4. | *Astragalus* | Fabaceae | 55 (06) = 61 |
| 5. | *Artemisia* | Asteraceae | 50 (04) = 54 |
| 6. | *Ranunculus* | Ranunculaceae | 42 (06) = 48 |
| 7. | *Saussurea* | Asteraceae | 44 (03) = 47 |
| 8. | *Polygonum* | Polygonaceae | 41 (02) = 43 |
| 9. | *Nepeta* | Lamiaceae | 39 (01) = 40 |
| 10. | *Corydalis* | Papaveraceae | 39 |
| 11. | *Silene* | Caryophyllaceae | 36 (03) = 39 |
| 12. | *Poa*[a] | Poaceae | 34 (03) = 37 |
| 13. | *Gentiana* | Gentianaceae | 35 |
| 14. | *Draba* | Brassicaceae | 29 (06) = 35 |
| 15. | *Euphorbia* | Euphorbiaceae | 34 |
| 16. | *Berberis* | Berberidaceae | 26 (06) = 32 |
| 17. | *Cyperus*[a] | Cyperaceae | 30 |
| 18. | *Saxifraga* | Saxifragaceae | 30 |
| 19. | *Allium*[a] | Alliaceae | 30 |
| 20. | *Salix* | Salicaceae | 29 |
| 22. | *Veronica* | Plantaginaceae | 27 |
| 21. | *Geranium* | Geraniaceae | 26 |
| 23. | *Persicaria* | Polygonaceae | 25 (01) = 26 |
| 24. | *Androsace* | Primulaceae | 23 (03) = 26 |
| 25. | *Primula* | Primulaceae | 23 (01) = 24 |

[a]Monocots
[b]mostly apomicts

tropical Fabaceae (Leguminosae), though Poaceae continues to be the second largest family. Lamiaceae and Brassicaceae assume lower places in the Jammu flora as the tropical influence increases, while Rosaceae, Ranunculaceae and Apiaceae, amongst larger families in the Kashmir flora, are replaced by more tropical Euphorbiaceae, Acanthaceae and Amaranthaceae. The larger genera in Jammu flora are also tropical, namely *Cyperus, Ficus, Euphorbia, Ipomoea, Indigofera, Fimbristylis, Scirpus, Desmodium, Crotalaria, Acacia, Senna,* etc.

Significantly, there are many angiosperm families in Jammu & Kashmir that contain 50% or more of their total species reported from India; for example Nymphaeaceae, Pontederiaceae, Basellaceae, Juglandaceae and Menyanthaceae (Singh et al. 2002). Similarly, almost all the species reported in each of several genera from India occur in this state, for example *Artemisia*, *Erigeron*, *Senecio*, *Taraxacum*, *Gnaphalium*, *Potentilla*, *Allium*, *Waldheimia*, *Tragopogon*, *Lathyrus*, *Lupinus* and *Oxytropis* (Singh and Hajra 1996). Notably, Orchidaceae, the third largest family of the Indian flowering plants, is represented in J&K by 43 species only, many of which are dangerously rare and scantily seen now (see also Stewart 1972, Akhter et al. 2011).

The species plus subspecies/varieties recorded in the present study together constitute 27.28% of all the species of angiosperms (18,532 – Singh and Dash 2018) known from India. More so, these taxa overall share 58.11% of the total species of angiosperms (8700) known from the Indian Himalayan region (Fig. 19.1). These floristic findings are remarkable because the entire J&K (pre-1947/prepartition, with an area of 222,236 km$^2$) forms 6.76% of the area of India (3,287,469 km$^2$). Considering only the territory of the state that is presently administered by India (101,387 km$^2$) (Husain 2000), and on which this review is based, it encompasses only 3.08% of the country's area. These facts make it evident that J&K is a megabiodiversity state of India, comparable with other Indian Himalayan regions (Fig. 19.2).

### *19.3.1 Taxonomic Checklist*

The family-wise inventory of genera with number of species and infra-specific taxa (subspecies/varieties) in each for the angiosperm flora (monocots + dicots) of J&K state is provided in Table 19.4 (Plates 19.1, 19.2, 19.3, 19.4, and 19.5).

### *19.3.2 Salient Features of Angiosperm Flora*

- The flora of Kashmir, initially said to have been tropical, changed to subtropical and temperate types during the Pleistocene era (Puri 1943, 1947; Vishnu-Mittre 1963). Thereafter, floristic elements from near and far-off regions have found

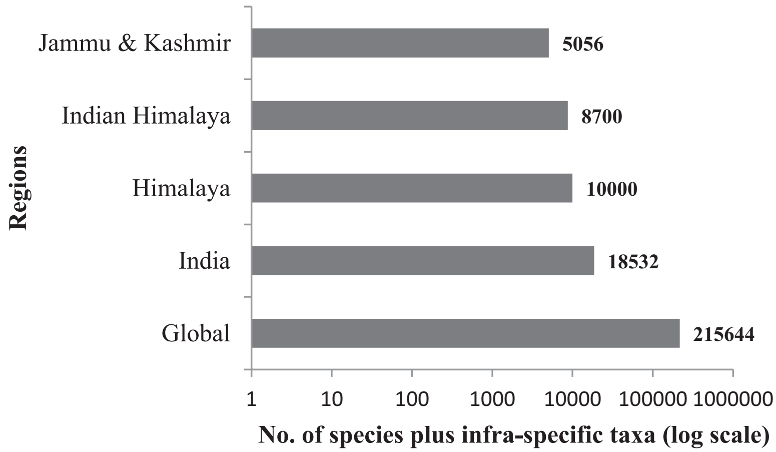


**Fig. 19.1** Comparison of number of angiosperm taxa in Jammu & Kashmir state with those in other regions

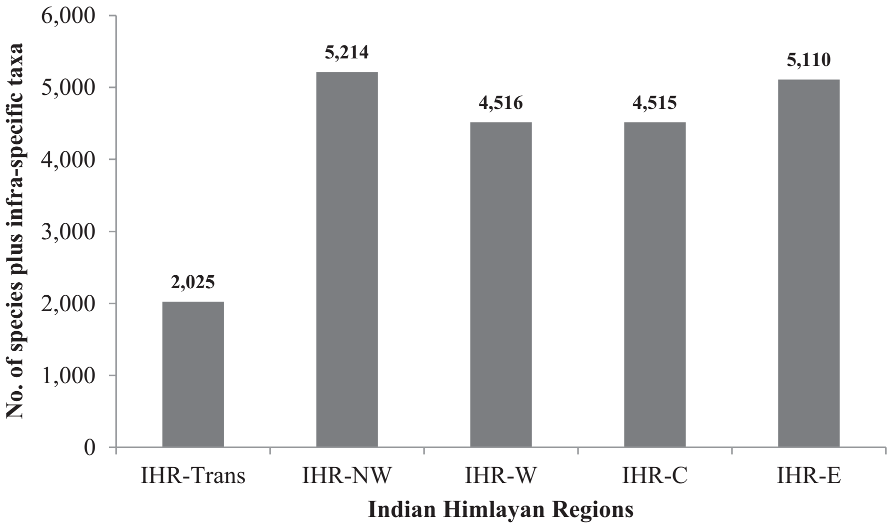


**Fig 19.2** Comparison of number of angiosperm taxa in different Indian Himalayan regions(*IHR* Indian Himalayan region, *Trans* Trans-Himalayas, *NW* North-western Himalayas, *W* Western Himalayas, *C* Central Himalayas, *E* Eastern Himalayas)

**Table 19.4** Taxonomic checklist of genera with number of species plus subspecies/varieties in angiosperm flora of J&K (number given in parenthesis with species denotes number of subspecies/varieties

| Family | Genus/genera in J&K | Number of species (plus subspecies/varieties) in J&K |
|---|---|---|
| **MONOCOTYLEDONS** | | |
| 1. ACORACEAE | ***Acorus*** | 01 |
| 2. AGAPANTHACEAE | ***Agapanthus*** | 01 |
| 3. ALISMATACEAE | ***Alisma*** (incl. ***Caldesia***[a]) | 06 |
| | ***Sagittaria*** | 02 |
| 4. ALLIACEAE | ***Allium*** (incl. ***Milula***) | 30 |
| 5. ALSTROEMERIACEAE | ***Alstroemeria*** | 01 |
| 6. AMARYLLIDACEAE | ***Amaryllis*** | 01 |
| | ***Crinum*** | 01 |
| | ***Galanthus*** | 01 |
| | ***Leucojum*** | 01 |
| | ***Narcissus*** | 03 |
| | ***Nerine*** | 01 |
| | ***Sternbergia*** | 02 |
| | ***Zephyranthes*** | 01 |
| 7. APONOGETONACEAE | ***Aponogeton*** | 01 |
| 8. ARACEAE | ***Alocasia*** | 01 |
| | ***Arisaema*** | 06 |
| | ***Arum*** | 01 |
| | ***Colocasia*** | 01 |
| | ***Philodendron*** | 01 |
| | ***Pothos*** | 01 |
| | ***Typhonium*** (incl. ***Sauromatum***) | 02 |
| | ***Wolffia*** | 02 |
| | ***Zantedeschia*** | 01 |
| 9. ARECACEAE (Palmae) | ***Chamaerops*** | 01 |
| | ***Phoenix*** | 03 |
| | ***Roystonea*** | 01 |
| | ***Trachycarpus*** | 01 |
| 10. ASPARAGACEAE (incl[a]. Agavaceae, Hyacinthaceae) | ***Agave*** (incl. ***Polianthes***) | 03 |
| | ***Asparagus*** | 06 |
| | ***Convallaria*** | 01 |
| | ***Drimia*** | 01 |
| | ***Furcraea*** | 01 |
| | ***Hosta*** | 02 |
| | ***Hyacinthoides*** | 01 |
| | ***Hyacinthus*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Maianthemum* (*Smilacina*[b])** | 01 |
| | ***Muscari*** | 01 |
| | ***Ophiopogon*** | 02 |
| | ***Ornithogalum*** | 01 |
| | ***Polygonatum*** | 04 |
| | ***Ruscus*** | 02 |
| | ***Scilla*** | 01 |
| | ***Theropogon*** | 01 |
| | ***Yucca*** | 02 |
| 11. ASPHODELACEAE | ***Aloe*** | 02 |
| | ***Asphodelus*** | 01 |
| | ***Eremurus*** | 03 |
| | ***Kniphofia*** | 01 |
| 12. BUTOMACEAE | ***Butomus*** | 01 |
| 13. CACTACEAE | ***Echinocactus*** | 01 |
| 14. CANNACEAE | ***Canna*** | 02 |
| 15. COLCHICACEAE | ***Colchicum*** | 01 |
| 16. COMMELINACEAE | ***Commelina*** | 03 |
| | ***Cyanotis*** | 01 |
| | ***Murdannia*** | 02 |
| | ***Tradescantia*** | 04 |
| 17. COSTACEAE (Zingiberaceae) | ***Costus*** | 01 |
| 18. CYPERACEAE | ***Blysmus*** | 03 |
| | ***Bolboschoenus*** | 01 |
| | ***Bulbostylis*** | 02 |
| | ***Carex*** | 78 (02) |
| | ***Cladium*** | 01 |
| | ***Cyperus*** | 30 |
| | ***Eleocharis*** (incl. ***Baeothryon***) | 14 (01) |
| | ***Eriophorum* (*Erioscripus*)** | 01 |
| | ***Fimbristylis*** | 12 |
| | ***Isolepis*** | 01 |
| | ***Kobresia*** | 16 |
| | ***Kyllinga*** | 01 |
| | ***Pycreus*** | 04 |
| | ***Schoenoplectus*** | 05 (02) |
| | ***Scirpus*** | 15 |
| | ***Trichophorum*** | 01 |
| 19. DIOSCOREACEAE | ***Dioscorea*** | 05 |
| 20. ELAEOCARPACEAE | ***Elaeocarpus*** | 05 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| 21. ERIOCAULACEAE | ***Eriocaulon*** | 03 |
| 22. HEMEROCALLIDACEAE | ***Hemerocallis*** | 01 |
| 23. HYDROCHARITACEAE | ***Blyxa*** | 01 |
| | ***Hydrilla*** | 01 |
| | ***Hydrocharis*** | 01 |
| | ***Najas*** | 04 |
| | ***Vallisneria*** | 01 |
| 24. HYPOXIDACEAE | ***Curculigo*** | 01 |
| | ***Hypoxis*** | 01 |
| 25. IRIDACEAE | ***Crocus*** | 02 |
| | ***Gladiolus*** | 01 |
| | ***Iris*** (incl. ***Belamcanda***) | 16 |
| | ***Tritonia*** **(*Crocosmia*)** | 01 |
| 26. JUNCACEAE | ***Juncus*** | 17 (01) |
| | ***Luzula*** | 02 |
| 27. JUNCAGINACEAE | ***Triglochin*** | 02 |
| 28. LEMNACEAE | ***Lemna*** | 06 |
| | ***Spirodela*** | 01 |
| | ***Gloriosa*** | 01 |
| 29. LILIACEAE | ***Fritillaria*** | 04 |
| | ***Gagea*** | 18 |
| | ***Lilium*** | 03 |
| | ***Liriope*** | 01 |
| | ***Lloydia*** | 03 |
| | ***Notholirion*** | 01 |
| | ***Tulipa*** | 03 |
| 30. MELANTHIACEAE (Trilliaceae) | ***Paris*** (incl**. *Trillidium***) | 02 |
| | ***Trillium*** | 01 |
| 31. MUSACEAE | ***Musa*** | 01 |
| 32. NARTHECIACEAE | ***Aletris*** | 01 |
| 33. ORCHIDACEAE | ***Calanthe*** | 02 |
| | ***Cephalanthera*** | 01 |
| | ***Cheirostylis*** | 01 |
| | ***Corallorhiza*** | 01 |
| | ***Cypripedium*** | 01 |
| | ***Dactylorhiza*** (incl. ***Coeloglossum***) | 03 |
| | ***Diphylax*** | 01 |
| | ***Epipactis*** | 04 |
| | ***Epipogium*** | 02 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/varieties) in J&K |
|---|---|---|
| | ***Eulophia*** | 02 |
| | ***Gastrodia*** | 01 |
| | ***Goodyera*** | 01 |
| | ***Gymnadenia*** | 01 |
| | ***Habenaria*** | 09 |
| | ***Herminium*** | 03 |
| | ***Malaxis*** | 02 |
| | ***Neottia*** (incl. ***Listera***) | 03 |
| | ***Nervilia*** | 01 |
| | ***Satyrium*** | 01 |
| | ***Spiranthes*** | 02 |
| | ***Zeuxine*** | 01 |
| 34. POACEAE (incl. Bambusaceae) | ***Acrachne*** | 01 |
| | ***Aegilops*** | 01 |
| | ***Agropyron*** | 03 |
| | ***Agrostis*** | 10 |
| | ***Alopecurus*** | 06 |
| | ***Alloteropsis*** | 01 |
| | ***Andropogon*** | 01 |
| | ***Anthoxanthum*** (incl. ***Hierochloe***) | 02 |
| | ***Apluda*** | 01 |
| | ***Aristida*** | 03 |
| | ***Arthraxon*** | 02 |
| | ***Arundinaria*** | 01 |
| | ***Arundinella*** | 02 |
| | ***Arundo*** | 01 |
| | ***Avena*** | 04 |
| | ***Avenula*** | 01 |
| | ***Bothriochloa*** | 05 |
| | ***Brachypodium*** (incl. ***Trachynia***) | 05 |
| | ***Briza*** | 01 |
| | ***Bromus*** | 13 |
| | ***Calamagrostis*** | 10 (01) |
| | ***Capillipedium*** | 02 |
| | ***Catabrosa*** | 01 |
| | ***Cenchrus*** | 02 |
| | ***Chionachne*** | 01 |
| | ***Chloris*** | 04 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Chrysopogon*** (incl. ***Vetiveria***) | 08 |
| | ***Cleistogenes*** (***Kengia***) | 01 |
| | ***Coix*** | 02 |
| | ***Colpodium*** (incl. ***Paracolpodium***) | 05 |
| | ***Crypsis*** | 01 |
| | ***Cymbopogon*** | 05 |
| | ***Cynodon*** | 01 |
| | ***Cyrtococcum*** | 01 |
| | ***Dactyloctenium*** | 01 |
| | ***Dactylis*** | 01 |
| | ***Danthonia*** | 02 |
| | ***Dendrocalamus*** | 02 |
| | ***Deschampsia*** | 02 |
| | ***Desmostachya*** | 01 |
| | ***Dichanthium*** | 02 |
| | ***Digitaria*** | 07 |
| | ***Dinebra*** | 01 |
| | ***Duthiea*** | 01 |
| | ***Echinochloa*** | 03 |
| | ***Eleusine*** | 03 |
| | ***Elymus*** | 18 |
| | ***Enneapogon*** | 01 |
| | ***Enteropogon*** | 01 |
| | ***Eragostis*** | 14 |
| | ***Eremopoa*** | 02 |
| | ***Eulalia*** | 02 |
| | ***Eulaliopsis*** | 01 |
| | ***Festuca*** | 21 (01) |
| | ***Glyceria*** | 01 |
| | ***Hackelochloa*** | 01 |
| | ***Helictotrichon*** | 02 |
| | ***Hemarthria*** | 01 |
| | ***Heteropogon*** | 01 |
| | ***Hordeum*** | 04 |
| | ***Hygroryza*** | 01 |
| | ***Imperata*** | 01 |
| | ***Isachne*** | 01 |
| | ***Ischaemum*** | 01 |
| | ***Koeleria*** | 02 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Lagurus*** | 01 |
| | ***Leptochloa*** | 03 |
| | ***Leersia*** | 01 |
| | ***Leucopoa*** | 01 |
| | ***Leymus*** | 01 |
| | ***Lolium*** | 02 (01) |
| | ***Lygeum*** | 01 |
| | ***Melica*** | 05 |
| | ***Microstegium*** | 02 |
| | ***Milium*** | 01 |
| | ***Mnesithea*** | 01 |
| | ***Miscanthus*** | 01 |
| | ***Moorochloa*** **(*Brachiaria*)** | 06 |
| | ***Muhlenbergia*** | 04 |
| | ***Neyraudia*** | 01 |
| | ***Oplismenus*** | 03 |
| | ***Orinus*** | 01 |
| | ***Oryza*** | 01 |
| | ***Oryzopsis*** | 05 |
| | ***Panicum*** | 06 |
| | ***Paspalidium*** | 02 |
| | ***Paspalum*** | 04 |
| | ***Pennisetum*** | 05 |
| | ***Phacelurus*** | 01 |
| | ***Phalaris*** | 03 |
| | ***Phleum*** | 03 |
| | ***Phragmites*** | 02 |
| | ***Poa*** **(**incl. ***Eremopogon*****)** | 34 (03) |
| | ***Pogonatherum*** | 01 |
| | ***Polypogon*** | 03 |
| | ***Puccinellia*** | 11 |
| | ***Rostraria*** | 01 |
| | ***Rothoellia*** | 01 |
| | ***Saccharum*** **(**incl. ***Erianthus*****)** | 08 |
| | ***Schismus*** | 02 |
| | ***Schizachyrium*** | 01 |
| | ***Sclerochloa*** | 01 |
| | ***Setaria*** | 07 |
| | ***Sorghum*** | 04 |
| | ***Spodiopogon*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Sporobolus*** | 02 |
| | ***Stipa*** | 25 |
| | ***Stipagrostis*** | 01 |
| | ***Tetrapogon*** | 01 |
| | ***Themeda*** | 02 |
| | ***Thysanolaena*** | 01 |
| | ***Tragus*** | 02 |
| | ***Trikeraia*** | 02 |
| | ***Tripogon*** | 03 |
| | ***Trisetum*** | 03 |
| | ***Trisetaria*** | 01 |
| | ***Triticum*** | 01 |
| | ***Urochloa*** | 01 |
| | ***Vulpia*** | 02 |
| | ***Zea*** | 01 |
| 35. PONTEDERIACEAE | ***Eichhornia*** | 01 |
| | ***Monochoria*** | 02 |
| 36. POTAMOGETONACEAE | ***Potamogeton*** | 14 |
| | ***Zannichellia*** | 01 |
| 37. SMILACACEAE | ***Smilax*** | 04 |
| 38. SPARGANIACEAE | ***Sparganium*** | 03 (01) |
| 39. TYPHACEAE | ***Typha*** | 05 |
| 40. ZINGIBERACEAE | ***Curcuma*** | 02 |
| | ***Elettaria*** | 01 |
| | ***Hedychium*** | 01 |
| | ***Roscoea*** | 01 |
| | ***Zingiber*** | 02 |
| ***Subtotal = 40*** | ***259*** | ***900 (13)*** |
| **DICOTYLEDONS** | | |
| 1. ACANTHACEAE | ***Andrographis (Indoneesiella)*** | 01 |
| | ***Barleria*** | 02 |
| | ***Blepharis*** | 01 |
| | ***Dicliptera*** | 01 |
| | ***Eranthemum*** | 01 |
| | ***Hygrophila*** | 01 |
| | ***Justicia*** (incl. ***Adhatoda***) | 05 |
| | ***Lepidagathis*** | 02 |
| | ***Peristrophe*** | 02 |
| | ***Petalidium*** | 01 |
| | ***Phlogacanthus*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Ruellia*** (incl. ***Dipteracanthus***) | 02 (01) |
| | ***Rungia*** | 02 |
| | ***Strobilanthes*** (incl. ***Aechmanthera***, ***Goldfussia***, ***Hemigraphis***, and ***Pteracanthus***) | 10 |
| | ***Thunbergia*** | 01 |
| 2. ACTINIDIACEAE | ***Actinidia*** | 01 |
| 3. ADOXACEAE | ***Adoxa*** | 01 |
| | ***Sambucus*** | 02 |
| | ***Viburnum*** | 08 |
| 4. AIZOACEAE | ***Mesembryanthemum*** (***Aptenia***) | 01 |
| | ***Trianthema*** | 01 |
| | ***Zaleya*** | 01 |
| 5. AMARANTHACEAE (incl. Chenopodiaceae) | ***Achyranthes*** | 02 (02) |
| | ***Acroglochin*** | 01 |
| | ***Aerva*** | 05 |
| | ***Alternanthera*** | 05 |
| | ***Amaranthus*** | 12 (03) |
| | ***Atriplex*** | 09 |
| | ***Axyris*** | 01 (02) |
| | ***Bassia*** | 01 |
| | ***Bosea*** | 01 |
| | ***Celosia*** | 01 |
| | ***Chenopodium*** | 19 (01) |
| | ***Corispermum*** | 04 |
| | ***Cyathula*** | 01 |
| | ***Deeringia*** | 01 |
| | ***Digera*** | 01 |
| | ***Gomphrena*** | 04 |
| | ***Halocharis*** | 02 |
| | ***Halogeton*** | 05 |
| | ***Haloxylon*** | 01 |
| | ***Kochia*** | 04 |
| | ***Krascheninnikovia*** | 02 |
| | ***Microgynoecium*** | 01 |
| | ***Pupalia*** | 01 |
| | ***Salsola*** | 03 (03) |
| | ***Spinacia*** | 01 |
| | ***Suaeda*** | 03 (01) |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| 6. ANACARDIACEAE | ***Cotinus*** | 01 |
| | ***Lannea*** | 01 |
| | ***Mangifera*** | 01 |
| | ***Pistacia*** | 04 |
| | ***Rhus*** | 04 |
| | ***Semecarpus*** | 01 |
| | ***Spondias*** | 01 |
| 7. ANNONACEAE | ***Artabotrys*** | 01 |
| | ***Miliusa*** | 01 |
| | ***Polyalthia*** | 01 |
| 8. APIACEAE (Umbelliferae) | ***Aegopodium*** | 01 |
| | ***Ammi*** | 02 |
| | ***Anethum*** | 01 |
| | ***Angelica*** | 02 (01) |
| | ***Anthriscus*** | 01 |
| | ***Apium*** | 02 |
| | ***Aulacospermum*** | 01 |
| | ***Berula*** | 01 |
| | ***Bunium*** | 01 |
| | ***Bupleurum*** | 17 (06) |
| | ***Carum*** | 01 (01) |
| | ***Centella*** | 01 |
| | ***Chaerophyllum*** | 04 |
| | ***Cicuta*** | 01 |
| | ***Conioselinum*** | 01 |
| | ***Conium*** | 01 |
| | ***Coriandrum*** | 01 |
| | ***Cuminum*** | 01 |
| | ***Daucus*** | 01 (01) |
| | ***Eryngium*** | 01 |
| | ***Ferula*** | 03 |
| | ***Foeniculum*** | 01 |
| | ***Heracleum*** | 06 |
| | ***Ligusticum*** | 03 |
| | ***Oenanthe*** | 01 |
| | ***Osmorhiza*** | 01 |
| | ***Petroslinum*** | 01 |
| | ***Peucedanum*** | 01 |
| | ***Pimpinella*** | 04 |
| | ***Pleurospermum*** | 08 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Prangos*** | 01 |
| | ***Psammogeton*** | 02 (01) |
| | ***Pycnocycla*** | 01 |
| | ***Sanicula*** | 01 (01) |
| | ***Scaligeria*** | 01 |
| | ***Scandix*** | 01 |
| | ***Schulzia*** | 01 |
| | ***Selinum*** | 06 |
| | ***Semenovia*** | 01 |
| | ***Sesli*** (incl. ***Eriocycla***) | 05 |
| | ***Sium*** | 03 |
| | ***Torilis*** | 05 |
| | ***Trachydium*** | 01 |
| | ***Trachyspermum*** | 03 |
| | ***Vicatia*** | 02 (01) |
| 9. APOCYNACEAE (incl. Asclepiadaceae) | ***Apocynum*** (***Trachomitum***) | 01 |
| | ***Asclepias*** | 02 |
| | ***Calotropis*** | 01 |
| | ***Caralluma*** | 01 |
| | ***Carissa*** | 01 |
| | ***Catharanthus*** | 01 |
| | ***Ceropegia*** | 02 |
| | ***Cryptolepis*** | 01 |
| | ***Cynanchum*** | 06 |
| | ***Dregea*** (***Wattakaka***) | 01 |
| | ***Gomphocarpus*** | 01 |
| | ***Holarrhena*** | 02 |
| | ***Holostemma*** | 01 |
| | ***Hoya*** | 01 |
| | ***Ichnocarpus*** | 01 |
| | ***Marsdenia*** | 01 |
| | ***Nerium*** | 02 |
| | ***Orthanthera*** | 01 |
| | ***Oxystelma*** | 01 |
| | ***Pergularia*** | 01 |
| | ***Periploca*** | 03 |
| | ***Plumeria*** | 03 |
| | ***Rauvolfia*** | 01 |
| | ***Tabernaemontana*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Telosma*** | 02 |
| | ***Thevetia (Cascabela)*** | 01 |
| | ***Trachelospermum*** | 02 |
| | ***Tylophora*** | 02 |
| | ***Vallaris*** | 01 |
| | ***Vinca*** | 02 |
| | ***Vincetoxicum*** | 03 |
| | ***Wrightia*** | 01 |
| 10. AQUIFOLIACEAE | ***Ilex*** | 02 |
| 11. ARALIACEAE | ***Aralia*** | 01 |
| | ***Fatsia*** | 01 |
| | ***Hedera*** | 03 |
| | ***Hydrocotyle*** | 02 |
| | ***Schefflera*** | 01 |
| 12. ARISTOLOCHIACEAE | ***Aristolochia*** | 02 |
| 13. ASTERACEAE (Compositae) | ***Achillea*** | 01 (01) |
| | ***Acroptilon*** | 01 |
| | ***Adenostemma*** | 01 |
| | ***Ageratum*** | 02 |
| | ***Ainsliaea*** | 02 |
| | ***Ajania*** | 01 |
| | ***Allardia*** (incl. ***Waldheimia***) | 05 |
| | ***Anaphalis*** | 15 (05) |
| | ***Anthemis*** | 01 |
| | ***Arctium*** | 01 |
| | ***Arnica*** | 01 |
| | ***Artemisia*** (incl. ***Seriphidum***) | 50 (04) |
| | ***Aster*** (incl. ***Heteropappus***) | 18 (02) |
| | ***Bellis*** | 01 |
| | ***Bidens*** | 08 (02) |
| | ***Blainvillea*** | 01 |
| | ***Blumea*** | 08 |
| | ***Caesulia*** | 01 |
| | ***Calendula*** | 02 |
| | ***Callistephus*** | 01 |
| | ***Calotis*** | 01 |
| | ***Carduus*** | 04 |
| | ***Carpesium*** | 04 (01) |
| | ***Carthamus*** | 03 |
| | ***Centaurea*** | 06 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Centipeda*** | 01 |
| | ***Chondrilla*** | 02 |
| | ***Chrysanthemum*** | 11 |
| | ***Cichorium*** | 02 |
| | ***Cicerbita*** | 05 (02) |
| | ***Cirsium*** (incl. ***Breea***) | 06 (01) |
| | ***Conyza*** | 06 |
| | ***Coreopsis*** | 02 |
| | ***Cosmos*** | 02 |
| | ***Cotula*** | 02 |
| | ***Cousinia*** | 05 |
| | ***Cremanthodium*** | 05 (01) |
| | ***Crepis*** | 12 (01) |
| | ***Crupina*** | 01 |
| | ***Cyathocline*** | 01 |
| | ***Dahila*** | 02 |
| | ***Dicoma*** (***Hochstetteria***) | 01 |
| | ***Dolomiaea*** | 02 |
| | ***Doronicum*** | 4 (01) |
| | ***Dubyaea*** | 01 |
| | ***Duhaldea*** | 03 |
| | ***Eclipta*** | 01 |
| | ***Echinops*** | 04 |
| | ***Emilia*** | 01 |
| | ***Enydra*** | 01 |
| | ***Erigeron*** | 17 (02) |
| | ***Eupatorium*** | 02 |
| | ***Filago*** | 04 |
| | ***Gaillarda*** | 02 |
| | ***Galinsoga*** | 03 |
| | ***Garhadiolus*** | 01 |
| | ***Gazania*** | 01 |
| | ***Gerbera*** | 03 (01) |
| | ***Glossocardia*** (***Glossogyne***) | 01 |
| | ***Gnaphalium*** | 11 (01) |
| | ***Guizotia*** | 01 |
| | ***Helianthus*** | 04 |
| | ***Helichrysum*** | 01 |
| | ***Hieracium*** | 04 (01) |
| | ***Hippolytia*** | 03 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Ifloga*** | 01 |
| | ***Inula*** | 17 (01) |
| | ***Ixeris*** | 02 |
| | ***Jurinea*** | 02 |
| | ***Koelpinia*** | 01 |
| | ***Lactuca*** | 17 (03) |
| | ***Laggera*** | 01 |
| | ***Lapsana*** | 01 |
| | ***Launaea*** | 07 |
| | ***Leibnitzia*** | 01 |
| | ***Leontopodium*** | 10 (02) |
| | ***Leucanthemum*** | 01 |
| | ***Liatris*** | 01 |
| | ***Ligularia*** | 05 (01) |
| | ***Lipschitziella*** | 01 |
| | ***Logfia*** | 01 |
| | ***Matricaria*** | 05 |
| | ***Microcephala*** | 01 |
| | ***Myriactis*** | 03 |
| | ***Olgaea*** | 01 |
| | ***Onopordum*** | 01 |
| | ***Parasenceio*** (incl. ***Cacalia***) | 03 |
| | ***Parthenium*** | 01 |
| | ***Pentanema*** | 02 |
| | ***Petasites*** | 01 |
| | ***Phagnalon*** | 03 |
| | ***Picris*** | 02 |
| | ***Prenanthes*** | 04 |
| | ***Pseudognaphalium*** | 02 (02) |
| | ***Psychrogeton*** | 02 (03) |
| | ***Pulicaria*** | 05 |
| | ***Rhynchospermum*** | 01 |
| | ***Rudbeckia*** | 02 |
| | ***Santolina*** | 01 |
| | ***Sanvitalia*** | 01 |
| | ***Saussurea*** | 44 (03) |
| | ***Sclerocarpus*** | 01 |
| | ***Scorzonera*** | 03 |
| | ***Senecio*** | 21 (02) |
| | ***Serratula*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Siegesbeckia*** | 01 |
| | ***Silybum*** | 01 |
| | ***Solidago*** | 04 (03) |
| | ***Solvia*** | 01 |
| | ***Sonchus*** | 04 |
| | ***Soroseris*** | 01 |
| | ***Sphaeranthus*** | 01 |
| | ***Spilanthes*** | 01 |
| | ***Stevia*** | 01 |
| | ***Symphyotrichum*** (incl. ***Brachyactis***) | 03 |
| | ***Synendrella*** | 01 |
| | ***Synotis*** | 01 |
| | ***Tagetes*** | 04 |
| | ***Tanacetum*** | 19 |
| | ***Taraxacum*** | 80 (03) |
| | ***Tragopogon*** | 06 |
| | ***Tricholepis*** | 06 |
| | ***Tridax*** | 01 |
| | ***Tussilago*** | 01 |
| | ***Uechtritzia*** | 02 |
| | ***Vernonia*** | 02 |
| | ***Xanthium*** | 03 |
| | ***Youngia*** | 04 (01) |
| | ***Zinnia*** | 04 |
| | ***Zoegia*** | 01 |
| 14. BALANOPHORACEAE | ***Balanophora*** | 01 |
| 15. BALSAMINACEAE | ***Impatiens*** | 19 (01) |
| 16. BASELLACEAE | ***Basella*** | 01 |
| 17. BEGONIACEAE | ***Begonia*** | 01 |
| 18. BERBERIDACEAE | ***Berberis*** (incl. ***Mahonia***) | 26 (06) |
| | ***Epimedium*** | 01 |
| | ***Nandina*** | 01 |
| | ***Podophyllum*** | 01 |
| 19. BETULACEAE | ***Alnus*** | 01 |
| | ***Betula*** | 01(-2) |
| | ***Carpinus*** | 01 |
| | ***Corylus*** | 03 |
| 20. BIEBERSTEINIACEAE | ***Biebersteinia*** | 01 |
| 21. BIGNONIACEAE | ***Bignonia*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Campsis*** | 02 |
| | ***Catalpa*** | 02 |
| | ***Incarvillea*** | 01 |
| | ***Jacaranda*** | 02 |
| | ***Kigelia*** | 01 |
| | ***Oroxylum*** | 01 |
| | ***Stereospermum*** | 01 |
| | ***Tecoma*** | 05 |
| | ***Tecomella*** | 01 |
| 22. BORAGINACEAE | ***Actinocarya*** | 02 |
| | ***Anchusa*** (incl. ***Lycopsis***) | 04 |
| | ***Arnebia*** | 06 |
| | ***Asperugo*** | 01 |
| | ***Bothriospermum*** | 01 |
| | ***Cordia*** | 04 |
| | ***Cynoglossum*** | 07 (01) |
| | ***Echium*** | 01 |
| | ***Ehretia*** | 04 (01) |
| | ***Eritrichum*** | 08 (03) |
| | ***Gastrocotyle*** | 01 |
| | ***Hackelia*** | 03 (01) |
| | ***Heliotropium*** | 06 (02) |
| | ***Lappula*** (incl. ***Echinospermum***) | 06 (03) |
| | ***Lasiocaryum*** | 02 |
| | ***Lepechiniella*** | 01 |
| | ***Lindelofia*** | 03 (02) |
| | ***Lithospermum*** (incl. ***Buglossoides***) | 05 (01) |
| | ***Microula*** | 01 |
| | ***Myosotis*** | 08 (02) |
| | ***Nemophila*** | 02 |
| | ***Nonea*** | 01 |
| | ***Onosma*** | 06 |
| | ***Paracaryum*** (incl. ***Mattiastrum***, ***Microparacaryum***) | 04 |
| | ***Phacelia*** | 01 |
| | ***Pseudomertensia*** | 09 (01) |
| | ***Rochelia*** | 09 |
| | ***Solenanthus*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Trichodesma*** | 01 |
| | ***Trigonotis*** | 02 |
| 23. BRASSICACEAE (Cruciferae) | ***Alliaria*** | 01 |
| | ***Alyssum*** (incl. ***Ptilotrichum***) | 05 (02) |
| | ***Aphragmus*** (***Lignariella***) | 02 |
| | ***Arabidopsis*** | 13 (01) |
| | ***Arabis*** | 14 |
| | ***Arcyosperma*** | 01 |
| | ***Asperuginoides*** (***Buchingera***) | 01 |
| | ***Atelanthera*** | 01 |
| | ***Aubrieta*** | 01 |
| | ***Barbarea*** | 02 (02) |
| | ***Brassica*** | 08 (09) |
| | ***Braya*** | 05 (01) |
| | ***Camelina*** | 01 |
| | ***Capsella*** | 03 |
| | ***Cardamine*** | 10 (03) |
| | ***Caulanthus*** (incl. ***Guillenia***, ***Microsisymbrium***) | 03 |
| | ***Chorispora*** | 05 (01) |
| | ***Christolea*** | 07 (02) |
| | ***Cochlearia*** | 01 |
| | ***Conringia*** | 01 |
| | ***Crambe*** | 01 (01) |
| | ***Crucihimalaya*** | 02 |
| | ***Descurainia*** | 01 |
| | ***Desideria*** | 04 |
| | ***Dilophia*** | 01 |
| | ***Diplotaxis*** | 01 |
| | ***Dontostemon*** | 01 |
| | **Draba** (incl. ***Drabopsis***, ***Erophila***) | 29 (06) |
| | ***Eruca*** | 01 (01) |
| | ***Erucaria*** | 01 |
| | ***Erucastrum*** | 01 |
| | ***Erysimum*** (incl. ***Cheiranthus***) | 09 (01) |
| | ***Euclidium*** | 02 |
| | ***Eutrema*** | 01 |
| | ***Goldbackia*** | 02 |
| | ***Hornungia*** (***Hymenolobus***) | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Iberis*** | 02 |
| | ***Isatis*** | 02 |
| | ***Lepidium*** (incl. ***Cardaria***, ***Coronopus***) | 10 (02) |
| | ***Lobularia*** | 01 |
| | ***Lunaria*** | 01 |
| | ***Malcolmia*** | 03 |
| | ***Matthiola*** | 04 (02) |
| | ***Megacarpaea*** | 02 |
| | ***Nasturtium*** | 02 |
| | ***Neotorulina*** (***Torularia***) | 01 |
| | ***Neslia*** | 01 (01) |
| | ***Noccaea*** | 02 |
| | ***Notoceras*** | 01 |
| | ***Parrya*** | 04 (03) |
| | ***Pegaeophyton*** | 01 |
| | ***Phaeonychium*** | 03 |
| | ***Pycnoplinthus*** | 01 |
| | ***Raphanus*** | 02 |
| | ***Rapistrum*** | 01 |
| | ***Rorippa*** | 07 (01) |
| | ***Sinapis*** | 02 |
| | ***Sisymbrium*** | 08 |
| | ***Smelowskia*** (incl. ***Ermania***, ***Hedenia***) | 07 |
| | ***Tauscheria*** | 01 |
| | ***Tetracme*** | 01 |
| | ***Thlaspi*** | 10 (02) |
| | ***Turritis*** | 01 |
| | ***Winklera*** (***Uranodactylus***) | 01 |
| 24. BUXACEAE | ***Buxus*** | 03 |
| | ***Sarcococca*** | 01 |
| 25. CACTACEAE | ***Cereus*** | 02 |
| | ***Nopalea*** | 01 |
| | ***Opuntia*** | 07 |
| 26. CAESALPINIACEAE (Leguminosae: Caesalpinoideae) | ***Bauhinia*** **(incl.** ***Phanera*****)** | 06 |
| | ***Caesalpinia*** | 04 |
| | ***Cassia*** | 01 |
| | ***Cercis*** | 01 |
| | ***Chamaecrista*** | 04 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Delonix*** | 02 |
| | ***Gleditsia*** | 01 |
| | ***Guilandina*** | 01 |
| | ***Parkinsonia*** | 01 |
| | ***Peltophorum*** | 01 |
| | ***Senna*** | 11 |
| | ***Tamarindus*** | 01 |
| 27. CALYCANTHCEAE | ***Chimonanthus*** | 01 |
| 28. CAMPANULACEAE | ***Asyneuma*** | 01 |
| | ***Campanula*** | 13 (03) |
| | ***Codonopsis*** | 05 |
| | ***Cyananthus*** | 01 |
| | ***Lobelia*** | 01 |
| | ***Platycodon*** | 01 |
| 29. CANNABACEAE | ***Cannabis*** | 01 |
| | ***Celtis*** | 02 |
| | ***Humulus*** | 01 |
| | ***Trema*** | 01 |
| 30. CAPPARACEAE | ***Cadaba*** | 01 |
| | ***Capparis*** | 05 (01) |
| | ***Crateva* (‘*Crataeva*’)** | 01 (01) |
| | ***Maerua*** | 01 |
| 31. CAPRIFOLIACEAE | ***Abelia*** | 02 (01) |
| | ***Cephalaria*** | 01 |
| | ***Dipsacus*** | 05 (01) |
| | ***Leycesteria*** | 01 |
| | ***Lonicera*** | 21 (01) |
| | ***Morina*** | 03 |
| | ***Scabiosa*** | 03 |
| | ***Valeriana*** | 08 |
| | ***Valerianella*** | 03 |
| | ***Weigela*** | 01 |
| 32. CARICACEAE | ***Carica*** | 01 |
| 33. CARYOPHYLLACEAE | ***Arenaria*** | 12 |
| | ***Cerastium*** | 11 (04) |
| | ***Dianthus*** | 16 (02) |
| | ***Gypsophila*** | 07 (01) |
| | ***Herniaria*** | 03 (01) |
| | ***Holosteum*** | 01 |
| | ***Lepyrodiclis*** | 02 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Minuartia*** | 05 (01) |
| | ***Myosoton*** | 01 |
| | ***Petrorhagia*** | 01 |
| | ***Pseudostellaria*** | 03 (01) |
| | ***Polycarpaea*** | 01 |
| | ***Sagina*** | 04 |
| | ***Saponaria*** | 02 |
| | ***Silene*** (incl. ***Cucubalus***-1; ***Lychnis***-7) | 36 (03) |
| | ***Spergula*** | 02 |
| | ***Spergularia*** | 01 |
| | ***Stellaria*** | 22 (04) |
| | ***Thylacospermum*** | 01 |
| | ***Vaccaria*** | 02 |
| 34. CELASTRACEAE | ***Cassine*** | 01 |
| | ***Celastrus*** | 01 |
| | ***Euonymus*** | 07 (01) |
| | ***Maytenus*** | 01 |
| | ***Parnassia*** | 06 |
| 35. CERATOPHYLLACEAE | ***Ceratophyllum*** | 01 |
| 36. CLEOMACEAE | ***Cleome*** | 08 |
| 37. COMBRETACEAE | ***Anogeissus*** | 01 |
| | ***Combretum*** (***Quisqualis***) | 01 |
| | ***Terminalia*** | 04 (01) |
| 38. CONVOLVULACEAE | ***Argyreia*** | 02 |
| | ***Convolvulus*** (incl. ***Calystegia***-1) | 03 |
| | ***Cuscuta*** | 11 |
| | ***Evolvulus*** (incl. ***Vovulopsis***-1) | 02 |
| | ***Ipomoea*** | 15 (01) |
| | ***Merremia*** | 03 |
| | ***Porana*** | 01 |
| 39. CORIARIACEAE | ***Coriaria*** | 01 |
| 40. CORNACEAE | ***Alangium*** | 01 |
| | ***Aucuba*** | 01 |
| | ***Cornus*** | 02 |
| 41. CRASSULACEAE | ***Crassula*** (incl. ***Tillaea***) | 03 |
| | ***Hylotelephium*** | 02 |
| | ***Kalanchoe*** (incl. ***Bryophyllum***) | 03 |
| | ***Orostachys*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Pseudosedum*** | 02 |
| | ***Rosularia*** (***Sempervivella***) | 05 |
| | ***Sedum*** (incl. ***Rhodiola***) | 15 (03) |
| 42. CUCURBITACEAE | ***Citrullus*** | 01 |
| | ***Coccianea*** | 01 |
| | ***Cucumis*** | 03 (01) |
| | ***Cucurbita*** | 03 |
| | ***Cyclanthera*** | 01 |
| | ***Diplocyclos*** | 01 |
| | ***Lagenaria*** | 01 |
| | ***Luffa*** | 02 |
| | ***Momordica*** | 01 |
| | ***Solena*** | 02 |
| | ***Trichosanthes*** | 02 |
| 43. DIDIEREACEAE | ***Portulacaria*** | 01 |
| 44. DIPSACACEAE | ***Datisca*** | 01 |
| 45. DIPTEROCARPACEAE | ***Hopea*** | 02 |
| | ***Shoera*** | 01 |
| 46. DROSERACEAE | ***Drosera*** | 01 |
| 47. EBENACEAE | ***Diospyros*** | 03 |
| 48. ELAEAGNACEAE | ***Elaeagnus*** | 05 |
| | ***Hippophae*** | 03 |
| 49. ELATINACEAE | ***Bergia*** | 01 |
| | ***Elatine*** | 02 |
| 50. ERICACEAE | ***Azalea*** | 01 |
| | ***Cassiope*** | 01 |
| | ***Gaultheria*** | 01 |
| | ***Lyonia*** | 01 |
| | ***Monotropa*** | 01 |
| | ***Orthilia*** | 01 |
| | ***Pyrola*** | 01 |
| | ***Rhododendron*** | 04 |
| 51. EUPHORBIACEAE | ***Acalypha*** | 02 |
| | ***Baliospermum*** | 01 |
| | ***Chrozophora*** | 02 |
| | ***Croton*** | 01 |
| | ***Euphorbia*** | 34 |
| | ***Jatropha*** | 01 |
| | ***Mallotus*** | 01 |
| | ***Ricinus*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Sapium*** | 01 |
| 52. FABACEAE (Leguminosae: Papilionoideae) | ***Abrus*** | 01 |
| | ***Aeschynomene*** | 02 |
| | ***Alhagi*** | 02 |
| | ***Alysicarpus*** | 08 (02) |
| | ***Amorpha*** | 01 |
| | ***Amphicarpaea*** | 01 |
| | ***Arachis*** | 01 |
| | ***Argyrolobium*** | 03 (01) |
| | ***Astracantha*** | 01 |
| | ***Astragalus*** | 55 (06) |
| | ***Butea*** | 01 |
| | ***Cajanus*** (incl. ***Atylosia***) | 06 |
| | ***Campylotropis*** | 05 |
| | ***Canavalia*** | 03 |
| | ***Caragana*** | 09 (01) |
| | ***Chesneya*** | 04 |
| | ***Christia*** | 01 |
| | ***Cicer*** | 05 |
| | ***Clitoria*** | 01 |
| | ***Codariocalyx*** | 01 |
| | ***Colutea*** | 03 (01) |
| | ***Crotalaria*** | 12 (02) |
| | ***Cullen*** | 02 |
| | ***Delbergia*** | 02 |
| | ***Dendrolobium*** | 01 |
| | ***Derris*** | 01 |
| | ***Desmodium*** | 13 (02) |
| | ***Dumasia*** | 01 |
| | ***Ebenus*** | 01 |
| | ***Eriosema*** | 01 |
| | ***Erythrina*** | 04 |
| | ***Flemingia*** | 04 |
| | ***Galactia*** | 01 |
| | ***Gliricida*** | 01 |
| | ***Glycine*** | 01 |
| | ***Glycyrrhiza*** | 01 |
| | ***Gueldenstaedtia*** | 01 (01) |
| | ***Hedysarum*** (incl. ***Stracheya***) | 09 (01) |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/varieties) in J&K |
|---|---|---|
| | ***Hylodesmum*** | 01 (01) |
| | ***Indigofera*** | 17 (01) |
| | ***Lablab*** | 01 (01) |
| | ***Laburnum*** | 01 |
| | ***Lathyrus*** | 11 |
| | ***Lens*** | 01 |
| | ***Lespedeza*** | 07 (02) |
| | ***Lotus*** | 02 (01) |
| | ***Lupinus*** | 03 |
| | ***Macrotyloma*** | 01 |
| | ***Medicago*** | 09 |
| | ***Meizotropis*** | 01 |
| | ***Melilotus*** | 04 |
| | ***Millettia*** | 02 |
| | ***Mucuna*** | 02 (01) |
| | ***Ohwia*** | 01 |
| | ***Onobrychis*** | 02 |
| | ***Ononis*** | 01 (02) |
| | ***Ophiocarpus*** | 01 |
| | ***Ougeinia*** | 01 |
| | ***Oxytropis*** | 19 (01) |
| | ***Parochetus*** | 01 |
| | ***Phaseolus*** | 02 |
| | ***Phyllodium*** | 01 |
| | ***Piptanthus*** | 01 |
| | ***Pisum*** | 01 |
| | ***Podolotus*** | 01 |
| | ***Psoralea*** | 01 |
| | ***Pueraria*** | 01 |
| | ***Pycnospora*** | 01 |
| | ***Rhynchosia*** | 05 (01) |
| | ***Robinia*** | 01 |
| | ***Rothia*** | 01 |
| | ***Sesbania*** | 04 |
| | ***Shuteria*** | 01 (01) |
| | ***Smithia*** | 03 |
| | ***Sophora*** | 03 (02) |
| | ***Spartium*** | 01 |
| | ***Spatholobus*** | 01 |
| | ***Spongiocarpella*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Tadehagi*** | 01 |
| | ***Taverniera*** | 01 |
| | ***Tephrosia*** | 04 |
| | ***Teramnus*** | 02 |
| | ***Thermopsis*** | 02 |
| | ***Trifolium*** | 10 |
| | ***Trigonella*** | 09 |
| | ***Uraria*** | 02 |
| | ***Vicia*** (incl. ***Faba***) | 12 |
| | ***Vigna*** | 08 (01) |
| | ***Wisteria*** | 01 |
| | ***Zornia*** | 01 |
| 53. FAGACEAE | ***Castanea*** | 01 |
| | ***Fagus*** | 01 |
| | ***Quercus*** | 08 |
| 54. GENTIANACEAE | ***Canscora*** | 02 |
| | ***Centaurium*** | 03 (02) |
| | **Gentiana** (incl. ***Alotis***, ***Ciminalis***, ***Comastoma***, ***Gentianodes***, ***Qaisera***) | 35 (06) |
| | ***Gentianella*** | 10 |
| | ***Gentianopsis*** | 03 |
| | ***Halenia*** | 01 |
| | ***Jaeschkca*** | 03 |
| | ***Lomatogonium*** | 06 |
| | ***Swertia*** | 10 |
| 55. GERANIACEAE | ***Erodium*** | 04 |
| | ***Geranium*** | 26 |
| | ***Pelargonium*** | 05 |
| 56. GESNERIACEAE | ***Chirita*** | 01 |
| | ***Corallodiscus*** | 01 |
| 57. GRASSULARIACEAE | ***Ribes*** | 08 |
| 58. HALORAGACEAE | ***Myriophyllum*** | 02 |
| 59. HAMAMELIDACEAE | ***Parrotiopsis*** | 01 |
| 60. HIPPOCASTANACEAE | ***Aesculus*** | 01 |
| 61. HYDRANGIACEAE | ***Deutzia*** | 04 |
| | ***Hydrangea*** | 02 |
| | ***Philadelphus*** | 06 |
| 62. ITEACEAE | ***Itea*** | 01 |
| 63. JUGLANDACEAE | ***Carya*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/varieties) in J&K |
|---|---|---|
| | ***Juglans*** | 02 |
| 64.LAMIACEAE (Labiatae) | ***Ajuga*** | 02 |
| | ***Anisochilus*** | 01 |
| | ***Anisomeles*** | 01 |
| | ***Callicarpa*** | 01 |
| | ***Caryopteris*** | 02 |
| | ***Chelonopsis*** | 01 |
| | ***Clerodendrum*** | 01 |
| | ***Clinopodium*** (incl. ***Calamintha***) | 02 |
| | ***Colebrookea*** | 01 |
| | ***Craniotome*** | 01 |
| | ***Drachocephalum*** | 05 |
| | ***Elsholtzia*** | 06 |
| | ***Eremostachys*** | 01 |
| | ***Glechoma*** | 01 |
| | ***Gmelina*** | 01 |
| | ***Gontscharovia*** | 01 |
| | ***Holmskiodia*** | 01 |
| | ***Hyptis*** | 01 |
| | ***Hyssopus*** | 01 |
| | ***Isodon*** | 03 |
| | ***Lamium*** | 02 |
| | ***Lavandula*** | 02 |
| | ***Leonurus*** | 01 |
| | ***Leucas*** | 11 |
| | ***Lycopus*** | 01 |
| | ***Marmoritis*** | 02 |
| | ***Marrubium*** | 04 |
| | ***Mentha*** | 07 |
| | ***Micromeria*** | 02 |
| | ***Mosla*** | 01 |
| | ***Nepeta*** | 39 (01) |
| | ***Ocimum*** | 02 |
| | ***Origanum*** | 01 |
| | ***Orthosiphon*** | 02 |
| | ***Otostegia*** | 01 |
| | ***Perilla*** | 01 |
| | ***Perovskia*** | 02 |
| | ***Phlomis*** | 05 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Platostoma* (*Acrocephalus*)** | 01 |
| | ***Plectranthus*** (incl. ***Coleus***) | 07 |
| | ***Pogostemon*** (incl. ***Eusteralis***) | 03 |
| | ***Premna*** | 03 |
| | ***Prunella*** | 01 |
| | ***Rosmarinus*** | 01 |
| | ***Roylea*** | 02 |
| | ***Salvia*** | 11 |
| | ***Satureja*** | 01 |
| | ***Scutellaria*** | 09 |
| | ***Sideritis*** | 01 |
| | ***Stachys*** | 09 |
| | ***Tectona*** | 01 |
| | ***Teucrium*** | 08 |
| | ***Thymus*** | 02 (02) |
| | ***Vitex*** | 02 |
| | ***Ziziphora*** | 03 |
| 65. LARDIZABALACEAE | ***Holboellia*** | 01 |
| 66. LAURACEAE | ***Cinnamomum*** | 01 |
| | ***Laurus*** | 01 |
| | ***Neolitsea*** | 02 |
| | ***Persea*** (incl. ***Machilus***) | 02 |
| 67. LENTIBULARIACEAE | ***Utricularia*** | 03 |
| 68. LINACEAE | ***Linum*** | 05 |
| | ***Reinwardtia*** | 01 |
| 69. LINDERNIACEAE | ***Lindernia*** | 08 |
| | ***Torenia*** | 01 |
| 70. LOGANIACEAE | ***Mitreola*** | 01 |
| 71. LORANTHACEAE | ***Dendrophthoe*** | 01 |
| | ***Loranthus*** | 04 |
| | ***Scurrula*** | 02 |
| 72. LYTHRACEAE | ***Ammannia*** | 03 |
| | ***Cuphea*** | 01 |
| | ***Lagerstroemia*** | 01 |
| | ***Lawsonia*** | 01 |
| | ***Lythrum*** | 02 |
| | ***Punica*** | 01 |
| | ***Rotala*** | 04 |
| | ***Trapa*** | 02 |
| | ***Woodfordia*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| 73. MAGNOLIACEAE | ***Liriodendron*** | 01 |
| | ***Magnolia*** | 05 |
| 74. MALPIGHIACEAE | ***Aspidopterys*** | 01 |
| | ***Galphimia*** | 01 |
| | ***Hiptage*** | 01 |
| | ***Mascagnia*** | 01 |
| 75. MALVACEAE | ***Abelmoschus* (~*Hibiscus*)** | 3 |
| | ***Abutilon*** | 07 |
| | ***Alcea*** | 03 |
| | ***Althaea*** | 03 |
| | ***Bombax*** | 01 |
| | ***Ceiba* (*Chorisia*)** | 01 |
| | ***Corchorus*** | 06 |
| | ***Firmiana*** | 01 |
| | ***Fioria* (~*Hibiscus*)** | 01 |
| | ***Gossypium*** | 02 |
| | ***Grewia*** | 05 |
| | ***Helicteres*** | 01 |
| | ***Hibiscus*** | 11 |
| | ***Kydia*** | 01 |
| | ***Lavatera*** | 02 |
| | ***Malva*** | 11 (01) |
| | ***Malvastrum*** | 01 |
| | ***Malvaviscus* (~*Hibiscus*)** | 01 |
| | ***Melochia*** | 01 |
| | ***Pterospermum*** | 01 |
| | ***Sida*** | 07 |
| | ***Sidalcea*** | 01 |
| | ***Sterculia*** | 02 |
| | ***Thespesia*** | 01 |
| | ***Tilia*** | 01 |
| | ***Triumfetta*** | 03 |
| | ***Urena*** | 01 |
| 76. MARTYNIACEAE | ***Martynia*** | 01 |
| 77. MELIACEAE | ***Azadirachta*** | 01 |
| | ***Melia*** | 01 |
| | ***Toona*** | 03 (02) |
| 78. MENISPERMACEAE | ***Cissampelos*** | 01 |
| | ***Cocculus*** | 02 |
| | ***Stephania*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Tinospora*** | 02 |
| 79. MENYANTHACEAE | ***Menyanthes*** | 01 |
| | ***Nymphoides*** | 02 |
| 80. MIMOSACEAE (Leguminosae: Mimosoideae) | ***Acacia*** | 12 |
| | ***Albizia*** | 05 (01) |
| | ***Calliandra*** | 03 |
| | ***Desmanthus*** | 01 |
| | ***Leucaenia*** | 01 |
| | ***Mimosa*** | 03 |
| | ***Neptunia*** | 01 |
| | ***Pithecellobium*** | 01 |
| | ***Prosopis*** | 01 |
| 81. MOLLUGINACEAE | ***Glinus*** | 01 |
| | ***Mollugo*** | 03 |
| 82. MORACEAE | ***Broussonetia*** | 01 |
| | ***Ficus*** | 15 |
| | ***Morus*** | 06 |
| 83. MORINGACEAE | ***Moringa*** | 01 |
| 84. MYRTACEAE | ***Callistemon*** | 02 |
| | ***Myrtus*** | 01 |
| | ***Psidium*** | 01 |
| | ***Syzygium*** | 01 |
| 85. NELUMBONACEAE | ***Nelumbo*** | 01 |
| 86. NITRARIACEAE | ***Nitraria*** | 01 |
| | ***Peganum*** | 01 (01) |
| 87. NYCTAGINACEAE | ***Boerhavia*** | 02 |
| | ***Bougainvillea*** | 02 |
| | ***Mirabilis*** | 01 |
| 88. NYMPHAEACEAE | ***Euryale*** | 01 |
| | ***Nymphaea*** | 08 |
| 89. OLEACEAE | ***Forsythia*** | 03 |
| | ***Fraxinus*** | 03 |
| | ***Jasminum*** | 08 (01) |
| | ***Ligustrum*** | 05 |
| | ***Nyctanthes*** | 01 |
| | ***Olea*** | 02 |
| | ***Osmanthus*** | 01 |
| | ***Syringa*** | 04 |
| 90. ONAGRACEAE | ***Circaea*** | 03 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Clarkia* (*Godetia*)** | 01 |
| | ***Epilobium*** | 22 |
| | ***Fuchsia*** | 01 |
| | ***Ludwigia*** | 02 |
| | ***Oenothera*** | 04 |
| 91. OROBANCHACEAE | ***Lathraea*** | 01 |
| | ***Orobanche*** | 10 |
| | ***Euphrasia*** | 15 |
| | ***Leptorhabdos*** | 01 |
| | ***Lindenbergia*** | 03 |
| | ***Odontites*** | 01 |
| | ***Pedicularis*** | 22 (03) |
| | ***Striga*** | 03 |
| 92. OXALIDACEAE | ***Biophytum*** | 02 |
| | ***Oxalis*** | 06 |
| 93. PAEONIACEAE | ***Paeonia*** | 03 |
| 94. PAPAVERACEAE (incl. Fumariaceae) | ***Argemone*** | 02 |
| | ***Corydalis*** | 39 (02) |
| | ***Eschscholzia*** | 01 |
| | ***Fumaria*** | 02 |
| | ***Hypecoum*** | 02 (01) |
| | ***Meconopsis*** | 04 |
| | ***Papaver*** | 08 |
| | ***Roemeria*** | 01 |
| 95. PASSIFLORACEAE | ***Passiflora*** | 02 |
| 96. PAULOWNIACEAE | ***Paulowina*** | 01 |
| 97. PEDALIACEAE | ***Pedalium*** | 01 |
| | ***Sessamum*** | 02 |
| 98. PHRYMACEAE | ***Phryma*** | 01 (01) |
| | ***Lancea*** | 01 |
| | ***Mazus*** | 03 |
| 99. PHYLLANTHACEAE | ***Andrachne*** | 02 |
| | ***Antidesma*** | 01 |
| | ***Briedelia*** | 02 |
| | ***Phyllanthus*** (incl. ***Emblica***) | 04 |
| | ***Fluegga*** | 01 |
| | ***Glochidion*** | 02 |
| | ***Securinega*** | 01 |
| 100. PHYTOLACCACEAE | ***Phytolacca*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| 101. PITTOSPORACEAE | ***Pittosporum*** | 01 |
| 102. PLANTAGINACEAE | ***Antirrhinum*** | 02 |
| | ***Bacopa*** | 02 |
| | ***Callitriche*** | 04 |
| | ***Digitalis*** | 03 |
| | ***Dopatrium*** | 01 |
| | ***Hippuris*** | 01 |
| | ***Kickxia*** | 02 |
| | ***Lagotis*** | 03 |
| | ***Limnophila*** | 02 |
| | ***Linaria*** | 02 |
| | ***Mecardonia* (~*Bacopa*)** | 01 |
| | ***Mimulus*** | 01 |
| | ***Penstemon*** | 01 |
| | ***Picrorhiza*** | 01 |
| | ***Plantago*** | 09 |
| | ***Scoparia*** | 01 |
| | ***Veronica*** (incl. ***Hebe***) | 27 |
| | ***Wulfenia*** | 01 |
| 103. PLATANACEAE | ***Platanus*** | 02 |
| 104. PLUMBAGINACEAE | ***Acantholimon*** | 01 |
| | ***Dictyolimon*** | 01 |
| | ***Limonium*** | 03 |
| | ***Plumbagella*** | 01 |
| | ***Plumbago*** | 01 |
| 105. POLEMONIACEAE | ***Phlox*** | 02 |
| | ***Polemonium*** | 01 |
| 106. POLYGALACEAE | ***Polygala*** | 10 |
| 107. POLYGONACEAE | ***Emex*** | 01 |
| | ***Fagopyrum*** | 05 |
| | ***Fallopia*** (incl. ***Bilderdykia***) | 03 |
| | ***Koenigia*** | 05 |
| | ***Oxyria*** | 01 |
| | ***Persicaria*** (incl. ***Aconogonon*, *Antenoron*, *Pleuropteropyrum*, *Rubrivena***) | 25 (01) |
| | ***Polygonum*** (incl. ***Bistorta***) | 41 (02) |
| | ***Rheum*** | 05 |
| | ***Rumex*** | 17 (01) |
| 108. PORTULACACEAE | ***Portulaca*** | 03 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Talinum*** | 01 |
| 109. PRIMULACEAE | ***Anagallis*** | 01 (01) |
| | ***Androsace*** | 23 (03) |
| | ***Cortusa*** | 02 |
| | ***Cyclamen*** | 01 |
| | ***Embelia*** | 02 |
| | ***Glaux*** | 01 |
| | ***Lysimachia*** | 05 |
| | ***Maesa*** | 01 |
| | ***Myrsine*** | 02 |
| | ***Primula*** | 23 (01) |
| | ***Samolus*** | 01 |
| 110. PROTEACEAE | ***Grevillea*** | 01 |
| 111. PUTRANJIVACEAE | ***Putranjiva*** | 01 |
| 112. RANUNCULACEAE | ***Aconitum*** | 10 (01) |
| | ***Actaea*** (incl. ***Cimicifuga***) | 02 |
| | ***Adonis*** | 02 |
| | ***Anemone*** (incl. ***Hepatica***, ***Pulsatilla***) | 11 (01) |
| | ***Aquilegia*** | 07 (03) |
| | ***Callianthemum*** | 03 |
| | ***Ceratocephala*** | 02 |
| | ***Caltha*** | 02 |
| | ***Clematis*** | 15 (01) |
| | ***Consolida*** | 04 |
| | ***Delphinium*** | 11 |
| | ***Halerpestis*** | 03 |
| | ***Helleborus*** | 01 |
| | ***Isopyrum*** | 03 |
| | ***Nigella*** | 02 |
| | ***Oxygraphis*** | 02 |
| | ***Paraquilegia*** | 02 |
| | ***Ranunculus*** (incl. ***Batrachium***) | 42 (06) |
| | ***Thalictrum*** | 16 |
| | ***Trollius*** | 01 |
| 113. RESEDACEAE | ***Oligomeris*** | 01 |
| 114. RHAMNACEAE | ***Berchemia*** | 03 |
| | ***Ceanothus*** | 01 |
| | ***Gouania*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Helinus*** | 01 |
| | ***Hovenia*** | 01 |
| | ***Rhamnella*** | 01 |
| | ***Rhamnus*** | 08 |
| | ***Sageretia*** | 06 |
| | ***Ventilago*** | 01 |
| | ***Ziziphus*** | 10 |
| 115. ROSACEAE | ***Agrimonia*** | 01 (01) |
| | ***Alchemilla*** | 03 |
| | ***Aruncus*** | 01 |
| | ***Chamaerhodos*** | 01 |
| | ***Chaenomeles*** | 02 |
| | ***Cotoneaster*** | 17 |
| | ***Crataegus*** | 04 |
| | ***Cydonia*** | 01 |
| | ***Eriobotrya*** | 01 |
| | ***Filipendula*** | 01 |
| | ***Geum*** | 03 |
| | ***Kerria*** | 01 |
| | ***Malus*** | 04 |
| | ***Potentilla*** (incl. ***Comarum***-1, ***Dasiphora***-2, ***Duchesnea***-1, ***Fragaria***-6, ***Sibbaldia***-5) | 64 (06) |
| | ***Prinsepia*** | 01 |
| | ***Prunus*** | 19 |
| | ***Pyracantha*** | 02 |
| | ***Pyrus*** | 02 |
| | ***Rosa*** | 21 |
| | ***Rubus*** | 19 |
| | ***Sorbaria*** | 02 |
| | ***Sorbus*** | 03 |
| | ***Spiraea*** | 11 |
| 116. RUBIACEAE | ***Argostemma*** | 01 |
| | ***Asperula*** | 02 (02) |
| | ***Catunaregam*** (***Xeromphis***) | 01 |
| | ***Galium*** | 20 |
| | ***Gardenia*** | 01 |
| | ***Hamelia*** | 01 |
| | ***Hedyotis*** | 05 |
| | ***Himalrandia*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Hymenodictyon*** | 01 |
| | ***Kohautia*** | 01 |
| | ***Leptodermis*** | 02 |
| | ***Mitragyna*** | 01 |
| | ***Oldenlandia*** | 01 |
| | ***Pavetta*** | 01 |
| | ***Randia*** | 01 |
| | ***Rubia*** | 07 |
| | ***Spermadictyon*** | 01 |
| | ***Spermococe*** (incl. ***Borreria***) | 02 |
| | ***Wendlandia*** | 03 |
| 117. RUTACEAE | ***Aegle*** | 01 |
| | ***Boenninghausenia*** | 01 |
| | ***Citrus*** **(incl.** ***Poncirus*****)** | 07 |
| | ***Dictamnus*** | 01 |
| | ***Feronia*** | 01 |
| | ***Murraya*** | 02 |
| | ***Naringi*** | 01 |
| | ***Skimmia*** | 01 |
| | ***Zanthoxylum*** | 01 |
| 118. SABIACEAE | ***Meliosma*** | 02 |
| | ***Sabia*** | 01 |
| 119. SALICACEAE | ***Casearia*** | 03 |
| | ***Flacourtia*** | 01 |
| | ***Populus*** | 09 |
| | ***Salix*** | 29 (02) |
| | ***Xylosoma*** | 01 |
| 120. SANTALACEAE | ***Arceuthobium*** | 02 |
| | ***Korthalsella*** | 01 |
| | ***Thesium*** | 02 |
| | ***Viscum*** | 02 |
| 121. SAPINDACEAE | ***Acer*** | 08 |
| | ***Cardiospermum*** | 01 |
| | ***Dodonaea*** | 01 |
| | ***Koelreuteria*** | 01 |
| | ***Sapindus*** | 01 |
| 122. SAXIFRAGACEAE | ***Astilbe*** | 01 |
| | ***Bergenia*** | 02 |
| | ***Saxifraga*** | 30 |
| 123. SCROPHULARIACEAE | ***Buddleja*** | 06 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/ varieties) in J&K |
|---|---|---|
| | ***Centranthera*** | 01 |
| | ***Diascia*** | 01 |
| | ***Limosella*** | 01 |
| | ***Scrophularia*** | 07 |
| | ***Verbascum*** | 04 |
| 124. SIMAROUBACEAE | ***Ailanthus*** | 01 |
| | ***Picrasma*** | 01 |
| 125. SOLANACEAE | ***Atropa*** | 02 |
| | ***Brugmansia*** | 01 |
| | ***Brunfelsia*** | 02 |
| | ***Capsicum*** | 02 |
| | ***Cestrum*** | 02 |
| | ***Datura*** | 04 |
| | ***Hyoscyamus*** | 02 |
| | ***Lycium*** | 01 |
| | ***Nicotiana*** | 04 |
| | ***Petunia*** | 01 |
| | ***Physalis*** | 07 |
| | ***Physochlaina*** | 01 |
| | ***Solanum*** (incl. ***Lycopersicon***) | 15 |
| | ***Withania*** | 01 |
| 126. SPHENOCLEACEAE | ***Sphenoclea*** | 01 |
| 127. STAPHYLEACEAE | ***Staphylea*** | 01 |
| 128. STERCULIACEAE | ***Dombeya*** | 01 |
| 129. SYMPLOCACEAE | ***Symplocos*** | 02 |
| 130. TAMARICACEAE | ***Myricaria*** | 06 |
| | ***Myrtama*** **(*Tamaricaria*)** | 01 |
| | ***Tamarix*** | 07 |
| 131. THEACEAE | ***Camellia*** | 01 |
| 132. THYMELAEACEAE | ***Daphne*** | 04 |
| | ***Stellera*** | 01 |
| | ***Thymelaea*** | 01 |
| | ***Wikstroemia*** | 01 |
| 133. TOVARICACEAE | ***Tovaria*** | 01 |
| 134. TROPAEOLACEAE | ***Tropaeolum*** | 01 |
| 135. ULMACAEAE | ***Ulmus*** | 03 |
| 136. URTICACEAE | ***Boehmeria*** | 01 |
| | ***Debregeasia*** | 01 |
| | ***Elatostema*** | 01 |
| | ***Girardinia*** | 01 |

(continued)

**Table 19.4** (continued)

| Family | Genus/genera in J&K | Number of species (plus subspecies/varieties) in J&K |
|---|---|---|
| | ***Laportea*** | 01 |
| | ***Lecanthus*** | 01 |
| | ***Parietaria*** | 03 |
| | ***Pilea*** | 02 |
| | ***Pouzolzia*** | 04 |
| | ***Oreocnide* (*Villebrunea*)** | 01 |
| | ***Urtica*** | 05 |
| 137. VERBENACEAE | ***Aloysia*** | 01 |
| | ***Duranta*** | 01 |
| | ***Lantana*** | 01 |
| | ***Phyla* (*Lippia*)** | 01 |
| | ***Verbena*** | 03 |
| 138. VIOLACEAE | ***Viola*** | 20 (04) |
| 139. VITACEAE | ***Ampelocissus*** | 01 |
| | ***Ampelopsis*** | 01 |
| | ***Cayratia*** | 01 |
| | ***Leea*** | 02 |
| | ***Parthenocissus*** | 05 |
| | ***Tetrastigma*** | 01 |
| | ***Vitis*** | 07 |
| 140. ZYGOPHYLLACEAE | ***Balanites*** | 01 |
| | ***Fagonia*** | 01 |
| | ***Tribulus*** | 01 |
| ***Sub. total = 140*** | ***1047*** | **3878 (265)** |
| ***Grand total= 180*** | ***1306*** | **4778 (278)=5056** |

[a]'incl.' denote inclusion with the given taxon
[b]Genera/families cited within parenthesis are synonymous with; prefix ~ denotes also treated with

entry into the state's territory in the course of its geological history, resulting in its present diverse flora.

- The floristic diversity of the state has attracted people since very early times. The floristic studies in the state date back to 1820–22, with William Moorcroft's first plant collection in Ladakh and Kashmir; the first account of Kashmir plants having been published by J. F. Royle (1833–39). Since then, its flora has been studied by a large number of local and foreign botanists.
- As of now, 5056 taxa (including 4778 species plus 278 subspecies/varieties) belonging to 1306 genera in 180 families of angiosperms are recorded from Jammu & Kashmir, thus making it a floristically mega-diverse state of India. It is pertinent to mention that the richness of angiosperm flora can even be more than reported in the present study because many far-flung and inaccessible alpine

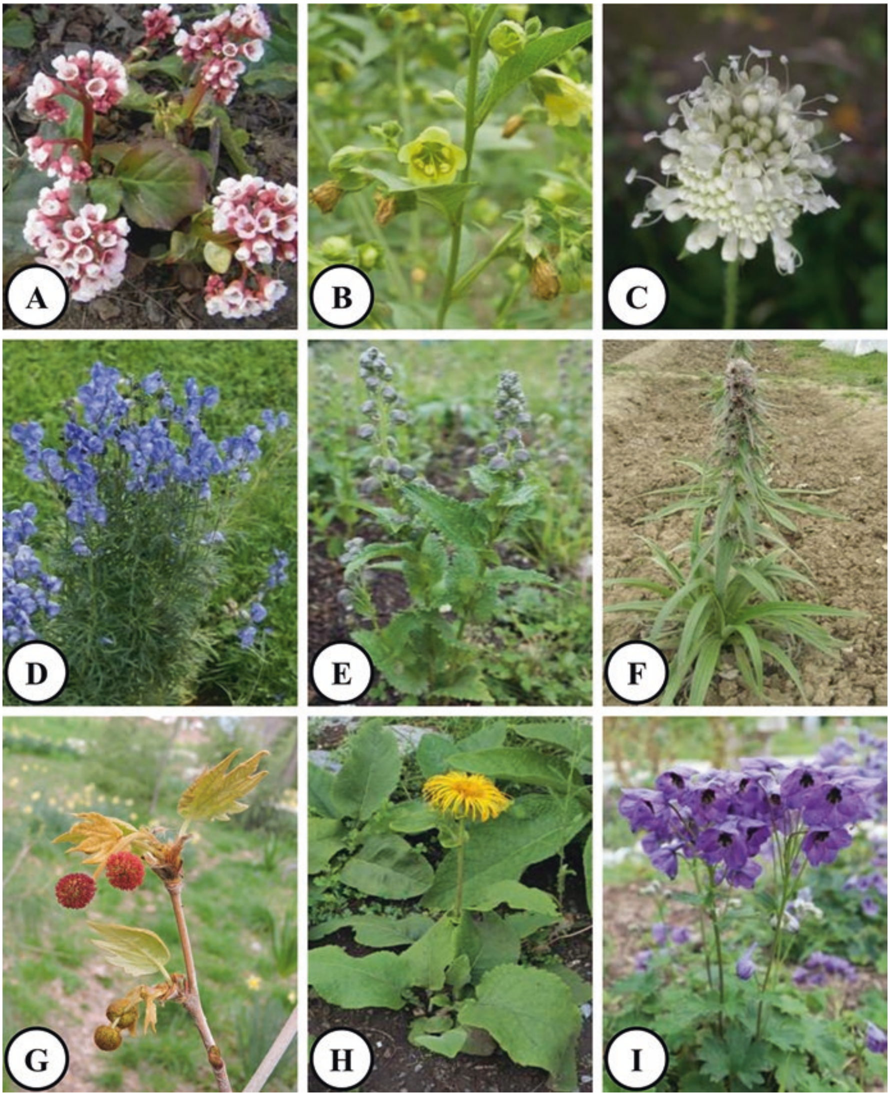


**Plate 19.1** (**a**) *Bergenia ciliata;* (**b**) *Atropa acuminata*; (**c**) *Dipsacus inermis*; (**d**) *Aconitum chasmanthum*; (**e**) *A. heterophyllum*; (**f**) *Arnebia benthamii*; (**g**) *Platanus orientalis*; (**h**) *Inula royleana*; (**i**) *Delphinium cashmerianum*

habitats in the mountainous landscapes of this Himalayan state still remain under- or even unexplored.

- Most of the overall species in the state angiosperm flora are contributed by 20 or so families (e.g. Asteraceae, Poaceae, Fabaceae, Brassicaceae, Rosaceae, Cyperaceae, Lamiaceae, Ranunculaceae, Caryophyllaceae, Boraginaceae, Apiaceae and Polygonaceae, each of which contain more than 100 species). The

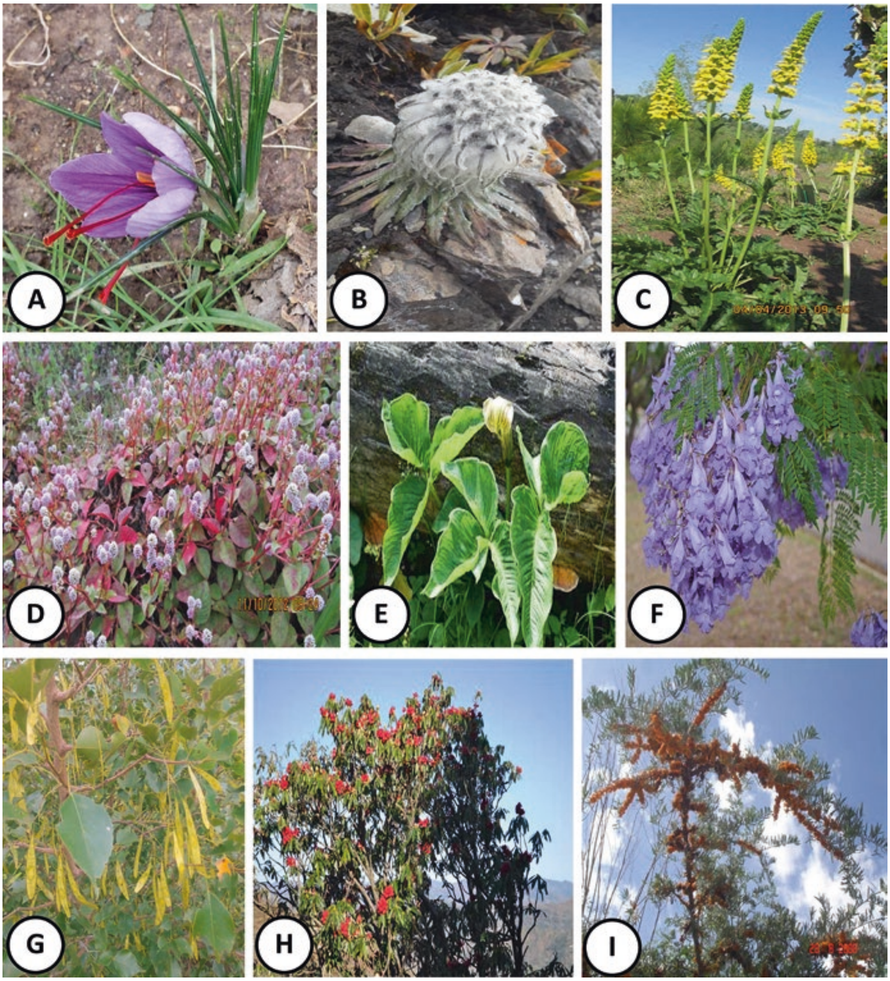

**Plate 19.2** (**a**) *Crocus sativus*; (**b**) *Saussurea sacra*; (**c**) *Eremostachys superba*; (**d**) *Polygonum capitatum*; (**e**) *Arisaema propinquum*; (**f**) *Jacaranda mimosifolia*; (**g**) *Dalbergia sissoo*; (**h**) *Rhododendron arboreum*; (**i**) *Hippophae rhamnoides*

larger genera in the flora include *Taraxacum, Carex, Potentilla*, *Astragalus*, *Artemisia*, *Ranunculus*, *Saussurea*, *Polygonum* s. l., *Nepeta*, *Corydalis*, *Silene* and *Poa.*

- Percentage of monocot species (including infra-specific taxa) is 18.05, as compared to 18.70 in the world. High percentage of monocots is due to relatively larger number of grasses and sedges, which alone contribute ca. 65 % of all the monocot species in this state.
- Rich floristic diversity in the state is due to its biogeographical heterogeneity into three distinct regions, each inhabited with plants adapted to its own topographi-

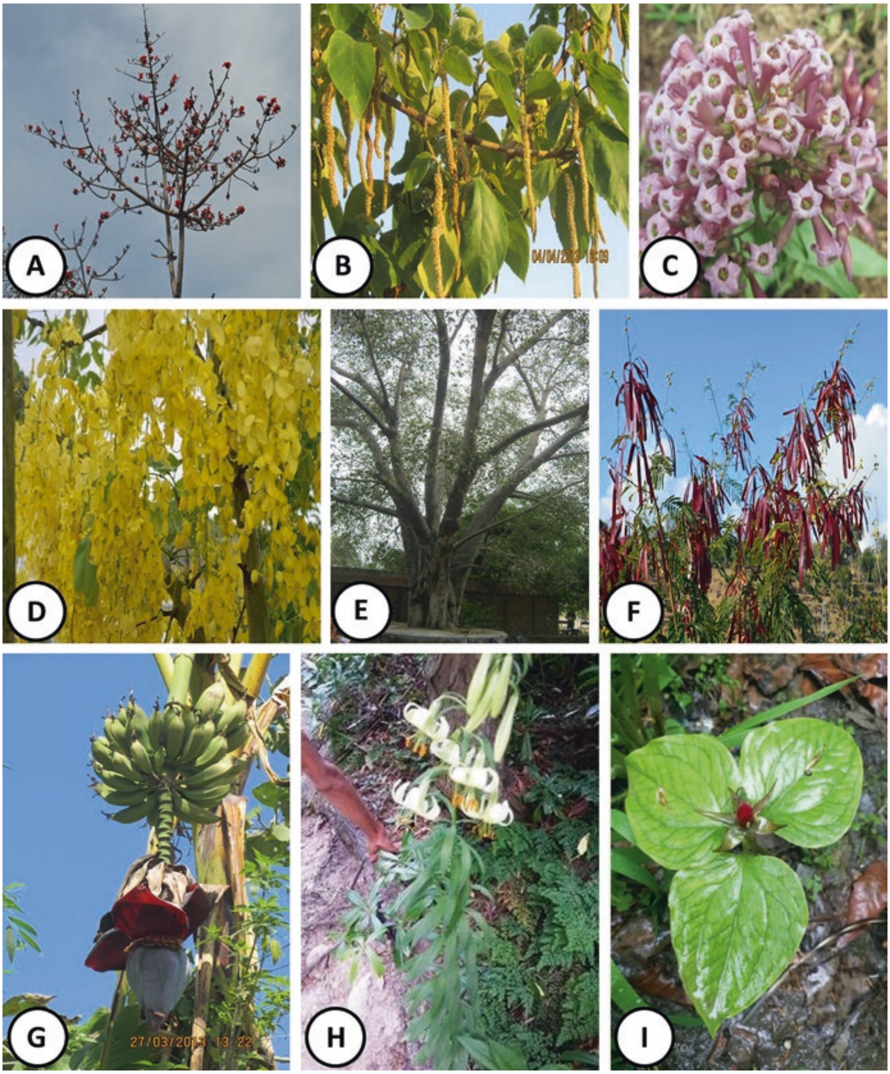


**Plate 19.3** (**a**) *Bombax ceiba*; (**b**) *Broussonetia papyrifera*; (**c**) *Cestrum diurnum*; (**d**) *Cassia fistula*; (**e**) *Ficus religiosa*; (**f**) *Leucaena glauaca*; (**g**) *Musa paradisiaca*; (**h**) *Lilium polyphyllum*; (**i**) *Trillium govanianum*

cal, altitudinal and climatic conditions; together with the confluence of floristic elements from neighbouring central Asian mountains of Karakoram, Hindukush and Pamir, the Mediterranean region; as well as its component of endemic elements.

- Angiosperm flora of the state is significant because of its high proportion (˃35%) of endemism (Vir Jee et al. 1989; Kachroo 1993). Considerably higher endemism in relatively younger mountain systems of the Himalayas is said to be

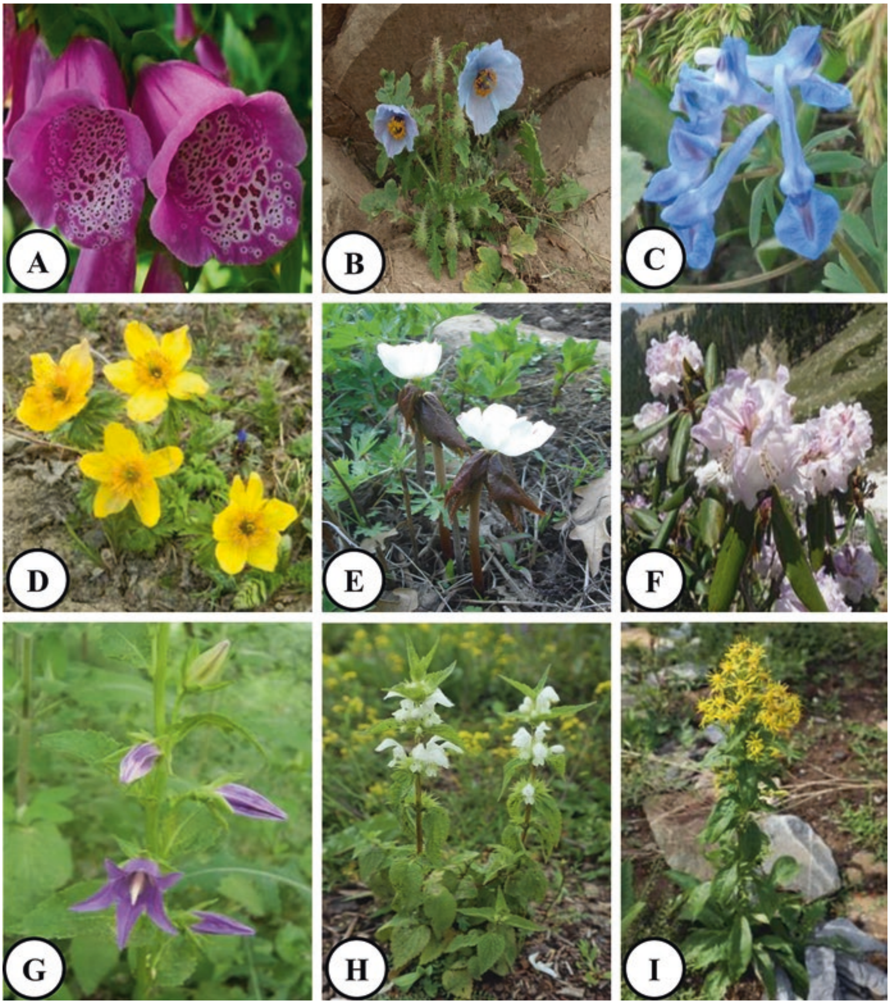


**Plate 19.4** (**a**) *Digitalis purpurea*; (**b**) *Meconopsis latifolia*; (**c**) *Corydalis cashmeriana*; (**d**) *Trollius acaulis*; (**e**) *Podophyllum hexandrum*; (**f**) *Rhododendron campanulatum*; (**g**) *Campanula latifolia*; (**h**) *Lamium album*; (**i**) *Senecio chrysanthemoides*

contributed together by its geographic position, physiography and geological history (Kachroo 1993). Pertinently, reports of too high endemism in the state take a broader view of endemism by including 'broad-range' endemics (which have a wide distribution from Afghanistan eastward to Myanmar). Nevertheless, the 'short-range' endemic taxa confined to the Kashmir region constitute about 10% (Dar et al. 2012).

- The flora is rich in arboreal component (Lambert 1933; Malik et al. 2010, 2019; Khuroo et al. 2010, 2011; Mughal et al. 2017). Woody plants ranging from low

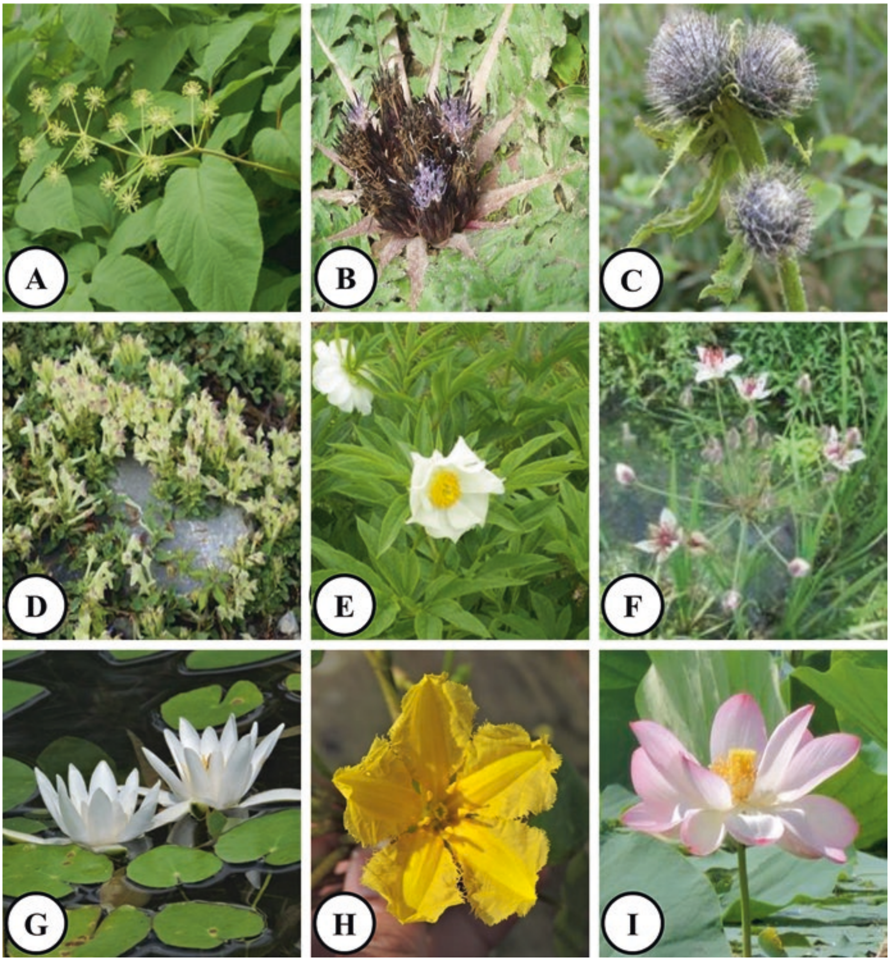


**Plate 19.5** (**a**) *Aralia cashmeriana*; (**b**) *Dolomiaea macrocephala*; (**c**) *Saussurea costus*; (**d**) *Scutellaria prostrata*; (**e**) *Paeonia emodi*; (**f**) *Butomus umbellatus*; (**g**) *Nymphaea candida*; (**h**) *Nymphoides peltata*; (**i**) *Nelumbo nucifera*

sub-shrubs to elegant Chinar trees (*Platanus orientalis*), the iconic state tree, form the most prominent part of the flora.

- Aquatic macrophyte flora is also richly represented, owing to a rich variety of freshwater bodies in the state, especially in Kashmir (Kak 1990; Rasheed et al. 2018; Ganie et al. 2019a). Lotus (*Nelumbo nucifera*), colourful water lilies (*Nymphaea* spp.), water chestnut (*Trapa natans*) and several species of *Potamogeton*, *Typha*, etc. adorn these water bodies.
- Significant proportion of the flora is exotic (Bhellum and Magotra 2012; Khuroo et al. 2012; Shabana et al. 2010, 2013), some species having achieved invasive proportions, for example *Parthenium hysterophorus*, *Lantana camara*, *Anthemis*

*cotula*, *Xanthium spinosum*, *X. indicum*, *Salvinia natans*, *Conyza bonariensis*, etc. Alien flora of the Kashmir region alone is represented by 571 plant species, constituting ca. 29% of total flora of the region (Khuroo et al. 2007a).
- The state is a treasure-house of economically important plants, a goldmine of medicinal and aromatic plants (Kaul 1997; Khan et al. 2006; Dar et al. 2007; Tali et al. 2019; Ganie et al. 2019b), a rich ethnobotanical heritage (Dar et al. 2018; Khan et al. 2004; Khuroo et al. 2007b; Malik et al. 2011) and harbours a rich genetic diversity of cultivated crops, including cereals and millets, pulses, rosaceous fruits, oil seeds, fibres, spices and condiments (Arora 1994).
- The state also abounds in a large number of wild ornamental plants of considerable floricultural significance. These include blue poppy (*Meconopsis latifolia*), besides *Fritillaria imperialis*, *Rosa webbiana, R. moschata, Lavatera kashmiriana, Bergenia ciliata, Aquilegia fragrans, Rhododendron campanulatum, Paeonia emodi,* etc.
- More than 10% plant species are threatened in this part of the Himalayan biodiversity hotspot (Dar and Naqshi 2001; Hamid et al. 2019). Many of these species have been included in the regional, national (BSI) and international (IUCN) Red Data books, signalling a need for their immediate conservation. Among angiosperms, *Picrorhiza kurrooa* is included in Appendix II of CITES. Three high-altitude plant species of Ladakh are included in the *Guinness Book of World Records*: *Arenaria bryophylla* (Caryophyllaceae) recorded at 4800 m and *Christolea himalayensis* (Brassicaceae) and *Stellaria decumbens* (Caryophyllaceae), both recorded at 5000 m. Most of the threatened plant species are endemic. Dhar and Kachroo (1983) reported 40 endemic species of Kashmir Himalaya as endangered. Hajra (1983) listed a number of endemic and threatened taxa from the state.

## 19.4 Concluding Remarks

Notwithstanding the floristic studies undertaken during last two centuries, Jammu and Kashmir state still awaits a complete, up-to-date list of flora. It is urgently needed to complete the explorations in the state and inventory its overall flora. Frequent discovery of new records and new taxa over the years (Dar and Naqshi 1990; Dar et al. 1995, 2010, 2011; Haq et al. 2010; Akhter et al. 2013, 2016; Lone and Dar 2017); rediscovery of *Allium auriculatum, Carex borii, C. pamirensis, Delphinium uncinatum* and *Cotoneaster lambertii*, etc. after a long gap of time; as also recollection of some rare and little known plants from the Kashmir Himalayas, namely *Aletris pauciflora* (Haemodoraceae), *Blyxa oryzetorum* (Hydrocharitaceae), *Phaeonychium albiflorum* (Brassicaceae) and *Lythrum hyssopifolia* (Lythraceae) after a gap of up to more than 150 years (Dar and Naqshi 1984), emphasize the necessity of such exploratory surveys.

Many genera in the angiosperm flora of J&K state, which are considerably rich in species and infra-specific taxa, are taxonomically complex and difficult to delimit;

thus, not often treated consistently in various floristic works. These include *Poa, Festuca*, *Carex, Taraxacum*, *Potentilla*, *Pedicularis, Astragalus*, *Euphrasia*, *Artemisia*, *Saussurea*, *Veronica*, *Ranunculus*, *Nepeta*, *Gentiana*, etc. Revisionary/ monographic and biosystematic studies need to be undertaken on these and other larger and taxonomically complex genera.

**Acknowledgements** Thanks are due to Dr. Tariq Ahmad Dar, Assistant Professor, Government. Degree College, Pulwama, for his help in arranging the taxa as per the system followed herein, and checking their names. G.H. Dar is thankful to the Ministry of Environment, Forest & Climate Change (MoEFCC), Government. of India, New Delhi, for supporting him as a Fellow, Mahatma Gandhi Chair on Ecology & Environment at BGSB University Rajouri from 2012–2015, during which period work on the review presented in this paper was initiated. A.A. Khuroo acknowledges the financial support from various funding agencies, SAC-ISRO (Ahmedabad), NRSC-ISRO (Hyderabad), SERB-DST (New Delhi) and MoEFCC (New Delhi), Government of India, which has helped in undertaking floristic surveys in different parts of the state over the last decade.

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# Chapter 20
# An Updated Checklist of Aquatic Macrophytes in Jammu and Kashmir State

**Aijaz Hassan Ganie, Shugufta Rasheed, Anzar A. Khuroo, and Ghulam Hassan Dar**

**Abstract** This chapter provides an updated checklist of aquatic macrophytes in the Indian Himalayan state of Jammu and Kashmir. In total, 191 species of aquatic macrophytes have been recorded from the state. These species include both aquatic and semiaquatic plants and belong to 80 genera in 37 families (22 belonging to dicotyledons, 12 monocotyledons, and 3 pteridophytes). The aquatic macrophytes belong to different growth forms: submerged, emergent, floating, free-floating, floating/emergent, emergent/submerged, and floating/submerged, which together comprise 92 species; the remaining 99 species are semiaquatic and emergent. Most of the macrophytes (160 species) occur in Kashmir, followed by Jammu with 94 and Ladakh region with 44 species.

**Keywords** Aquatic Plants · Macrophytes · Checklist · Documentation · Identification · J&K state

## 20.1 Introduction

Aquatic macrophytes refer to a diverse group of aquatic photosynthetic organisms that are large enough to be seen with the naked eye. They include all those macroalgae, bryophytes (mosses and liverworts), pteridophytes (ferns), and spermatophytes (seed-bearing plants), the vegetative parts of which actively grow either permanently or periodically (for at least several weeks each year) submerged below, floating on, or growing up through the water surface (Denny 1985; Pieterse 1990;

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_20

Chambers et al. 2008). The importance of aquatic macrophytes in maintaining ecosystem structure, function, and overall stability is well recognized (Devlin 1967).

Globally, the aquatic macrophytes are distributed among seven plant divisions: Cyanobacteria, Chlorophyta, Rhodophyta, Xanthophyta, Bryophyta, Pteridophyta, and Spermatophyta, consisting of at least 41 orders and 103 families (Chambers et al. 2008). The vascular aquatic macrophytes are represented by 33 orders and 88 families, with about 2,614 species in ca. 412 genera. The highest diversity of vascular macrophyte species is reported in the Neotropics (984 spp.), intermediate in the Orient (664 spp.), Nearctic (644 spp.), and Afrotropics 614 spp.); lower in the Palearctic and Australasia (497 and 439 spp., respectively), followed by the Pacific region and Oceanic islands (108 spp.); whilst only a few vascular macrophyte species have been found in the Antarctica, all confined to sub-Antarctic freshwater habitats (Chambers et al. 2008). In the contemporary aquatic flora of India, Cook (1996) reported more than 600 plant species from different regions of the country. Of these, 28 species belong to pteridophytes, while the remaining species are spermatophytes.

In the state of Jammu and Kashmir (J&K), perusal of historical literature reveals that floristic account of the vegetation is known since 12$^{th}$ century as narrated in the Rajatarangni, the oldest available record of Kashmir history. The first record of aquatic plants collected from the Kashmir Valley is that of William Moorcroft who collected plants from the marshes and lakes of Kashmir (Moorcroft and Trebeck 1841). Royle (1833–1840) also collected aquatic plants from this part of the world and published in his *Illustrations of Botany of the Himalayan Mountains and Flora of Cashmere*. Godfrey Vigne and Von Huegel collected plants from rivers, lakes, and marshy habitats of Srinagar, Baramulla, and Hazara (Kak 1988). Rao (1961) listed 51 aquatic plant species from this region. The first comprehensive account on aquatic vegetation of Srinagar was given by Kaul and Zutshi (1967), wherein they listed 117 species of macrophytes. Javied (1971) listed a few macrophytes from different aquatic habitats of Srinagar. Stewart (1972) made the most extensive floristic studies in the region, recording more than 2,500 vascular plant species, including 159 aquatic plant species from Kashmir Himalaya. Kak (1990), based on his field surveys, reported 196 aquatic angiosperm species from Kashmir Himalaya, these species belong to 82 genera in 44 families. Pandit (2001), however, has reported only 117 species of aquatic macrophytes from north-western Himalayas. Surprisingly, later on, Pandit (2005) reported only 38 species from various freshwater bodies of Kashmir Himalaya. This varying and scattered information available on aquatic flora of the state is the main reason why it is often impossible to give a reliable estimate of its aquatic flora.

Perusal of recently published scientific literature, herbarium studies, and extensive field exploration have revealed that several species which were earlier reported from the state have been either wrongly identified (Ganie et al. 2015a), or may have got extirpated due to natural and human-led changes occurring in the aquatic bodies over the period of time. In addition, some alien aquatic plant species, which were until very recently unknown from this region, have now appeared in its water bodies. These include lower as well as higher plants, have often become naturalized, and are spreading quite rapidly (Khuroo et al. 2007a; Khuroo et al. 2011; Ahad et al. 2012; Ganie et al. 2016).

It is a common experience that incorrect identification and poor documentation of species is one of the biggest problems in proper management practices (Khuroo et al. 2007b). Thus, the first and foremost requirement for effective management is correct taxonomic identification of taxa. Also, in practice, correct identification is vital in identifying rare, threatened, and endangered plant species (Dar et al. 2012). In particular, aquatic plants are difficult to identify properly because of their inconspicuous floral characters and convergent vegetative morphology. Many aquatic plant groups are still in need of basic taxonomic treatments. It is in this context that the present study aims to provide a comprehensive database of aquatic macrophytes of J&K, a biodiversity-rich state in the Indian Himalayas; this in turn may prove pivotal in scientific, systematic, and sustainable management of aquatic ecosystems in the region.

## 20.2 Materials and Methods

Jammu and Kashmir is a state located in the north-western part of India, with topography mostly of mountainous terrain. It consists of three regions: Jammu, the Kashmir Valley, and Ladakh, together covering an area of 222,236 km$^2$ (Dar et al. 2002). The Zanskar Range separates the Kashmir Valley from Ladakh, while the Pir Panjal Range, which encloses the Valley from the west and south, separates it from the Great Plains of Northern India. Along the north-eastern flank of the Valley runs the main range of the Himalayas. The state has a network of glaciated streams, rivers, and lakes in alpine, subalpine, and lower plains. The alpine lakes are typically located above the tree line and are fed mainly by glaciers. These lakes have rocky basins, remain covered with ice from October to May, and are mostly devoid of macrophyte vegetation. The subalpine lakes are situated in the midst of the coniferous forests. A typical example of this is Nilnag Lake with abundant macrophyte vegetation. The famous freshwater lakes located in the lower plains include Anchar Lake, Dal Lake, Hokarsar, Wular Lake, Manasbal Lake, Mansar Lake, Sanasar Lake, and Surinsar Lake. These water bodies, both lotic and lentic ones, harbour rich diversity of aquatic macrophytes.

For the present study, the database on aquatic macrophytes of J&K state has been generated on the basis of perusal of relevant literature supplemented with extensive field surveys and herbarium studies in KASH, JAH, as well as herbarium Department of Botany, Jammu University. The information and identification of macrophytes has been authenticated and augmented by consulting various floras and herbaria.

The checklist is arranged according to the APG-III classification (Haston et al. 2009), as provided online on ‘The Plant List’ (www.plantlist.org). In the checklist, the currently valid scientific name of each taxon with its respective family is supplemented with useful information on growth form, provincial distribution (Kashmir, Jammu, and Ladakh), and source(s) of its record in the state. Changes in circumscription of some genera and families have been made in accordance with APG-III classification system (Appendix 20.1). For example, among the dicotyledons, the taxa previously recognized under Hippuridaceae and some taxa of Scrophulariaceae (*Veronica*) have been shifted to Plantaginaceae, and the Trapaceae have been fully merged with Lythraceae. Among monocotyledons, Lemnaceae have been merged with Araceae, Najadaceae with Hydrocharitaceae, and Sparganiaceae with Typhaceae.

### *20.2.1 Terminology and Definitions Used*

The terms and their definitions followed in the present chapter are given as under:

(a) Aquatic plants: Plants that grow in water wholly or partly, and cannot complete their life cycle without water.
(b) Semiaquatic plants: Plants that grow in water-saturated soil and complete part of their life cycle in water.
(c) Amphibious plants: Plants that grow on land, as well as in water. These plants are able to complete their life cycle in both the habitats.
(d) Moisture-loving plants (Mesophytes): These are primarily terrestrial plants but thrive well under moist conditions too.
(e) Free floating: These aquatic plants are not attached to substratum by means of roots.
(f) Floating: These aquatic plants are attached to the substratum by roots and are in contact with water surface and air mostly by means of leaves.
(g) Submerged: These aquatic plants grow wholly under the surface of water.
(h) Emergent**:** These are aquatic and/or semiaquatic plants that are rooted in shallow water, with vegetative and reproductive parts emerging above the water surface.

## 20.3 Results and Discussion

Extensive field explorations in different aquatic habitats, in-depth herbarium studies, and systematic review of relevant publications on floristic diversity of macrophytes in J&K revealed 191 aquatic and semiaquatic plant species as growing in the state (Plates 20.1, 20.2, and 20.3). These plant species belong to 80 genera in 37 families; of the latter, 22 families belong to dicotyledons, 12 to monocotyledons, and 3 to pteridophytes (Appendix 20.1; Fig. 20.1).

In addition, two macro-algae (*Chara* sp. and *Nitella* sp.) have been recorded from different aquatic habitats of the region during the present study. Proportional distribution of these macrophytes into different plant groups revealed that 40.31% are dicotyledons, 57.59%monocotyledons, while 2.09% species are pteridophytes (Fig. 20.2).

In angiosperms, families with 6 or more species are depicted in Fig. 20.3. Among the dicotyledons, Polygonaceae lead the group with 11 species in 3 genera; it is followed by Lythraceae with 8 species in 4 genera. Among the monocotyledons, Cyperaceae with 50 species in 11 genera stand first and is followed by Potamogetonaceae with 16 species in 2 genera (Fig. 20.3). In pteridophytes,

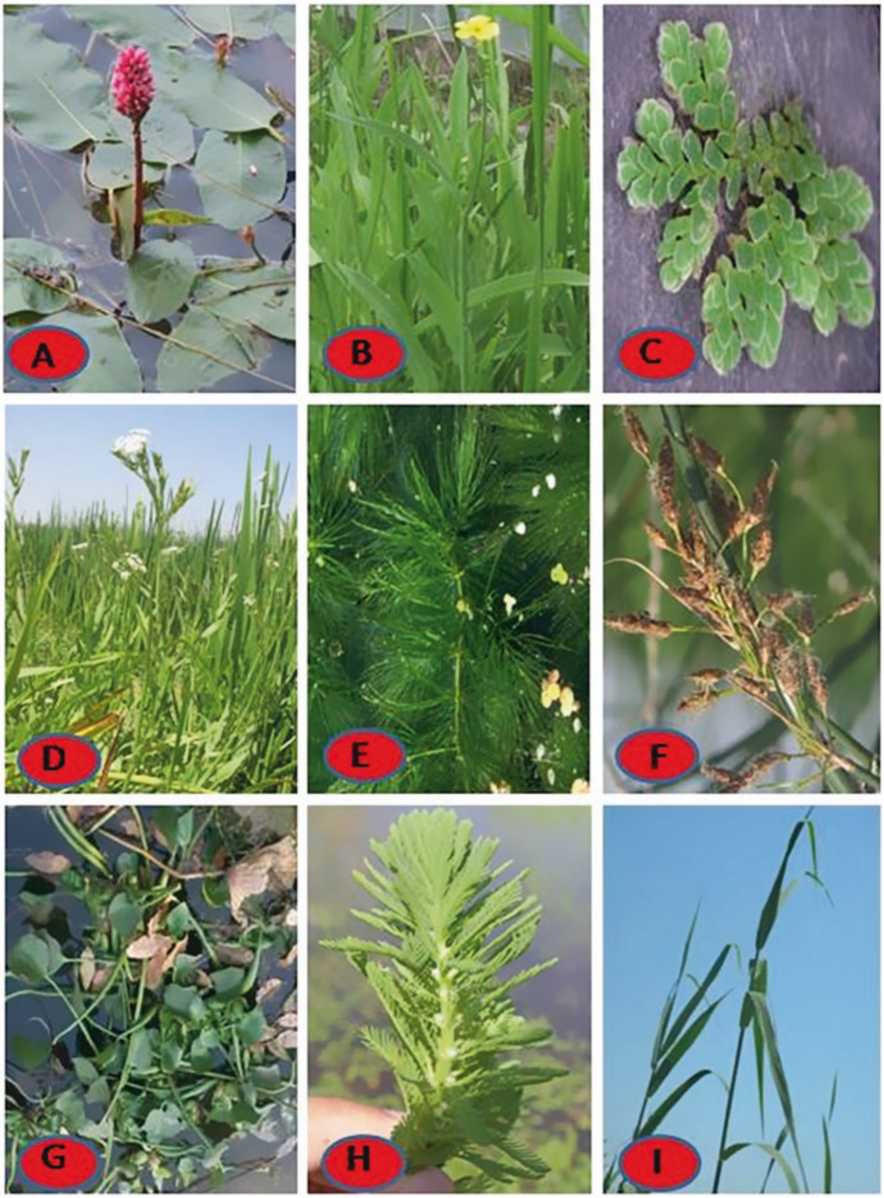



**Plate 20.1** (**a**) *Persicaria amphibium*; (**b**) *Ranunculus lingua*; (**c**) *Azolla cristata*; (**d**) *Sium lalijugum*; (**e**) *Ceratophyllum demersum*; (**f**) *Fimbristylis dicholoma*; (**g**) *Eichhornia crassipes*; (**h**) *Myriophyllum aquaticum*; (**i**) *Phragmites australis*

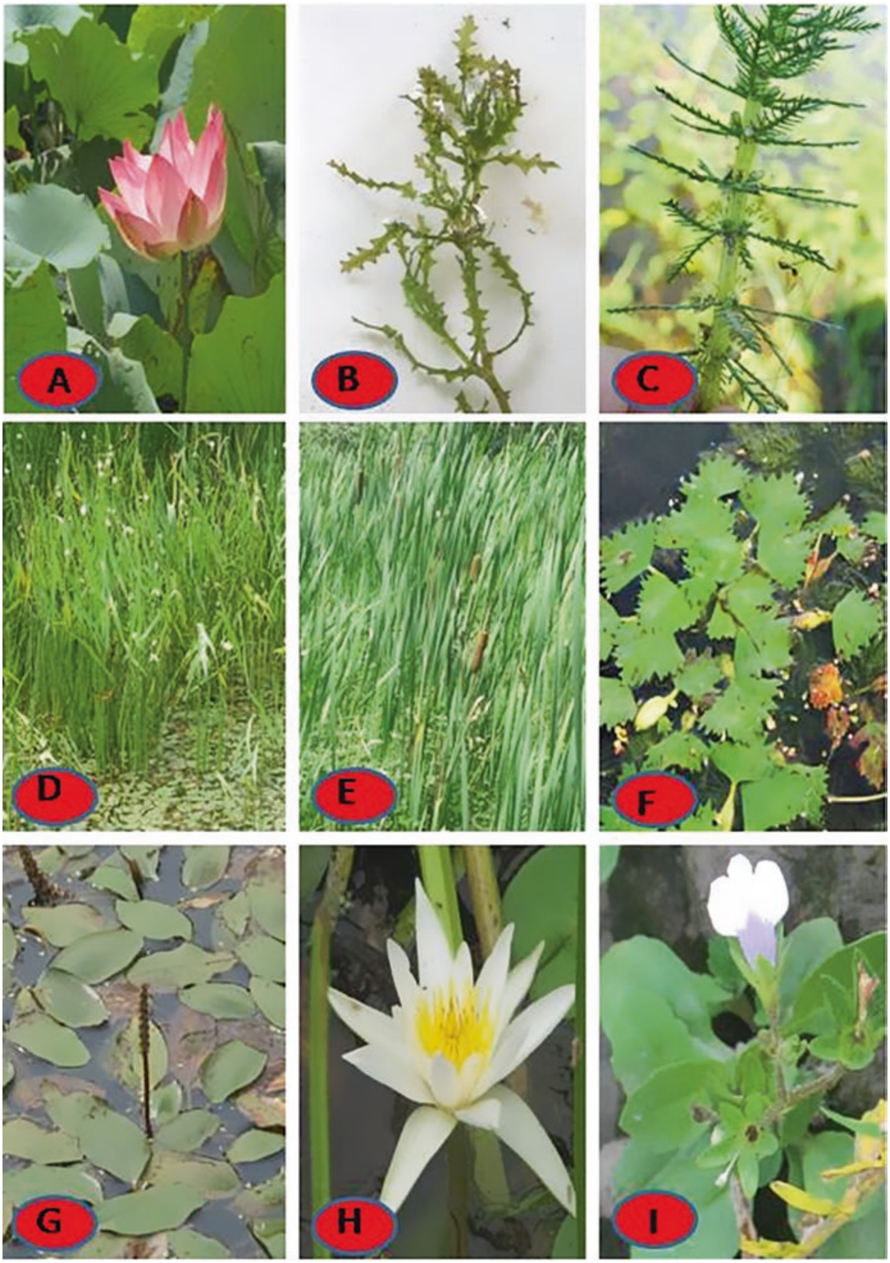



**Plate 20.2** (**a**) *Nelumbo nucifera*; (**b**) *Najas marina*; (**c**) *Myriophyllum verticillatum*; (**d**) *Sagittaria sagittifolia*; (**e**) *Typha latifolia*; (**f**) *Trapa natans*; (**g**) *Potamogeton nodosus*; (**h**) *Nymphaea alba*; (**i**) *Mazus pumilus*

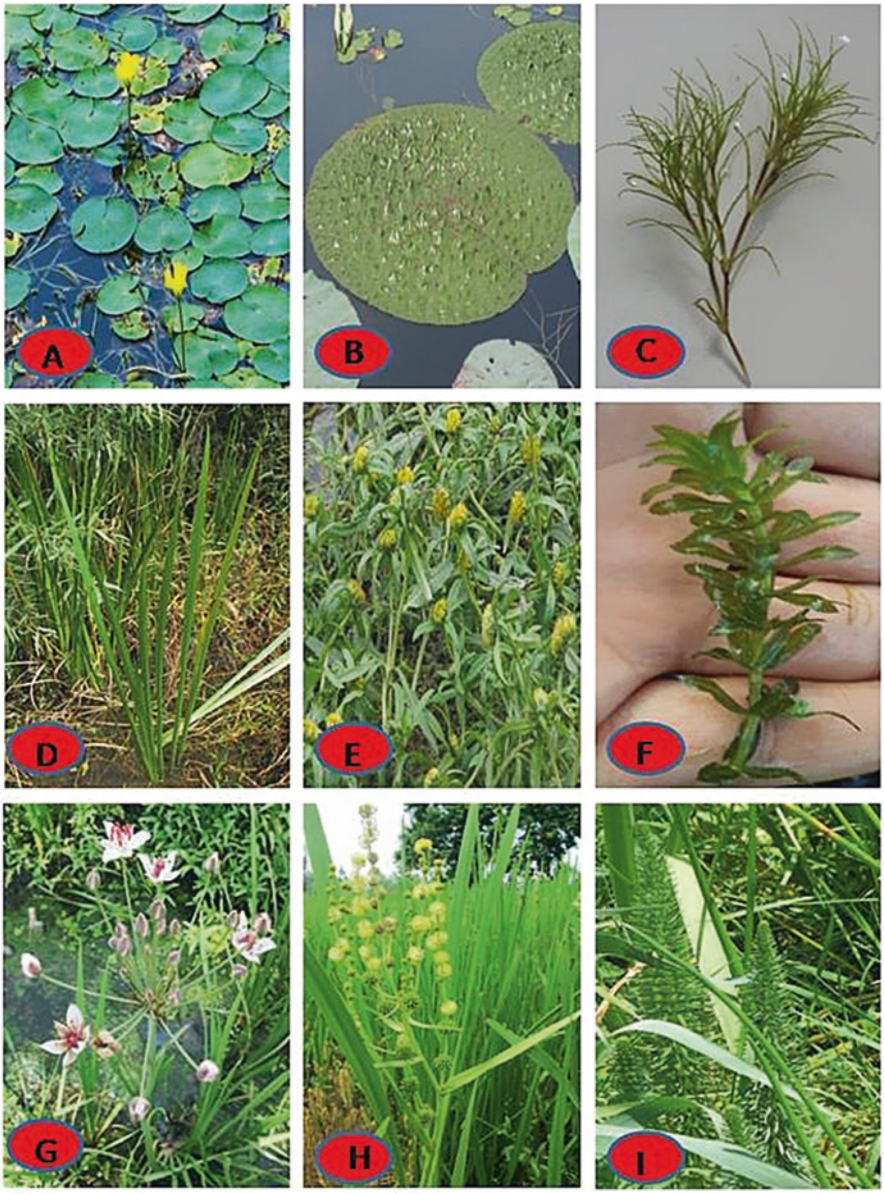



**Plate 20.3** (**a**) *Nymphoides peltata*; (**b**) *Euryale ferox*; (**c**) *Najas graminea*; (**d**) *Acorus calamus*; (**e**) *Bidens cernua*; (**f**) *Hydrilla verticillata*; (**g**) *Butomus umbellatus*; (**h**) *Sparganium erectum*; (**i**) *Hippuris vulgaris*

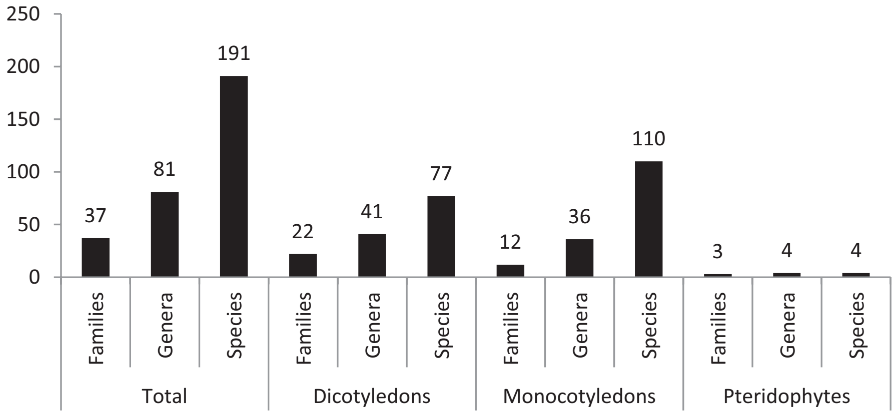
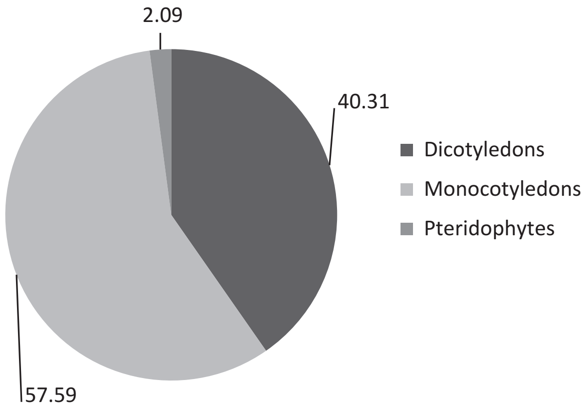



**Fig. 20.1** Taxonomic conspectus of aquatic macrophytes growing in Jammu and Kashmir state

**Fig. 20.2** Proportion of aquatic macrophytes belonging to various taxonomic groups in Jammu and Kashmir state




Salviniaceae contribute 2 species, followed by Equisetaceae and Marsileaceae with a single species each.

The present study revealed that macrophytes in the state can be classified into two broad categories: aquatic and semiaquatic plants. While almost all the semi-aquatic plants are emergent, the aquatic macrophytes belong to different growth forms, either in rooted or free-floating condition. Of these plants, 31 species are submerged, 27 emergent, 20 floating, 10 free-floating, 2 floating/emergent, 2 emergent/submerged, and 1 floating/submerged. The percentage of different growth forms of these species is given in Fig. 20.4.

Some of the plant species have also been included in the present study that grow both in aquatic and terrestrial habitats, and are referred to as amphibious species. These plant species (e.g., *Impatiens glandulifera, Persicaria hydropiper*) thrive well under both kinds of habitats and complete their life cycle in both of them. A total of 13 amphibious plant species grow in J&K state.

Several plant species (e.g., *Callitriche obtusangula)*, reported as aquatic by earlier workers from the Kashmir Valley have been excluded from the present study

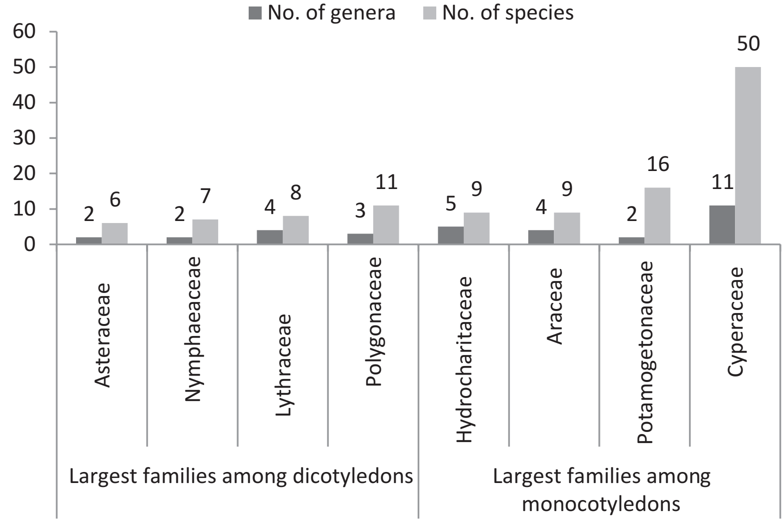
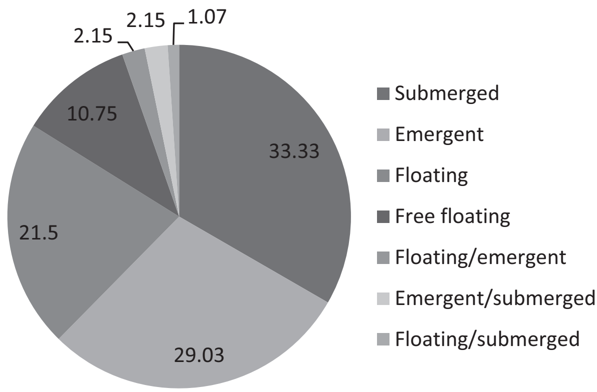



**Fig. 20.3** Largest macrophyte families among dicotyledons and monocotyledons in Jammu and Kashmir state

**Fig. 20.4** Percentage of various growth forms of aquatic macrophytes in Jammu & Kashmir




because despite our extensive field surveys and rigorous herbarium studies, no authentic record was found; however, these species do grow either in Jammu or Ladakh region. It was also revealed that some aquatic plant species (e.g., *Helanthium tenellum*, *Paspalum dilatatum*) reported from the state by earlier workers (Kaul and Zutshi 1967; Kak 1990; Cook 1996; Pandit et al. 2005) have no herbarium records and also have not been recorded during the present study. These species have either disappeared over the period of time due to change in tropic status of water bodies, or might have been mis-identified previously. It has further come to light that many terrestrial species (e.g., *Xanthium strumarium, Aconitum violaceum*) too were reported as aquatic plants by previous workers (Shah and Reshi 2014), which have been excluded from the present study.

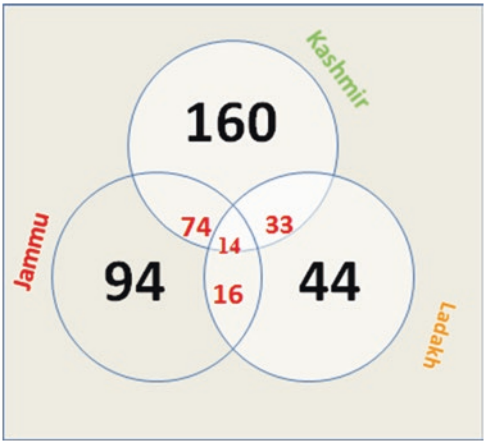



**Fig. 20.5** Number of macrophyte species and common species between different regions of Jammu and Kashmir

It has been found that majority of macrophyte species (160) occur in different aquatic habitats of Kashmir Valley, followed by 94 species in Jammu, and 44 species in Ladakh region. In all, the three regions of the state share 14 species of macrophytes; the number of species in each region and the common species between Kashmir and Jammu, Ladakh and Jammu, Kashmir and Ladakh is depicted in Fig. 20.5.

## 20.4 Concluding Remarks

Aquatic macrophytes depict an interesting diversity, which needs to be adequately documented and correctly identified. The first and foremost requirement for effective management of aquatic ecosystems is the correct taxonomic identification of constituent species because aquatic plants are difficult to identify properly due to their inconspicuous floral characters, convergent vegetative morphology, and prevalent hybridization. The state of J&K is very rich in freshwater bodies which are home to a correspondingly rich diversity of macrophytes. The comprehensive database generated during the present study can provide ecological information regarding the presence of invasive alien species, increase or decrease in the frequency of these species, and help in identifying locations colonized by species that could cause excessive damage to aquatic ecosystems. The information generated during the present study can be utilized to formulate an effective management plan or aquatic-weed control programme, and may prove useful to policy makers in formulating the desired management strategies. Hopefully, it will prove pivotal in scientific, systematic, and sustainable organization of aquatic ecosystems in the state.

**Acknowledgements** We are thankful to the Head, Department of Botany, University of Kashmir, Srinagar, for providing necessary facilities. A. A. Khuroo acknowledges the financial support from various funding agencies, SERB-DST & MoEFCC, Government of India, New Delhi, which has helped in undertaking floristic surveys in different parts of the state over the last decade. The sincere support and help rendered by the staff at the Centre for Biodiversity & Taxonomy, University of Kashmir is greatly acknowledged.

## Appendix 20.1: The Aquatic Macrophytes Occurring in Jammu and Kashmir

| S. No. | Scientific name | Family[a] | Growth form | Kashmir | Jammu | Ladakh | Source(s) record in the State |
|---|---|---|---|---|---|---|---|
| **A. Dicotyledons** | | | | | | | |
| 1. | *Alternanthera caracasana* Kunth. | Amaranthaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) and Present study |
| 2. | *Alternanthera philoxeroides* (Mart.) Griseb | Amaranthaceae | Semiaquatic | 1 | 1 | 0 | Masoodi and Fareed (2012) and Present study |
| 3. | *Amaranthus blitum* L. | Amaranthaceae | Semiaquatic | 1 | 0 | 0 | Kaul and Zutshi (1967)and Present study |
| 4. | *Amaranthus blitum* ssp. *oleraceus* (L.) Costea | Amaranthaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) and Present study |
| 5. | *Sium latijugum* C.B.Cl. | Apiaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990), Bhellum and Magotra (2012), and Present study |
| 6. | *Berula erecta* Coville | Apiaceae | Semiaquatic | 1 | 0 | 0 | Stewart (1972)and Present study |
| 7. | *Cicuta virosa* L. | Apiaceae | Semiaquatic | 1 | 0 | 0 | Cook (1996) and Present study |
| 8. | *Hydrocotyl sibthorphoides* Lam. | Apiaceae | Semiaquatic | 0 | 1 | 0 | Cook (1996)and Present study |
| 9. | *Bidens cernua* L. | Asteraceae | Semiaquatic | 1 | 0 | 1 | Kak (1990), Klimes and Dickore (2009), and Present study |
| 10. | *Bidens tripartita* (L.) L. | Asteraceae | Semiaquatic | 1 | 1 | 1 | Kak (1990), Sharma and Kachroo (1981), Klimes and Dickore (2009), and Present study |
| 11. | *Bidens bipinnata* L. | Asteraceae | Semiaquatic | 0 | 1 | 0 | Sharma and Kachroo (1981)and Present study |
| 12. | *Bidens biternata* (Lour) Merrill & Sherff | Asteraceae | Semiaquatic | 0 | 1 | 1 | Sharma and Kachroo (1981), Klimes and Dickore (2009), and Present study |
| 13. | *Bidens pilosa* L. | Asteraceae | Semiaquatic | 0 | 1 | 0 | Sharma and Kachroo (1981) |

(continued)

| S. No. | Scientific name | Family[a] | Growth form | Kashmir | Jammu | Ladakh | Source(s) record in the State |
|---|---|---|---|---|---|---|---|
| 14. | *Eclipta prostrata* L. | Asteraceae | Semiaquatic | 1 | 1 | 0 | Kaul and Zutshi (1967), Sharma and Kachroo (1981), and Present study |
| 15. | *Cardamine impatiens* L. | Brassicaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990), Bhellum and Magotra (2012) |
| 16. | *Nasturtium officinale* R. Br. | Brassicaceae | Emergent | 1 | 1 | 0 | Kak (1990), Sharma and Kachroo (1981), and Present study |
| 17. | *Callitriche truncata* Guss | Callitricaceae | Submerged | 1 | 0 | 0 | Kak (1990) and Present study |
| 18. | *Callitriche obtusangula* Le Gall | Callitricaceae | Submerged | 0 | 0 | 1 | Klimes and Dickore (2009) |
| 19. | *Callitriche palustris* L. | Callitricaceae | Submerged | 1 | 0 | 1 | Kak (1990), Klimes and Dickore (2009) |
| 20. | *Stellaria aquatica* (L.) Scop. | Caryophyllaceae | Semi aquatic | 1 | 1 | 0 | Kak (1990), Bhellum and Magotra (2012), and Present study |
| 21. | *Sagina saginoids* H. Karst. | Caryophyllaceae | Semi aquatic | 1 | 1 | 1 | Kak (1990), Bhellum and Magotra (2012), Klimes and Dickore (2009), and Present study |
| 22. | *Ceratophyllum demersum* L. | Ceratophyllaceae | Submerged | 1 | 1 | 0 | Kak (1990), Bhellum and Magotra (2012), and Present study |
| 23 | *Ceratophyllum platyacanthum* subsp. *oryzetorum* (Kom.) Les | Ceratophyllaceae | Submerged | 1 | 0 | 0 | Ganie et al. (2015b) and Present study |
| 24. | *Ipomoea aquatica* Forssk. | Convolvulaceae | Floating/ emergent | 0 | 1 | 0 | Sharma and Kachroo (1981) |
| 25. | *Elatine ambigua* Wight | Elatinaceae | Submerged | 1 | 0 | 0 | Kak (1990) and Present study |
| 26. | *Elatina triandra* Schk. | Elatinaceae | Submerged | 1 | 0 | 0 | Kak (1990) and Present study |
| 27. | *Bergia ammanniodes* Heyne ex Roth | Elatinaceae | Emergent | 0 | 1 | 0 | Sharma and Kachroo (1981) and Present study |
| 28. | *Aeschynomene indica* L. | Fabaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990), Sharma and Kachroo (1981), and Present study |
| 29. | *Myriophyllum spicatum* L. | Haloragaceae | Submerged | 1 | 1 | 1 | Kak (1990), Sharma (2008), Klimes and Dickore (2009), and Present study |
| 30. | *Myriophyllum verticillatum* L. | Haloragaceae | Emergent/ submerged | 1 | 0 | 0 | Kak (1990 and Present study |

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|---|---|---|---|---|---|---|---|
| 31. | *Myriophyllum aquaticum* (Vell.) Verdc. | Haloragaceae | Emergent/ submerged | 1 | 0 | 0 | Kak (1990), Arshid et al. (2011), and Present study |
| 32. | *Utricularia aurea* Lour. | Lentibulariaceae | Submerged | 1 | 1 | 0 | Kak (1990), Sharma and Kachroo (1981), and Present study |
| 33. | *Utricularia australis* R. Br. | Lentibulariaceae | Submerged | 0 | 0 | 1 | Klimes and Dickore (2009) |
| 34. | *Lythrum salicaria* L. | Lythraceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) and Present study |
| 35. | *Ammannia auriculata* Willd. | Lythraceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981), and Present study |
| 36. | *Ammania baccifera* L. | Lythraceae | Semiaquatic | 1 | 1 | 0 | Kak (1990), Sharma and Kachroo (1981), and Present study |
| 37. | *Ammania multiflora* Roxb. | Lythraceae | Semiaquatic | 1 | 1 | 0 | Kak (1990), Sharma and Kachroo (1981) |
| 38. | *Rotala densiflora* Koehn. | Lythraceae | Semiaquatic | 1 | 1 | 0 | Kak (1990), Sharma and Kachroo (1981), and Present study |
| 39. | *Trapa kashmirensis* Wojcicki | Lythraceae | Floating | 1 | 0 | 0 | Wojcicki (2001) and Present study |
| 40. | *Trapa natans* L. | Lythraceae[c] | Floating | 1 | 0 | 0 | Kak (1990) and Present study |
| 41. | *Trapa natans* var. *bispinosa* (Roxb.) Makino | Lythraceae[c] | Floating | 1 | 0 | 0 | Kak (1990) and Present study |
| 42. | *Rotala indica* Koehn. | Lythraceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981) |
| 43. | *Nymphoides peltata* Kuntze | Menyanthaceae | Floating | 1 | 1 | 0 | Kak (1990); Bhellum and Magotra (2012); Present study |
| 44. | *Menyanthes trifoliata* L. | Menyanthaceae | Emergent | 1 | 0 | 0 | Kak (1990) and Present study |
| 45. | *Nymphoides indica* Kuntze | Menyanthaceae | Floating | 0 | 1 | 0 | Swami and Gupta (1998) |
| 46. | *Nymphoides cristata* Kuntze | Menyanthaceae | Floating | 0 | 1 | 0 | Sharma and Kachroo (1981) |
| 47. | *Nelumbo nucifera* Gaertn. | Nelumbonaceae | Floating/ emergent | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981), and Present study |
| 48. | *Euryale ferox* Salisb. | Nymphaeaceae | Floating | 1 | 0 | 0 | Kak (1990) and Present study |
| 49. | *Nymphaea lotus* L. | Nymphaeaceae | Floating | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981) |
| 50. | *Nymphaea tetragona* George | Nymphaeaceae | Floating | 1 | 0 | 0 | Kak (1990) and Present study |

(continued)

| S. No. | Scientific name | Family[a] | Growth form | Kashmir | Jammu | Ladakh | Source(s) record in the State |
|---|---|---|---|---|---|---|---|
| 51. | *Nymphaea mexicana* Zucc. | Nymphaeaceae | Floating | 1 | 0 | 0 | Kak (1990) and Present study |
| 52. | *Nymphaea candida* Presl | Nymphaeaceae | Floating | 1 | 0 | 0 | Kak (1990) and Present study |
| 53. | *Nymphaea alba* L. | Nymphaeaceae | Floating | 1 | 1 | 0 | Kak (1990); Bhellum and Magotra (2012), and Present study |
| 54. | *Nymphaea nouchali* Burm. f. | Nymphaeaceae | Floating | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981) |
| 55. | *Epilobium palustris* L. | Onagraceae | Semiaquatic | 0 | 0 | 1 | Klimes and Dickore (2009) |
| 56. | *Epilobium tomentosum* Boiss. | Onagraceae | Semiaquatic | 0 | 1 | 0 | Sharma and Kachroo (1981) |
| 57. | *Mazus pumilus* Steenis | Phrymaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Bhellum and Magotra (2012), and Present study |
| 58. | *Dopatrium junceum* (Roxb.) Buch. Ham. | Plantaginaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990), Sharma and Kachroo (1981), and Present study |
| 59. | *Hippuris vulgaris* L. | Plantaginaceae[c] | Emergent | 1 | 0 | 1 | Kak (1990); Klimes and Dickore (2009), and Present study |
| 60. | *Limnophila indica* Druce | Plantaginaceae[c] | Semiaquatic | 0 | 1 | 0 | Sharma and Kachroo (1981); Cook (1996) |
| 61. | *Veronica anagallis-aquatica* L. | Plantaginaceae[c] | Semiaquatic | 1 | 1 | 0 | Kak (1990); Bhellum and Magotra (2012), and Present study |
| 62. | *Veronica salina* Schur. | Plantaginaceae[c] | Semiaquatic | 1 | 1 | 1 | Kaul and Zutshi (1967); Bhellum and Magotra (2012); Klimes and Dickore (2009) |
| 63. | *Persicaria barbata* H. Hara (Syn: *Polygonum barbatum* L.) | Polygonaceae | Emergent | 0 | 1 | 0 | Sharma and Kachroo (1981) |
| 64. | *Persicaria glabra* M. Gomez (Syn: *Polygonum glabrum* Willd.) | Polygonaceae | Emergent | 1 | 1 | 0 | Kaul and Zutshi (1967), Sharma and Kachroo (1981), and Present study |
| 65. | *Persicaria minor* Opiz. (Syn: *Polygonum minus* Huds.) | Polygonaceae | Emergent | 1 | 0 | 0 | Kaul and Zutshi (1967) and Present study |
| 66. | *Polygonum aviculare* L. | Polygonaceae | Emergent | 1 | 1 | 1 | Kaul and Zutshi (1967), Sharma and Kachroo (1981), Klimes and Dickore (2009), and Present study |

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|---|---|---|---|---|---|---|---|
| 67. | *Persicaria lapathifolia* (L.) Delarbe (Syn: *Polygonum lapathifolium* L.) | Polygonaceae | Semiaquatic | 1 | 1 | 1 | Kak (1990); Sharma and Kachroo (1981); Klimes and Dickore (2009) |
| 68. | *Persicaria amphibian* Delarbe (Syn: *Polygonum amphibium* L.) | Polygonaceae | Floating | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981), and Present study |
| 69. | *Persicaria nepalensis* Miyabe (Syn: *Polygonum nepalense* Meisn.) | Polygonaceae | Semiaquatic | 1 | 1 | 1 | Kak (1990); Klimes and Dickore (2009); Kapur and Sarin (1990), and Present study |
| 70. | *Rumex paulsenianus* Rech. | Polygonaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) |
| 71. | *Rumex conglomerates* Murray | Polygonaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) |
| 72. | *Rumex chalapensis* Mill. | Polygonaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) |
| 73. | *Rumex aquaticus* L. | Polygonaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) and Present study |
| 74. | *Ranunculus lingua* L. | Ranunculaceae | Emergent | 1 | 0 | 0 | Kak (1990) and Present study |
| 75. | *Ranunculus trichophyllus* Chaix ex Vill | Ranunculaceae | Submerged | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981) |
| 76. | *Ranunculus natans* C. A. Mey | Ranunculaceae | Floating | 0 | 0 | 1 | Lone et al. (2010) |
| 77. | *Halerpestes sarmentosa* Kom (Syn: *Ranunculus sarmentosus* Adams) | Ranunculaceae | Floating | 0 | 0 | 1 | Lone et al. (2010) |
| 78. | *Limosella aquatica* L. | Scrophulariaceae | Submerged | 1 | 0 | 1 | Kak (1990); Klimes and Dickore (2009) |
| **B. Monocotyledons** | | | | | | | |
| 79. | *Alisma gramineum* Lej. | Alismataceae | Emergent | 1 | 0 | 0 | Kak (1990) and Present study |
| 80. | *Alisma lanceolatum* With. | Alismataceae | Emergent | 1 | 0 | 0 | Kak (1990) and Present study |
| 81. | *Alisma plantago-aquatica* L. | Alismataceae | Emergent | 1 | 1 | 1 | Kak (1990; Sharma and Kachroo (1981); Klimes and Dickore (2009), and Present study |

(continued)

| S. No. | Scientific name | Family[a] | Growth form | Kashmir | Jammu | Ladakh | Source(s) record in the State |
|---|---|---|---|---|---|---|---|
| 82. | *Sagittaria sagittifolia* L. | Alismataceae | Emergent | 1 | 1 | 0 | Kak (1988); Kak (1990); Sharma and Kachroo (1981) |
| 83. | *Sagittaria latifolia* Willd. | Alismataceae | Emergent | 1 | 0 | 0 | Kak (1990) |
| 84. | *Sagittaria guayanensis* Kunth | Alismataceae | Emergent | 0 | 1 | 0 | Sharma and Kachroo (1981) |
| 85. | *Acorus calamus* L. | Araceae | Emergent | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981), and Present study |
| 86. | *Lemna minor* Griff. | Araceae[c] | Free floating | 1 | 1 | 1 | Kak (1990); Klimes and Dickore (2009); Sharma (2008), and Present study |
| 87. | *Lemna gibba* L. | Araceae[c] | Free floating | 1 | 1 | 0 | Kak (1990), Bhellum and Magotra (2012), and Present study |
| 88. | *Lemna trisulca* L. | Araceae[c] | Free floating | 1 | 0 | 0 | Kak (1990) and Present study |
| 89. | *Lemna turionifera* Landolt | Araceae[c] | Free floating | 1 | 0 | 0 | Cook (1996) |
| 90. | *Lemna aeguinoctialis* Welw. | Araceae[c] | Free floating | 1 | 1 | 0 | Cook (1996); Sharma and Kachroo (1981) |
| 91. | *Spirodela polyrhiza* (L.) Schleid | Araceae[c] | Free floating | 1 | 1 | 0 | Kak (1990), Bhellum and Magotra (2012), and Present study |
| 92. | *Wolfffia brasiliensis* Wedd. | Araceae[c] | Free floating | 1 | 0 | 0 | Kak (1990) and Present study |
| 93. | *Wolffia arrhiza* (L.) Horkel | Araceae[c] | Free floating | 1 | 0 | 0 | Cook (1996) and Present study |
| 94. | *Butomus umbellatus* L. | Butamaceae | Emergent | 1 | 0 | 0 | Kak (1990) and Present study |
| 95. | *Carex diluta* M.Bieb. | Cyperaceae | Semiaquatic | 1 | 0 | 1 | Kak (1990); Klimes and Dickore (2009) |
| 96. | *Carex foliosa* D. Don | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) |
| 97. | *Carex nubigena* D.Don | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Bhellum and Magotra (2012) |
| 98. | *Carex fedia* Nees | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990), Sharma and Kachroo (1981), and Present study |
| 99. | *Carex notha* Kunth | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Kaul and Zutshi (1967) |
| 100. | *Carex kashmirensis* C. B. Cl. | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Haq et al. (2011) |
| 101. | *Carex orbicularis* Booth. | Cyperaceae | Semiaquatic | 1 | 0 | 1 | Haq et al. (2011); Klimes and Dickore (2009) |

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|---|---|---|---|---|---|---|---|
| 102. | *Carex infuscata* Nees | Cyperaceae | Semiaquatic | 1 | 0 | 1 | Klimes and Dickore (2009); Haq et al. (2011) |
| 103. | *Carex dimorpholepis* Steud. | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Haq et al. (2011) and Present study |
| 104. | *Carex psychrophila* Nees | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Haq et al. (2011) and Present study |
| 105. | *Carex maritima* Gunnerus | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Kaul and Zutshi (1967) |
| 106. | *Pycreus sanguinolentus* Nees | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Bhellum and Magotra (2012) |
| 107. | *Pycreus flavidus* T. Koyama | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) and Present study |
| 108. | *Pycreus pumilus* (L.) Nees | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Bhellum and Magotra (2012) |
| 109. | *Cyperus cuspidatus* Kunth | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Cook (1996) and Present study |
| 110. | *Cyperus rotundus* L. | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Bhellum and Magotra (2012) |
| 111. | *Cyperus fuscus* L. | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) and Present study |
| 112. | *Cyperus serotinus* Rottb. | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981) |
| 113. | *Cyperus michelianus* Delile. | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) and Present study |
| 114. | *Cyperus cyperiodes* O.Ktze | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981) |
| 115. | *Cyperus glomeratus* L. | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Swami and Gupta (1998) |
| 116. | *Cyperus difformis* L. | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981) |
| 117. | *Cyperus iria* L. | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981) |
| 118. | *Cyperus compressus* L. | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Cook (1996) and Present study |
| 119. | *Cyperus distans* L. f. | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Cook (1996), Present study, and Swami and Gupta (1998) |
| 120. | *Cyperus nutans* var. *eleusinoides* Haines | Cyperaceae | Semiaquatic | 0 | 1 | 0 | Sharma and Kachroo (1981) |
| 121. | *Cyperus laevigatus* L. | Cyperaceae | Semiaquatic | 0 | 1 | 0 | Sharma and Kachroo (1981) |
| 122. | *Bolboschaenus maritimus* Palla | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981) |
| 123. | *Schoenoplectus triqueter* Palla | Cyperaceae | Emergent | 1 | 0 | 1 | Kak (1990); Klimes and Dickore (2009) |
| 124. | *Schoenoplectus lacustris* Palla | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) |

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| S. No. | Scientific name | Family[a] | Growth form | Kashmir | Jammu | Ladakh | Source(s) record in the State |
|---|---|---|---|---|---|---|---|
| 125. | *Schoenoplectus tabernaemantani* Palla | Cyperaceae | Semiaquatic | 1 | 0 | 1 | Kak (1990); Klimes and Dickore (2009) |
| 126. | *Schoenoplectiella mucronata* (L.) J. Jung & H. K. Choi | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) and Present study |
| 127. | *Schoennoplectiella juncoides* Lye. | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981) |
| 128. | *Isolepis setaceus* R. Br. | Cyperaceae | Semiaquatic | 1 | 0 | 1 | Kak (1990); Klimes and Dickore (2009) |
| 129. | *Cladium mariscus* Pohl | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) and Present study |
| 130. | *Eleocharis atropurpurea* (Retz.) J. Presl & C. Presl | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo(1981), and Present study |
| 131. | *Eleocharis uniglumis* Schult. | Cyperaceae | Semiaquatic | 1 | 0 | 1 | Kak (1990); Klimes and Dickore (2009), and Present study |
| 132. | *Eleocharis quinqueflora* O. Schwarz | Cyperaceae | Semiaquatic | 0 | 0 | 1 | Klimes and Dickore (2009) |
| 133. | *Eleocharis mitracarpa* Steudel | Cyperaceae | Semiaquatic | 0 | 0 | 1 | Klimes and Dickore (2009) |
| 134. | *Eleocharis tetraquetra* Nees | Cyperaceae | Semiaquatic | 0 | 1 | 0 | Bhellum and Magotra (2012) |
| 135. | *Eleocharis tuberclosa* R. Br. | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) and Present study |
| 136. | *Eleocharis accicularis* (L.) Roem. & Schi. | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) and Present study |
| 137. | *Eleocharis parishii* Britton | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) and Present study |
| 138. | *Eleocharis palustris* R. Br. | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981) |
| 139. | *Eriophorum comosum* Wall. | Cyperaceae | Semiaquatic | 0 | 1 | 0 | Kak (1990) |
| 140. | *Fimbristylis dichotoma* Vahl. | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981) |
| 141. | *Fimbristylis dichotoma* subsp. *podocarpa* T. Koyama | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Bhellum and Magotra (2012), and Present study |
| 142. | *Fimbristylis littoralis* Gaudichaud | Cyperaceae | Semiaquatic | 1 | 0 | 0 | Cook (1996) and Present study |
| 143. | *Fimbristylis quinquangularis* (Vahl) Kunth. | Cyperaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Swami and Gupta (1998); Present study |
| 144 | *Fimbrystylis squarrosa* Vahl. | Cyperaceae | Semiaquatic | 1 | 0 | 1 | Kak (1990); Klimes and Dickore (2009) |

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|---|---|---|---|---|---|---|---|
| 145. | *Eriocaulon cinereum* Sieb. | Eriocaulaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Bhellum and Magotra (2012) |
| 146. | *Blyxa aubertii* Rich. | Hydrocharitaceae | Submerged | 1 | 0 | 0 | Cook (1996) and Present study |
| 147. | *Hydrilla verticillata* (L.F.) Royle | Hydrocharitaceae | Submerged | 1 | 1 | 0 | Kak (1990); Sharma (2008), and Present study |
| 148. | *Hydrocharis dubia* Blacker | Hydrocharitaceae | Emergent | 1 | 0 | 0 | Kak (1990) and Present study |
| 149. | *Hydrocharis morsus-ranae* L. | Hydrocharitaceae | Emergent | 1 | 0 | 0 | Ganie et al. (2016) and Present study |
| 150. | *Vallisneria spiralis* Linn. | Hydrocharitaceae | Floating | 0 | 1 | 0 | Sharma (2008) and Present study |
| 151. | *Najas marina* L. | Hydrocharitaceae[c] | Submerged | 1 | 0 | 0 | Kak (1990): Present study |
| 152. | *Najas graminea* Dol. | Hydrocharitaceae[c] | Submerged | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981), and Present study |
| 153. | *Najas minor* Miki[b] | Hydrocharitaceae[c] | Submerged | 1 | 0 | 0 | Cook (1996) and Present study |
| 154. | *Najas indica* Cham. | Hydrocharitaceae | Submerged | 0 | 1 | 0 | Sharma (2008) |
| 155. | *Juncus effusus* L. | Juncaceae | Semiaquatic | 1 | 0 | 0 | Kak (1990) and Present study |
| 156. | *Juncus thomsonii* Buchen. | Juncaceae | Semiaquatic | 1 | 0 | 1 | Kak (1990); Klimes and Dickore (2009) |
| 157. | *Juncus inflexus* L. | Juncaceae | Semiaquatic | 1 | 1 | 0 | Kak (1990); Bhellum and Magotra (2012) |
| 158. | *Juncus articulatus* L. | Juncaceae | Semiaquatic | 1 | 1 | 1 | Kak (1990); Klimes and Dickore (2009); Bhellum and Magotra (2012) |
| 159. | *Juncus bufonius* L. | Juncaceae | Semiaquatic | 1 | 1 | 1 | Kak (1990); Klimes and Dickore (2009); Bhellum and Magotra (2012) |
| 160. | *Juncus prismatocarps* R. Br. | Juncaceae | Semiaquatic | 0 | 1 | 0 | Bhellum and Magotra (2012) |
| 161. | *Triglochin palustris* L. | Juncaginaceae | Semiaquatic | 1 | 0 | 1 | Kak (1990); Klimes and Dickore (2009) |
| 162. | *Phragmites australis* (Cav.) Trin. ex Steud. | Poaceae | Emergent | 1 | 0 | 1 | Kak (1990); Klimes and Dickore (2009), and Present study |
| 163. | *Echinochloa colonum* Link | Poaceae | Emergent | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981), and Present study |
| 164. | *Echinochloa crusgalli* Beauv. | Poaceae | Emergent | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981), and Present study |
| 165. | *Polypogon fugax* Nees | Poaceae | Emergent | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981) |

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| S. No. | Scientific name | Family[a] | Growth form | Kashmir | Jammu | Ladakh | Source(s) record in the State |
|---|---|---|---|---|---|---|---|
| 166. | *Monochoria vaginalis* Presl. | Pontederiaceae | Emergent | 1 | 1 | 0 | Kak (1990); Bhellum and Magotra (2012), and Present study |
| 167. | *Eichhornia crassipes* Solms | Pontederiaceae | Emergent | 0 | 1 | 0 | Sharma and Kachroo (1981), and Present study |
| 168. | *Stuckenia amblyphylla Holub* (Syn: *Potamogeton amblyphyllus* C.A. May) | Potamogetonaceae | Submerged | 1 | 0 | 1 | Ganie et al. 2012 and Present study |
| 169. | *Potamogeton perfoliatus* L. | Potamogetonaceae | Submerged | 1 | 1 | 1 | Kak (1990); Sharma and Kachroo (1981); Klimes and Dickore (2009), and Present study |
| 170. | *Potamogeton natans* L. | Potamogetonaceae | Floating | 1 | 0 | 1 | Kak (1990); Klimes and Dickore (2009), and Present study |
| 171. | *Potamogeton nodosus* Poir. | Potamogetonaceae | Floating | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981), and Present study |
| 172. | *Stuckenia pectinata* Borner (Syn:*Potamogeton pectinatus* Borner) | Potamogetonaceae | Submerged | 1 | 1 | 0 | Kak (1990); Sharma and Kachroo (1981), and Present study |
| 173. | *Potamogeton crispus* L. | Potamogetonaceae | Submerged | 1 | 1 | 1 | Kak (1990); Sharma and Kachroo (1981); Klimes and Dickore (2009); Present study |
| 174. | *Potamogeton leucens* L. | Potamogetonaceae | Submerged | 1 | 0 | 0 | Ganie et al. 2012 and Present study |
| 175. | *Potamogeton pusillis* Roxb. | Potamogetonaceae | Submerged | 1 | 0 | 1 | Ganie et al. 2012; Kak (1990); Klimes and Dickore (2009); Present study |
| 176. | *Potamogeton berchtoldii* Fieber | Potamogetonaceae | Submerged | 1 | 0 | 0 | Ganie et al. 2012 and Present study |
| 177. | *Potamogeton trichoides* Cham. | Potamogetonaceae | Submerged | 1 | 0 | 0 | Ganie et al. 2012 and Present study |
| 178. | *Potamogeton wrightii* Morong. | Potamogetonaceae | Floating/ submerged | 1 | 0 | 0 | Ganie et al. 2012 and Present study |
| 179. | *Stuckenia macrocarpa* Tzvelev (Syn: *Potamogeton macrocarpous* Dobrochot) | Potamogetonaceae | Submerged | 0 | 0 | 1 | Kaplan (2008) |

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|---|---|---|---|---|---|---|---|
| 180. | *Stuckenia pamirica* Z. Kaplan (Syn: *Potamogeton pamiricus* Baagoe) | Potamogetonaceae | Submerged | 0 | 0 | 1 | Kaplan (2008) |
| 181. | *Stuckenia vaginata* Holub (Syn: *Potamogeton vaginatus* Turcz.) | Potamogetonaceae | Submerged | 0 | 0 | 1 | Kaplan (2008) |
| 182. | *Stuckenia filiformis* Borner (Syn: *Potamogeton filiformis* Pers.) | Potamogetonaceae | Submerged | 0 | 0 | 1 | Kaplan (2008) |
| 183. | *Zannichellia palustris* L. | Potamogetonaceae[c] | Submerged | 1 | 1 | 1 | Kak (1990); Sharma and Kachroo (1981) |
| 184. | *Sparganium erectum* L. | Typhaceae[c] | Semiaquatic | 1 | 0 | 0 | Kak (1990) and Present study |
| 185. | *Typha latifolia* L. | Typhaceae | Semiaquatic | 1 | 0 | 0 | Cook (1996); Shah and Reshi (2014), and Present study |
| 186. | *Typha orientalis* Presl. | Typhaceae | Semiaquatic | 1 | 0 | 0 | Ganie et al. 2015a and Present study |
| 187. | *Typha domingensis* Pers. | Typhaceae | Semiaquatic | 1 | 1 | 1 | Kak (1990); Sharma and Kachroo (1981), and Present study |
| **C. Pteridophytes** | | | | | | | |
| 188. | *Equisetum diffusum* Don. | Equisetaceae | Emergent | 1 | 0 | 0 | Kaul and Zutshi (1967) and Present study |
| 189. | *Marsilea quadrifolia* L. | Marsileaceae | Floating | 1 | 0 | 0 | Kaul and Zutshi (1967) and Present study |
| 190. | *Azolla cristata* Kaulf. | Salviniaceae | Free floating | 1 | 0 | 0 | Ahad et al. 2012 and Present study |
| 191. | *Salvinia natans* (L.) All. | Salviniaceae | Free floating | 1 | 0 | 0 | Kaul and Zutshi (1967), Cook (1996), and Present study |

Syn= Synonym; 1= present; 0= absent

[a]Families have been arranged as per The Plant List (www.plantlist.org)

[b]Recent molecular studies by Donald Les (unpublished data), University of Connecticut, Storrs (Connecticut 06269-3043 U.S.A) revealed that *Najas oguraensis* and *N. minor* should be merged and treated as a single species of *N. minor*

[c]Family name has been changed in accordance with APG-III classification (Haston et al. 2009)

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# Chapter 21
# Diversity in Medicinal and Aromatic Flora of the Kashmir Himalaya

**Aijaz Hassan Ganie, Bilal A. Tali, Irshad A. Nawchoo, Anzar A. Khuroo, Zafar A. Reshi, and Ghulam Hassan Dar**

**Abstract** In the Kashmir Himalaya, 833 plant species, belonging to 378 genera in 112 families, are used as medicinal and aromatic plants (MAPs). In all, 749 (89.91%) species belong to dicotyledons, 66 (7.92%) to monocotyledons, 10 (1.20%) to gymnosperms, while 8 (0.96%) species belong to pteridophytes. The family Asteraceae has the largest number of 126 MAP species. In total, 709 (85.14%) species are herbs, 59 (7.06%) shrubs, 31 (3.71%) sub-shrubs, and 34 (3.60%) trees. Most of these species (818) inhabit terrestrial habitats; however, 10 are aquatic and some are parasitic herbs. The MAPs are used either as whole plant or its parts to treat more than 50 types of diseases in human beings and livestock. Some of the medicinal plants are used to treat more than one disease; likewise, more than one medicinal plant may be used to treat a particular disease. MAPs are distributed in temperate, subalpine and alpine regions, within an altitudinal range of 1580–4100 m asl. A large number of MAPs have been rendered endangered due to various anthropogenic threats operative in the region.

**Keywords** Medicinal and Aromatic Plants · Ailments · Ethno-medicine · Kashmir Himalaya

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_21

## 21.1 Introduction

Plants are a vital component of global biodiversity and ensure environmental sustainability. They provide food (around 7,000 species are used for food), fibre, fuel, shelter and medicine. Healthy ecosystems comprising of plant diversity provide the conditions and processes that sustain life and are essential for the well-being and livelihoods of human kind. Besides sustenance, plants are a great source of medicines; especially in traditional medicine they are useful in the treatment of various diseases (Bako et al. 2005). In fact, traditional medicine has not only played a vital role in health care but has also provided vital leads to the discovery of most pharmaceutically active substances in plants (Principe 1991; Pearce and Puroshothaman 1992), which have been used in the commercial production of drugs.

There is no reliable figure for the total number of medicinal plants on Earth, and the numbers for different countries and regions vary greatly (Schippmann et al. 2002). Rough estimates for the number of species used medicinally include: 35,000–70,000 or 53,000 worldwide (Schippmann et al. 2002). According to the World Health Organization (WHO), the majority of the world's human population, especially in the developing countries, depends on traditional medicine. It has been estimated that up to 90% of the population in developing countries rely on the use of medicinal plants to meet their primary health care needs (WHO 2002). About 25% of the drugs prescribed worldwide have origin from plants, 121 such active compounds are in current use. Of the 252 drugs considered as basic and essential by the WHO, 11% are exclusively of plant origin and a significant number are synthetic drugs obtained from natural precursors. It is estimated that 60% of antitumour and anti-infectious drugs already in the market or under clinical trial are of natural origin (Yue-Zhong Shu 1998). The vast majority of these cannot yet be synthesized commercially and are still obtained from wild or cultivated plants. Natural compounds can act as lead compounds, allowing the design and rational planning of new drugs, bio-mimetic synthesis development and the discovery of new therapeutic properties not yet attributed to known compounds. The last three decades have seen substantial growth in herbal product markets across the world. Rapidly rising exports of medicinal plants during the past decade attests the worldwide interest in these products as well as in traditional health systems. According to the Secretariat of the Convention on Biological Diversity, global sales of herbal products totalled an estimated US$ 60 billion in 2002 (WHO 2003).

Mostly spurred by this surge in demand for herbal products, medicinal plant resources are being harvested in increasing volumes, mostly from wild populations, to meet the demands of local, regional and international markets (Kuipers 1997; Lange 1998). Generally, the medicinal plant collectors are rarely aware of the proper collection and storage practices (Maikhuri et al. 1998; Nautiyal et al. 2001), which results in destructive harvesting and finally leads to the poor natural regeneration (Rao et al. 2000). Furthermore, the removal of the entire plant before seed maturation reduces the possibility of seed development for future regeneration (Sheldon et al. 1998). Owing to various anthropogenic factors, like urbanization, overexploitation of plants, unregulated grazing, frequent forest fire and the pollution stress, there is a perceptible decline in the population of many medicinal plants rendering them rare and threatened (Jain 2000). According to Walter and Gillett (1998), about 34,000 species or 8% of the world's flora are threatened with extinction and of the India's 15,000 flowering plants, about 3,000 species are threatened (Jain 2000). In the North-West Himalayas, which represents a rich repository of a highly diverse germplasm, several medicinally important plant species are facing increasing risk of endangerment (Dhar and Kachroo 1983). Nearly 400 plant species are used by the phyto-pharmaceutical industry to manufacture standard medicine based on Indian system of medicine (ISM); many of these species have been assessed as endangered, vulnerable and threatened due to deforestation, overexploitation and substantial loss of habitats in the wild (Chakrabarti and Varshney 2001; Kala and Sajwan 2007).

Kashmir Himalayas harbour diverse habitats that support equally rich floristic wealth that has been used as a resource-base by its populace since time immemorial. Indeed, the region has ever been known for its economically valued plants and their products, such as medicine, food, fodder and fibre (Dar et al. 2008). Owing to the rich and unique floristic diversity, a good proportion of plants are used as medicine in one or other form. Over the last half century, various scientific studies dealing with the medicinal and aromatic plants (MAPs) of the region have been carried out by Kapoor and Sarin (1977); Kak (1983); Dar et al. (1984); Kachroo and Nahvi (1987); Kaul et al. (1990); Kaul (1997); Nawchoo and Buth (1990, 1994); Dar et al. (2002); Khan et al. (2004, 2006); Dar et al.(2007); Chalk and Agarwal (2008); Ballabh and Chaurasia (2009); Malik et al. (2011) etc. However, all these studies have focused on the ethno-medicinal uses of these plants in the region. Very little information is available on taxonomic diversity of these MAPs in the Kashmir Himalayas. It is in this context that the present chapter provides a synthesis on the diversity and distribution of MAPs in this part of the Indian Himalayas.

## 21.2 Materials and Methods

Exhaustive field explorations in different areas of the Kashmir Himalayas and widespread literature survey by perusing the relevant publications were carried out to document the diversity of MAPs growing in the Kashmir Himalayas.

### 21.2.1 Areas Surveyed and Record of Ethno-Medicinal Information

Extensive field surveys were carried out throughout Himalayas of Kashmir during the past several years. The geographical coordinates of the surveyed areas were recorded using geographical positioning system (GPS). During field surveys, structured interviews were also carried out to elicit secret knowledge from locals inhabiting inaccessible areas of the region. Appropriate methodology was followed during the present study; usually, the survey in each locality started with the interview of elderly and experienced members, locally known as ‘Hakeems’. Often they accompanied to the field for authentication of plant specimens collected from wild habitats. The common people of the surveyed localities who have used these plants were also interviewed. The detailed information so gathered, in particular that related to part(s) used, methodology of preparation, and method of use was recorded. To bring element of accuracy, the information obtained from one locality was cross checked with that of others.

### 21.2.2 Identification of Plant Species

The identification of plants was carried out by experts at the Centre for Biodiversity & Taxonomy, University of Kashmir, and by comparing the plant specimens with already identified ones deposited at the University of Kashmir Herbarium (KASH). For authentication of doubtful species, different floras and e-resources were also consulted.

### 21.2.3 Perusal of Relevant Literature

The survey of relevant literature was conducted at various institutions in Kashmir, which include the Indian Institute of Integrative Medicine (IIIM), Sanatnagar (Srinagar); Sher-e-Kashmir University of Agricultural Science & Technology (SKUAST), Shalimar (Srinagar); and the University of Kashmir, Hazratbal (Srinagar).

## 21.3 Results and Discussion

Overall, 833 species are used as MAPs in the Kashmir Himalayas. These species belong to 378 genera in 112 families. In total, 749 (89.91%) species belong to dicotyledons, 66 (7.92%) to monocotyledons, 10 (1.20%) to gymnosperms, while 8

**Table 21.1** Conspectus of medicinal and aromatic plants (MAPs) of the Kashmir Himalayas

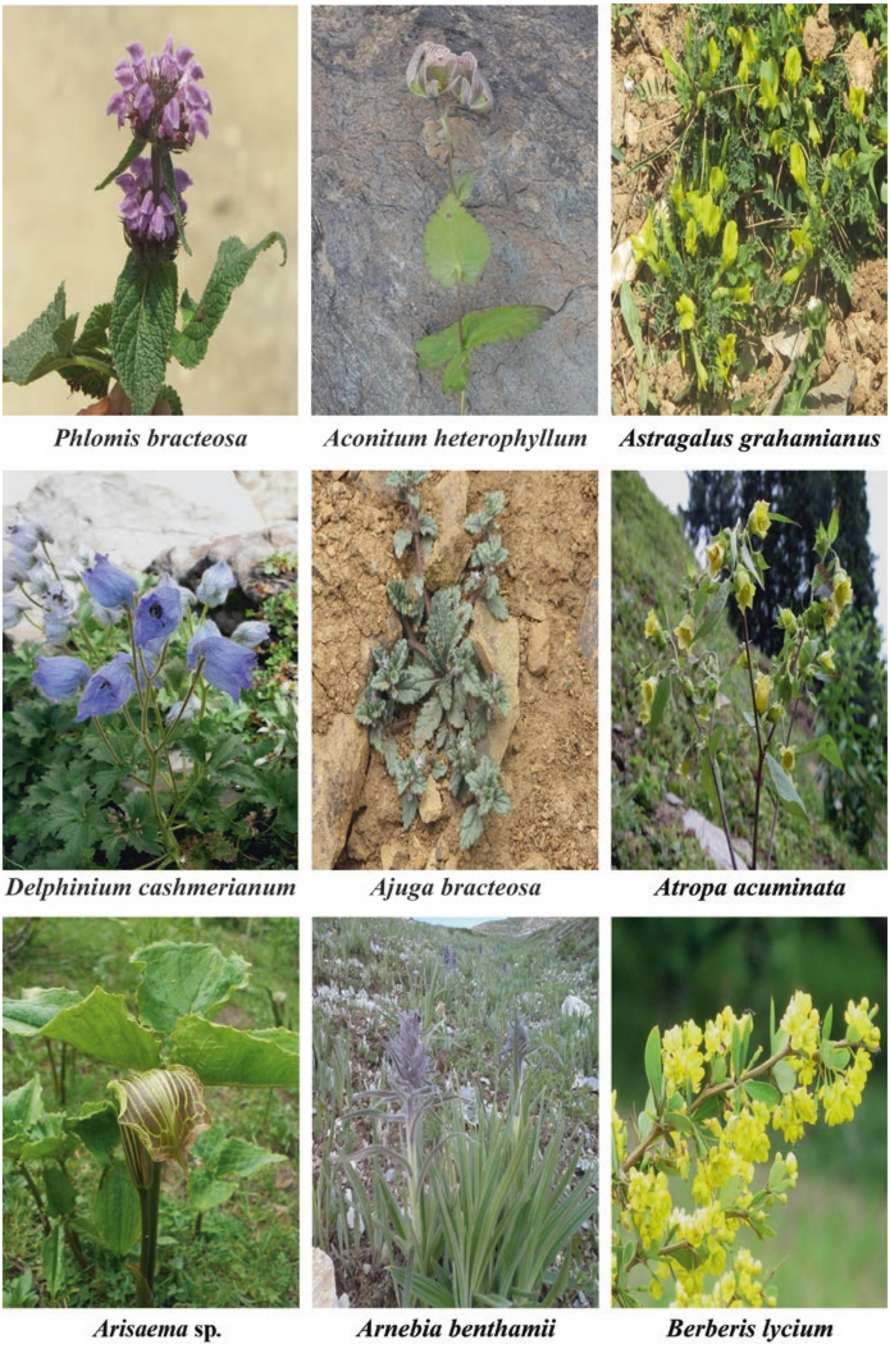
| Group | Number of | | |
|---|---|---|---|
| | Families | Genera | Species |
| Dicotyledons | 91 | 328 | 749 |
| Monocotyledons | 13 | 42 | 66 |
| Gymnosperms | 4 | 4 | 10 |
| Pteriodophytes | 4 | 4 | 8 |
| Total | **112** | **378** | **833** |

(0.96%) species belong to pteridophytes (Table 21.1; Plates 21.1, 21.2, 21.3, and 21.4). Asteraceae lead the group with 126 species in 48 genera, followed by Lamiaceae with 54 species in 20 genera. Among monocotyledons, Liliaceae with 24 species stand first, followed by Orchidaceae with 12 species, Iridaceae with 6, Poaceae with 5, and Araceae and Amaryllidaceae with 4 species each. In gymnosperms, Cupressaceae tops the list with 4 species; whereas in pteriodophytes, Aspleniaceae with 3 species tops the families, followed by Adiantaceae and Equisetaceae with 2 species each (Table 21.2).

The study revealed that these MAPs belong to different life forms: 709 species being herbs, 59 shrubs, 31 sub-shrubs, and 34 trees. The percentage composition of these life forms is given in Fig. 21.1. Majority (818) of these herbs are terrestrial; however, 10 species are aquatic, belonging to families Nelumbonaceae, Nymphaeaceae, Trapaceae, Alismaceae, Ranunculaceae, Juncaginaceae, Rosaceae and Araceae. Some species of families Ranunculaceae, Rubiaceae, Smilacaceae and Dioscoreaceae are climbers, while members of Orobanchaceae and Cuscutaceae are parasitic herbs (Fig. 21.2).

It has been revealed that different plant parts, such as shoots, leaves, flowers, fruits, seeds, etc., of MAPs are used to treat various diseases of human beings and livestock; in some cases, even the whole herb is also used. Categorization of species on the basis of plant part(s) used to treat various diseases is graphically shown in Fig. 21.3. Majority (253) of the species are used as whole herbs. In addition to usual plant parts, sometimes latex, plant ash, water extract and oils obtained from plants are also used to treat different diseases. The plant or plant parts are used in different forms, such as poultice, decoction, extract, infusion, paste, powder and juice; sometimes, the plant parts are mixed with other ingredients and given orally or used externally. In total, these MAPs are used to treat more than 50 types of diseases in human beings and livestock. The number of MAPs used to treat common diseases in human beings and livestock is given in Fig. 21.4. It is also observed that some of the medicinal plants are used to treat more than one disease; likewise, more than one medicinal plant is also used to treat a particular disease.

These MAPs are distributed in temperate (plain lands), subalpine and alpine regions within an altitudinal range of 1,580–4,100 m asl. The representative MAPs growing in various geographical zones of Kashmir Himalaya are depicted in Table 21.3.



***Phlomis bracteosa*** ***Aconitum heterophyllum*** ***Astragalus grahamianus***

***Delphinium cashmerianum*** ***Ajuga bracteosa*** ***Atropa acuminata***

***Arisaema* sp.** ***Arnebia benthamii*** ***Berberis lycium***

**Plate 21.1** Representative medicinal plants of Kashmir Himalaya

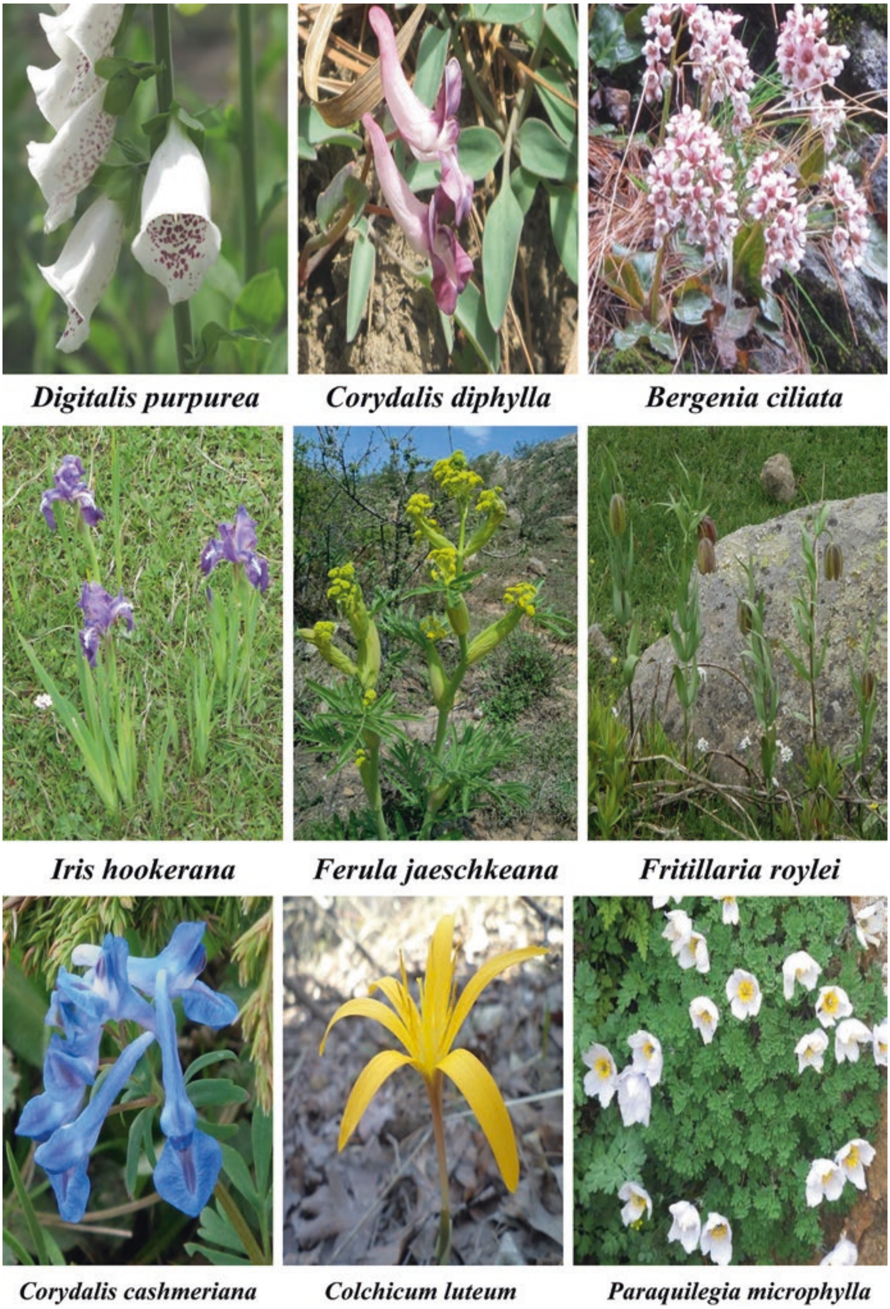



**Plate 21.2** Representative medicinal plants of Kashmir Himalaya


**Plate 21.3** Representative medicinal plants of Kashmir Himalaya


**Plate 21.4** Representative medicinal plants of Kashmir Himalaya

**Table 21.2** Family-wise list of genera with number of species of MAPs in the Kashmir Himalayas

| Family | Names of genera and number of species in brackets | Total number of species in family |
|---|---|---|
| **A. Dicotyledons** | | |
| Aceraceae | *Acer* (1) | 1 |
| Amaranthaceae | *Achyranthes* (1); *Amaranthus* (2); *Celosia* (2) | 5 |
| Anacardiaceae | *Rhus* (1) | 1 |
| Apiaceae | *Angelica* (2); *Anthriscus* (1); *Apium* (1); *Bupleurum* (3); *Carum* (2); *Pleurospermum* (2); *Chaerophyllum* (2); *Coriandrum* (1); *Eryngium* (2); *Ferula* (1); *Foeniculum* (1); *Prangos* (1); *Conium* (1); *Heracleum* (3); *Bunium* (1); *Archangelica* (1); *Caucalis* (1); *Daucus* (1); *Aegopodium* (1); *Ligusticum* (2); *Pimpinella* (2); *Sanicula* (1); *Selinum* (1); *Seseli* (1) | 35 |
| Apocynaceae | *Nerium* (1) | 1 |
| Araliaceae | *Aralia* (1); *Hedera* (1) | 2 |
| Asclepiadaceae | *Cynanchum* (2); *Vincetonicum* (1) | 3 |
| Asteraceae | *Achillea* (1); *Artemisia* (20); *Aster* (1); *Brachyactis* (2); *Calendula* (1); *Centaurea* (3); *Cichorium* (1); *Cirsium* (3); *Cousinia* (1); *Cremanthodium* (3); *Crepis* (1); *Echinops* (2); *Erigeron* (3); *Filago* (1); *Gnaphalium* (1); *Inula* (6); *Jurinea* (2); *Koelpinia* (1); *Lactuca* (5); *Launaea* (1); *Lavetera* (1); *Leontopodium* (3); *Psychrogeton* (1); *Saussurea* (13); *Senecio* (6); *Tragopogon* (3); *Tanacetum* (6); *Taraxacum* (2); *Tussilago* (1); *Cotula* (1); *Arctium* (1); *Anaphalis* (5); *Blumea* (1); *Chrysanthemum* (4); *Dendranthema* (1); *Scorzonera* (2); *Youngia* (1); *Waldheimia* (4); *Carduus* (1); *Sonchus* (1); *Xanthium* (1); *Zinnia* (1); *Solidago* (1); *Tagetus* (1); *Anthemis* (1); *Helianthus* (1); *Matricaria* (1) | 126 |
| Balsaminaceae | *Impatiens* (3) | 3 |
| Berberidaceae | *Berberis* (5); *Epimedium* (1) | 6 |
| Boraginaceae | *Arnebia* (3);*Microula* (1);*Onosma* (2); *Actinocarya* (1); *Lappula* (1); *Mattiastrum* (2); *Lindelofia* (1); *Cynoglossum* (2) | 13 |
| Brassicaceae | *Christolia* (1); *Descurainia* (1); *Lepidium* (2); *Sisymbrium* (2); *Thlapsi* (5); *Atelanthera* (1); *Brassica* (2); *Capsella* (1); *Matthiola* (1); *Conringia* (1); *Dontostemon* (1); *Ermania* (1); *Cardamine* (2); *Arabidopsis* (1); *Erysimum* (3); *Arabis* (3); *Rorippa* (1); *Nasturtium(1); Raphanus (1); Megacarpea (1)* | 32 |
| Caesalpinaceae | *Cassia*(1) | 1 |
| Campanulaceae | *Campanula* (1); *Codonopsis* (3) | 4 |
| Cannabinaceae | *Cannabis* (1); *Humulus* (1) | 2 |
| Capparidaceae | *Capparis* (1) | 1 |
| Caprifoliaceae | *Sambucus* (2); *Lonicera* (1); *Viburnum* (2) | 5 |
| Caryophyllaceae | *Cerastium* (1); *Dianthus* (2); *Minuartia* (1); *Sagina* (1); *Saponaria* (1); *Lychnis* (2); *Myosoton* (1); *Silene* (6); *Arenaria* (2); *Stellaria* (1) | 18 |
| Celastraceae | *Euonymus(2)* | 2 |

(continued)

**Table 21.2** (continued)

| Family | Names of genera and number of species in brackets | Total number of species in family |
|---|---|---|
| Chenopodiaceae | *Chenopodium*(5); *Salsola* (1); *Halogeton* (1); *Krascheninikovia*(1) ; *Corispermum*(1); | 9 |
| Convolvulaceae | *Convolvulus* (1) | 1 |
| Crassulaceae | *Sedum*(8); *Hylotelephium*(1); *Sempervivella*(2); *Rhodiola* (4) | 15 |
| Cucurbitaceae | *Momordica* (1); *Cucurbita* (1); *Solena* (1) | 3 |
| Cuscutaceae | *Cuscuta* (3) | 3 |
| Datiscaceae | *Datisca* (1) | 1 |
| Dipsacaceae | *Dipsacus* (1); *Perocephalus* (1) | 2 |
| Elaeagnaceae | *Hippophae* (1) | 1 |
| Ericaceae | *Rhododendron* (2); *Cassiope* (1); *Gaultheria* (1) | 4 |
| Euphorbiaceae | *Euphorbia* (10) | 10 |
| Fumariaceae | *Corydalis*(12); *Fumaria* (2) | 14 |
| Gentianaceae | *Gentiana*(15); *Gentianella*(2); *Homatogonium*(1); *Jaeschkea*(3); *Swertia*(6); *Gentianopsis*(2); *Lomatogonium*(1) | 30 |
| Geraniaceae | *Biebersteinia*(2); *Erodium*(2); *Geranium*(7) | 11 |
| Hamamelidaceae | *Parrotiopsis(1)* | 1 |
| Hippocastanaceae | *Aesculus*(2) | 2 |
| Hyperiacaceae | *Hypericum*(2) | 2 |
| Juglandaceae | *Juglans*(1) | 1 |
| Lamiaceae | *Ajuga*(2); *Dracocephalum*(2); *Elsholtzia*(3); *Marrubium*(1); *Mentha*(3); *Nepeta*(17); *Origanum*(2); *Plectranthus*(1); *Prunella*(1); *Ocimum*(1); *Thymus*(2); *Salvia*(6); *Stachys*(2); *Perovskia*(1); *Scutellaria*(3); *Calamintha*(1); *Phlomis*(1); *Clinopodium*(2); *Lamium* (2); *Rabdosia*(1) | 54 |
| Lentbulariaceae | *Urticularia*(1); *Pinguicula*(1) | 2 |
| Lauraceae | *Neolitsea(1); Persea(1)* | 2 |
| Linaceae | *Linum*(1) | 1 |
| Malvaceae | *Althaea*(1); *Lavatera*(1); *Malva* (4); *Alcea*(1) | 7 |
| Meliaceae | *Melia*(1) | 1 |
| Moraceae | *Ficus*(1); *Morus*(2) | 3 |
| Morinaceae | *Morina*(3) | 3 |
| Nelumbonaceae | *Nelumbo*(1) | 1 |
| Nitrariaceae | *Peganum*(1) | 1 |
| Nyctaginaceae | *Mirabilis*(1) | 1 |
| Nymphaeaceae | *Nymphaea*(2); *Euryale*(1) | 3 |
| Oleaceae | *Fraxinus*(1) | 1 |
| Onagraceae | *Chamaenerion*(1); *Epilobium*(3) | 4 |
| Orobanchaceae | *Orobanche*(1) | 1 |
| Oxalidaceae | *Oxalis*(3) | 3 |
| Paeoniaceae | *Paeonia(1)* | 1 |

(continued)

**Table 21.2** (continued)

| Family | Names of genera and number of species in brackets | Total number of species in family |
|---|---|---|
| Papaveraceae | *Argemone*(1); *Hypecoum*(1); *Meconopsis*(5);*Papaver*(3) | 10 |
| Papilionaceae | *Asatragalus*(13); *Chesneya*(1); *Cicer*(1); *Indigofera*(1); *Medicago*(2); *Oxytropis*(4); *Vicia*(2); *Glycine*(1); *Lotus*(1); *Trigonella*(2); *Sophora*(1); *Caragana*(1) ; *Hedysarum*(1); *Trifolium(2)* | 33 |
| Parnassiaceae | *Parnassia*(3) | 3 |
| Pedaliaceae | *Martynia*(1); *Sesamum*(1) | 2 |
| Phytolaccaceae | *Phytolacca*(1) | 1 |
| Plantaginaceae | *Plantago*(9) | 9 |
| Platanaceae | *Platanus*(1) | 1 |
| Plumbaginaceae | *Acantholimon*(1); *Plumbago*(1) | 2 |
| Podophyllaceae | *Podophyllum*(1) | 1 |
| Polemoniaceae | *Polemonium*(2) | 2 |
| Polygalaceae | *Polygala(2)* | 2 |
| Polygonaceae | *Fagopyrum*(2); *Oxyria*(1); *Polygonum*(11); *Rheum* (3); *Rumex*(8); *Persicaria*(2); *Aconogonum*(1) | 28 |
| Portulacaceae | *Portulaca*(1) | 1 |
| Primulaceae | *Anagallis*(1); *Androsace*(5); *Glaux*(1); *Primula*(4) | 11 |
| Punicaceae | *Punica* (1) | 1 |
| Pyrolaceae | *Pyrola*(1) | 1 |
| Ranunculaceae | *Aconitum*(6); *Actaea*(1); *Adonis*(2); *Anemone*(6); *Aquilegia*(4); *Ceratocephalus*(1); *Cimicifuga*(1); *Clematis*(4); *Delphinium*(7); *Halespestes*(1); *Ranunculus*(10); *Thalictrum*(7); *Paraquilegia*(1); *Caltha*(1), *Trollius*(2) | 54 |
| Rhamnaceae | *Ziziphus*(2); *Rhamnus*(2) | 4 |
| Rosaceae | *Fragaria*(2); *Geum*(3); *Potentilla*(11); *Rosa*(3); *Crataegus*(2); *Pyrus*(2); *Agrimonia*(2); *Cotoneaster*(1); *Prunus*(3); *Rubus*(3); *Malus*(1); *Sorbus* (2) | 35 |
| Rubiaceae | *Galium* (4); *Rubia* (1) | 5 |
| Rutaceae | *Dictamnus* (1); *Skimmia* (3); *Xanthoxylum* (1) | 5 |
| Salicaceae | *Salix*(2); *Populus*(1) | 3 |
| Sapindaceae | *Desmodium* (1) | 1 |
| Saxifragaceae | *Bergenia* (4); *Saxifraga* (5) | 9 |
| Scrophulariaceae | *Euphrasia* (3); *Pedicularis* (9); *Picrorhiza* (1); *Verbascum* (1); *Wulfenia* (1); *Lagotis* (2); *Digitalis* (2); *Scruphularia* (6); *Veronica* (3); | 29 |
| Smilacaceae | *Simlax* (2) | 2 |
| Solanaceae | *Atropa*(1); *Datura*(1); *Hyoscyamus* (1)*Physochlaina* (1); *Solanum* (5); *Lycium* (1) | 10 |
| Tamaricaceae | *Myricaria* (4); *Tamarix* (1) | 5 |
| Thymeliaceae | *Daphne* (2) | 2 |

(continued)

**Table 21.2** (continued)

| Family | Names of genera and number of species in brackets | Total number of species in family |
|---|---|---|
| Trapaceae | *Trapa (1)* | 1 |
| Ulmaceae | *Ulmus* (1) | 1 |
| Urticaceae | *Urtica* (3) | 3 |
| Valerianaceae | *Valeriana* (5) | 5 |
| Verbenaceae | *Verbena* (1) | 1 |
| Violaceae | *Viola* (7) | 7 |
| Viscaceae | *Viscum* (1) | 1 |
| Vitaceae | *Vitis* (1) | 1 |
| Zygophyllaceae | *Tribulus* (1) | 1 |
| **B. Monocotyledons** | | |
| Alismataceae | *Sagittaria* (1) | 1 |
| Amaryllidaceae | *Narcissus* (3); *Sternbergia* (1) | 4 |
| Araceae | *Acorus*(1)*; Arisaema* (3) | 4 |
| Corylaceae | *Corylus (1)* | 1 |
| Cyperaceae | *Cyperus* (1)*; Carex* (2) | 3 |
| Dioscoraceae | *Dioscorea* (1) | 1 |
| Grossulariaceae | *Ribes* (2) | 2 |
| Iridaceae | *Iris* (5)*; Crocus* (1) | 6 |
| Juncaginaceae | *Triglochin* (1) | 1 |
| Liliaceae | *Allium*(10)*; Asparagus*(2)*; Colchicum*(1);*Tulipa*(1)*; Fritillaria*(2)*; Gagea*(1)*; Polygonatum*(3); *Eremurus*(1); *Lilium*(1); *Trillium*(1); *Lloydia*(1) | 24 |
| Menyanthaceae | *Menyanthes*(1)*; Nymphoides* (1) | 2 |
| Orchidaceae | *Herminium*(1)*; Satyrium(1); Dactylorhiza* (1)*; Epipactis* (2); *Neottia* (1); *Cephalanthera* (1); *Goodyrea* (1); *Listera* (1); *Spiranthes* (1); *Malaxis* (1); *Cypripedium* (1) | 12 |
| Poaceae | *Melica* (1)*; Eragrostis* (1)*; Leucopoa* (1); *Sorghum* (1); *Triticum* (1) | 5 |
| **C. Gymnosperms** | | |
| Cupressaceae | *Juniperus* (4) | 4 |
| Ephedraceae | *Ephedra* (2) | 2 |
| Pinaceae | *Pinus* (2) | 2 |
| Taxaceae | *Taxus* (2) | 2 |
| **D. Pteriodophytes** | | |
| Adiantaceae | *Adiantum* (2) | 2 |
| Aspeliniaceae | *Asplenium* (3) | 3 |
| Dryopteridaceae | *Dryopteris* (1) | 1 |
| Equisetaceae | *Equisetum* (2) | 2 |

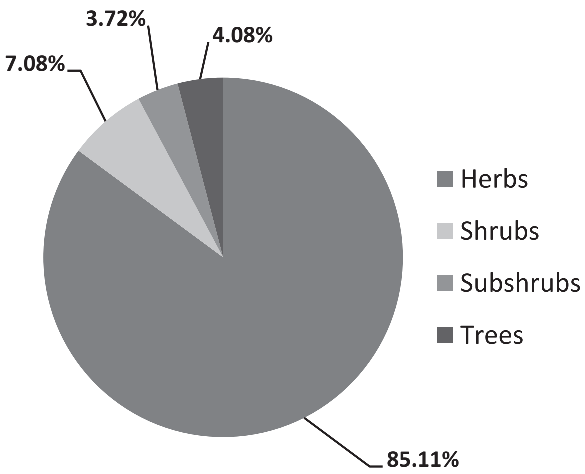



**Fig. 21.1** Percentage of various life forms in medicinal and aromatic plants of the Kashmir Himalayas

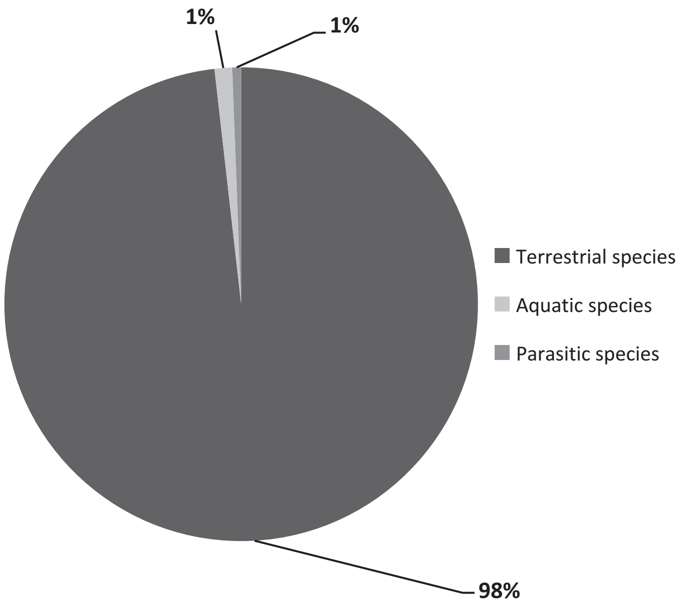



**Fig. 21.2** Proportion of medicinal and aromatic plant species distributed in various habitats in the Kashmir Himalayas

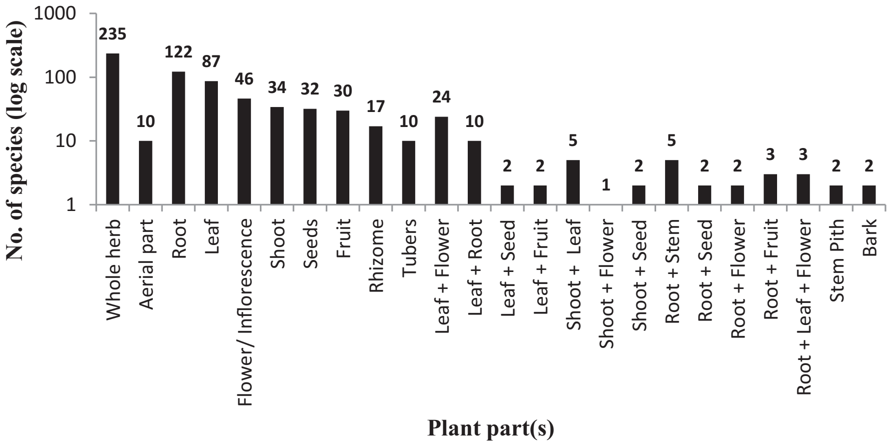



**Fig. 21.3** Number of species with different plants part(s) used for treating diseases

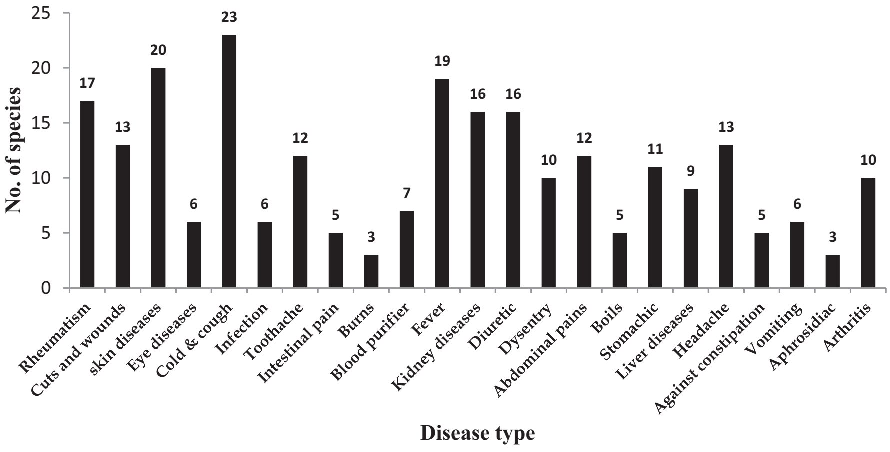



**Fig. 21.4** Number of plants species used to treat different diseases of human beings and livestock

**Table 21.3** Distribution of MAPs in different altitudinal zones in the Kashmir Himalaya

| Altitudinal zones | Representative species |
|---|---|
| 1. Low-altitude plains (1580–1800 m) | *Adiantum capillus-veneris, Colchicum luteum, Gagea gageoids, Hyoscyamus niger, Prunella vulgaris, Hypericum perforatum, Taraxacum officinale, Viola odorata, Berberis lycium, Conium maculatum, Mentha arvensis, Mentha longifolia, Malva sylvestris, Malva neglecta, Peganum harmala, Plantago lanceolata, Plantago major, Salvia moorcroftiana, Gentiana kurroo, Ajuga bracteosa, A. parviflora, Thymus linearis, Thymus serpyllum, Fumaria indica, Cotula anthemoides, Iris kashmeriana, I.ensata, Narcissus pseudonarcissus, Narcissus poeticus, Fritillaria imperialis, Solanumnigrum, Daturastramonium, Foeniculum vulgare, Tulipa stellata, Asparagus racemosus, Daphne mucronata, Ranunculus muricatus, Convolvulus arvensis, Indigofera heterantha, Papaver rhoeus, Geranium wallichianum, Delphinium denudatum, Spiranthes sinensis, Lavatera kashmiriana, Cichorium intybus, Rosa webbiana, Achillea millefolium, Artemisia absinthium, Astragalus grahamianus, Althaea officinalis, Nepeta cataria, Fragaria nubicola, Tussilago farfara, Marubium vulgare, Arctium lappa, Urtica dioca, Equisetum arvensis, Nasturtium officinale, Acorus calamus, Ficus carica, Xanthoxylum armatum* |
| 2. Temperate and subalpine zone (1800–3200 m) | *Atropa acuminata, Arisaema jacquemontii, Podophyllum hexandrum, Skimmia anquetilia, Primula denticulata, P. rosea, Digitalis lanata, D. purpurea, Hyoscyamus niger, Viburnum grandiflorum, Paeonia emodi, Phytolacca acinosa, Ferula jaechkeana, Eremurus himalaicus, Heracelum candicans, Mentha piperita, Artemisia scoparia, Corydalis diphylla, C. thyrsiflora, Onosma hispidum, Aguilegia pubiflora, A. fragrans, Artemisia maritima, Aconitum heterophyllum, Anemone rupicola, Saussurea heteromalla, S. albescens, Lychnis coronaria, Viola indica, Dipsacus inermis, Gentiana carinata, Dioscorea deltoidea, Cephalanthera longifolia, Polygonatum verticillatum, Inulara cemosa, Anaphalis triplinervis, Valeriana pyrolifolia, V. jatamansii, Solenanthus circinnatus, Salvia hians, Trillium govanianum, Polymonium caerulum* |
| 3. Alpine zone (above 3200 m) | *Bergenia ciliata, Aquilegia nivalis, Jurinea macrocephala, Aconitum violaceum, Meconopsis latifolia, Phlomis bracteoasa, Corydalis cashmeriana*, *Saussurea costus, Trollius acaulis, Adonis chrysocyathus*, *Bergenia stracheyi, Rheum webbianum, R. spiciforme, Inula royleana, Fritillaria roylei, Geum elatum, P. atrosanguinea, P. anserine, Swertia petiolata*, *Scutellaria linearis, Primula macrophylla, Euphorbia wallichii, Iris hookeriana, Androsace mucronifolia, Lagotis cashmeriana, Delphinium cachemrianum, Aconitum chasmanthum, Picrorhiza kurrooa, Arnebia benthamii, Saussurea roylei., Corydalis crassissima, Hedysarum cachemirianum, Meconopsis aculeate, Silene nigrescens., Saxifraga sibirica, Saxifraga lychnitis, Rhodiola himalensis, Sedum ewersii, Epilobium laxum, Pleurospermum candollei, Codonopsis ovata, Rhododendron anthopogon, Gaultheria trichophylla, Pedicularis pyramidata, Phlomis bracteosa, Nepeta laevigata, Polygonum affinis., Allium humile., Oxytropis cachemirianum, Paraquilegia microphylla* |

Over the decades, the rich and unique medicinal-plant flora of Kashmir Himalayas has been facing high degree of threat because of various anthropogenic and natural activities, due to which a large number of species are rendered threatened. Threats to MAPs operative in the Kashmir Himalayas include overgrazing, overharvesting for fodder, landslides/soil erosion, constructional activities in natural areas, flash floods, overexploitation for local use/overharvesting, cement factory dust, mining/stone quarrying, conversion of forests and grasslands into agricultural land, alien species invasion and huge tourist influx.

## 21.4 Concluding Remarks

The present chapter reveals that 833 plant species are used as medicinal and aromatic plants in this part of the Himalaya. Correct taxonomic identification and documentation of these MAPs and their bio-prospective value can provide baseline information about their traditional utilization, which has a great potential for regional development. The knowledge of scientific use of these resources for primary health care can prove helpful in creating awareness regarding sustainable utilization and conservation of this prized plant wealth. Various anthropogenic factors are seen to have rendered many of the MAPs as threatened. This highlights the importance of present review to consolidate work on scientific identification and documentation of MAPs of this region with a view to prepare an exhaustive database on this plant wealth which, in turn, is vital for creating mass awareness about these valued plants, together with their sustainable utilization and conservation. This baseline information is also very important as concerns among the developing countries about the emerging threats of bio-piracy and intensities of IPR controversies are increasing day by day. Thus, the need of the hour is to speedily document this valuable information of ethno-botany and diversity of the MAPs.

**Acknowledgments** Authors are thankful to the Head, Department of Botany, University of Kashmir for providing necessary facilities. We highly acknowledge the financial support provided by the UGC-New Delhi to the Department of Botany, University of Kashmir under Special Assistance Programme (SAP).

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# Chapter 22
# An Annotated Inventory of Arboreal Flora in Jammu and Kashmir State

**Akhtar H. Malik, Anzar A. Khuroo, Ghulam Hassan Dar, and Zafar S. Khan**

**Abstract** Arboreal or woody flora, as a surrogate of biota, is immensely useful for rapid assessment and monitoring of biodiversity in a region. The present chapter provides an annotated inventory of the arboreal flora of the state of Jammu and Kashmir in India, including both native and exotic species. At the present stage of investigation, the arboreal flora of the state comprises 768 species, belonging to 362 genera in 106 families. This flora includes 382 species which are exclusively wild-growing, 323 species are cultivated for different purposes, and 63 species are cultivated and grow in the wild as well. Growth form-wise, the trees, shrubs, sub-shrubs, and woody climbers are represented by 291, 364, 39, and 74 species, respectively. The three regions – Jammu, Kashmir, and Ladakh – contribute 561, 384, and 92 species, respectively, to the total arboreal flora of this Himalayan state.

**Keywords** Arboreal Flora · Inventory · Biodiversity · Documentation · Himalayas

## 22.1 Introduction

An annotated and updated inventory of biota has been recognized as the foundation stone for the development of global biodiversity information infrastructure (Khuroo et al. 2007a). This has assumed much significance in achieving the challenging goals of documentation, conservation, and sustainable use of biodiversity at the local, regional, and global scales (Dar et al. 2012, 2014). In view of this, world over, renewed research programmes have been initiated to document the biodiversity

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_22

occurring within different regions. The Indian Himalayan state of Jammu and Kashmir (J&K) is endowed with a rich plant biodiversity of immense scientific curiosity and huge economic potential (Singh et al. 1998; Dar et al. 2002; Malik et al. 2010, 2011, 2015; Dar and Khuroo 2013). The J&K state represents a unique biospheric unit in north-western extremity of the Himalayan range. Being an important region of the globally recognized biodiversity hotspot – the Himalayas – (Mittermeier et al. 2005; Zachos and Habel 2011), the biodiversity documentation in the state assumes immediate priority more so from the viewpoint of conservation and sustainable use of highly valued bioresources of the state.

Of the various components of floristic wealth in the state, those plant species that possess a woody habit – also called as arboreal species – represent one of the dominant elements. Historically, for J&K, it was Lambert's (1933) *List of Trees and Shrubs for Kashmir and Jammu Forest Circles* that first exclusively dealt with woody element of plant diversity. This work, carried out more than 84 years ago, did not include arboreal element from the Ladakh region, which forms more than 70% of the total land area of the state. Ara et al. (1995) documented the arboreal flora in Kashmir region, reporting 295 species of trees and shrubs (both indigenous and exotic), distributed over 120 genera in 60 families. Mughal et al. (2017) recently documented the arboreal flora in Poonch district, reporting 341 species of trees and shrubs, distributed over 180 genera in 78 families. Since then, the newly available taxonomic information and nomenclatural changes have necessitated an updated taxonomic inventory of this important component of biodiversity in the state.

In recent times, such types of taxonomic datasets of arboreal flora have gained immediate utility in biodiversity conservation and its sustainable use in the region. This is because, on one hand, expanding human enterprise has put a large number of arboreal species in the state, in particular forest trees and shrubs, under high risk of extinction due to habitat degradation and other unsustainable developmental activities (Kaul and Handoo 1998; Oza 2003); and, on the other hand, a large number of exotic arboreal species have been introduced for cultivation, many of which are now naturalizing in the wild (Khuroo et al. 2007b, 2010, 2011). Recently, Malik et al. (2010) have reported 521species of woody plants from J&K. Expanding further on this study, the present chapter provides an annotated inventory of the arboreal flora in this state, with particular focus on taxonomic composition, wild/cultivated status, diversity of growth forms, and regional distribution.

## 22.2 Materials and Methods

### *22.2.1 Study Area*

Phytogeographically, the state of J&K is divided into three distinct regions: the Jammu with more of tropical, subtropical, and temperate elements; the Kashmir with its characteristic temperate and alpine flora; and the cold-arid Ladakh showing predominance of alpine mesophytes, cold-desertic, and oasitic florisitic elements.

Whereas the Jammu region receives annual precipitation up to 1700 mm through the south-west monsoon, Kashmir receives about 1050 mm, mostly in the form of winter snow. The formidable walls of Trans-Himalayan ranges completely prevent rain clouds from entering the interior valleys of Ladakh, causing cold-arid climate with bare minimum precipitation of 100 mm per year (Hussain 2002).

### 22.2.2 Definitions and Terminology Used

In the present study, arboreal flora comprises of all those species that possess woody tissues along the plant body, wholly or partially (Khuroo et al. 2010). This flora includes different growthforms which are defined as follows: (i) tree (T) is a woody perennial plant, usually tall, with a single bole or trunk that bears a crown of branches; (ii) shrub (S) is a woody perennial plant generally smaller than a tree, and with several stems arising from ground level; (iii) sub-shrub (SS) is a low shrub, sometimes with partially herbaceous stem but with woody rootstock; and (iv) a woody climber (CL) is a plant with woody stem that grows upwards by twining round nearby plants and other support.

The evergreen or deciduous nature of all the woody plant species –- trees, shrubs, sub-shrubs and climbers has been documented. While the evergreen (E) are woody plant species that retain most of their leaves throughout the year, those where almost all the leaves fall off during the autumn have been referred to as the deciduous (D) plants. Thus, in all, the following eight growth forms along with abbreviations have been designated: deciduous tree (DT), evergreen tree (ET), deciduous shrub (DS), evergreen shrub (ES), deciduous sub-shrub (DSS), evergreen sub-shrub (ESS), deciduous climber (DCL), and evergreen climber (ECL).

In the present study, distribution of the arboreal flora was recognized based on the actual occurrence of each plant species in the state. Thus, the following categories were used: Jammu region only (J), Kashmir region only (K), Ladakh region only (L), Jammu and Kashmir regions (JK), Jammu and Ladakh regions (JL), Kashmir and Ladakh regions (KL), and all the three regions (JKL).

### 22.2.3 Data Sources

The present inventory of arboreal flora was arrived at based on the perusal of scattered floristic literature published over the last two centuries (see Coventry 1923–30; Blatter 1928–29; Lambert 1933; Javied 1968; Stewart 1972; Singh and Kachroo 1976; Kachroo et al. 1977; Sharma and Kachroo 1981; Dhar and Kachroo 1983; Polunin and Stainton 1984; Stainton 1988; Sharma and Jamwal 1988, 1998; Kapur and Sarin 1990; Ara et al. 1995; Swami and Gupta 1998; Dar and Christensen 2003;

Dar and Dar 2005,2006; Dar and Khan 2007; Chaurasia et al. 2007; Malik et al. 2010, 2012, 2015; Bhellum et al. 2013; Aslam et al. 2013, Dar and Malik 2017; Mughal et al. 2017; Dar and Malik 2017; Dvorsky et al. 2018; Akhter et al. 2013). The database so generated was enriched with ground truth data obtained during the extensive floristic surveys and field observations made by the authors over the last three decades. Authentication of the database was achieved by studying the herbarium specimens collected from three regions of the state and deposited in the University of Kashmir Herbarium (KASH) and **Janaki Ammal Herbarium** (RRLH) located at the Indian Institute of Integrative Medicine (IIIM), Jammu.

During the perusal of literature, original publications have been used to avoid the error of judgement by the previous workers. While assembling the database, the most time-consuming work was to determine correctness of those plant species reported by previous workers under different synonyms. In all such cases, latest nomenclatural changes have been incorporated to recognize the currently valid scientific names. Though cumbersome, such an effort has brought clarity to the confusing maze of synonyms, which often arbitrarily inflates the number of species. Nomenclature of taxa was corrected/updated using relevant taxonomic literature (Hooker 1872–1897; Stewart 1972; Sharma and Kachroo 1981–82) and online resources, such as various e-floras, International Plant Names Index (IPNI), Catalogue of Life, PlantList and GRIN. The resultant inventory of species in the database has been arranged in an alphabetical order.

## 22.3 Results and Discussion

At the present stage of investigation, the arboreal flora of the J&K state comprises of 768 species, distributed among 362 genera in 106 families (Table 22.1, Fig. 22.1). Nearly half of all these species (346 spp., 45.05%) belong to the first 10 largest families, a pattern similar to other temperate and Mediterranean regions of the Northern Hemisphere (Domínguez and Schwartz 2005; Lambdon et al. 2008). The remaining species (422 spp., 54.95%) are distributed among 96 families. Rosaceae is the largest family with 83 species, closely followed by Fabaceae with 79 species (Fig. 22.1). On the other extreme, there are 19 families that are represented by a single species each, for example, Coriariaceae (*Coriaria nepalensis*), Moringaceae (*Moringa oleifera*), Hamamelidaceae (*Parrotiopsis jacquemontiana*), and Taxaceae (*Taxus wallichiana*) (see Table 22.1).

Overall, 382 species are exclusively wild growing, while 323 species are cultivated for different purposes. In addition, there are 63 species that grow in the wild and are cultivated as well in the state, for example, *Acer negundo, Aesculus indica, Ailanthus altissima, Populus alba, Robinia pseudoacacia*, *Salix alba*, *Spartium junceum*, *Sapium sebiferum*, etc.

**Table 22.1** Inventory of arboreal flora in Jammu and Kashmir state

| S. No. | Scientific name of species | Family | Wild/Cultivated[a] | Growth-form[a] | Distribution[a] | Data sources[b] |
|---|---|---|---|---|---|---|
| 1 | *Abelia × grandiflora* Rehder | Caprifoliaceae | CL | DS | K | 14,17 |
| 2 | *Abelia triflora* R. Br. ex Wall. | Caprifoliaceae | WL | DS | JK | 3,4,12,18 |
| 3 | *Abies pindrow* Royle | Pinaceae | WL | ET | JK | 2,3,8,10,12,18,23 |
| 4 | *Abies spectabilis* (D. Don) Mirb. | Pinaceae | WL | ET | JK | 2,3,8,10,19 |
| 5 | *Abrus precatorius* L. | Fabaceae | WL | DCL | J | 4,10,12,19 |
| 6 | *Abutilon bidentatum* Hochst. ex A. Rich. | Malvaceae | CL | DS | J | 1,4,18 |
| 7 | *Abutilon × hybridum* Voss | Malvaceae | CL | ES | K | 17 |
| 8 | *Abutilon indicum* (L.) Sweet | Malvaceae | CL | DSS | J | 3,4,10, 11,18 |
| 9 | *Abutilon pictum* (Gillies ex Hook.) Walp. | Malvaceae | CL | DSS | J | 15 |
| 10 | *Abutilon ramosum* Guill. | Malvaceae | CL | DSS | J | 3,4,10,18 |
| 11 | *Acacia auriculiformis* Benth. | Fabaceae | CL | DT | J | 15,19,21 |
| 12 | *Acacia catechu* (Linn. f.) Willd. | Fabaceae | WL | DT | J | 3,4,10,11,19 |
| 13 | *Acacia farnesiana* (L.) Willd. | Fabaceae | WL | DS | J | 1,4,10,18 |
| 14 | *Acacia jacquemontii* Benth. | Fabaceae | WL | DS | J | 19 |
| 15 | *Acacia modesta* Wall. | Fabaceae | WL | DT | J | 3,4,10,11,18,19 |
| 16 | *Acacia nilotica* (L.) Del. | Fabaceae | WL | DT | J | 4,10,11,18,19 |
| 17 | *Acacia torta* (Roxb.) Craib. | Fabaceae | WL | DCL | J | 3,10,18 |
| 18 | *Acacia seyal* Delile | Fabaceae | WL | DT | J | 19 |
| 19 | *Acer acuminatum* Wall. | Sapindaceae | WL | DT | JK | 1,9,12,18 |
| 20 | *Acer caesium* Wall. ex Brandis | Sapindaceae | WL | DT | JK | 1,4,9,12,18,19,23 |
| 21 | *Acer cappadocicum* Gled. | Sapindaceae | CW | DT | JK | 1,3,11 |
| 22 | *Acer negundo* L. | Sapindaceae | CW | DT | JK | 11,14,18 |
| 23 | Acer oblongum Wall. | Sapindaceae | WL | DT | J | 1,4,12,19 |
| 24 | *Acer palmatum* Thunb. | Sapindaceae | CL | DT | K | 14,17 |
| 25 | *Acer pentapomicum* J. L. Stewart | Sapindaceae | WL | DT | J | 1,4,12 |

(continued)

**Table 22.1** (continued)

| S. No. | Scientific name of species | Family | Wild/Cultivated[a] | Growth-form[a] | Distribution[a] | Data sources[b] |
|---|---|---|---|---|---|---|
| 26 | *Actinidia chinensis* Planch | Actinidiaceae | CL | DS | K | 17 |
| 27 | *Aegle marmelos* (L) Correa | Rutaceae | WL | DT | J | 3,4,10,11,18,19,21 |
| 28 | *Aesculus indica* (Wall. ex Comb.) Hk. f. | Sapindaceae | CW | DT | JK | 3,4,10,11,18,19 |
| 29 | *Aeschynomene aspera* Linn., | Fabaceae | CL | DS | J | 21 |
| 30 | *Agave americana* L. | Asparagaceae | CL | ES | K | 17 |
| 31 | *Agave vivipara* L. | Asparagaceae | CL | ES | J | 21 |
| 32 | *Ailanthus altissima* (Mill.) Swingle | Simaroubaceae | CW | DT | JK | 1,2,3,4,11,19,21 |
| 33 | *Alangium chinense* (Lour.) Harms | Cornaceae | CL | DT | J | 19 |
| 34 | *Albizia julibrissin* Durazz. | Fabaceae | CL | DT | JK | 2,3,18,19 |
| 35 | *Albizia julibrissin* var. *mollis* (Wall.) Benth. | Fabaceae | WL | DT | J | 19 |
| 36 | *Albizia lebbeck* (L.) Benth. | Fabaceae | WL | DT | J | 4,10,11,19,21 |
| 37 | *Albizia odoratissima* (L. f.) Benth. | Fabaceae | WL | DT | J | 3,4,10,19 |
| 38 | *Alnus nitida* (Spach) Endl. | Betulaceae | WL | DT | JK | 1,3,4,12,19 |
| 39 | *Aloysia citriodora* Palau | Verbenaceae | CL | DS | K | 17 |
| 40 | *Alstonia scholaris* (L.) R.Br. | Apocynaceae | WL | ET | J | 19 |
| 41 | *Amorpha fruticosa* L. | Fabaceae | CL | DS | K | 2,17,18 |
| 42 | *Ampelocissus latifolia* (Roxb.) Planch. | Vitaceae | WL | DCL | J | 3,10,18 |
| 43 | *Ampelocissus jacquemontii* Raizada | Vitaceae | WL | DCL | J | 10,18 |
| 44 | *Ampelopsis vitifolia* subsp. *vitifolia* Planch. | Vitaceae | WL | DCL | K | 2,3,18 |
| 45 | *Anogeissus latifolia* Wall. | Combretaceae | WL | DT | J | 1,15 |
| 46 | *Antidesma acidum* Retz. | Phyllanthaceae | WL | DS(-DT) | J | 4,10,12 |
| 47 | *Antigonon leptopus* Hook. & Arn. | Polygonaceae | WL | DCL | J | 19 |
| 48 | *Aralia cachemirica* Decne. | Araliaceae | WL | DSS | K | 1,3,14 |
| 49 | *Araucaria heterophylla* Franco | Araucariaceae | CL | ET | K | 14,17,18 |
| 50 | *Araucaria columnaris* (G.Forst.) Hook. | Araucariaceae | CL | ET | J | 19 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 51 | *Araucaria cunninghamii* Mudie | Araucariaceae | CL | ET | J | 21 |
| 52 | *Argyreia nasirii* D. F. Austin | Convolvulaceae | WL | DCL | J | 4 |
| 53 | *Aristolochia punjabensis* Lace | Aristolochiaceae | CL | DCL | J | 19 |
| 54 | *Artabotrys hexapetalus* (L.f.) Bhandari | Annonaceae | CL | ECL | J | 15,18 |
| 55 | *Asclepias curassavica* L. | Apocynaceae | WL | ESS | J | 19 |
| 56 | *Asparagus adscendens* Roxb. | Asparagaceae | CL | DSS | J | 4,10,18,21 |
| 57 | *Asparagus asiaticus* L. | Asparagaceae | CL | DSS | J | 3,4,18 |
| 58 | *Aspidopterys wallichii* Hook. f. | Malpighinaceae | WL | ECL | J | 3,4,10 |
| 59 | *Astragalus chlorostachys* Lind. | Fabaceae | WL | DSS | JK | 2,3,4,19 |
| 60 | *Astragalus grahamianus* Benth. | Fabaceae | WL | DSS | JK | 2,3,18,23 |
| 61 | *Astragalus oplites* Benth. ex Parker | Fabaceae | WL | DSS | L | 3,18,22 |
| 62 | *Astragalus rhizanthus* subsp. *candolleanus* (Benth.) Podlech | Fabaceae | WL | DSS | KL | 2,3,4,5,12,22 |
| 63 | *Astragalus stewartii* Baker | Fabaceae | WL | DSS | K | 3,18 |
| 64 | *Astragalus zanskarensis* Benth. ex Bunge | Fabaceae | WL | DSS | L | 3,5,18 |
| 65 | *Aucuba japonica* Thunb. | Garryaceae | CL | ES | K | 17 |
| 66 | *Azadirachta indica* A. Juss. | Meliaceae | CL | DT | J | 3,4,11,12 |
| 67 | *Baliospermum solanifolium* Suresh | Euphorbaceae | WL | DS | J | 19 |
| 68 | *Bambusa bambos* (L.)Voss | Poaceae | CL | DT | J | 19 |
| 69 | *Barleria cristata* L. | Acanthaceae | WL | DSS | J | 21 |
| 70 | *Barleria prionitis* L. | Acanthaceae | CL | DS | J | 1,4,18 |
| 71 | *Beaucarnea gracilis* Lem. | Asparagaceae | CL | DT | J | 21 |
| 72 | *Bauhinia purpurea* L. | Fabaceae | CL | DT | J | 15,18,19 |
| 73 | *Bauhinia vahlii* Wt. & Arn. | Fabaceae | CL | ECL | J | 3,4,11 |
| 74 | *Bauhinia variegata* L. | Fabaceae | CL | DT | J | 4,11,18,19,21 |
| 75 | *Berberis aquifolium* Pursh | Berberidaceae | CL | ES | K | 17 |
| 76 | *Berberis aristata* DC. | Berberidaceae | WL | DS | JK | 3,18,19 |

(continued)

**Table 22.1** (continued)

| S. No. | Scientific name of species | Family | Wild/Cultivated[a] | Growth-form[a] | Distribution[a] | Data sources[b] |
|---|---|---|---|---|---|---|
| 77 | *Berberis calliobotrys* Aitch. ex Koehne | Berberidaceae | WL | DS | K | 3,18 |
| 78 | *Berberis chitria* Lindl. | Berberidaceae | WL | DS | K | 3,18 |
| 79 | *Berberis glaucocarpa* Stapf | Berberidaceae | WL | DS | J | 3,18 |
| 80 | *Berberis huegeliana* C.K.Schn. | Berberidaceae | WL | DS | K | 3,18 |
| 81 | *Berberis jaeschkeana* var. *jaeschkeana* | Berberidaceae | WL | DS | JK | 3,4,12,19 |
| 82 | *Berberis kashmirana* Ahrendt | Berberidaceae | WL | DS | K | 3,18 |
| 83 | *Berberis kunawurensis* Royle | Berberidaceae | WL | DS | JK | 3,4,12,16 |
| 84 | *Berberis lycium* Royle | Berberidaceae | WL | ES | JK | 1,4,6,11,12,,19,23 |
| 85 | *Berberis orthobotrys* subsp. *capitata* Jafri, | Berberidaceae | WL | DS | K | 3,4,18 |
| 86 | *Berberis orthobotrys* subsp. *orthobotrys* | Berberidaceae | WL | DS | K | 3,4,18 |
| 87 | *Berberis pachyacantha* subsp. *pachyacantha* | Berberidaceae | WL | DS | JKL | 1,3,5,19 |
| 88 | *Berberis pachyacantha* subsp. *zabeliana* (C.K.Schneid.) Jafri | Berberidaceae | WL | DS | K | 3,16 |
| 89 | *Berberis parkeriana* Schneid | Berberidaceae | WL | DS | JK | 3,15 |
| 90 | *Berberis pseudumbellata* subsp. *pseudumbella* | Berberidaceae | WL | DS | JK | 3,18 |
| 91 | *Berberis royleana* Ahr. | Berberidaceae | WL | DS | K | 3 |
| 92 | *Berberis thunbergii* DC. | Berberidaceae | CL | DS | K | 17 |
| 93 | *Berberis ulicina* Hook. f. & Thom. | Berberidaceae | WL | DS | L | 3,5,16 |
| 94 | *Betula alnoides* Buch.-Ham. ex D. Don | Betulaceae | WL | DT | J | 19 |
| 95 | *Betula utilis* D. Don. | Betulaceae | WL | DT | JKL | 1,3,4,5,12,19,23 |
| 96 | *Betula utilis* var. *jacquemontii* (Spach) H.J.P.Winkl. | Betulaceae | WL | DT | L | 22 |
| 97 | *Boehmeria macrophylla* Hornem. | Urticaceae | CW | DSS | J | 3,4,10,11 |
| 98 | *Bombax ceiba* L. | Malvaceae | WL | DT | J | 4,6,11,19,21 |
| 99 | *Bosea amherstiana* (Moq.) Hook.f. | Amaranthaceae | WL | DS | J | 19 |
| 100 | *Bougainvillea glabra* Choisy | Nyctaginaceae | CL | DCL | J | 1,15 |

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|---|---|---|---|---|---|---|
| 101 | *Bougainvillea spectabilis* Willd. | Nyctaginaceae | CL | DCL | J | 1,15,19, 21 |
| 102 | *Brunfelsia pauciflora* (Cham. & Schltdl.) Benth. | Solanaceae | CL | ES | K | 17 |
| 103 | *Broussonetia papyrifera* L'Hér. ex Vent | Moraceae | CL | DT | J | 19,21 |
| 104 | *Bridelia retusa* (L.) Spreng. | Phyllanthaceae | WL | DT | J | 3,4,12 |
| 105 | *Bridelia verrucosa* Haines | Phyllanthaceae | WL | DT | J | 3,4,12 |
| 106 | *Brucea javanica* (L.) Merr. | Simaroubaceae | WL | DS | J | 6,15 |
| 107 | *Brugmansia suaveolens* (Humb. & Bonpl. ex Willd.) Bercht. & J.Presl | Solanaceae | CL | DS | J | 21 |
| 108 | *Buddleja asiatica* Lour. | Scrophulariaceae | CL | DS | JK | 2,4,11,19,21 |
| 109 | *Buddleja crispa* Benth. | Scrophulariaceae | CW | DS | JK | 2,3,11,19 |
| 110 | *Buddleja davidii* Franch | Scrophulariaceae | CW | DS | K | 2,17,18 |
| 111 | *Buddleja paniculata* Wall. | Scrophulariaceae | WL | DS | J | 19 |
| 112 | *Butea monosperma* (Lam.) Taub. | Fabaceae | WL | DT | J | 3,4,10,12,18,19 |
| 113 | *Buxus wallichiana* Baill. | Buxaceae | WL | ET | J | 3,12,18, 19,21 |
| 114 | *Buxus sempervirens* L. | Buxaceae | CL | ES(-ET) | K | 14,17,18 |
| 115 | *Caesalpinia bonduc* (L.) Roxb. | Fabaceae | CW | DS | J | 4,11,18 |
| 116 | *Caesalpinia decapetala* Alston | Fabaceae | WL | DS | J | 19 |
| 117 | *Cajanus mollis* (Benth.) Maesen | Fabaceae | WL | DCL | J | 3,4,11,12 |
| 118 | *Callicarpa macrophylla* Vahl | Lamiaceae | WL | DS | J | 3,10,18,19 |
| 119 | *Callistemon citrinus* (Curtis) Skeels | Myrtaceae | CL | ET | JK | 15,17,19 |
| 120 | *Callistemon viminalis* (Sol. ex Gaertn.) G.Don | Myrtaceae | CL | ET | J | 21 |
| 121 | *Calotropis acia* Buch.-Ham. | Apocynaceae | WL | ES | J | 15 |
| 122 | *Calotropis gigantea* (L.) Dryand. | Apocynaceae | WL | ES | J | 15 |
| 123 | *Calotropis procera* (Willd.) R. Br. | Apocynaceae | CW | ES | J | 4,11,18,19,21 |

(continued)

**Table 22.1** (continued)

| S. No. | Scientific name of species | Family | Wild/Cultivated[a] | Growth-form[a] | Distribution[a] | Data sources[b] |
|---|---|---|---|---|---|---|
| 124 | *Camellia japonica* L. | Theaceae | CL | ES | K | 17 |
| 125 | *Campsis radicans* Seem. | Bignoniaceae | CL | DCL | K | 2,17,18 |
| 126 | *Campsis × tagliabuana* (Vis.) Rehder | Bignoniaceae | CL | DCL | K | 17 |
| 127 | *Campylotropis eriocarpa* (DC.) Schindl. | Fabaceae | WL | DS | K | 3,12,18 |
| 128 | *Campylotropis macrostyla* (D.Don) Miq. | Fabaceae | WL | DS | J | 11,18,21 |
| 129 | *Campylotropis meeboldii* (Schindl.) Schindl. | Fabaceae | WL | DS | K | 3 |
| 130 | *Campylotropis stenocarpa* (Klotzsch) Schindl. | Fabaceae | WL | DS | K | 3 |
| 131 | *Capparis decidua* (Forssk.) Edgew. | Capparaceae | WL | DS | J | 3,18 |
| 132 | *Capparis sepiaria* L. | Capparaceae | WL | ES | J | 4,11 |
| 133 | *Capparis spinosa* L. | Capparaceae | WL | DS | L | 3,5,12,22 |
| 134 | *Caragana brevifolia* Kom. | Fabaceae | WL | DS | KL | 3,18 |
| 135 | *Caragana brevispina* Benth. var.*brevispina* | Fabaceae | WL | DS | JK | 1,2,3,12,18,19 |
| 136 | *Caragana gerardiana* Benth. | Fabaceae | WL | DS | J | 19 |
| 137 | *Caragana versicolor* (Wall.) Benth. | Fabaceae | WL | DS | JKL | 3,5,18,19, 22 |
| 138 | *Carica papaya* L. | Caricaceae | CL | DT | J | 15,19 |
| 139 | *Carissa carandas* Linn | Apocynaceae | WL | ES | J | 15 |
| 140 | *Carissa spinarum* L. | Apocynaceae | WL | ES | JK | 1,3,4,11,19,21 |
| 141 | *Carpinus viminea* Wall. ex Lindl | Betulaceae | WL | DT | K | 3,18 |
| 142 | *Carya illinoinensis* (Wangenh.) K.Koch | Juglandaceae | CL | DT | JK | 15,19,21 |
| 143 | *Casearia tomentosa* Roxb. | Salicaceae | WL | DT | J | 4,10,11,19 |
| 144 | *Cascabela thevetia* (L.) Lippold | Apocynaceae | CL | ET | J | 19,21 |
| 145 | *Cassia fistula* L. | Fabaceae | WL | DT | J | 4,11,19,21 |
| 146 | *Cassia floribunda* Collad. | Fabaceae | CL | DT | J | 19 |
| 147 | *Cassia javanica* L. | Fabaceae | CL | DT | JK | 15 |
| 148 | *Cassine glauca* (Rottb.) Kuntze | Celastraceae | WL | ET | J | 2,3,4,18 |

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|---|---|---|---|---|---|---|
| 149 | *Cassiope fastigiata* (Wall.) D. Don | Ericaceae | WL | ESS | JK | 3,12,19,23 |
| 150 | *Castanea sativa* Mill. | Fagaceae | CL | DT | K | 1,2,18 |
| 151 | *Casuarina equisetifolia* Forst. | Casuarinaceae | CL | DT | J | 3,18 |
| 152 | *Catharanthus roseus* (L.) G.Don | Apocynaceae | CL | ESS | J | 21 |
| 153 | *Catalpa bignonioides* Walt. | Bignoniaceae | CL | DT | JK | 2,14,17,19 |
| 154 | *Catunaregam spinosa* (Thunb.) Tirveng. | Rubiaceae | WL | DT(-DS) | J | 3,4,11,18 |
| 155 | *Cayratia trifolia* (L.) Domin | Vitaceae | CL | DCL | J | 19 |
| 156 | *Ceanothus thyrsiflorus* Eschw. | Rhamnaceae | CL | ES | K | 17 |
| 157 | *Cedrela serrata* (Royle) M. Roem. | Meliaceae | WL | DT | JK | 3,10,11,12,18 |
| 158 | *Cedrus deodara* (Roxb.) G. Don | Pinaceae | WL | ET | JK | 3,10,11,12,19,23 |
| 159 | *Ceiba speciosa* (A.St.-Hil.) Ravenna (*Chorisia speciosa*) | Malvaceae | CL | DT | J | 15,19,21 |
| 160 | *Celastrus paniculatus* Willd. | Celastraceae | CW | DCL | JK | 1,3,4,11,12,17 |
| 161 | *Celtis australis* L. (incl. *C. eriocarpa*) | Cannabaceae | WL | DT | JK | 1,2,3,4,10,19,23 |
| 162 | *Celtis tetrandra* Roxb. | Cannabaceae | WL | DT | J | 19 |
| 163 | *Cercis siliquastrum* L. | Fabaceae | CL | DT | K | 2,14,17 |
| 164 | *Chaenomeles speciosa* (Sweet) Nakai | Rosaceae | CL | DS | K | 2,14,18 |
| 165 | *Cestrum diurnum* L. | Solanaceae | CL | ET | J | 21 |
| 166 | *Cestrum nocturnum* L. | Solanaceae | CL | ET | J | 19 |
| 167 | *Chamaerops humilis* L. | Arecaceae | CL | ET | K | 17 |
| 168 | *Chimonanthus praecox* (L.) Link | Calycanthaceae | CL | DS | K | 17 |
| 169 | *Cissampelos pareira* L. | Menispermaceae | CL | DCL | J | 3,4,10,11,19 |
| 170 | *Citrus aurantiifolia* Swingle | Rutaceae | CL | ET | J | 19 |
| 171 | *Citrus maxima* (Burm.) Merr. | Rutaceae | CL | ET | J | 19 |
| 172 | *Citrus medica* L. | Rutaceae | CL | ES(-ET) | J | 19 |
| 173 | *Citrus reticulata* Blanco | Rutaceae | CL | ET | JK | 3,18,19 |
| 174 | *Citrus sinensis* Osback | Rutaceae | CL | ET | JK | 3,17,18,19 |

(continued)

**Table 22.1** (continued)

| S. No. | Scientific name of species | Family | Wild/Cultivated[a] | Growth-form[a] | Distribution[a] | Data sources[b] |
|---|---|---|---|---|---|---|
| 175 | *Citrus trifoliata* L. | Rutaceae | CL | ES | JK | 17,18 |
| 176 | *Clematis buchananiana* DC. | Ranunculaceae | WL | DCL | JK | 2,3,10,11,12,19 |
| 177 | *Clematis connata* DC. | Ranunculaceae | WL | DCL | JK | 3,4,10,11,12,18,19 |
| 178 | *Clematis gouriana* Roxb. | Ranunculaceae | CL | DCL | JK | 4,10,11,12,18,19 |
| 179 | *Clematis grata* Wall. | Ranunculaceae | WL | DCL | JK | 2,3,4,10,12,18,19 |
| 180 | *Clematis graveolens* Lind. | Ranunculaceae | WL | DCL | JK | 2,3,10,11,12,19 |
| 181 | *Clematis montana* Buch. -Ham. ex DC. | Ranunculaceae | WL | DCL | JK | 10,11,18 |
| 182 | *Clematis orientalis* L. | Ranunculaceae | WL | DCL | L | 5,18,19,21,22 |
| 183 | *Clematis puberula* Hk. f. & T. | Ranunculaceae | WL | DCL | J | 3,10,11,18,19 |
| 184 | *Clematis tangutica* (Maxim.) Korsh. | Ranunculaceae | WL | DCL | L | 22 |
| 185 | *Clematis tibetana* Kuntze | Ranunculaceae | WL | DCL | L | 5,18 |
| 186 | *Clematis* x *jackmanii* T. Moore | Ranunculaceae | CL | DCL | K | 17 |
| 187 | *Clerodendrum chinense* (Osbeck) Mabb. | Lamiaceae | CL | DS | J | 10,18,19 |
| 188 | *Cocculus laurifolius* DC. | Menispermaceae | CL | ES | J | 3,10,11 |
| 189 | *Cocculus pendulus* (J.R. & G. Forst.) Diels | Menispermaceae | WL | ES | J | 3,18 |
| 190 | *Codariocalyx motorius* (Houtt.) H.Ohashi | Fabaceae | WL | DSS | J | 4,10,11 |
| 191 | *Colebrookea oppositifolia* Smith | Lamiaceae | WL | DS | J | 4,10,11,21,19 |
| 192 | *Combretum indicum* (L.) DeFilipps | Combretaceae | CL | DCL | J | 15 |
| 193 | *Cordia dichotoma* Forst. | Boraginaceae | CL | DT | J | 4,18,19 |
| 194 | *Cordia gharaf* Ehrenb. ex Asch. | Boraginaceae | WL | DT | J | 4,18 |
| 195 | *Cordia myxa* L. | Boraginaceae | CW | DT | JK | 4,6,18,19,21 |
| 196 | *Cordia vestita* Hook. F & Thoms. | Boraginaceae | WL | DT | K | 1,2,18 |
| 197 | *Coriaria nepalensis* Wall. | Coriaraceae | WL | DS | JK | 3,14,19 |
| 198 | *Corylus ferox* Wall. | Betulaceae | WL | DT | K | 1,2,18 |
| 199 | *Corylus jacquemontii* Dcne. | Betulaceae | WL | DT | JK | 3,14,18 |

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|---|---|---|---|---|---|---|
| 200 | *Cornus macrophylla* Wall. | Cornaceae | WL | ET | J | 19 |
| 201 | *Cornus oblonga* Wall. | Cornaceae | WL | ES | J | 19 |
| 202 | *Corymbia citriodora* K.D.Hill & L.A.S.Joh. | Myrtaceae | CL | DT | J | 15,19 |
| 203 | *Cotinus coggygria* Scop. | Anacardiaceae | CL | DS | JK | 3,6,11,18,19 |
| 204 | *Cotoneaster acuminatus* Lindl. | Rosaceae | WL | DS | KL | 3,5,12,18 |
| 205 | *Cotoneaster affinis* Lindl. | Rosaceae | WL | DS | JL | 5,10,18,19,22 |
| 206 | *Cotoneaster bacillaris* Wall. ex Lindl. | Rosaceae | WL | DS | K | 3 |
| 207 | *Cotoneaster aitchisonii* Schneid. | Rosaceae | WL | DS | K | 2,18 |
| 208 | *Cotoneaster frigidus* Wall. ex Lindl. | Rosaceae | WL | DS | K | 2,18 |
| 209 | *Cotoneaster humilis* Dunn. | Rosaceae | WL | DS | JK | 2,3,4,12 |
| 210 | *Cotoneaster integerrimus* Medik. | Rosaceae | WL | DS | L | 2,3,5,12 |
| 211 | *Cotoneaster microphyllus* Wall. ex Lindl. | Rosaceae | WL | ES | JK | 3,4,2,12,18,19,23 |
| 212 | *Cotoneaster minuta* Saporta | Rosaceae | WL | DS | K | 2,3,18 |
| 213 | *Cotoneaster nummularius* Fisch. & C.A. Mey. | Rosaceae | WL | DS | JKL | 2,3,4,5,12,18,23 |
| 214 | *Cotoneaster obovata* Wall.ex Dunn | Rosaceae | WL | DS | K | 2,3 |
| 215 | *Cotoneaster rosea* Edgew. | Rosaceae | WL | DS | K | 1,2,3,12,18 |
| 216 | *Crataegus laevigata* (Poir.) DC. | Rosaceae | CL | DT | K | 17 |
| 217 | *Crataegus songarica* C. Koch. | Rosaceae | WL | DT | JK | 1,2,3,12,18,23 |
| 218 | *Crateva adansonii* DC. | Capparaceae | CL | DT | J | 3,4,18 |
| 219 | *Crotalaria spectabilis* Roth. | Fabaceae | CW | DSS | J | 3,10,11,18 |
| 220 | *Cryptolepis dubia* (Burm.f.) M.R.Almeida | Apocynaceae | WL | DCL | J | 4,11,18,19 |
| 221 | *Cryptomeria japonica* (Thunb. ex L.f.) D.Don | Taxodiaceae | CL | ET | K | 2,8,17,18 |
| 222 | *Cuphea hyssopifolia* Kunth | Lythraceae | CL | ESS | J | 21 |
| 223 | *Cupressus arizonica* Greene | Cupressaceae | CL | ET | K | 2,8,18 |
| 224 | *Cupressus funebris* Endl. | Cupressaceae | CL | ET | J | 15,17 |
| 225 | *Cupressus cashmeriana* Royle ex Carrière | Cupressaceae | CL | ET | K | 2,8,17,18 |
| 226 | *Cupressus gigantea* W.C.Cheng & L.K.Fu | Cupressaceae | CL | ET | J | 21 |

(continued)

**Table 22.1** (continued)

| S. No. | Scientific name of species | Family | Wild/Cultivated[a] | Growth-form[a] | Distribution[a] | Data sources[b] |
|---|---|---|---|---|---|---|
| 227 | *Cupressus sempervirens* L. | Cupressaceae | CL | ET | JK | 8,17,19 |
| 228 | *Cupressus torulosa* D. Don | Cupressaceae | CL | ET | JK | 2,3,8,14,18,19 |
| 229 | *Cycas revoluta* Thunb. | Cycadaceae | CL | ES | JK | 3,17,18,19 |
| 230 | *Cydonia oblonga* Mill. | Rosaceae | CL | DT | JK | 2,3,4,14,18,19 |
| 231 | *Dalbergia sissoo* Roxb. | Fabaceae | CW | DT | J | 2,3,10,11 |
| 232 | *Daphne mucronata* Royle, | Thymelaeaceae | WL | ES | JK | 3,4,10,11,19 |
| 233 | *Daphne papyracea* Wall. ex W.W.Sm. & Cave | Thymelaeaceae | WL | ES | JK | 2,4,18,19 |
| 234 | *Debregeasia saeneb* Hepper & J.R.I.Wood | Urticaceae | WL | ES | J | 3,4,10,11,18,19,21 |
| 235 | *Dendrocalamus strictus* Nees | Poaceae | CL | DT | J | 19,21 |
| 236 | *Dendrophthoe falcata* Ettingsh. | Loranthaceae | CL | DS | J | 19 |
| 237 | *Deeringia amaranthoides* (Lam.) Merr. | Amaranthaceae | CL | DS | J | 4,18 |
| 238 | *Delonix regia* (Hook.) Raf. | Fabaceae | CL | DT | J | 15,18 |
| 239 | *Desmodium elegans* DC. | Fabaceae | WL | DS | JK | 2,3,10,19 |
| 240 | *Desmodium multiflorum* DC. | Fabaceae | WL | DS | J | 19 |
| 241 | *Desmodium laxiflorum* DC. | Fabaceae | WL | DS | JK | 15,18,19 |
| 242 | *Desmodium velutinum* (Willd.) DC. | Fabaceae | WL | DSS | J | 4,10,11,18 |
| 243 | *Deutzia corymbosa* R.Br. ex G.Don | Hydrangeaceae | WL | DS | J | 1,3,19 |
| 244 | *Deutzia campacta* Craib. | Hydrangeaceae | CL | DS | J | 10,11,18 |
| 245 | *Deutzia gracilis* Siebold & Zucc. | Hydrangeaceae | CL | DS | K | 14 |
| 246 | *Deutzia* × *magnifica* (Lemoine) Rehder | Hydrangeaceae | CL | DS | K | 2,17,18 |
| 247 | *Deutzia staminea* R. Br. ex Wall. | Hydrangeaceae | WL | DS | JK | 1,3,4,10,11,18,19 |
| 248 | *Dictamnus albus* L. | Rutaceae | WL | DS | K | 3,4,18 |
| 249 | *Diospyros kaki* L. | Ebenaceae | CL | DT | JK | 3,17,19 |
| 250 | *Diospyros lotus* L. | Ebenaceae | WL | DT | JK | 3,14,15,18,19 |
| 251 | *Diospyros montana* Roxb. | Ebenaceae | WL | DT | J | 1,3,14,15 |

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|---|---|---|---|---|---|---|
| 252 | *Dodonaea viscosa* Jacq. | Sapindaceae | CW | ES | J | 3,4,10,11,18,19,21 |
| 253 | *Dolichandra unguis-cati* G.Lohmann | Sapindaceae | CL | DCL | J | 19 |
| 254 | *Drepanostachyum falcatum* (Nees) Keng f. | Poaceae | CL | ES | J | 21 |
| 255 | *Dombeya burgessiae* Gerrard ex Harv. & Sond. | Malvaceae | CL | ES | J | 14,15,18 |
| 256 | *Duranta erecta* L. | Verbenaceae | WL | DS | J | 15,19,21 |
| 257 | *Ehretia acuminata* R.Br. | Boraginaceae | CW | DT | J | 1,3,4,11,18 |
| 258 | *Ehretia laevis* Roxb. | Boraginaceae | WL | DT | J | 3,4,18 |
| 259 | *Elaeagnus angustifolia* L. | Elaeagnacaeae | CW | DT | JK | 2,3,10,18 |
| 260 | *Elaeagnus parvifolia* Wall. ex Royle | Elaeagnacaeae | WL | DS | JKL | 3,4,6,5,11 |
| 261 | *Elaeagnus umbellata* Thunb. | Elaeagnacaeae | WL | DT(-DS) | JK | 3,12,19,21 |
| 262 | *Embelia robusta* Roxb. | Primulaceae | WL | DS | J | 3,4,10 |
| 263 | *Ephedra gerardiana* Wall. ex Stapf | Ephedraceae | WL | ES | JKL | 3,12,5,22 |
| 264 | *Ephedra intermedia* Schrenk & Mey. | Ephedraceae | WL | ES | L | 3,12,18,22 |
| 265 | *Ephedra regeliana* Florin | Ephedraceae | WL | ES | L | 3,18,22 |
| 266 | *Eranthemum pulchellum* Andr. | Acanthaceae | WL | ES | J | 1,4,18,19 |
| 267 | *Eriobotrya japonica* (Thunb.) Lindl. | Rosaceae | CL | ET | JK | 2,10,14,19 |
| 268 | *Erythrina suberosa* Roxb. | Fabaceae | CL | DT | J | 3,12,18 |
| 269 | *Eucalyptus alba* Reinw. ex Blume | Myrtaceae | CL | DT | J | 1,18 |
| 270 | *Eucalyptus globulus* Labbil. | Myrtaceae | CL | DT | J | 15,21 |
| 271 | *Eucalyptus tereticornis* Smith | Myrtaceae | CL | DT | J | 15 |
| 272 | *Euonymus echinatus* Wall. | Celastraceae | WL | ECL | J | 3,4,12,18 |
| 273 | *Euonymus europaeus* L. | Celastraceae | CL | DT | J | 19 |
| 274 | *Euonymus fimbriatus* Wall. | Celastraceae | WL | DT | JK | 1,2,3,18 |
| 275 | *Euonymus fortunei* (Turcz.) Hand.-Mazz. | Celastraceae | CL | ES | K | 17 |
| 276 | *Euonymus hamiltonianus* Wall. | Celastraceae | WL | ET | JK | 1,2,3,4,12,18,19 |
| 277 | *Euonymus japonicus* Thunb. | Celastraceae | CL | ET(-ES) | JK | 2,14,17,18 |
| 278 | *Euonymus lucidus* D.Don | Celastraceae | WL | ET | J | 3 |

(continued)

**Table 22.1** (continued)

| S. No. | Scientific name of species | Family | Wild/Cultivated[a] | Growth-form[a] | Distribution[a] | Data sources[b] |
|---|---|---|---|---|---|---|
| 279 | *Euphorbia pulcherrima* Willd. ex Klotzsch | Euphorbiaceae | CL | DS | J | 15,18 |
| 280 | *Euphorbia royleana* Boiss. | Euphorbiaceae | WL | DS | J | 4,10,11,12 |
| 281 | *Euphorbia tirucalli* L. | Euphorbiaceae | CL | DS | J | 15,18 |
| 282 | *Fatsia japonica* Decne. & Planch. | Araliaceae | CL | ES | K | 2,17,18 |
| 283 | *Fagus sylvatica* L. | Fagaceae | CL | DT | K | 17 |
| 284 | *Ficus auriculata* Lour. | Moraceae | WL | ES(-ET) | J | 19,21 |
| 285 | *Ficus benghalensis* L. | Moraceae | CL | ET | J | 4,10,11,12,18,19 |
| 286 | *Ficus benjamina* L. | Moraceae | CW | ES(-ET) | J | 19,21 |
| 287 | *Ficus carica* L. | Moraceae | CW | DT | JK | 2,4,10,18 |
| 288 | *Ficus elastica* Roxb. ex Hornem. | Moraceae | WL | ET | J | 19 |
| 289 | *Ficus hispida* L. f. | Moraceae | CW | DT | JK | 2,3,4,12,18 |
| 290 | *Ficus neriifolia* Sm. | Moraceae | CW | ET | J | 19 |
| 291 | *Ficus palmata* Forssk. | Moraceae | CW | DT | JK | 3,4,10,11,12,19,21 |
| 292 | *Ficus pumila* L. | Moraceae | CW | ECL | J | 19,21 |
| 293 | *Ficus racemosa* L. | Moraceae | WL | ET | J | 3,4,10,11,12,21 |
| 294 | *Ficus religiosa* L. | Moraceae | CL | DT | J | 3,4,10,19 |
| 295 | *Ficus sarmentosa* Buch. -Ham. ex J. E. Sm | Moraceae | WL | ECL | J | 11,19,21 |
| 296 | *Ficus semicordata* Buch-Ham. | Moraceae | WL | ET | J | 10 |
| 297 | *Ficus virens* Aiton. | Moraceae | CW | DT | J | 3,4,11,19 |
| 298 | *Flacourtia indica* (Burm. f.) Merill. | Salicaceae | WL | DT | J | 3,4,10,11,19 |
| 299 | *Flemingia macrophylla* (Willd.) O. Ktze. | Fabaceae | WL | DS | J | 10,12,18 |
| 300 | *Flemingia semialata* Roxb. | Fabaceae | WL | DS | J | 19 |
| 301 | *Flueggea virosa* Roxb. ex Willd. | Phyllanthaceae | WL | DT | J | 3,4,10,12 |
| 302 | *Forsythia viridissima* Lind. | Oleaceae | WL | DS | K | 2,14,18 |
| 303 | *Fraxinus americana* L. | Oleaceae | CL | DT | K | 17 |

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|---|---|---|---|---|---|---|
| 304 | *Fraxinus excelsior* L. | Oleaceae | CL | DT | K | 17 |
| 305 | *Fraxinus floribunda* Wall. | Oleaceae | WL | DT | J | 19 |
| 306 | *Fraxinus hookeri* Wenzig. | Oleaceae | WL | DT | JK | 3,14,15,19 |
| 307 | *Fraxinus xanthoxyloides* (G.Don) Wall. ex A. DC. | Oleaceae | WL | DT | JK | 3,4,12 |
| 308 | *Gardenia jasminoides* J.Ellis | Rubiaceae | CL | ES | J | 14,15,19 |
| 309 | *Gaultheria trichophylla* Royle | Ericaceae | WL | ESS | JK | 1,3,4,12,19 |
| 310 | *Galphimia gracilis* Bartl. | Malpighiaceae | CL | ES | J | 21 |
| 311 | *Gleditsia triacanthos* L. | Fabaceae | CL | DT | JK | 17,19 |
| 312 | *Ginkgo biloba* L. | Ginkgoaceae | CL | DT | K | 2,14,17 |
| 313 | *Glochidion heyneanum* Wight. | Phyllanthaceae | CL | DT | J | 3,4,10,1,19 |
| 314 | *Gmelina arborea* Roxb. | Lamiaceae | CW | DT | J | 3,4 |
| 315 | *Gomphocarpus physocarpus* E.Mey. | Apocynaceae | CW | ES | J | 21 |
| 316 | *Grevillea pteridifolia* Knight | Proteaceae | CL | ET | J | 15 |
| 317 | *Grevillea robusta* A.Cunn. ex R.Br. | Proteaceae | CL | ET | J | 15,19,21 |
| 318 | *Grewia asiatica* L. | Malvaceae | CL | DT | J | 19 |
| 319 | *Grewia optiva* J.R.Drumm. ex Burret | Malvaceae | CL | DT | J | 4,11,12,19 |
| 320 | *Grewia tenax* (Forssk.) Fiori | Malvaceae | CL | DS | J | 3,4,10,18 |
| 321 | *Gymnosporia royleana* Laws. | Celastraceae | WL | ES | J | 4,11,12,19 |
| 322 | *Hamelia patens* Jacq. | Rubiaceae | CL | ES | J | 14,15,18 |
| 323 | *Hedera canariensis* Willd. | Araliaceae | CL | ECL | K | 17 |
| 324 | *Hedera helix* L. | Araliaceae | CL | ECL | JK | 13,17,18 |
| 325 | *Hedera nepalensis* K. Koch | Araliaceae | WL | ECL | JK | 1,3,4,11,19 |
| 326 | *Helicteres isora* L. | Malvaceae | CW | DT | J | 3,4,10 |
| 327 | *Helinus lanceolatus* (Wall.) Brandis | Rhamnaceae | WL | DS | J | 3,4,10,18,19,21 |
| 328 | *Hibiscus hirtus* L. | Malvaceae | CL | ES | J | 3,4,10 |
| 329 | *Hibiscus mutabilis* L. | Malvaceae | CL | DS | J | 15,19,21 |

(continued)

**Table 22.1** (continued)

| S. No. | Scientific name of species | Family | Wild/Cultivated[a] | Growth-form[a] | Distribution[a] | Data sources[b] |
|---|---|---|---|---|---|---|
| 330 | *Hibiscus rosa-sinensis* L. | Malvaceae | CL | DS | JK | 3,18,19 |
| 331 | *Hibiscus schizopetalus* (Dyer) Hook. f. | Malvaceae | CL | DS | J | 15,19 |
| 332 | *Hibiscus syriacus* L. | Malvaceae | CL | DS | K | 2,18,17,19 |
| 333 | *Hibiscus vitifolius* L. | Malvaceae | CL | DS | J | 1,4,18 |
| 334 | *Himalrandia tetrasperma* T.Yamaz. | Rubiaceae | WL | DS | J | 3,10,11,12,19,21 |
| 335 | *Hippophae rhamnoides* L. | Elaeagnacaeae | WL | DS | JKL | 3,12,18,23 |
| 336 | *Hippophae rhamnoides* var. *turkestanica* Rousi. | Elaeagnacaeae | WL | DS | L | 2,16,18,22 |
| 337 | *Hippophae tibetana* Schltdl. | Elaeagnacaeae | WL | DS | L | 22 |
| 338 | *Hiptage benghalensis* (L.) Kurz. | Malpighinaceae | WL | ECL | J | 1,4,10,19 |
| 339 | *Holarrhena pubescens* Wall. ex G.Don | Apocynaceae | WL | ES | J | 3,10,18 |
| 340 | *Holboellia latifolia* Wall. | Berberidaceae | WL | ECL | J | 3,4,10,19 |
| 341 | *Holmskioldia sanguinea* Retz. | Lamiaceae | WL | ES | J | 3,10,18 |
| 342 | *Hydrangea arborescens* L. | Hydrangeaceae | CL | DS | K | 17 |
| 343 | *Hydrangea macrophylla* (Thunb.) Ser. | Hydrangeaceae | CL | DS | K | 17 |
| 344 | *Hymenodictyon orixense* (Roxb.) Mabb. | Rubiaceae | WL | DT | J | 4,12,18 |
| 345 | *Hypericum androsaemum* L. | Hypericaceae | CL | DS | K | 14,18 |
| 346 | *Hypericum dyeri* Rehder | Hypericaceae | WL | DS | J | 1,10,18,19 |
| 347 | *Hypericum hookerianum* Wright & Arn. | Hypericaceae | WL | DS | K | 2,14,18 |
| 348 | *Hypericum oblongifolium* Choisy | Hypericaceae | WL | DS | JK | 1,4,10,11,19 |
| 349 | *Hypericum uralum* Buch. Ham ex D. Don. | Hypericaceae | WL | DS | JK | 2,10,11,19 |
| 350 | *Ichnocarpus frutescens* W. T. Aiton. | Apocynaceae | WL | ECL | J | 3,4,18,21 |
| 351 | *Ilex dipyrena* Wall. | Aquifoliaceae | WL | ET | J | 3,4,11,12,19 |
| 352 | *Ilex excelsa* (Wall.) Voigt | Aquifoliaceae | WL | ES | J | 3,11,18 |
| 353 | *Indigofera atropurpurea* Hornem. | Fabaceae | WL | DS | J | 3,4,12,19 |
| 354 | *Indigofera cassioides* Rottl..ex DC. | Fabaceae | WL | DS | J | 3,4,10,11,19,21 |

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|---|---|---|---|---|---|---|
| 355 | *Indigofera hebepetala* Benth. | Fabaceae | WL | DS | JK | 1,2,3,4,10,12,19 |
| 356 | *Indigofera heterantha* Brandis | Fabaceae | WL | DS | JKL | 1,2,3,5,10,18,23 |
| 357 | *Indigofera tinctoria* L. | Fabaceae | CL | DS | J | 4,10,18 |
| 358 | *Inula cappa* (Ham.) DC. | Asteraceae | WL | DS | J | 3,4,10,11 |
| 359 | *Ipomoea cairica* (L.)Sweet | Convolvulaceae | CL | DCL | J | 19,21 |
| 360 | *Ipomoea crassicaulis* (Benth.) B.L. Rob | Convolvulaceae | WL | DS | J | 4,18 |
| 361 | *Isodon rugosus* (Wall. ex Bth.) Codd. | Lamiaceae | WL | DS | JK | 3,19,23 |
| 362 | *Itea nutans* Royle | Iteaceae | CL | DT | J | 19 |
| 363 | *Jacaranda mimosifolia* D.Don | Bignoniaceae | CL | DT | J | 15,18,19,21 |
| 364 | *Jasminum arborescens* Roxb. | Oleaceae | CW | DS | J | 3,4,10,12 |
| 365 | *Jasminum auriculatum* Vahl. | Oleaceae | CW | DS | J | 3,4,12 |
| 366 | *Jasminum coarctatum* Roxb. | Oleaceae | WL | DS | J | 10,18 |
| 367 | *Jasminum dispermum* Wall. ex Roxb. | Oleaceae | WL | DS | J | 3,4,10,19 |
| 368 | *Jasminum grandiflorum* L. | Oleaceae | CL | DS | J | 3,19 |
| 369 | *Jasminum officinale* L. | Oleaceae | CW | DS(-DCL) | JK | 2,3,4,11,19 |
| 370 | *Jasminum humile* L. | Oleaceae | WL | DS | JK | 3,4,10,11,12,19,21 |
| 371 | *Jasminum multiflorum* (Burm. f.) Andr. | Oleaceae | CW | DS | J | 3,10,18,19 |
| 372 | *Jasminum mesnyi* Hance | Oleaceae | CL | DS | JK | 14,19 |
| 373 | *Jasminum nudiflorum* Lindl. | Oleaceae | CL | DS | K | 17 |
| 374 | *Jasminum sambac* (L.) Aiton | Oleaceae | CL | DCL(-DS) | J | 19 |
| 375 | *Jatropha curcas* L. | Euphorbiaceae | CW | DS | J | 3,11,19 |
| 376 | *Juglans nigra* L. | Juglandaceae | CL | DT | K | 2,12,18 |
| 377 | *Juglans regia* L. | Juglandaceae | CL | DT | JKL | 3,4,5,18,19,23 |
| 378 | *Juniperus chinensis* Linn. | Cupressaceae | CL | ET | J | 15,17,18,25 |
| 379 | *Juniperus communis* L. | Cupressaceae | WL | ES | JKL | 7,18,19,25 |
| 380 | *Juniperus horizontalis* Moench | Cupressaceae | CL | ES | J | 21 |
| 381 | *Juniperus indica* Bertol. | Cupressaceae | WL | ET(-ES) | KL | 3,25 |

(continued)

**Table 22.1** (continued)

| S. No. | Scientific name of species | Family | Wild/Cultivated[a] | Growth-form[a] | Distribution[a] | Data sources[b] |
|---|---|---|---|---|---|---|
| 382 | *Juniperus polycarpos* K.Koch | Cupressaceae | WL | ET(-ES) | JL | 25 |
| 383 | *Juniperus pseudosabina* Fisch. & C.A.Mey. | Cupressaceae | WL | ET(-ES) | JL | 3,25 |
| 384 | *Juniperus squamata* Buch.-Ham. ex D.Don | Cupressaceae | WL | ES | JK | 3,8,10,18,19,23,25 |
| 385 | *Juniperus semiglobosa* Regel | Cupressaceae | WL | ET | KL | 2,3,5,8,10,,22,25 |
| 386 | *Justicia adhatoda* L. | Acanthaceae | WL | ES | J | 4,11,18,19 |
| 387 | *Kerria japonica* (L) DC. | Rosaceae | CL | DS | K | 1,2,18 |
| 388 | *Kigelia africana* Benth. | Bignoniaceae | CL | DT | J | 15,18,19 |
| 389 | *Koelreuteria bipinnata* Franch. | Sapindaceae | CL | DT | J | 21 |
| 390 | *Koelreuteria paniculata* Laxm. | Sapindaceae | CL | DT | K | 2,17,18 |
| 391 | *Krascheninnikovia ceratoides* (L.) Guldenst. | Chenopodiaceae | WL | DS | L | 5,22 |
| 392 | *Kydia calycina* Roxb. | Malvaceae | WL | DT | J | 1,4,18,19 |
| 393 | *Laburnum anagyroides* Medicus. | Fabaceae | CL | DT | K | 2,17,18 |
| 394 | *Lagerstroemia indica* L. | Lythraceae | CL | DT | JK | 2,17,18,19,21 |
| 395 | *Lannea coromandelica* (Houtt.) Merr. | Anacardiaceae | WL | DT | J | 1,3,4,11,19 |
| 396 | *Lantana camara* L. | Verbenaceae | WL | ES | J | 3,4,10,11,19 |
| 397 | *Laurus nobilis* L. | Lauraceae | CL | ET | K | 2,17,18 |
| 398 | *Lavandula angustifolia* Mill. | Lamiaceae | CL | ES | K | 2,14,18 |
| 399 | *Lawsonia inermis* L. | Lythraceae | CL | DS | J | 15 |
| 400 | *Lepidagathis cuspidata* Nees. | Acanthaceae | WL | DS | J | 4,11,18 |
| 401 | *Leptadenia reticulata* (Retz.) Wight & Arn. | Apocynaceae | WL | DCL | J | 15 |
| 402 | *Leptodermis virgata* Edgew. | Rubiaceae | WL | DS | JK | 3,4,18 |
| 403 | *Leptodermis lanceolata* Wall. | Rubiaceae | WL | DS | J | 3,10,11,18,19,21 |
| 404 | *Leptopus cordifolius* Decne. | Phyllanthaceae | WL | DS | J | 3,10,11 |
| 405 | *Lespedeza elegans* Camb. | Fabaceae | WL | DS | JK | 1,3,14,18 |
| 406 | *Lespedeza gerardiana* Maxim | Fabaceae | WL | DS | J | 19 |

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|---|---|---|---|---|---|---|
| 407 | *Lespedeza juncea* var. *sericea* Lace & Hauech | Fabaceae | WL | DS | J | 19 |
| 408 | *Leucaena leucocephala* (Lam.) deWit | Fabaceae | CL | ET(ES) | J | 19,21 |
| 409 | *Leycesteria formosa* Wall | Caprifoliaceae | CL | DS | J | 19 |
| 410 | *Ligustrum japonicum* Thunb. | Oleaceae | CL | ES | K | 17 |
| 411 | *Ligustrum lucidum* W.T.Aiton | Oleaceae | CL | ET | JK | 2,3,14,17,18,21 |
| 412 | *Ligustrum ovalifolium* Haussk. | Oleaceae | CL | ES | K | 2,14,18,19 |
| 413 | *Ligustrum vulgare* L | Oleaceae | CL | ES(-ET) | K | 2,14,17,18 |
| 414 | *Litchi chinensis* Sonn. | Sapindaceae | CL | ET | J | 19 |
| 415 | *Lonicera acuminata* Wall | Caprifoliaceae | CL | DS | J | 19 |
| 416 | *Lonicera angustifolia* Wall. ex DC. | Caprifoliaceae | WL | DS | JKL | 3,4,12 |
| 417 | *Lonicera asperifolia* (Dcne.) H.& T. | Caprifoliaceae | WL | DS | KL | 3, 5,22 |
| 418 | *Lonicera discolor* Lindl. | Caprifoliaceae | WL | DS | L | 1,3,5 |
| 419 | *Lonicera hispida* Pall. ex Schult | Caprifoliaceae | WL | DS | JK | 3,4,12,23 |
| 420 | *Lonicera japonica* Thunb. | Caprifoliaceae | CL | ECL | JK | 2,12,17,18,19,21 |
| 421 | *Lonicera nitida* E.H. Wilson | Caprifoliaceae | CL | ES | K | 17 |
| 422 | *Lonicera microphylla* Wild. ex Roem. & Schultz. | Caprifoliaceae | WL | DS | L | 3,18,22 |
| 423 | *Lonicera myrtillus* H. & T. | Caprifoliaceae | WL | DS | JKL | 3,18 |
| 424 | *Lonicera obovata* Royle ex Hook. f. & Thoms. | Caprifoliaceae | WL | DS | JKL | 3,4,12,18 |
| 425 | *Lonicera purpurascens* (Dcne.) Walp. | Caprifoliaceae | WL | DS | JKL | 3,4,12,18 |
| 426 | *Lonicera quinquelocularis* Hardw. | Caprifoliaceae | WL | DS(-DT) | JK | 1,3,4,11,18,19,23 |
| 427 | *Lonicera semenovii* Regel | Caprifoliaceae | WL | DS | KL | 3,18,22 |
| 428 | *Lonicera spinosa* (Dcne.) Walp. | Caprifoliaceae | WL | DS | L | 3,18,22 |
| 429 | *Lonicera vaccinioides* Rehder | Caprifoliaceae | WL | DS | KL | 3,18 |
| 430 | *Lonicera webbiana* Wall. ex DC. | Caprifoliaceae | WL | DS | JKL | 3,18,19 |
| 431 | *Loranthus cordifolius* Wall. | Loranthaceae | CW | DS | J | 19 |

(continued)

**Table 22.1** (continued)

| S. No. | Scientific name of species | Family | Wild/Cultivated[a] | Growth-form[a] | Distribution[a] | Data sources[b] |
|---|---|---|---|---|---|---|
| 432 | *Lycium ruthenicum* Murray | Solanaceae | WL | DS | L | 3,5,18,22 |
| 433 | *Lyonia ovalifolia* (Wall.) Drude | Ericaceae | WL | DS(-DT) | J | 15,18,19 |
| 434 | *Lysiloma latisiliquum* (L.) Benth. | Fabaceae | WL | DT | J | 15,18 |
| 435 | *Machilus duthiei* King | Lauraceae | WL | ET | J | 19 |
| 436 | *Maesa montana* A. DC. | Primulaceae | WL | DS | J | 3,10,11 |
| 437 | *Magnolia champaca* Baill. ex Pierre | Magnoliaceae | CW | ET | J | 19 |
| 438 | *Magnolia grandiflora* L. | Magnoliaceae | CL | ET | JK | 2,12,18,19,21 |
| 439 | *Magnolia kobus* DC. | Magnoliaceae | CL | DT | K | 2,14,17,18 |
| 440 | *Magnolia liliflora* Desr. | Magnoliaceae | CL | DS(-DT) | K | 2,14,17,18 |
| 441 | *Magnolia × soulangeana* Soul.-Bod. | Magnoliaceae | CL | DT | K | 17 |
| 442 | *Magnolia stellata* Maxim. | Magnoliaceae | CL | DT | K | 17 |
| 443 | *Mahonia borealis* Takeda | Berberidaceae | CL | ES | K | 6,14,18 |
| 444 | *Mahonia japonica* (Thunb.) DC. | Berberidaceae | CL | ES | K | 17 |
| 445 | *Mallotus philippensis* (Lam.) Muell. | Euphorbiaceae | CW | DT | J | 4,10,11,12 |
| 446 | *Malus × purpurea* (E.Barbier) Rehder | Rosaceae | CL | DT | K | 17,18 |
| 447 | *Malus baccata* (L.) Borkh. | Rosaceae | CW | DT | JK | 2,3,12,17 |
| 448 | *Malus domestica* Borkh. | Rosaceae | CL | DT | JKL | 2,3,12,23 |
| 449 | *Malvaviscus arboreus* Cav. | Malvaceae | CL | ES | J | 15,19 |
| 450 | *Melia azedarach* L. | Meliaceae | WL | DT | JK | 1,3,10,12,17,19,21 |
| 451 | *Meliosma simplicifolia* Walp. | Sabiaceae | WL | ET | J | 3 |
| 452 | *Millingtonia hortensis* L.f | Bignoniaceae | CL | DT | J | 15 |
| 453 | *Mimosa pudica* L. | Fabaceae | CL | DSS | J | 1,10 |
| 454 | *Mimosa himalayana* Gamble | Fabaceae | WL | DS | J | 4,10,11,19 |
| 455 | *Mitragyna parvifolia* (Roxb.) Korth. | Oleaceae | CL | DT | J | 3,4,12 |
| 456 | *Moringa oleifera* Lam., | Moringaceae | WL | DT | J | 4,10 |

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|---|---|---|---|---|---|---|
| 457 | *Morus alba* L. | Moraceae | CW | DT | JKL | 1,3,4,10,12,21,23 |
| 458 | *Morus laevigata* Wall. | Moraceae | CW | DT | K | 1,2,18 |
| 459 | *Morus nigra* L. | Moraceae | CW | DT | KL | 3,18,17,19 |
| 460 | *Morus serrata* Roxb. | Moraceae | CL | DT | JK | 2,4,10,12,18,19 |
| 461 | *Mucuna pruriens* (L.) DC. | Fabaceae | CL | DCL | J | 19 |
| 462 | *Murraya koenigii* (L.) Spreng. | Rutaceae | WL | DS | J | 3,10,19 |
| 463 | *Murraya paniculata* (L.) Jack. | Rutaceae | WL | DS | J | 3,4,10,19 |
| 464 | *Myricaria elegans* Royle | Tamaricaceae | WL | DS | KL | 2,22 |
| 465 | *Myricaria rosea* W.W. Sm. | Tamaricaceae | WL | DS | L | 5 |
| 466 | *Myricaria germanica* (L.) Desv. | Tamaricaceae | WL | DS | KL | 2,3,5,12,18,22 |
| 467 | *Myrtus communis* L. | Myrtaceae | CL | ES | K | 17,18 |
| 468 | *Myrsine africana* L. | Primulaceae | CW | ES | J | 3,4,11,19 |
| 469 | *Nandina domestica* Thunb. | Berberidaceae | CL | ES | K | 17 |
| 470 | *Neolamarckia cadamba* Bosser | Rubiaceae | CL | DT | J | 15 |
| 471 | *Neolitsea pallens* (D. Don) Momiyama & Hara | Lauraceae | WL | ET | J | 3,10,18,19 |
| 472 | *Nerium oleander* L. | Oleaceae | CL | ES | JK | 4,14,17,18,19 |
| 473 | *Nyctanthes arbor-tristis* L. | Oleaceae | CL | DT | J | 4,10,11,12,19 |
| 474 | *Olea europaea* subsp. *cuspidata* (Wall. & G. Don) Cif. | Oleaceae | WL | ET(-ES) | J | 21 |
| 475 | *Olea europaea* L. | Oleaceae | CW | ET | JK | 10,11,14,17,19 |
| 476 | *Opuntia dillenii* (Ker Gawl.) Haw. | Cactaceae | CL | ES | J | 19 |
| 477 | *Oreocnide frutescens* (Thunb.) Miq. | Urticaceae | WL | ES | JK | 3,11,19 |
| 478 | *Oroxylum indicum* (L.) Vent. | Bignoniaceae | WL | ET | J | 3,4,12 |
| 479 | *Osmanthus fragrans* Lour. | Oleaceae | CL | ET | K | 2,17,18 |
| 480 | *Paeonia emodi* Wall. ex Hk. f. | Paeoniaceae | WL | DSS | JK | 4,10,12,23 |
| 481 | *Paeonia officinalis* L. | Paeoniaceae | CL | DSS | K | 17 |
| 482 | *Paeonia suffruticosa* And. | Paeoniaceae | CL | DSS | K | 14,17 |

(continued)

**Table 22.1** (continued)

| S. No. | Scientific name of species | Family | Wild/Cultivated[a] | Growth-form[a] | Distribution[a] | Data sources[b] |
|---|---|---|---|---|---|---|
| 483 | *Parkinsonia aculeata* L. | Fabaceae | WL | ET | J | 15 |
| 484 | *Parrotiopsis jacquemontiana* Rehdr. | Hamamelidaceae | WL | DS | JK | 1,3,4,10,12,19,23 |
| 485 | *Parthenocissus quinquefolia* (L.) Planch. | Vitaceae | CL | ECL | K | 2,17,18 |
| 486 | *Parthenocissus semicordata* (Wall.) Planch. | Vitaceae | CL | DCL | J | 3,4,18,19 |
| 487 | *Parthenocissus tricuspidata* Planch. | Vitaceae | CL | DS | K | 2,17,18 |
| 488 | *Paulownia tomentosa* Steud. | Paulowniaceae | CL | DT | K | 17 |
| 489 | *Passiflora caerulea* L. | Passifloraceae | CL | ECL | K | 17 |
| 490 | *Pelargonium capitatum* (L.) L'Hér. | Geraniaceae | CL | DSS | J | 19 |
| 491 | *Peltophorum pterocarpum* (DC.) Backer ex K. Heyne, | Fabaceae | WL | DT | J | 15,18 |
| 492 | *Persea duthiei* (King ex Hk. f.) Kost. | Lauraceae | WL | ET | J | 3,10,18 |
| 493 | *Persea odoratissima* (Nees) Kost. | Lauraceae | WL | ET | J | 4,10,18,19 |
| 494 | *Philadelphus coronarius* L | Hydrangeaceae | CL | DS | K | 17 |
| 495 | *Philadelphus confusus* Piper | Hydrangeaceae | CL | DS | K | 2,18 |
| 496 | *Philadelphus incanus* Koehne | Hydrangeaceae | CL | DS | K | 2,18 |
| 497 | *Philadelphus pubescence* Lois. | Hydrangeaceae | CL | DS | K | 2,18 |
| 498 | *Philadelphus tomentosus* Wall. ex Royle | Hydrangeaceae | CW | DS | JK | 3,14,18 |
| 499 | *Philadelphus* × *virginalis* Rehder | Hydrangeaceae | CL | DS | K | 17 |
| 500 | *Phoenix loureiroi* Kunth | Arecaceae | CL | ET | J | 21 |
| 501 | *Phoenix sylvestris* (L.) Roxb. | Arecaceae | CL | ET | J | 15,18,19 |
| 502 | *Phyllanthus emblica* L. (*Emblica officinalis*) | Phyllanthaceae | WL | DT | J | 3,4,10,11,12,19,21 |
| 503 | *Picea smithiana* (Wall.) Boiss. | Pinaceae | WL | ET | JK | 2,3,8,10,12,19,23 |
| 504 | *Pinus canariensis* Smith. | Pinaceae | CL | ET | K | 2,8,18 |
| 505 | *Pinus gerardiana* Wall. ex Lamb. | Pinaceae | WL | ET | J | 3,12,18 |
| 506 | *Pinus halepensis* Miller | Pinaceae | CL | ET | K | 2,8,17,18 |

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|---|---|---|---|---|---|---|
| 507 | *Pinus radiata* D.Don | Pinaceae | CL | ET | K | 17 |
| 508 | *Pinus roxburghii* Sargent | Pinaceae | WL | ET | JK | 2,3,8,10,11,19 |
| 509 | *Pinus wallichiana* A. B. Jackson | Pinaceae | WL | ET | JK | 3,8,10,11,12,19,23 |
| 510 | *Pittosporum napaulense* (DC.) Rehdr. & Wills. | Pittosporaceae | WL | ES(-ET) | J | 3,4,18 |
| 511 | *Pistacia chinensis* subsp. *integerrima* Rech. f. | Anacardiaceae | CL | DT | JK | 17,19 |
| 512 | *Pistacia khinjuk* Stocks | Anacardiaceae | CL | DT | J | 19 |
| 513 | *Platanus occidentalis* L. | Platanacaee | CL | DT | K | 2,17,18 |
| 514 | *Platanus orientalis* L. | Platanacaee | CL | DT | JK | 1,2,3,4,10,17,19 |
| 515 | *Platycladus orientalis* (L.) Franco | Cupressaceae | CL | ES | K | 2,3,8,14 |
| 516 | *Plumeria obtusa* L. | Apocynaceae | CL | DT | J | 21 |
| 517 | *Plumeria rubra* L. | Apocynaceae | WL | DT | J | 15,19 |
| 518 | *Podocarpus neriifolius* D.Don | Podocarpaceae | CL | ET | J | 21 |
| 519 | *Pogostemon benghalense* (Burm. f.) O. Ktze | Lamiaceae | CL | DS | J | 1,4,10 |
| 520 | *Polyalthia longifolia* (Sonn.) Thwaites | Annonaceae | CL | ET | J | 15 |
| 522 | *Populus alba* L. | Salicaceae | CW | DT | KL | 1,2,3,5,12,19,23 |
| 522 | *Populus balsamifera* L. | Salicaceae | CL | DT | K | 17 |
| 523 | *Populus ciliata* Wall. ex Royle | Salicaceae | CW | DT | JK | 1,2,4,12,18,19,<br>21,22,23 |
| 524 | *Populus deltoides* Marsh. | Salicaceae | CL | DT | KL | 2,17,18 |
| 525 | *Populus euphratica* Olivier | Salicaceae | CL | DT | KL | 3,18 |
| 526 | *Populus nigra* L. | Salicaceae | CL | DT | KL | 1,2,3,18,19 |
| 527 | *Populus pamirica* Kom. | Salicaceae | WL | DT | JL | 7,18,22,23 |
| 528 | *Potentilla arbuscula* D. Don, | Rosaceae | WL | DS | L | 22 |
| 529 | *Potentilla dryadanthoides* (Juz.) Viroshilov | Rosaceae | WL | DS | L | 22 |
| 530 | *Premna barbata* Wall. ex Schauer | Lamiaceae | WL | DT | J | 3,4,10 |
| 531 | *Premna mollissima* Roth | Lamiaceae | CL | DT | J | 4,10 |
| 532 | *Prinsepia utilis* Royle | Rosaceae | WL | DS | J | 3,4,10,12,18,19,21 |

(continued)

**Table 22.1** (continued)

| S. No. | Scientific name of species | Family | Wild/Cultivated[a] | Growth-form[a] | Distribution[a] | Data sources[b] |
|---|---|---|---|---|---|---|
| 533 | *Prunus dulcis* (Mill.) D.A.Webb | Rosaceae | CL | DT | JK | 1,14,19 |
| 534 | *Prunus armeniaca* L. | Rosaceae | CL | DT | JKL | 1,2,3,4,5,10,19,23 |
| 535 | *Prunus avium* (L.) L. | Rosaceae | CL | DT | JK | 14,19,23 |
| 536 | *Prunus bokhariensis* Royle ex Schn. | Rosaceae | CL | DT | JK | 2,18,19 |
| 537 | *Prunus cerasifera* Ehr. | Rosaceae | CL | DT | JK | 1,2,18,23 |
| 538 | *Prunus cerasus* L. | Rosaceae | CL | DT | JK | 2,3,18,21 |
| 539 | *Prunus cornuta* (Wall. ex Royle) Steud. | Rosaceae | WL | DT | JK | 2,4,10,12,18,19,23 |
| 540 | *Prunus domestica* L. | Rosaceae | CL | DT | JK | 2,3,18,19 |
| 541 | *Prunus glandulosa* Thunb. | Rosaceae | CL | DT | K | 17 |
| 542 | *Prunus laurocerasus* L. | Rosaceae | CL | DT | K | 14,17 |
| 543 | *Prunus mume* (Siebold) Siebold & Zucc. | Rosaceae | CL | DT | K | 17 |
| 544 | *Prunus persica* (L.) Batsch. | Rosaceae | CL | DT | JK | 1,2,4,10,11,17,18,19,21 |
| 545 | *Prunus prostrata* Labill. | Rosaceae | CL | DS | K | 1,2,3,12 |
| 546 | *Prunus* x *subhirtella* Miq. | Rosaceae | CL | DT | K | 17 |
| 547 | *Prunus tomentosa* Thunb. | Rosaceae | CL | DS | JK | 1,2,3,4,12,18 |
| 548 | *Pseudocaryopteris bicolor* P.D.Cantino | Lamiaceae | WL | DS | J | 10,11,18,19,21 |
| 549 | *Pterospermum acerifolium* Willd. | Malvaceae | CL | ET | J | 3,4,18 |
| 550 | *Pterygota alata* (Roxb.) R.Br. | Malvaceae | CL | ET | J | 14,15 |
| 551 | *Psidium guajava* L. | Mrytaceae | CL | ES | J | 19 |
| 552 | *Pueraria tuberosa* (Willd.) DC. | Fabaceae | CL | DCL | J | 19 |
| 553 | *Punica granatum* L. | Punicaceae | CW | DS | JK | 2,3,4,11,12,19 |
| 554 | *Putranjiva roxburghii* Wall | Putranjivaceae | CL | ET | J | 21 |
| 555 | *Psidium guajava* L. | Myrtaceae | CL | ET | J | 21 |
| 556 | *Pyrostegia venusta* Miers | Bignoniaceae | WL | ECL | J | 15,19 |
| 557 | *Pyrus communis* L. | Rosaceae | CL | DT | JKL | 1,2,3,5,4,19,23 |

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|---|---|---|---|---|---|---|
| 558 | *Pyrus pashia* Buch. - Ham. ex DC. | Rosaceae | WL | DT | JK | 2,3,10,11,19,21 |
| 559 | *Pyrus pyrifolia* (Burm.) Nakai. | Rosaceae | CL | DT | K | 2,3,17,18 |
| 560 | *Pterospermum acerifolium* Willd. | Sterculiaceae | CL | DT | J | 21 |
| 561 | *Quercus baloot* Griff. | Fagaceae | WL | ET | JK | 3,14 |
| 562 | *Quercus floribunda* Lindl. ex A. Camus | Fagaceae | WL | ET | J | 3,10,18,19,21 |
| 563 | *Quercus glauca* Thunb. | Fagaceae | WL | ET | JK | 3,4,10,11,18 |
| 564 | *Quercus incana* Bartram | Fagaceae | WL | ET | JK | 3,4,10,11 |
| 565 | *Quercus oblongata* D. Don | Fagaceae | WL | ET | J | 4,10,11,21 |
| 566 | *Quercus robur* L. | Fagaceae | CL | DT | K | 1,3,17,18 |
| 567 | *Quercus suber* L. | Fagaceae | CL | DT | K | 17 |
| 568 | *Quercus semecarpifolia* Smith | Fagaceae | WL | ET | JK | 3,4,12,19 |
| 569 | *Rauvolfia serpentina* (L.) Benth. ex Kurz | Apocynaceae | CL | ESS | J | 15,19 |
| 570 | *Reinwardtia indica* Dumort. | Linaceae | WL | DS | J | 3,4,10,11,18,19,21 |
| 571 | *Ruellia sindica* Ghafoor & Heine | Acanthaceae | WL | DS | J | 21 |
| 572 | *Rhamnus pentapomica* Parker | Rhamnaceae | WL | DS | J | 3,4,18 |
| 573 | *Rhamnus prostrata* Jacq. | Rhamnaceae | WL | DS | JKL | 2,3,4,12,18,22 |
| 574 | *Rhamnus purpurea* Edgew. | Rhamnaceae | WL | DT | JK | 2,3,10,11,12 |
| 575 | *Rhamnus triquetra* Wall. ex Roxb. | Rhamnaceae | WL | DS(-DT) | J | 3,4,12,19 |
| 576 | *Rhamnus virgata* Roxb. | Rhamnaceae | WL | DS(-DT) | JK | 2,3,4,12,19 |
| 577 | *Rhododendron anthopogon* D. Don | Ericaceae | WL | ES | JKL | 2,3,4,18,19,23 |
| 578 | *Rhododendron arboreum* Smith | Ericaceae | WL | ET | J | 3,4,10,11,18,19 |
| 579 | *Rhododendron campanulatum* D. Don | Ericaceae | WL | ES | JK | 1,3,4,12,18,19,23 |
| 580 | *Rhododendron lepidotum* Wall ex D. Don | Ericaceae | WL | ES | JK | 2,3,4,18,19 |
| 581 | *Rhus chinensis* Mill. | Anacardaceae | CL | DT | J | 19 |
| 582 | *Rhus punjabensis* J. L. Stewart ex Brandis | Anacadiaceae | WL | DT | J | 3,4,12,19 |
| 583 | *Rhus succedanea* L. | Anacadiaceae | WL | DT | JK | 1,2,3,4,12,14,19 |

(continued)

**Table 22.1** (continued)

| S. No. | Scientific name of species | Family | Wild/Cultivated[a] | Growth-form[a] | Distribution[a] | Data sources[b] |
|---|---|---|---|---|---|---|
| 584 | *Ribes alpestre* Wall. ex Dcne. | Grossulariaceae | WL | DS | K | 3,7,18 |
| 585 | *Ribes glaciale* Wall | Grossulariaceae | WL | DS | JKL | 1,3,4,12 |
| 586 | *Ribes himalense* Royle ex Decne. | Grossulariaceae | WL | DS | KL | 2,3 |
| 587 | *Ribes orientale* Desf. | Grossulariaceae | WL | DS | JKL | 2,3,4,22 |
| 588 | *Ribes villosum* Wall. | Grossulariaceae | WL | DS | K | 2,3,18 |
| 589 | *Ricinus communis* L. | Euphorbiaceae | CW | DSS | JK | 3,4,10,11,12,18,21 |
| 590 | *Rhynchosia pseudo-cajan* Cambess. | Fabaceae | CL | DS | J | 19 |
| 591 | *Robinia pseudoacacia* L. | Fabaceae | CW | DT | JKL | 1,2,4,10,12,18,19,23 |
| 592 | *Rosa banksiae* W. T. Aiton. | Rosaceae | CL | DCL | K | 2,17,18 |
| 593 | *Rosa brunonii* Lindl. | Rosaceae | WL | DCL | JK | 1,2,3,10,21 |
| 594 | *Rosa × centifolia* L. | Rosaceae | CL | DCL | J | 10,18 |
| 595 | *Rosa chinensis* Jacq. | Rosaceae | CL | DS | JK | 2,18,19 |
| 596 | *Rosa corymbifera* Bank. L. | Rosaceae | CL | DS | JK | 2,3,18 |
| 597 | *Rosa × damascena* Herrm. | Rosaceae | CL | DS | K | 2,3,12,14 |
| 598 | *Rosa foetida* Herrm. | Rosaceae | CL | DS | JK | 2,3,18 |
| 599 | *Rosa hemisphaerica* Herrm. | Rosaceae | WL | DS | JKL | 2,3,18 |
| 600 | *Rosa indica* L. | Rosaceae | CL | DS | JK | 3,14,21 |
| 601 | *Rosa macrophylla* Lindl. | Rosaceae | WL | DS | JKL | 2,3,10,12,18,19 |
| 602 | *Rosa moschata* Herrm. | Rosaceae | CL | DS | JK | 1,4,19 |
| 603 | *Rosa multiflora* Thunb. | Rosaceae | WL | DS | JK | 3,18,19 |
| 604 | *Rosa rugosa* Thunb. | Rosaceae | CL | DS | K | 17 |
| 605 | *Rosa rubiginosa* L. | Rosaceae | CW | DS | J | 19 |
| 606 | *Rosa sericea* Lindl. | Rosaceae | WL | DS | KL | 3 |
| 607 | *Rosa webbiana* Wall. ex Royle | Rosaceae | WL | DS | JKL | 1,2,3,4,22,18,19,23 |

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|---|---|---|---|---|---|---|
| 608 | *Rosmarinus officinalis* L. | Lamiaceae | CL | ES | K | 12,14,17,18 |
| 609 | *Rubus antennifer* Hook. f. | Rosaceae | WL | DS | K | 1,2,3,18 |
| 610 | *Rubus biflorus* Buch.-Ham. ex Sm. | Rosaceae | WL | DS | JK | 2,3,4,19 |
| 611 | *Rubus ellipticus* Sm. | Rosaceae | WL | ES | JK | 1,3,4,11,12,18,19 |
| 612 | *Rubus hoffmeisterianus* Kunth & C.D.Bouché | Rosaceae | WL | ES | K | 3 |
| 613 | *Rubus lasiococcus* A.Gray | Rosaceae | CW | DS | J | 19 |
| 614 | *Rubus macilentus* Jacquem. ex Cambess | Rosaceae | WL | DS | JK | 3,10,12,19 |
| 615 | *Rubus niveus* Thunb. | Rosaceae | WL | DS | JK | 1,3,2,11,12,18,19 |
| 616 | *Rubus paniculatus* Smith | Rosaceae | WL | DS | J | 1,3,10,11,12,19 |
| 617 | *Rubus pedunculosus* D. Don. | Rosaceae | WL | DS | KL | 1,2,3,18 |
| 618 | *Rubus pungens* Camb. | Rosaceae | WL | DS | JK | 1,2,3,4,12,18 |
| 619 | *Rubus saxatilis* L. | Rosaceae | WL | DS | KL | 3 |
| 620 | *Rubus ulmifolius* Schott. | Rosaceae | WL | DS | JK | 1,2,3,18,19 |
| 621 | *Rumex hastatus* D. Don, | Polygonaceae | WL | DSS | JK | 14,21,23 |
| 622 | *Rydingia limbata* (Benth.) Scheen & V.A.Albert | Lamiaceae | WL | ES | J | 21 |
| 623 | *Sabia campanulata* Wall. ex Roxb. | Sabiaceae | WL | DCL | JK | 3 |
| 624 | *Sabia paniculata* Edgew. ex Hook.f. &Thomson | Sabiaceae | CL | DCL | J | 19 |
| 625 | *Sageretia filiformis* (Roth. ex Schult.) G. Don | Rhamnaceae | WL | DS | J | 3,10,18,19 |
| 626 | *Sageretia thea* (Osbeck) M. C. Johnston | Rhamnaceae | WL | ES | J | 10,11,18,19 |
| 627 | *Salix acmophylla* Boiss. | Salicaceae | CL | DT | JK | 3,18 |
| 628 | *Salix alba* L. | Salicaceae | CW | DT | JKL | 1,2,3,5,12 |
| 629 | *Salix aegyptiaca L.* | Salicaceae | CL | DT | K | 14,17 |
| 630 | *Salix babylonica* L. | Salicaceae | CL | DT | JKL | 1,2,3,4,11,12,21 |
| 631 | *Salix caesia* Vill. | Salicaceae | WL | DS | L | 22 |
| 632 | *Salix daphnoides* Vill. | Salicaceae | CL | DS | KL | 2,3,5,12,18 |

(continued)

**Table 22.1** (continued)

| S. No. | Scientific name of species | Family | Wild/Cultivated[a] | Growth-form[a] | Distribution[a] | Data sources[b] |
|---|---|---|---|---|---|---|
| 633 | *Salix denticulata* Anders. | Salicaceae | WL | DS | KL | 2,3,12,7,18 |
| 634 | *Salix flabellaris* Anders. | Salicaceae | WL | DS | KL | 2,3,5,7,18 |
| 635 | *Salix fragilis* L. | Salicaceae | CL | DT | KL | 2,5,12,17 |
| 636 | *Salix karelinii* Turez. | Salicaceae | WL | DS | KL | 2,3,7,18,22 |
| 637 | *Salix lindleyana* Wall. ex Anders. | Salicaceae | WL | DT | KL | 2,3 |
| 638 | *Salix matsudana* Koidzumi | Salicaceae | CL | DT | K | 20 |
| 639 | *Salix pycnostachya* Andr. | Salicaceae | CW | DS | KL | 2,3,18,22 |
| 640 | *Salix purpurea* L. | Salicaceae | CL | DS | K | 17 |
| 641 | *Salix sericocarpa* Andr. | Salicaceae | WL | DT | JKL | 2,3,18,22 |
| 642 | *Salix viminalis* L. | Salicaceae | CL | DT | KL | 3,12,18 |
| 643 | *Salix wallichiana* Andr. | Salicaceae | WL | DS | K | 1,3,12,19 |
| 644 | *Salix wilhelmsiana* M. B. | Salicaceae | CW | DS | L | 2,18 |
| 645 | *Sambucus nigra* L. | Adoxaceae | CL | DS | K | 2,14,17,18 |
| 646 | *Sambucus wightiana* Wall. ex Wight & Arn. | Adoxaceae | WL | DSS | JK | 14,18,19 |
| 647 | *Santolina chamaecyparissus* L. | Asteraceae | CL | ESS | K | 14 |
| 648 | *Sapindus mukorossi* Gaertn. | Sapindaceae | WL | DT | J | 3,4,10,19,21 |
| 649 | *Senna siamea* H.S.Irwin & Barneby | Caesalpinaceae | CL | DT | J | 21 |
| 650 | *Sarcococca pruniformis* Lindl. | Sapindaceae | CL | ES(-ET) | JK | 3,19 |
| 651 | *Sapium sebiferum* (L.) Roxb. | Euphorbiaceae | CW | DT | J | 4,10,11,12 |
| 652 | *Saraca asoca* (Roxb.) de Wilde | Fabaceae | CL | ET | J | 15 |
| 653 | *Schefflera actinophylla* (Endl.) Harm | Araliaceae | CL | ES | K | 17 |
| 654 | *Senna corymbosa* (Lam.) H.S.Irwin & Barneby | Fabaceae | CL | ES | J | 15 |
| 655 | *Senna siamea* (Lamk.) H.S. Irwin & Barneby | Fabaceae | CL | ET | J | 21 |
| 656 | *Senna sulfurea* (Collad.) H.S.Irwin & Barneby | Fabaceae | CL | DS(-DT) | J | 19 |
| 657 | *Sequoiadendron giganteum* J.Buchholz | Taxodiaceae | CL | ET | K | 2,8,17,18 |

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|---|---|---|---|---|---|---|
| 658 | *Sesbania grandiflora* (L.) Pers. | Fabaceae | CL | DS | J | 15 |
| 659 | *Sesbania sesban* (L.) Merr. | Fabaceae | CL | DS | J | 15 |
| 660 | *Sida cordifolia* L. | Malvaceae | CW | DSS | J | 3,4,11 |
| 661 | *Sida rhombifolia* L | Malvaceae | CW | DS | J | 4,10,11 |
| 662 | *Skimmia anquetilia* N.P.Taylor & Airy Shaw | Rutaceae | WL | ES | JK | 3,2,10,11,14,18,19 |
| 663 | *Smilax aspera* L. | Smilacaceae | WL | ECL | JK | 3,4,11,12,18,21 |
| 664 | *Smilax domingensis* Willd. | Smilacaceae | WL | ECL | J | 19 |
| 665 | *Smilax elegans* Wall. ex Kunth | Smilacaceae | WL | ECL | JK | 3,10,11,12,18 |
| 666 | *Smilax lanceifolia* Roxb. | Smilacaceae | WL | ECL | J | 19 |
| 667 | *Smilax menispermoidea* DC. | Smilacaceae | WL | DCL | J | 10,18 |
| 668 | *Smilax vaginata* Dcne. | Smilacaceae | WL | DSS | JK | 3,4,12,19 |
| 669 | *Solanum erianthum* D. Don | Solanaceae | CL | DS(DT) | J | 3,4,10,11,19 |
| 670 | *Solanum rudepannum* Dunal | Solanaceae | CW | DS | J | 3,4,11 |
| 671 | *Solanum anguivi* Lam. | Solanaceae | CL | DSS | J | 3,10,18 |
| 672 | *Solanum incanum* L. | Solanaceae | CL | DS | J | 3,4,11 |
| 673 | *Solanum pseudocapsicum* L. | Solanaceae | CW | ES | JK | 3,10,11,17,19,21 |
| 674 | *Solanum viarum* Dunal | Solanaceae | CL | DS | JK | 17,19 |
| 675 | *Solanum torvum* Sw. | Solanaceae | CL | ES | J | 21 |
| 676 | *Sophora japonica* L. | Fabaceae | CL | DT | K | 1,2,17,18 |
| 677 | *Sophora mollis* (Royle) Baker | Fabaceae | WL | DS | JK | 3,12,19 |
| 678 | *Sophora moorcroftiana* Benth ex Baker | Fabaceae | WL | DS | KL | 2,3,1,22 |
| 679 | *Sorbaria tomentosa* (Lindl.) Rehder | Rosaceae | WL | DS | JKL | 1,2,3,10,19 |
| 680 | *Sorbus domestica* L. | Rosaceae | CL | DS | K | 2,17 |
| 681 | *Sorbus lantata* (D. Don) S. Schauer | Rosaceae | WL | DT | K | 2,3,18 |
| 682 | *Spartium junceum* L. | Fabaceae | CW | DS | K | 2,18 |
| 683 | *Spermadictyon suaveolens* Roxb. | Rubiaceae | WL | DS | J | 4,10,11,19 |
| 684 | *Spiraea arcuata* Hook. f. | Rosaceae | WL | DS | J | 4,10,18 |

(continued)

**Table 22.1** (continued)

| S. No. | Scientific name of species | Family | Wild/Cultivated[a] | Growth-form[a] | Distribution[a] | Data sources[b] |
|---|---|---|---|---|---|---|
| 685 | *Spiraea bella* Sims. | Rosaceae | WL | DS | JK | 2,3,4,10,12 |
| 686 | *Spiraea canescens* D. Don | Rosaceae | WL | DS | JK | 1,2,3,4,10,12,19 |
| 687 | *Spiraea canotoniensis* Lour. | Rosaceae | CL | DS | K | 2,3,18,19,21 |
| 688 | *Spiraea corymbosa* Muhl. | Rosaceae | CL | DS | K | 14,18 |
| 689 | *Spiraea hypericifolia* L. | Rosaceae | WL | DS | LK | 3,12 |
| 690 | *Spiraea japonica* L. | Rosaceae | CL | DS | K | 17 |
| 691 | *Spiraea prunifolia* Sieb.& Zucc. | Rosaceae | CL | DS | K | 2,17,18 |
| 692 | *Spiraea vaccinifolia* D. Don | Rosaceae | WL | DS | JK | 2,3,4,10 |
| 693 | *Spiraea* × *vanhouttei (Briot) Zabel* | Rosaceae | CL | DS | K | 17,18 |
| 694 | *Staphylea emodi* Wall. ex Brandis. | Staphyleaceae | WL | DS | JK | 1,2,3,4,19 |
| 695 | *Stereospermum chelonoides* DC. | Bignoniaceae | WL | DT | J | 3,4,18 |
| 696 | *Strobilanthes atropurpureus* Nees | Acanthaceae | WL | DSS | J | 15 |
| 697 | *Strobilanthes glutinosus Nees* | Acanthaceae | WL | DS | J | 21 |
| 698 | *Strobilanthes wallichii* Nees | Acanthaceae | WL | DSS | J | 19 |
| 699 | *Symplocos paniculata* (Thunb.) Miq. | Symplocaceae | WL | DS | J | 3,10,18,19 |
| 700 | *Syringa emodi* Wall. ex Royle | Oleaceae | WL | DS | JK | 1,2,4,12 |
| 701 | *Syringa x persica* Linn., | Oleaceae | CL | DS | K | 1,2,3,17 |
| 702 | *Syringa vulgaris* L. | Oleaceae | CW | DS | K | 1,2,17,18 |
| 703 | *Syzygium cumini* (L.) Skeels | Myrtaceae | WL | ET | J | 4,10,19,21 |
| 704 | *Tamarindus indica* L. | Fabaceae | CW | ET | J | 15 |
| 705 | *Tamarix gallica* L. | Tamaricaceae | CL | DT | JL | 3,7,10,16 |
| 706 | *Tamarix parviflora* DC. | Tamaricaceae | CL | DS(-DT) | K | 2,12,14,17,18 |
| 707 | *Tamarix dioica* Roxb. | Tamaricaceae | CL | DS(-DT) | J | 3,4,12,18 |
| 708 | *Tabernaemontana divaricata* R.Br. ex Roem. & Schult. | Apocynaceae | CL | ES(-ET) | J | 19,21 |
| 709 | *Taxodium distichum* (L.) Rich. | Taxodiaceae | CL | ET | K | 13,17,18 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 710 | *Taxus wallichiana* Zucc. | Taxaceae | WL | ET | JK | 2,3,8,19 |
| 711 | *Tecoma capensis* (Thunb.) Lindl. | Bignoniaceae | CL | ES | J | 15 |
| 712 | *Tecoma stans* (L.) Juss. ex Kunth | Bignoniaceae | CL | ES(-ET) | J | 15,19 |
| 713 | *Tecomella undulata* (Sm.) Seem. | Bignoniaceae | CL | DT | J | 21 |
| 714 | *Terminalia arjuna* Wt. & Arn. | Combretaceae | WL | ET | J | 4,18,21 |
| 715 | *Terminalia bellirica* (Gaertn.) Roxb. | Combretaceae | WL | ET | J | 4,11,18 |
| 716 | *Terminalia chebula* Retz. | Combretaceae | WL | ET | J | 4,18,19,21 |
| 717 | *Terminalia crenulata* Roth, | Combretaceae | WL | DT | J | 15,19 |
| 718 | *Thuja occidentalis* L. | Cupressaceae | CL | ET | JK | 14,17,19 |
| 719 | *Tilia platyphyllos* Scop. | Malvaceae | CL | DT | K | 2,17 |
| 720 | *Tinospora sinensis* (Lour.) Merr. | Menispermaceae | CL | DCL | J | 4,10,11,19,21 |
| 721 | *Toona ciliata* M.Roem. | Meliaceae | WL | DT | J | 4,10,11,12,19,21 |
| 722 | *Toona sinensis* (Juss.) M.Roem. | Meliaceae | CL | DT | J | 19 |
| 723 | *Toxicodendron wallichii* Kuntze | Anacardiaceae | WL | DT | J | 19 |
| 724 | *Trachelospermum jasminoides* (Lindl.) Lem. | Apocynaceae | CL | ES(ECL) | K | 17 |
| 725 | *Trachelospermum lucidum* (D. Don) Schum. | Apocynaceae | WL | ECL | J | 19 |
| 726 | *Trachycarpus fortunei* (Hook.) H.Wendl. | Arecaceae | CL | ET | JK | 17,21 |
| 727 | *Trema politoria* (Planch.) Blume | Cannabaceae | WL | ET | J | 3,4,10,11 |
| 728 | *Triumfetta rhomboidea* Jacq. | Malvaceae | CW | DSS | J | 4,11,18 |
| 729 | *Tylophora hirsuta* Wight | Apocynaceae | WL | ES | J | 1,4,18 |
| 730 | *Ulmus villosa* Brandis ex Gamble | Ulmaceae | CW | DT | JK | 1,2,3,4,18,19,21 |
| 731 | *Ulmus wallichiana* Planch. | Ulmaceae | WL | DT | JKL | 1,2,3,4,5,19 |
| 732 | *Urena lobata* L. | Malvaceae | WL | DSS | J | 4,10,11 |
| 734 | *Vallaris solanacea* (Roth) O. Kuntze | Apocynaceae | WL | ES | J | 3,4,18,19 |
| 735 | *Veronica speciosa* R.Cunn. ex A.Cunn. | Plantaginaceae | CL | ES | K | 17 |
| 736 | *Viburnum cotinifolium* D. Don | Adoxaceae | WL | DS | JK | 1,3,4,11,19 |
| 737 | *Viburnum cylindricum* Buch.-Ham. exD.Don | Adoxaceae | WL | DS | J | 19 |

(continued)

**Table 22.1** (continued)

| S. No. | Scientific name of species | Family | Wild/Cultivated[a] | Growth-form[a] | Distribution[a] | Data sources[b] |
|---|---|---|---|---|---|---|
| 738 | *Viburnum grandiflorum* Wall.ex DC. | Adoxaceae | WL | DS | JK | 1,2,3,4,9,12,19,23 |
| 739 | *Viburnum mullaha* Buch.-Ham. ex D.Don | Adoxaceae | WL | DS | J | 3,19 |
| 740 | *Viburnum nervosum* D. Don | Adoxaceae | WL | DS | J | 1,3,4,11,12 |
| 741 | *Viburnum opulus* L. | Adoxaceae | CL | DS | JK | 14,17,19 |
| 742 | *Viscum album* L. | Loranthaceae | WL | ES | JKL | 18,19 |
| 743 | *Vinca major* L. | Apocynaceae | CW | ECL | JK | 1,3,17,18 |
| 744 | *Vitis flexuosa* Thunb. | Vitaceae | CL | DCL | J | 19 |
| 745 | *Vitis jacquemontii* R. Parker | Vitaceae | WL | DCL | JK | 3,21 |
| 746 | *Vitis parvifolia* Roxb | Vitaceae | WL | DCL | J | 3,4,12 |
| 747 | *Vitis trifolia* L. | Vitaceae | CL | DCL | J | 3,4,10 |
| 748 | *Vitis vinifera* L | Vitaceae | CL | DCL | JK | 2,12,19 |
| 749 | *Vitis vulpina* L. | Vitaceae | CL | DCL | K | 2,12,18 |
| 750 | *Vitis labruscana* L.H. Bailey | Vitaceae | CL | DCL | K | 2,17,18 |
| 751 | *Vitex negundo* L. | Lamiaceae | CL | DS | J | 3,4,10,11,19,21 |
| 752 | *Weigela florida* (Bunge) A. DC. | Caprifoliaceae | CL | DS | K | 2,17 |
| 753 | *Wendlandia heynei* Santapau & Merchant | Rubiaceae | WL | DT | J | 3,4,10,11,19 |
| 754 | *Withania somnifera* (L.) Dunal | Solanaceae | CL | ES | J | 19,21 |
| 755 | *Wikstroemia canescens* Wall. ex Meisn. | Thymelaeaceae | CW | DS | JK | 2,3,4,10,11 |
| 756 | *Wisteria sinensis* DC. | Fabaceae | CL | DCL | K | 14,17,18 |
| 757 | *Woodfordia fruticosa* (L.) Kurz. | Lythraceae | WL | ES | J | 4,10,11,19,21 |
| 758 | *Wrightia arborea* (Dennst.) Mabb. | Apocynaceae | WL | DT | J | 3,4,18 |
| 759 | *Xylosma longifolia* Clos | Salicaceae | WL | DS(-DT) | J | 1,4,10 |
| 760 | *Yucca aloifolia* L. | Asparagaceae | CL | ES | JK | 2,14,17,18,19 |
| 761 | *Yucca gloriosa* L. | Asparagaceae | CL | ES | K | 17 |
| 762 | *Zamia furfuracea* L.f. ex Aiton | Zamiaceae | CL | ET | J | 21 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 763 | *Zanthoxylum armatum* DC. | Rutaceae | WL | DS(-DT) | J | 3,4,10,11,19,21 |
| 764 | *Ziziphus jujuba* Mill. subsp. *spinosa* (Bunge) Peng, Li & Li | Rhamnaceae | WL | DS | K | 24 |
| 765 | *Ziziphus jujuba* Mill. subsp. *jujuba* | Rhamnaceae | WL | DS(-DT) | JK | 2,3,4,10,11, 24 |
| 766 | *Ziziphus mauritiana* Lamk. | Rhamnaceae | WL | DS(-DT) | J | 2,3,4,10,11,18,21 |
| 767 | *Ziziphus nummularia* (Burm. f.) Wight & Arn | Rhamnaceae | WL | ES | J | 10,19 |
| 768 | *Ziziphus oxyphylla* Edgew. | Rhamnaceae | WL | DS | J | 2,3,4,10,12,19,21 |

[a]**Abbreviations used: Wild/cultivated status** – *WL* Wild, *CL* Cultivated, *CW* Cultivated and wild; **Growth-form** – *DT* deciduous tree, *ET* evergreen tree, *DS* deciduous shrub, *ES* evergreen shrub, *DSS* deciduous sub-shrub, *ESS* evergreen sub-shrub, *DCL* deciduous climber, *ECL* evergreen climber; **Distribution** – *J* Jammu region only, *K* Kashmir region only, *L* Ladakh region only, *JK* Jammu and Kashmir regions, *JL* Jammu and Ladakh regions, *KL* Kashmir and Ladakh regions, *JKL* all the three region

[b]Data sources: 1 = Lambert (1933), 2 = Ara et al. (1995), 3 = Stewart (1972), 4 = Sharma and Kachroo (1981), 5 = Kachroo et al. (1977), 6 = Polunin and Stainton (1984), 7 = Dhar and Kachroo (1983), 8 = Dar and Dar (2006), 9 = Sharma and Jamwal (1988), 1998, 10 = Swami and Gupta (1998), 11 = Kapur and Sarin (1990), 12 = Singh and Kachroo (1976), 13 = Dar and Dar (2005), 14 = Dar and Khan (2007), 15 = Bhellum et al. (2013), 16 = Chaurasia et al. (2007), 17 = Aslam et al. (2013), 18 = Malik et al. (2010), 19 = Mughal et al. (2017), 20 = Malik et al. (2012), 21 = Dar and Malik (2017), 22 = Dvorsky et al. (2018), 23 = Malik et al. (2015), 24 = Akhter et al. (2013), 25 = Dar and Christensen (2003)

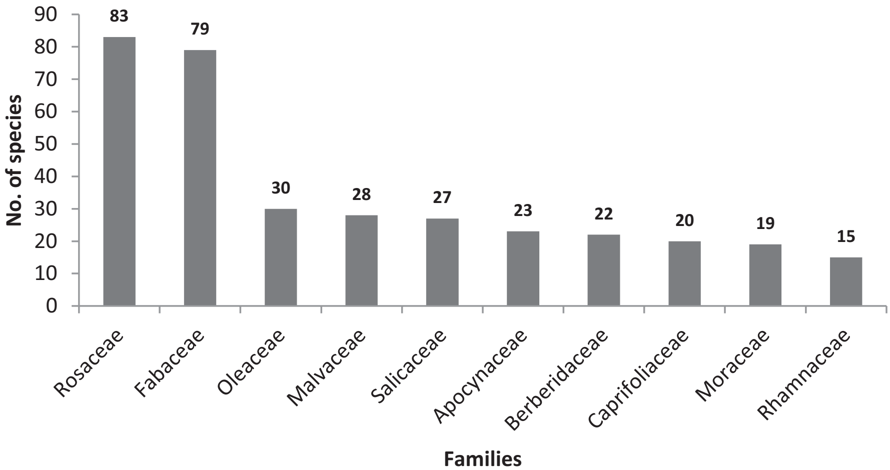


**Fig. 22.1** The 10 largest families in terms of number of species in the arboreal flora of the state of J&K

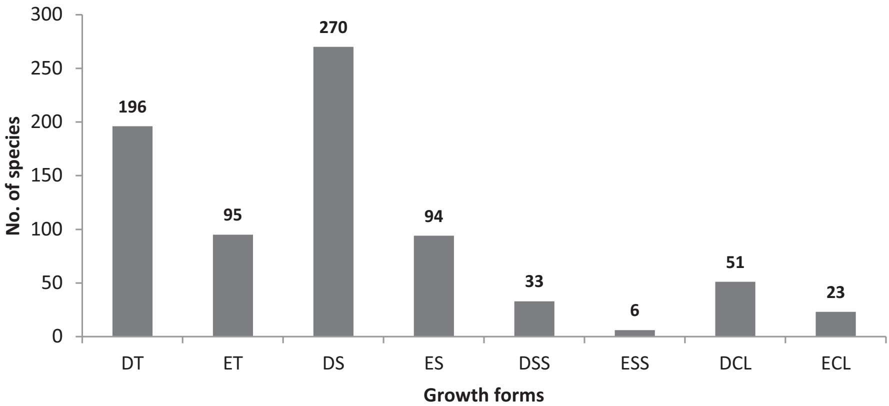


**Fig. 22.2** Contribution of different growth forms in terms of number of species in the arboreal flora of J&K

The different growth forms in arboreal flora of the state are represented disproportionately. The deciduous shrubs form the dominant component, contributing 270 species; these are followed in a descending order by deciduous trees (196 spp.), evergreen trees (95 spp.), evergreen shrubs (94 spp.), deciduous climbers (51 spp.), deciduous sub-shrubs (33 spp.), evergreen climbers (23 spp.), and evergreen sub-shrubs (6 spp.) (Fig. 22.2). The dominance of deciduous shrubs and trees in the state can be attributed to the harsh winter conditions in its Kashmir and Ladakh regions. In order to survive the unfavourable conditions of freezing temperatures of the winter, the trees and shrubs shed their leaves during autumn season, for example, *Aesculus indica, Acer caesium, Populus alba,* and *Platanus orientalis*. Majority of the evergreen shrubs and trees occur in the Jammu region (e.g. *Buxus wallichiana*, *Ficus benghalensis, Ilex dipyrena, Quercus inacana, Pinus gerardiana,* and *P. roxburghi,*); at the same time, evergreen element in the Kashmir region is represented by some conifers (e.g., *Abies pindrow, Cedrus deodara, Picea smithiana, Pinus wallichiana, Taxus wallichiana*), and few exotic species (e.g., *Cryptomeria japonica, Pinus canariensis, Pinus halepensis, Euonymus japonicas*, and *Eriobotrya japonica*). Some of the invasive species growing in the state are: *Aesculus indica*, *Ailanthus altissima*, *Lantana camara*, *Mimosa pudica*, *Ricinus communis*, and *Robinia pseudoacacia* (Plate 22.1).

Phytogeographically, the arboreal flora shows interesting distribution pattern in the state. Overall, 561 species occur in the Jammu region, followed by 384 species in the Kashmir, and 92 species in the Ladakh region. In terms of exclusive regional distribution, 352 species in total arboreal flora are restricted to the Jammu region; whereas about (154) of species are restricted to the Kashmir region, and only 27 species to the Ladakh region (Fig. 22.3). Such a clear decreasing trend, in terms of number of species, from Jammu to Kashmir to Ladakh regions is due to markedly variable climatic conditions between these three regions. The subtropical and temperate-like climates prevalent in Jammu and Kashmir regions, respectively, are suitable for the ecological adaptation and evolutionary success of arboreal elements. Strikingly, there are 170 species whose distribution range is spread across the regions of Jammu and Kashmir. In contrast, there are only 26 species that share their distribution range between Kashmir and Ladakh regions; and just 5 species distributed across Jammu and Ladakh regions. Furthermore, there are 34 species whose distribution range spans across the entire state. The sharing of more arboreal species between Jammu and Kashmir regions can be attributed to their wider geographic proximity and relatively less sharp climatic gradient. As against this, the lesser number of arboreal elements shared between Jammu and/or Kashmir with Ladakh can be explained in terms of significantly wide climatic mismatch. Ladakh, being a cold-arid desert, supports very less proportion of arboreal elements. The arboreal species in this region are represented by dwarf, creeping, and cushion-forming shrubs (e.g., *Ephedra gerardiana, Caragana versicolor*) and a few cultivated tree species (e.g., *Salix alba*, *Prunus armeniaca*) (Plate 22.2).

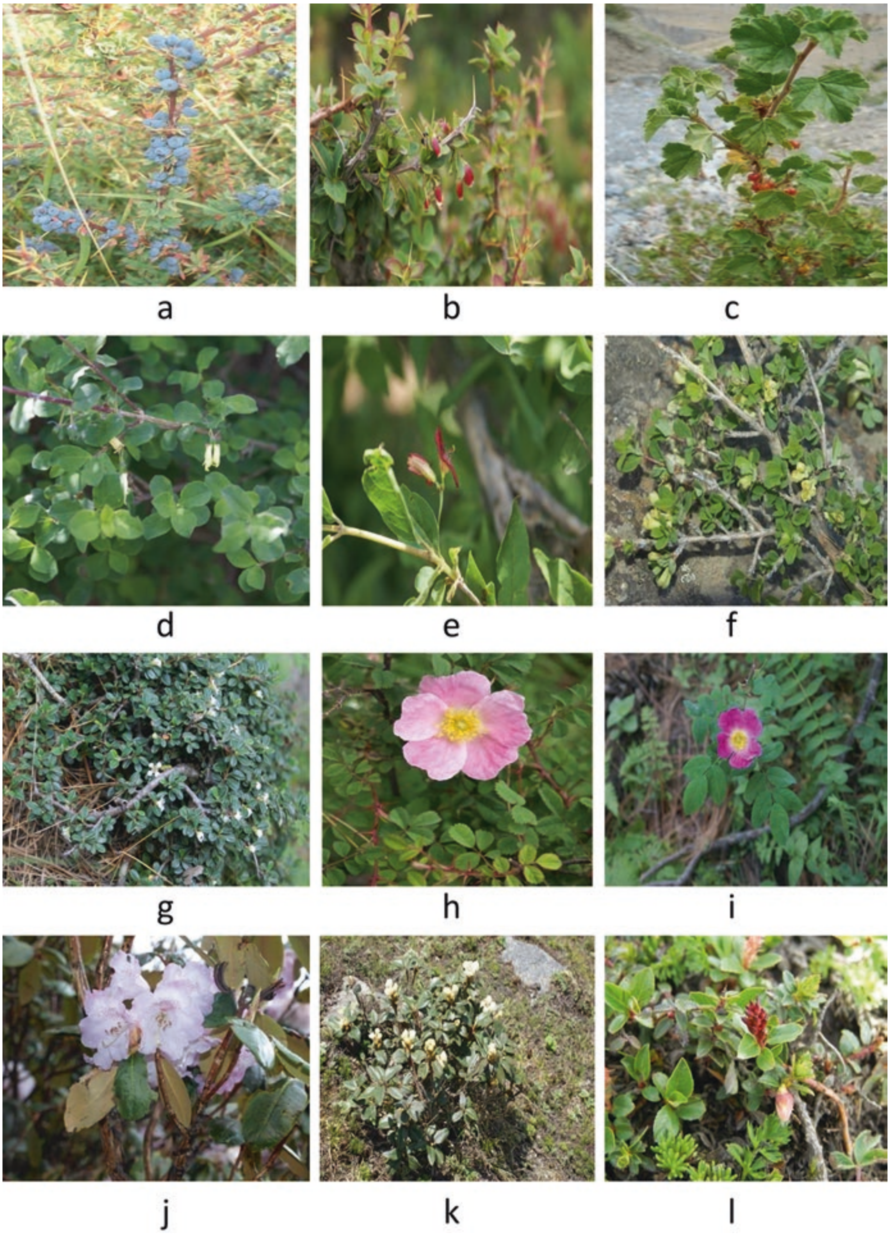


**Plate 22.1** (**a**) *Berberis ulicina* (**b**) *B. jaeschkeana* (**c**) *Ribes orientale* (**d**) *Lonicera asperifolia* (**e**) *L.webbiana* (**f**) *L. obovata* (**g**) *Cotoneaster microphyllus* (**h**) *Rosa webbiana* (**i**) *R.macrophylla* (**j**) *Rhododendron campanulatum* (**k**) *R. anthopogon* (**l**) *Salix flabellaris*

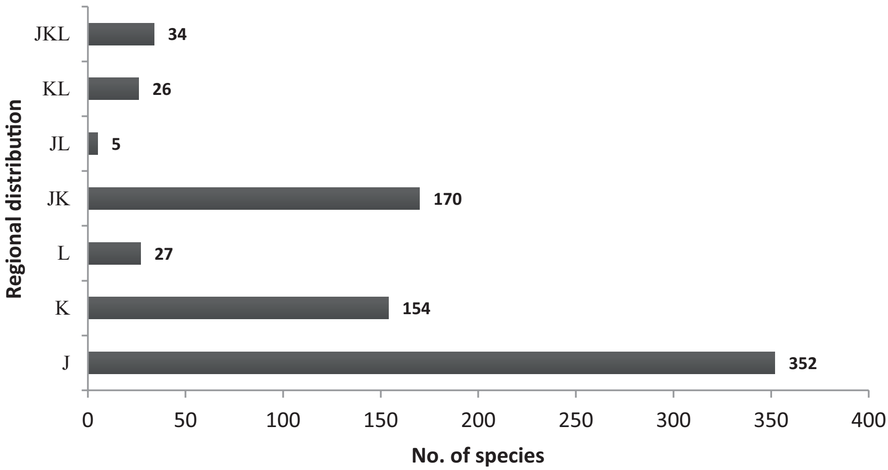


**Fig. 22.3** Regional distribution in terms of number of species in the arboreal flora of the J&K state

## 22.4 Concluding Remarks

Taxonomic inventory of life forms that exist on planet Earth serves as the starting point in the biodiversity studies carried out at the local, regional, and global scales. The present chapter provides an annotated inventory of arboreal flora of the J&K state, with the hope that it could furnish the crucial baseline data for use by the researchers, policy makers, land managers, common public, and other stakeholders interested in the conservation and sustainable use of biodiversity. The arboreal species, such as trees determine the type, richness, and abundance of other biota through the regulation of limiting resources (Abbate et al. 2012). In a multi-storied forest, the overstorey species mostly represented by trees affect not only the overall community composition but also the resource distribution, microclimatic conditions, nutrient cycles, and disturbance regime (Molder et al. 2008). The overstorey species richness has been found to be one of the main determinants of understorey species richness in some vegetation types (Burrascano et al. 2011). Rueda et al. (2010) demonstrated that tree pattern was a strong predictor of fauna patterns (birds, butterflies, mammals) at European scale. Recently, a lot of studies on past climate change have been based on dendrochronology of arboreal species (Collins et al. 2012). Therefore, making updated databases, such as the one in present study, is fundamental to evaluate the effect of future global climate change on biodiversity.

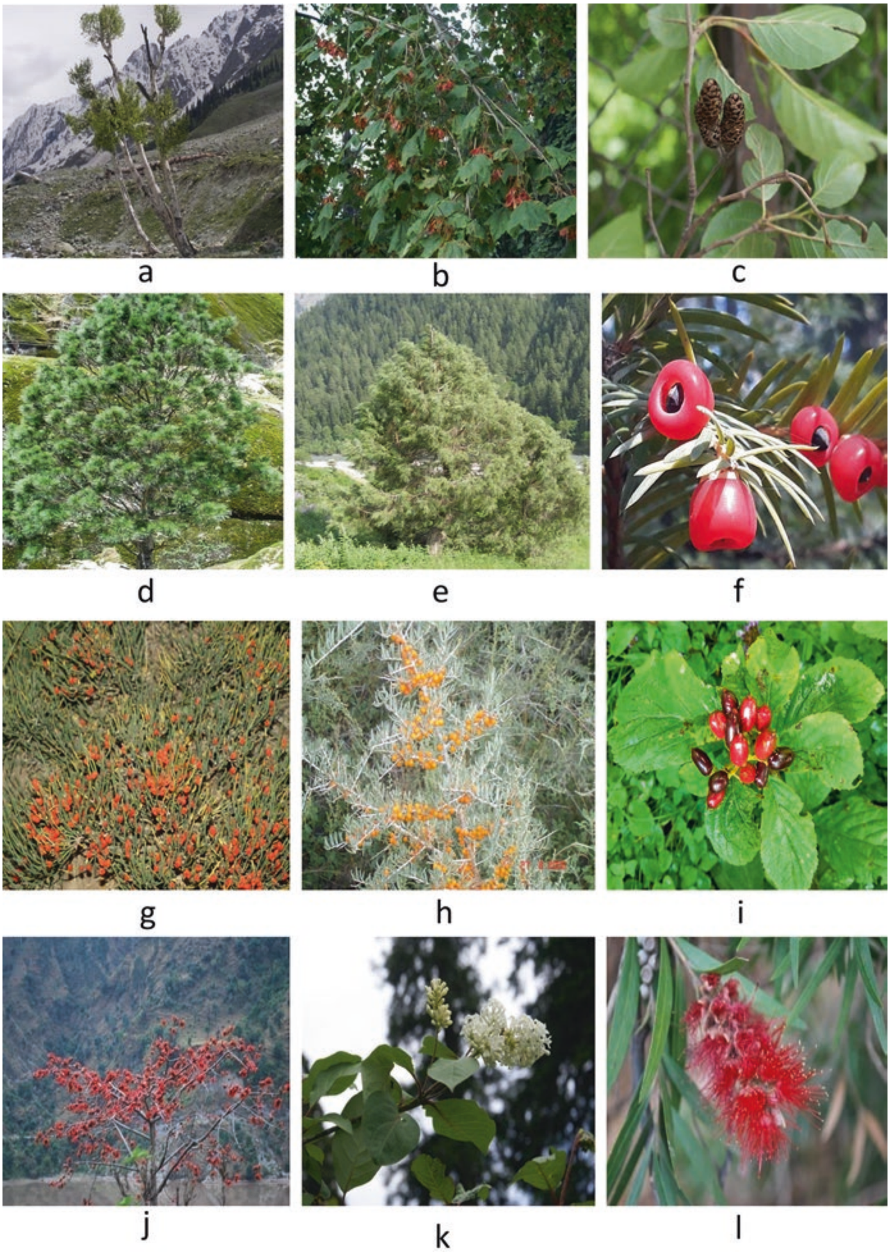


**Plate 22.2** (**a**) *Betula utilis* (**b**) *Acer caesium* (**c**) *Alnus nitida* (**d**) *Pinus gerardiana* (**e**) *Juniperus semiglobosa* (**f**) *Taxus wallichiana* (**g**) *Ephedra gerardiana* (**h**) *Hippophae rhamnoides* (**i**) *Viburnum grandiflorum* (**j**) *Bombax ceiba* (**k**) *Syringa emodi* (**l**) *Callistemon citrinus*

**Acknowledgements** The authors are thankful to the Head, Department of Botany, University of Kashmir, Srinagar, for providing necessary facility during the course of present study. The supporting staff at the Centre for Biodiversity and Taxonomy, University of Kashmir is acknowledged for their help in the field surveys and herbarium studies.

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# Chapter 23
# Asteraceae in Jammu and Kashmir Himalaya: A Floristic Account

**B. L. Bhellum**

**Abstract** The Jammu and Kashmir Himalaya enjoys remarkable richness and diversity in Asteraceae, representing nearly 50% of all the taxa of this family in India. A total of 554 species belonging to 133 genera under 12 tribes are reported from the Kashmir Himalaya; these species constitute ca. 11% of its entire angiosperm flora. The constituent members are distributed in all three climatic zones, subtropical, temperate and alpine; 68.8% species inhabit the Kashmir region, while the rest 31.2% occur in the Jammu region. The tribe Cichorieae is the largest, contributing 27.7% species in 20 genera; followed by Cardueae with 16.4% species in 21 genera, and Inulaeae with 12.8% species in 16 genera. Ten larger Asteraceae genera in two regions are *Taraxacum, Artemisia, Saussurea, Erigeron, Lactuca, Senecio, Aster, Inula, Anaphalis,* and *Gnaphalium*; these together contain 46.5% of all species in the family. Overall, 63 genera are represented by a single species each. Many of these species (95; 18.6%) in 24 genera are endemic to this Himalayan region. The rich endemic genera are *Taraxacum* (42.1%), *Saussurea* (10.5%), *Artemisia* (6.3%), *Lactuca* (4.44%), *Chondrilla* (4.2%), *Senecio* (4.2%), *Jurinella* (3.33), *Crepis* (3.1%) and *Erigeron* (3.1%). As many as 54 species are exotic. Information on economic importance of taxa is also appended.

**Keywords** Asteraceae · Tribes · Floristic account · Jammu and Kashmir Himalaya · India

## 23.1 Introduction

The family Asteraceae (Compositae) warrants intensive and extensive study because of its significant diversification as compared to other groups of flowering plants. It is recognized at a glance by its capitulum ('head') type of inflorescence, and show

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_23

a great deal of variability in terms of ray and disc florets, number of stamens and their association, shape of anthers, style and stigma types. Variation is also pronounced in the pappus, shape, size and morphology of achenes. The family is highly evolved among dicotyledons and majority of its species are herbs. The members of this family are unique, capable of occupying different habitats types, including aquatic, arid, marshy and cold desert. Members of Asteraceae are capable of growing on poor soils, moist soils, dry rocks; in aquatic conditions, arid regions, and other types of habitats. The dispersal efficiency of Asteraceae has led its members to travel long distances. Thus, distribution range of its different species across different continents around the globe has become a remarkable feature of these taxa. Some species of this family have a very narrow range of distribution.

Asteraceae is one of the largest families of flowering plants in the world, having 23,600 species in 1620 genera (Stevens 2001). In India, the family is represented by 900 taxa belonging to 167 genera (Hajra et al. 1995). In Jammu and Kashmir (J&K) State, it is the largest family of flowering plants, reported to be represented by 481 species in 109 genera (Singh and Mathur 2001). The authors who have made significant contribution in Jammu and Kashmir State are Royle (1839), Hooker f. (1872–1897), Clarke (1876), Duthie (1893–1894), Stewart (1916, 1967, 1972, 1979), Coventry (1923–1930), Blatter (1927–1929), Lambert (1933), Rao (1960, 1961), Van Soest (1961, 1963), Wali and Tiku (1964), Singh and Wafai (1971, 1973), Singh and Gohil (1972), Rau (1975), Kachroo et al. (1977), Koul (1977), Nayar (1980), Kaul (1986), Sharma and Kachroo (1981, 1983), Dar and Kachroo (1982, 1983), Naqushi et al. (1984), Kak (1990), Dhar and Kachroo (1983), Dar and Naqushi (1984, 2001), Sharma and Jamwal (1988, 1998), Vir Jee et al. (1989), Dar et al. (1990, 1995, 2002), Hamal et al. (1990), Bhellum and Magotra (1992, 1994, 1996, 2012a, b, c, d, e, f, g, h, 2013), Padha et al. (1994), Magotra and Bhellum (1998), Bhellum et al. (2013), Singh and Kachroo (1994), Swamy and Gupta (1998), Singh and Singh (2002), Singh et al. (2002), Vidyarthi (2003), Khuroo et al. (2004, 2007), and Reshi et al. (2008, 2009).

In this chapter, 554 species, spread over 133 genera from 12 tribes in Asteraceae have been recorded from the J&K Himalaya. These species occur in different climatic conditions, some special habitats and varied altitudinal zones in this region. The phytogeographical and climatic variation has a tremendous impact on the richness and diversity of Asteraceae in the region. Provided here is the numerical size of each tribe of the family in terms of its genera and species, number of species in dominant genera, together with some other aspects, such as economic importance, endemics, and exotic nature of asteraceous species in the study area.

## 23.2 Material and Methods

This chapter is based on the collection of specimens of the family Asteraceae from different areas in J&K, mostly between 2003 and 2007. Forays of two different types were undertaken round the year: collection trips to distant places were of the duration of 3–7 days, while brief trips of 1–2 days' duration were executed alone or in the company of one or more helpers. This way, it was possible to make collections from different parts of the state. In the first few years the collections were huge, but subsequently they yielded only few specimens. While collecting the plant specimens, field numbers were allotted and relevant data about each plant species was recorded in the field book. The specimens were carried to the laboratory in polythene bags, rucksacks or in plant presses, depending upon the length of the trip and the distance of the place of collection. The plants collected were pressed in wooden presses wrapped in blotters. These specimens were changed frequently after 24 h to reduce the discoloration of foliage and flowers and to avoid rotting. The dried specimens were mounted on the herbarium sheets by stitching. Printed labels with relevant data entered on them were pasted at the lower right corner of sheets. These plants were identified with the help of relevant taxonomic literature on Asteraceae and using Dissection Microscope and Stereoscope.

## 23.3 Results and Discussion

Since the mountains are inaccessible, highly rugged terrains, vertical cliffs and exposed rocks towards north, northeast and northwest amplify the local climatic variations; with the result, the mountains offer greater and a remarkable diversity of species, particularly on the Himalayan ranges rather than the lowlands of the Jammu region. The local variations in hilly areas of the region are pronounced in the climate and soil types, contributing to plant diversity at various elevation levels. The present contribution provides significant data to study and analyse evolutionary trends in species of Asteraceae.

Members of Asteraceae enjoy different types of extremes in terms of temperature in the Jammu and Kashmir regions. The vegetation in the Kashmir Himalaya varies according to both altitude and climatic conditions such as temperate, subalpine and alpine. The distribution of Asteraceae members is predominately in temperate areas. Thus, most of the overall taxa recorded from the state occur in the Kashmir region, followed by Ladakh; the Jammu region is poor in asteraceous taxa. Majority of the species grow on the northern slopes, while the southern slopes are sparsely vegetated. Although the hillsides are exceedingly stony, yet they host many colourful taxa.

The exotic species occur from the tropical deciduous forests in the foot-hills to the temperate forests. The thick arboreal vegetation of the mountain ridges is broken by cultivated fields, or lovely meadows supporting herbaceous plants. *Artemesia japonica, A. nilagirica, Eclipta prostrate, Galinsoga parviflora, Gnaphalium affine, Ixeris polycephala, Lactuca dissecta, Launaea procumbens, Sonchus oleraceus,* and species of *Taraxacum* are frequently seen in the temperate–subalpine zone. The common species that occur in pastures are: *Aster himalaica, Crepis sanctum, Hieracium vulgaum, Ligularia sibirica, Tagetes minuta,* and *Tanacetum dolychophyla.*

The species growing along subalpine valleys are chiefly of mesic nature; these include *Achellia mellefoliim, Aster molliusculus, Myriactis wallichii, Senecio nudicaulis, S. vulgaris, Taraxacum officinale, Xanthium spinosum, X. strumarium.* The common species of Asteraceae in Ladakh are *Allardia glabra, Aster heterochaeta, Erigeron alpinus, Anaphalus nubigena, Inula barbata, Artemisia amygdalina, Cremanthodium decaisnei, Lactuca decipiens, Lactuca scariola, Senecio chrysanthemoides, Arctium lappa, Saussurea albescens, Jurinea ceratocarpa, Tragopogon pratense,* and *Taraxacum officinale.*

Many of the species of this family are found only in the Himalaya, several others are endemic to Western Himalaya, such as *Anaphalis royleana*, *Artemisia amygdalina, Bidens minima, Chondrilla graminea, Carthamus pulchra, Chrysanthemum tibeticum*, *Circium falconeri*, *Cousenia falconeri*, *Cremanthodium plantagineum, Crepis dachhigamensis, Doronicum falconeri*, *Erigeron semibarbata, Heteropappus holohermaphroditus*, *Hieracium umbellatum* var. *lanceolatum*, *Inula clarkei, Jurinea himalaica* var. *tibetica*, *Lactuca kashmiriana*, *Lenotopodium monocephalum, Ligularia jacquemontiana*, *Picris hieracioides, Saussurea bracteata, Scorzonera alba*, *Senecio laetus* var. *analogus, Tragopogon kashmirianus*.

In all, 554 species of Asteraceae, belonging to 133 genera are reported from Jammu and Kashmir regions. These species together form ca. 11% of all the angiosperm flora of the state. This figure is very close to that of the eastern North America (12.7%), followed by Texas (13.4%), New Zealand (12.5%) and California (13.6%). These taxa belong to 12 tribes, viz. Anthemideae, Astereae, Calenduleae, Cardueae, Cichorieae, Eupatorieae, Heliantheae, Inuleae, Mutisieae, Senecioneae, Tageteae, and Vernonieae; the taxonomic richness of these tribes is illustrated in Table 23.1.

Cichorieae is the largest tribe, contributing 154 (27.7%) species in 19 genera; followed by Cardueae with 91 (16.4%) species in 22 genera, Anthemideae with 79 (14.2%) species in 12 genera, and Inulaeae with 71 (12.8%) species in 18 genera

**Table 23.1** Numerical size of genera and species in different tribes of Asteraceae in Jammu & Kashmir

| S. No. | Name of tribe | Number of genera | Number of species |
|---|---|---|---|
| 1. | Anthemideae | 12 | 79 |
| 2. | Astereae | 17 | 62 |
| 3. | Calenduleae | 1 | 02 |
| 4. | Cardueae | 22 | 91 |
| 5. | Cichorieae | 19 | 154 |
| 6. | Eupatorieae | 3 | 7 |
| 7. | Heliantheae | 19 | 33 |
| 8. | Inuleae | 18 | 71 |
| 9. | Mutisieae | 7 | 09 |
| 10. | Senecioneae | 12 | 39 |
| 11. | Tageteae | 1 | 03 |
| 12. | Vernonieae | 2 | 04 |
| **Total:** | | **133** | **554** |

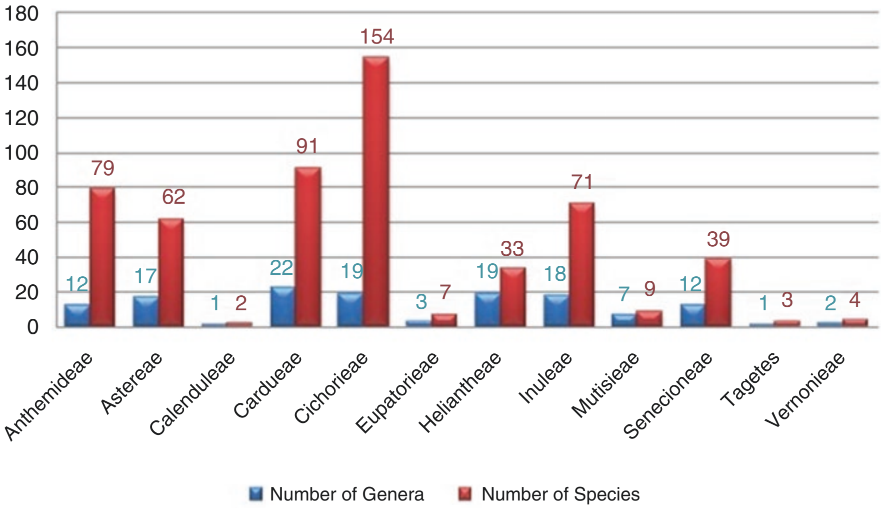


**Fig. 23.1** Numerical size of different tribes showing number of genera and species in each tribe of Asteraceae in the Kashmir Himalaya

**Table 23.2** Comparative numerical size of the ten larger genera of Asteraceae in Jammu and Kashmir, India and the world

| S. No. | Name of genus | Number of species in | | |
|---|---|---|---|---|
| | | Jammu & Kashmir | India | World |
| 1. | *Taraxacum* F.H. Wigg. | 80 | 83 | 1000 |
| 2. | *Artemisia* L. | 42 | 42 | 500 |
| 3. | *Saussurea* DC. | 40 | 61 | 403 |
| 4. | *Erigeron* L. | 19 | 19 | 390 |
| 5. | *Lactuca* L. | 16 | 24 | 150 |
| 6. | *Senecio* L. | 15 | 15 | 100 |
| 7. | *Aster* L. | 14 | 23 | 250 |
| 8. | *Inula* L. | 13 | 20 | 90 |
| 9. | *Anaphalis* DC. | 10 | 31 | 40 |
| 10. | *Gnaphalium* L. | 09 | 10 | 10 |

(Fig. 23.1). As many as 68.8% species inhabit the Kashmir region, while the remaining 31.2% occur in the Jammu region; this shows that Asteraceae is dominant in the Kashmir region.

The ten larger genera, in terms of the number of species, are *Taraxacum* (80 species), followed by *Artemisia* (42 species), *Saussurea* (40 species), *Erigeron* (19 species), *Lactuca* (16 species), *Senecio* (15 species), *Aster* (14 species), *Inula* (13 species), *Anaphalis* (10 species) and *Gnaphalium* (9 species) (Table 23.2).

These ten dominant genera together contain 46.5% of the total number of species found in Asteraceae of Jammu and Kashmir. The three largest genera are *Taraxacum, Artemisia* and *Saussurea*, containing 14.4%, 7.5% and 7.2% total species of the family, respectively. Overall, 63 genera are represented by a single species each. The genus-to-species ratio in Asteraceae in the flora of Jammu and Kashmir is 1:4.1.

### *23.3.1 Asteraceous Taxa Endemic to Jammu and Kashmir Himalaya*

Many (95) of the overall species, belonging to 24 genera, are endemic to this Himalayan region. The high degree of endemism in the family is because of the unique topography, ecosystems and geographic position of the mostly mountainous state. These endemic species form 17.14% of total species of Asteraceae in two regions. Therefore, such species need attention for conservation as their distributional range is narrow in Jammu and Kashmir and its adjoining areas.

The endemic taxa of Asteraceae in J&K are as follows: *Artemisia amygdalina* Decne., *A. banihalensis* Kaul et Bakshi, *A. cashemirica* Kaul & Bakshi, *A. salsoloides* Willd. var. *vellayi* Hemsl., *A. stronglycephalum* Pamp. var. *typica* f. *gemunia* Pamp., *A. stronglycephalum* Pamp., *Bidens minima* Huds., *Bidens tetraspinosa* Kak and Javeid, *Cacalia levingii, Chondrilla graminea* M. Bieb. var. *kashmiriana* Hk. f., *C. pauciflora* Ledeb., *C. maniforma, C. setulosa* Clarke, *Chrysanthemum tibeticum* Hk. f. & Thoms., *Circium wallichii* (DC.). var. *pletlepis* Hook. f., *Cousenia falconeri* Hk. f., *Cremanthodium ellisii* Kitam., *Crepis Jaeschkei* Vierh, *E. pseudohyrcanicus* Grierson ex. Stewart, *Erigeron semibarbata* (DC.) Hk. f., *Gerbera lacei* Watt., *Heteropappus holohermaphroditus* Grierson, *Hieracium umbellatum* L. var. *lanceolatum* Hook. f., *Inula clarkei* (Hk. f.) R. R. Stewart, *Inula.royleana* DC., *Jurinella macrocephala* var. *tibetica* (Stewart) Karthik & Moorthy, *J. macrocephala* Aswal & Goel, *J. rosulata* Klatt., *Lactuca. kashmiriana* Mamgain & R. R. Rao, *L. lessertiana* Clarke var. *lyrata* Stebbins; *L. tatarica* (L.) Mey., *L. benthamii* Clarke, *Launaea microcephala* Hook. f., *Leontopodium conocephalum* Edgew., *Ligularia jacquemontiana* (Decne.) Rau, *L. sibirica* (L.) Cass. var. *racemosa* (DC.) Kitam., *Olgaea thomsoii* (Hk.f.) Iljin., *Picris hieracioides* L., *Saussurea bracteata* Decne., *S. candolleana* (Wall. ex DC.) Clarke, *S. clarkei* Hook. f., *S. costus* (Falc.) Lipschitz.; *S. glanduligera* Sch.-Bip.; *S. graminifolia* wall. ex DC.; *S. obvallata* (DC.) Beh.-Bip., *S. stoliczkai* Clarke, *S. subulata* Clarke, *S. uniflora* (DC.) Sch.-Bip., *Scorzonera alba* Stewart, *Senecio ladakhensis* Chowdhery et Mathur; *S. laetus* var. *analogus* (DC.) R. Mathur ex Karthik & Moorthy, *S. laetus* var. *specatabilis* (DC.) R. Mathur ex Karthik & Moorthy, *S. laetus* var. *cymbiformis* (DC.) Aswal, *Tragopogon kashmirianus* Singh, *Taraxacum amblylepidocarpum* V. Soest, *T. apargiaeforme* Dahlst., *T. coronatum* Hand.-Mazz., *T. elegans* V. Soest, *T. eriocarpum* H. Hartm., *T. flavum* V. Soest, *T. fulvescens* V. Soest, *T. fulvo–brunneum* V. Soest; *T. gulmargense* V. Soest, *T. harbhajan-singhii* V. Soest, *T. harbhajan-singhii* ssp. *pahalgamense* V. Soest, *T. helianthemum* V. Soest, *T. heteroloma* Hand.–Mazz., *T. hooftii* V. Soest, *T. karakoricum* V. Soest, *T. kashmirense* V. Soest, *T. kjellmaniiforme* V. Soest; *T. ladakense* V. Soest; *T. laevigatum* (Willd.) DC.; *T. latibasis* V. Soest, *T. lobbichleri*,

V. Soest, *T. longicarpum* V. Soest, *T. luridum* G. Hagl., *T. nagaricum* V. Soest, *T. nasiri* V. Soest, *T. nigrum* V. Soest, *T. nivale* J. Lange, *T. parvuliforme* V. Soest, *T. phoenicolepis* V. Soest, *T. pseudobicorne* V. Soest, *T. pseudoeriopodum* V. Soest, *T. pseudostaticifolium* Hand-Mazz., *T. pseudosteven* V. Soest, *T. stereodiforme* V. Soest, *T. stewartii* (Spreng.) DC., *T. violaceo-maculatum* V. Soest, *T. vulpinum* f. *pallidocarpum* V. Soest, *T. xanthophyllum* Haglund.

The highest percentage of endemism is found in the genus *Taraxacum* (42.1%), followed by *Saussurea* (10.5%), *Artemisia* (6.3%), *Lactuca* (4.44%), *Chondrilla* (4.2%), *Senecio* (4.2%), *Jurinella* (3.33), *Crepis* (3.1%) and *Erigeron* (3.1%). The lowest percentage in terms of number of endemic taxa is found in genera *Bidens, Chrysanthemum, Circium, Cousenia, Cremanthodium, Gerbera, Heteropappus, Hieracium, Inula, Leontopodium, Ligularia, Olgea, Picris, Scarzonera* and *Tragopogon*.

### *23.3.2 Exotic Asteraceous Taxa in Jammu and Kashmir Himalaya*

Introduced exotic species are conspicuous in orchards and parks and gardens in various parts of Jammu and Kashmir. Some of these have become naturalized over a period and form a significant part of the flora. As many as 54 exotic species of Asteraceae (Table 23.3) are recorded from Kashmir Himalaya; several of these have become weedy, affecting growth and proliferation of native species.

The asteraceous weeds of common occurrence in the flora of Jammu and Kashmir are *Ageratum conyzoides, Anthemis cotula*, *Arctium lappa, Bidens* spp., *Blainvillea acmella, Cichorium intybus, Carthamus oxycanthus, Echinops echinatus, Eclipta prostrata, Galinsoga parviflora, G. quadriradiatus, Ixeris polycephala, Parthenium hysterophorus, Senecio vulgaris, Sonchus* spp., *Symphyotrichum subulatum, Xanthium strumarium* and *X. spinosum.*

### *23.3.3 Economically Useful Asteraceous Species in the Kashmir Himalaya*

Asteraceae are of great economic value. There are well-known species of Asteraceae which yield food, fodder, oils, dyes and perfumes. Several of its taxa are variously utilized by the local inhabitants, such as for medicines, as vegetables, in religious ceremonies, etc. These are categorized as follows (Plates 23.1 and 23.2):

- **Medicinal Species**

A large number of species are used as medicines, some being of major medicinal value and others having little impact. Common medicinal plants of Asteraceae in the

**Table 23.3** List of exotic asteraceous taxa in Jammu and Kashmir with their nativity

| S. No. | Name of species | Nativity |
|---|---|---|
| 1. | *Achillea millefolium* L. | N. Asia; Europe and America |
| 2. | *Ageratum conyzoides* L. | South America |
| 3. | *A. houstanianum* Mill | Mexico |
| 4. | *Artemisia abrotanum* L. | Asia |
| 5. | *A. absinthium* L. | British Isles |
| 6. | *A. dranculus* L. | Europe |
| 7. | *A. japonica* Thunb. | Japan |
| 8. | *A. vulgaris* L. | British Isles |
| 9. | *Aster falconeri* Clarke ssp. *nepalensis* Grierson | Nepal |
| 10. | *A. tibeticus* Hook. f. | Mexico |
| 11. | *Bellis perennis* L. | South Europe |
| 12. | *Bidens comosus* (Gray) Wiegand | North America |
| 13. | *Breea arvensis* (L.) Less. | Asia and Europe |
| 14. | *Carduus crispus* L. | Europe |
| 15. | *Centaurea calycitrapa* L. | Europe |
| 16. | *C. cyanus* L. | Mediterranean regions and Europe |
| 17. | *Chrysanthemum carinatum* L. | Japan |
| 18. | *Chrysanthemum cinerarifolium* Vis. | Yugoslavia and Italy |
| 19. | *Cichorium intybus* L. | Europe |
| 20. | *C. endivia* L. | Mediterranean regions |
| 21. | *Conyza bonariensis* L. | Argentina |
| 22. | *C. canadensis* L. | North America and Canada |
| 23. | *C. japonica* (Thumb.) Less. | Japan |
| 24. | *Dhalia imperalis* Roezl. ex Ortgies | South Mexico to Columbia |
| 25. | *D. pinnata* Cav. | Mexico |
| 26. | *Eclipta prostrata* (L.) L. | South America |
| 27. | *Erigeron swatensis* Grierson ex Stewart | Pakistan |
| 28. | *Eupatorium coelestunum* L. | USA |
| 29. | *Galinsoga parviflora* Cav. | Tropical America |
| 30. | *G. quadriradiata* Ruiz et Pavon | Mexico |
| 31. | *Gnaphalium purpureum* L. | Tropical America |
| 32. | *Guizotia abyssinica* (L. f.) Cass. | Tropical Africa |
| 33. | *Helianthus annuus* L. | C. and N. America; West Indies |
| 34. | *H. debilis* Nutt. | America |
| 35. | *H. tuberosum* L. | Eastern USA |
| 36. | *Inula britanica* L. | Europe |
| 37. | *Lactuca sativa* L. | Mediterranean region |
| 38. | *Parthenium hysterophorus* L. | C. and N. America; West Indies |
| 39. | *Sclerocarpus africanus* Jacq. | Tropical Africa |
| 40. | *Silybum marianum* (L.) Gaertn. | South Europe |
| 41. | *Solidago canadensis* L. | America |

(continued)

**Table 23.3** (continued)

| S. No. | Name of species | Nativity |
|---|---|---|
| 42. | *S. virga-aurea* L. | North America |
| 43. | *Sonchus oleraceous* L. | Probably Europe and Eurasia |
| 44. | *Stevia ovata* Willd. | Brazil and Paraguay |
| 45. | *Synedrella vialis* (Less.) A. Gray | South America |
| 46. | *Tagetes erecta* L. | Africa or Mexico |
| 47. | *T. minuta* L. | South America |
| 48. | *T. patula* L. | Mexico |
| 49. | *Tridex procumbens* L. | South America |
| 50. | *Xanthium spinosum* Wallroth | South America |
| 51. | *X. strumarium* L. | Europe |
| 52. | *Youngia japonica* (L.) DC. | Japan |
| 53. | *Zinnia elegans* Jacq. | Mexico |
| 54. | *Z. linearis* Benth. | Mexico |

region include: *Anaphalis busua, A. cinnamomum, A. contorta, A. cornuta, A. cuneifolia, A. nubigena, Arctium lappa, Artemisia absinthium, A. annua, A. brevifolia, A. dubia, A. campacta, A. capillaris, A. drunculus, A. maritima, A. nilagirica, A. parviflora, A. persica, A. roxburghiana, A. sievertiana, A. vestita, Aster diplostephoides, A. falconeri, Carthamus tinctorius, Catamixis baccharoides, Centaurea depressa, C. iberica, Cremanthium illisii, Circium arvense, Echinops cornigerus, Eclipta prostrata, Conyza canadensis, Gerbera nepalensis, Gnaphalium leutoalbum, Inula graveolens, Jurinea macrophylla, Lactuca sativa, L. orientalis, L. tartarica, Leontopodium alpinum, Saussurea albescens, S. atkinsonii, S. obvallata, S. sacra, S. taraxifolia, S. thomsoni, S. ceratocarpa, Senecio chrysanthemoides, S. vulgaris, S. krachenninkovii, S. jacquemontianus, Sonchus asper, S. oleraceus, Tagetes minuta, Tanacetum gracile, T. fruticulosum, Taraxacum officinale, Tridex procumbens, Waldheimia nivea, W. stoliczkii, W. tomentosum, Xanthium strumarium*, *Youngia japonica*.

- **Food and Vegetable Species**

*Carthamus tinctorius, Cichorium intybus, Cynara scolymus, Helianthus annuus, H. tuberosum, Lactuca sativa, Taraxacum officinale, Xanthium indicum.*

- **Ornamental Species**

Ornamental species of Asteraceae have been a source of attraction for people across the world, for bearing florets of different colors. Aggregation of multicolor florets in a capitulum amazingly adds to the ornamental look of asteraceous members. Some ornamental species of common occurrence in Jammu and Kashmir are: *Arnica montana, Calendula officinalis, Centaurea cyanus, Chrysanthemum bracteata, Conoclinium coelestinum, Coreopsis tinctoria, Cosmos bipinnata, Gaillardia amblyodon, G. pulchra, Garhadiolus minutissimus.*

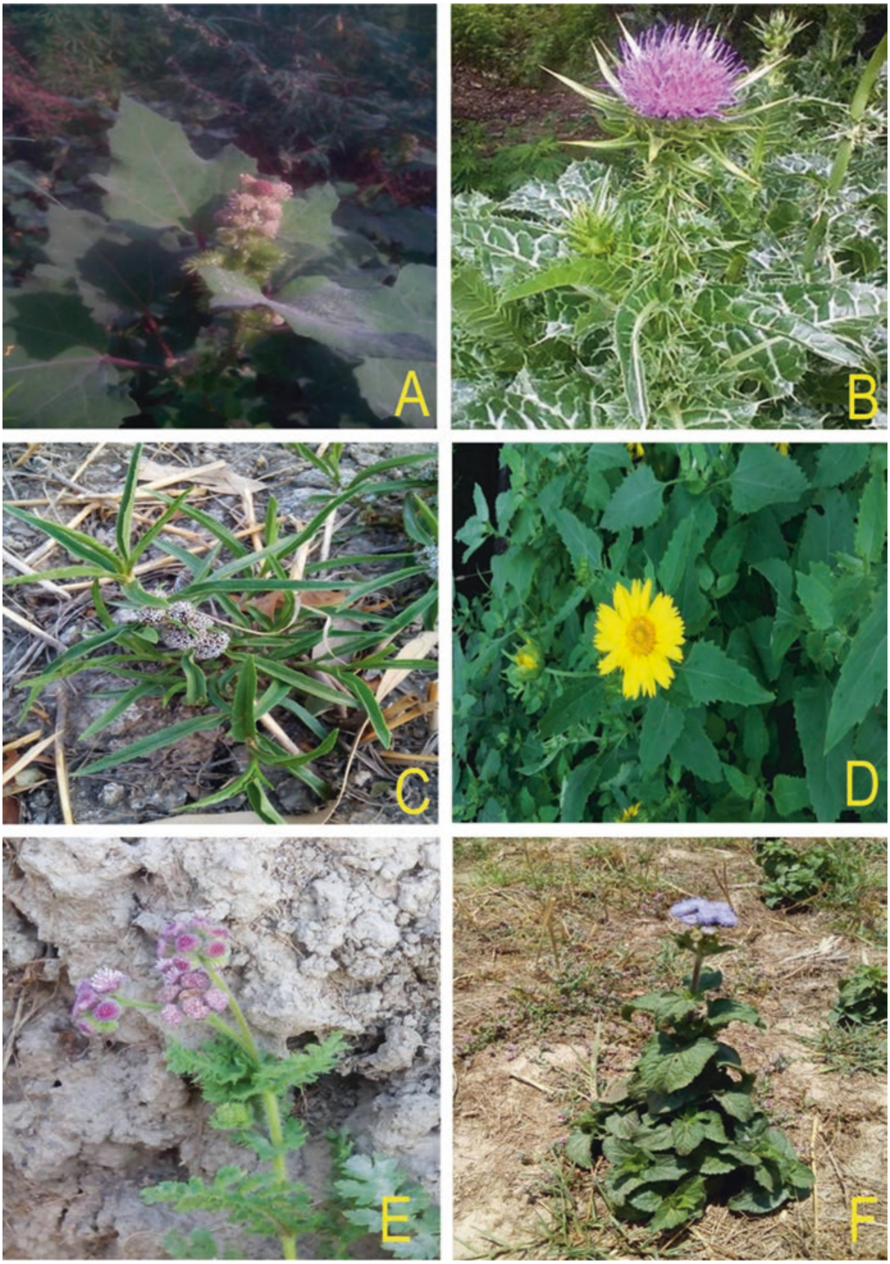


**Plate 23.1** (**a**) *Xanthium strumarium*, (**b**) *Silybum marianum*, (**c**) *Caesulia axillaris*, (**d**) *Verbesina encelioides*, (**e**) *Cyathocline purpurea*, (**f**) *Ageratum houstonianum*


**Plate 23.2** (**a**) *Eclipta alba*, (**b**) *Bidens biternata*, (**c**) *Conyza bonariensis*, (**d**) *Circium verutum*, (**e**) *Tridex procumbens*, (**f**) *Senecio nudicaulis*

## 23.4 Concluding Remarks

The rich taxonomic diversity of Asteraceae in J&K State is supported by diverse habitats encountered across this Himalayan region. The threatened endemics of Asteraceae in the state need protection from the anthropogenic activities of land use and climate change. The family has to be given proper research attention in order to study the details considering different parameters such as distribution, phytochemistry, conservation, and sustainable use.

**Acknowledgements** The author is grateful to Prof. A. K. Koul, ex-Dean Academic Affairs, BGSB University, Rajouri, for encouragement and reading the manuscript; and to Dr. Rani Magotra, former Professor of Botany, University of Jammu, for encouragement. Sincere thanks are due to Prof. I. A. Hamal, Ex-Vice Chancellor, BGSBU, Rajouri, for encouragement; and to Prof. G. H. Dar, ex-Fellow, Mahatma Gandhi Chair on Ecology and Environment, BGSBU, Rajouri, for very fruitful discussions and guidance whenever needed.

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## Chapter 24
# Leguminosae in Jammu and Kashmir State: A Systematic Checklist

**M. Sanjappa and K. Ambarish**

**Abstract** A sysytematic checklist is prepared for Leguminosae in Jammu and Kashmir State. The family is represented in this state by 399 species belonging to 106 genera from 36 tribes under three customarily recognized subfamilies: Caesalpinoideae (33 species in 11 genera belonging to 4 tribes), Mimosoideae (28 species in 9 genera belonging to 4 tribes), and Papilionoideae (338 species in 86 genera belonging to 28 tribes). Papilionoideae is the largest subfamily, accounting for 84% of all legume species reported from the State. Among Caesalpinoideae, *Senna* is the largest genus here, being represented by 11 species; among Mimosoideae, *Acacia* is the largest genus with 12 species; whereas among Papilionoideae, *Astragalus* is the largest genus with 55 species, followed by *Oxytropis* (19 species), *Indigofera* (17 species), *Desmodium* (13 species), *Crotalaria* and *Vicia* (12 species each), *Lathyrus* (11 species) and *Trifiloium* (10 species). Three legume species from the state (*Hedysarum astragaloides*, *H. cashmirianum*, and *H. microcalyx*) are included in the Red Data Book of Indian Plants, while 12 species are listed in the IUCN Red List.

**Keywords** Leguminosae · Fabaceae · Jammu & Kashmir State · Systematic checklist

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_24

## 24.1 Introduction

Leguminosae are a fascinating group of flowering plants and are second to cereals in their economic importance. Among the flowering plants they are unique in two respects: firstly, their ability to enrich soil nitrogen through symbiotic nitrogen fixation in association with root and stem nodule bacteria-*Rhizobium* and its allies; and secondly, protein-rich seeds which form a major source of vegetable protein consumed by man and both domesticated and wild animals. Because of these biological properties, legume crops are used in low-input agriculture; legumes, in general, are also the most consumed vegetables. It is only legumes that show promise of supplying vastly required and affordable vegetable proteins, both for the poor and to many people, of late, preferring vegetarian diet. Less than 30 legume species are extensively used and cultivated. Although global efforts are being made to assess potential species for their utilization, many are yet to be assessed and majority of them are still exploited from their natural habitats unsustainbly. Legumes yield a wide range of industrial products, such as drugs, dyes, resins, tannins, gums and a variety of timber products. Some of the legumes are the world's best-known ornamentals. Much of the beauty and aesthetics of urban landscapes owes to legume trees which bear elegant foliage and praise-worthy blooms in a range of colours. Ecologically, the family is as versatile as grasses and, infact, in most ecosystems they co-exist. Some of the legumes are bottom-up control species in the ecosystem, whereas others act as keystone species (Sanjappa, 2001).

With about 19,581 species belonging to 765 genera, Leguminosae (Fabaceae *nom. alt*.) is the third largest family of flowering plants (after Asteraceae with 21,000 species and Orchidaceae with 20,000 species). Legumes are significant components of nearly all terrestrial biomes and are found throughout the world, with maximum diversity in tropics and subtropics. The chief centres of distribution of the family are Africa, Madagascar and South America. The family includes a myriad of life-forms, from tiny herbs to gigantic trees. The family is customarily subdivided into three subfamilies, viz. Caesalpinioideae, Mimosoideae and Papilionoideae. Some consider these subfamilies as distinct families.

All legumes bear pods, a characteristic by which most of them can be recognized. The pods may be round or flat, long or short, thin or thick, papery or leathery, woody or fleshy, with or without wings. Some are as small as pin heads, some the size of a cricket ball, while others can be a meter long. Usually, the pods split lengthwise along one or both the margins to expose and release one to several seeds. Because of their economic and ecological value to mankind, legumes have received much attention from taxonomists and agriculture scientists all over the world. This is also evident from the fact that a global database (International Legume Database and Information System-ILDIS) for the family was developed and is one of the widely used ones.

The Leguminosae in Jammu and Kashmir (J&K) are represented by 399 species in 106 genera, with maximum species' richness and diversity in the temperate areas. A checklist of all the legumes known from J&K state is given here. The largest genus is *Astragalus* with 55 species; 12 of which are endemic, with a few species extending distribution to adjoining areas in Himachal Pradesh. Since Leguminosae in the Jammu and Kashmir Flora is yet to be published by the Botanical Survey of India, this chapter will serve as a precursor to detailed account of the family for the state.

## 24.2 Diversity of Leguminosae in Jammu and Kashmir State: A Systematic Checklist (Recent nomenclatural updations have been effected in the checklist)

**LEGUMINOSAE** Adans., Fam. Pl. 2: 306. 1763, *nom. cons*. *Nom. alt*. **Fabaceae** Lindl., Bot. Reg. 22: ad t. 1845. 1836, *nom. cons*. Type: *Faba* Mill.

### *24.2.1 Leguminosae: Cercidoidea*

**Bauhinia** L., Sp. Pl. 1: 374. 1753.

**1.** ***B. purpurea*** L., Sp. Pl. 1: 375. 1753; Baker in Hook. f., Fl. Brit. India 2:284. 1878. Tree, often cultivated.

**2.** ***B. racemosa*** Lam., Encycl. 1(2): 390. 1785; Baker in Hook. f., Fl. Brit. India 2:276. 1878. Shrub/Tree, often cultivated.

**3.** ***B. tomentosa*** L., Sp. Pl. 1: 375. 1753. Shrub/Tree, often cultivated.

**4.** ***B. variegata*** L., Sp. Pl. 1: 375. 1753; Baker in Hook. f., Fl. Brit. India 2:284. 1878. Tree.

**Cercis** L., Sp. Pl. 1: 374. 1753.

**1.** ***C. siliquastrum*** L., Sp. Pl. 1: 374. 1753; Parker, For. Fl. Punj. ed. 3. 183. 1956. Shrub/Tree, cultivated in J&K and Punjab in India.

### *24.2.2 Leguminosae: Caesalpinioideae*

***Biancaea*** Tod., Nuovi Gen. Sp. Orto Palermo: 21. 1860, descr. emended E. Gagnon & G. P. Lewis, PhytoKeys 71: 69. 2016.

**1.** ***Biancaea decapetala*** (Roth) O. Deg., Fl. *hawaiiensis* K7. 1936; E. Gagnon & G. P. Lewis, PhytoKeys 71: 69. 2016. *Reichardia decapetala* Roth, Nov. Pl. Sp. 212. 1821.

**2.** ***Biancaea sappan*** (L.) Tod., Hort. Bot. Panorm. 1(1): 3. 1875; E. Gagnon & G. P. Lewis, PhytoKeys 71: 69. 2016.

*Caesalpinia sappan* L., Sp. Pl. 381. 1753; Baker in Hook.f., Fl. Brit. India 2: 255. 1878;

**Caesalpinia** L., Sp. Pl. 1: 380. 1753.

**1. *C. crista*** L., Sp. Pl. 1: 380. 1753. Climbing shrub.

**2. *C. pulcherrima*** (L.) Sw., Observ. Bot. 166. 1791; Baker in Hook. f., Fl. Brit. India 2:255. 1878. Shrub/Tree, often cultivated.

**Cassia** L., Sp. Pl. 1: 376. 1753, *nom. cons*.

***C. fistula*** L., Sp. Pl. 1: 377. 1753; Baker in Hook. f., Fl. Brit. India 2: 261. 1878. Tree.

**Chamaecrista** Moench, Methodus 272. 1794.

**1. *C. absus*** (L.) H. S. Irwin & Barneby, Mem. New York Bot. Gard. 35: 664. 1982. *Cassia absus* L., Sp. Pl. 376. 1753; Baker in Hook.f., Fl. Brit. India 2: 265. 1878. Annual herb.

**2. *C. mimosoides*** (L.) Greene, Pittonia 4(20): 27. 1899. *Cassia mimosoides* L., Sp. Pl. 379. 1753; Baker in Hook.f., Fl. Brit. India 2: 266.1878. Annual herb.

**3. *C. nomame*** (Honda) H. Ohashi, J. Jap. Bot. 64(7): 215. 1989. *Sooja nomame* Siebold, Verh. Batav. Genootsch. Kunst. 12: 56. 1830. 1878. Annual herb.

**4. *C. pumila*** (Lam.) V. Singh, J. Econ. Taxon. Bot. 16(3): 600. 1992. *Cassia pumila* Lam., Encycl. 1: 651. 1785; Baker in Hook.f., Fl. Brit. India 2: 266. 1878. Annual herb.

**Delonix** Raf., Fl. Tellur 2: 92. 1837.

**1. *D. elata*** (L.) Gamble, Fl. Madras 1(3): 396. 1919. *Poinciana elata* L., Cent. Pl. II: 16. 1756. Tree.

**2. D. *regia*** (Bojer ex Hook.) Raf., Fl. Tellur. 2: 92. 1837. *Poinciana regia* Bojer ex Hook., Bot. Mag. 56: t. 2884. 1829. Tree.

**Guilandina** L., Sp. Pl. 381. 1753.

***G. bonduc*** L., Sp. Pl. 381. 1753; Baker in Hook. f., Fl. Brit. India 2:255. 1878. Climbing shrub.

**Parkinsonia** L., Sp. Pl. 1: 375. 1753.

***P. aculeata*** L., Sp. Pl. 1: 375. 1753; Baker in Hook. f., Fl. Brit. India 2:260. 1878. Shrub/Tree.

**Peltophorum** (Vogel) Benth., J. Bot. (Hooker) 2: 75. 1840, *nom. cons*.

***P. pterocarpum*** (DC.) Backer ex K. Heyne, Nutt. Pl. Ned.-Ind., ed. 2. 2: 755. 1927. *Inga pterocarpa* DC., Prodr. (DC.) 2: 441. 1825. Perennial herb.

**Senna** Mill., Gard. Dict. Abr,. ed. 4. 1280. 1754.

**1. *S. alata*** (L.) Roxb., Fl. Ind. 2: 349. 1832. *Cassia alata* L., Sp. Pl. 1: 378. 1753; Baker in Hook. f., Fl. Brit. India 2:264. 1878. Shrub.

**2. *S. auriculata*** (L.) Roxb., Fl. Ind. 2, 2: 349. 1832. *Cassia auriculata* L., Sp. Pl. 1: 379. 1753; Baker in Hook. f., Fl. Brit. India 2:263. 1878. Shrub.

**3. *S. hirsuta*** (L.) H. S. Irwin & Barneby, Phytologia 44(7): 499. 1979. *Cassia hirsuta* L., Sp. Pl. 1: 378. 1753. Herb/Shrub.

**4. *S. italica*** Mill., Gard. Dict., ed. 8. Senna no. 2. 1768. Herb/Shrub.

**5.** ***S. multijuga*** (Rich.) H. S. Irwin & Barneby, Mem. New York Bot. Gard. 35: 492. 1982. Herb/Shrub.

**6.** ***S. occidentalis*** (L.) Link, Handbuch 2: 140. 1829. *Cassia occidentalis* L., Sp. Pl. 1: 377. 1753; Baker in Hook. f., Fl. Brit. India 2:262. 1878. Herb.

**7.** ***S. siamea*** (Lam.) H. S. Irwin & Barneby, Mem. New York Bot. Gard. 35: 98. 1982. *Cassia siamea* Lam., Encycl. 1(2): 648. 1785; Baker in Hook. f., Fl. Brit. India 2:264. 1878. Tree.

**8.** ***S. sophera*** (L.) Roxb., Fl. Ind. 2, 2: 347. 1832. *Cassia sophera* L., Sp. Pl. 1: 379. 1753; Baker in Hook. f., Fl. Brit. India 2:262. 1878. Shrub.

**9.** ***S. sulfurea*** (Collad.) H. S. Irwin & Barneby, Mem. New York Bot. Gard. 35: 78. 1982. *Cassia sulfurea* Collad., Hist. Nat. Méd. Casses 84. 1816. Shrub.

**10.** ***S. surattensis*** (Burm. f.) H. S. Irwin & Barneby, Mem. New York Bot. Gard. 35(1): 81. 1982. *Cassia surattensis* Burm. f., Fl. Ind. 97. 1768. Shrub/Tree.

**11.** ***S. tora*** (L.) Roxb., Fl. Ind. 2: 340. 1832. *Cassia tora* L., Sp. Pl. 1: 376. 1753; Baker in Hook. f., Fl. Brit. India 2:263. 1878. Herb/Shrub.

**Leguminosae: Detarioideae Tamarindus** L., Sp. Pl. 1: 34. 1753.

***T. indica*** L., Sp. Pl. 1: 34. 1753; Baker in Hook. f., Fl. Brit. India 2:273 1878. Tree.

## *24.2.3 Mimosoid clade of* Caesalpinioideae

**Acacia** Mill., Gard. Dict. Abr., ed. 4 : 25. 1754.

**1.** ***A. auriculiformis*** A. Cunn. ex Benth., London J. Bot. 1: 377. 1842. Tree.

**2. A. mearnsii** De Wild., Pl. Bequaert. 3:61. 1925.

**3.** ***A. melanoxylon*** R. Br., Hortus Kew. ed. 2. 5: 462. 1813. Tree.

**Albizia** Durazz., Mag. Tosc. 3(4): 13. 1772.

**1.** ***A. chinensis*** (Osbeck) Merr., Amer. J. Bot. 3(10): 575. 1917. *Mimosa chinensis* Osbeck, Dagb. Ostind. Resa 233. 1757. Tree.

**2.** ***A. julibrissin*** Durazz., Mag. Tosc. 3(4): 11. 1772; Baker in Hook. f., Fl. Brit. India 2: 300. 1878. var.***julibrissin*****.** Tree.

var. ***mollis*** (Wall.) Benth., London J. Bot. 3: 91. 1844. *Acacia mollis* Wall., Pl. Asiat. Rar. 2: 76. t. 177. 1831. Tree.

**3.** ***A. lebbeck*** (L.) Benth., London J. Bot. 3: 87. 1844 (*'lebbek'*); Baker in Hook. f., Fl. Brit. India 2: 298. 1878. *Mimosa lebbeck* L., Sp. Pl. 1: 516. 1753. Tree.

**4.** ***A. odoratissima*** (L. f.) Benth., London J. Bot. 3: 88. 1844. *Mimosa odoratissima* L. f., Suppl. Pl. 437. 1782. Tree.

**5.** ***A. procera*** (Roxb.) Benth., London J. Bot. 3: 89. 1844 ('Albizzia'); Baker in Hook. f., Fl. Brit. India 2: 299. 1878. *Mimosa procera* Roxb., Pl. Coromandel 2: 12-13. t. 121. 1799. Tree.

**Calliandra** Benth. in Hook., Lond. J. Bot. 2:138. 1840.

**1.** ***C. houstoniana*** var. ***anomala*** (Kunth) Barneby, Mem. New York Bot. Gard. 74(3): 179. 1998. *Inga anomala* Kunth, Mimos. Pl. Legum. 70. t. 22. 1819-24.

Cultivated in gardens throughout drier parts, native to C America.

**2.** ***C. haematocephala*** Hassk., Retzia. 216. Parker, For. Fl. Punj. ed.3.202.1956.

Cultivated in gardens throughout drier parts, native to tropical America.

**3.** ***C. inermis*** (L.) Druce, Rep. Bot. Exch. Cl. Brit. Isles. 1913. 3:415. 1914. *Gleditsia inermis* Linn., Sp. Pl. ed. 2.1509. 1763. Cultivated in gardens throughout drier parts, native to Mexico.

**Desmanthus** Willd., Sp. Pl., ed. 4(2): 1044. 1806, *nom. cons.*

***Desmanthus pernambucanus*** (L.) Thell., Mém. Soc. Sci. Nat. Math. Cherbourg, sér. 4. 38: 256. 1912.

**Mimosa pernambucana** L., Sp. Pl. 1: 519. 1753

***Desmanthus virgatus*** auct. non (L.) Willd., Sp. Pl. 4:1047. 1806; Baker in Hook.f., Fl. Brit. India 2 : 290.1878. Shrub.

**Leucaena** Benth. in Hook., J. Bot. 4: 416. 1842 nom. cons.

***L. leucocephala*** (Lam.) de Wit, Taxon 10: 54. 1961**.** *Mimosa leucocephala* Lam., Encycl.,1(1): 12. 1783. Cultivated throughout in drier parts, native to C America.

**Mimosa** L, Sp. Pl. 1: 516. 1753.

**1.** ***M. himalayana*** Gamble., Bull. Misc. Inform. Kew 1920(1): 4. 1920. Shrub.
**2.** ***M. pudica*** L., Sp. Pl. 1: 518. 1753; Baker in Hook. f., Fl. Brit. India 2: 291. 1878. Herb/Shrub.
**3.** ***M. rubicaulis*** Lam., Encycl. 1: 20. 1783; Baker in Hook. f., Fl. Brit. India 2: 291. 1878. Shrub.

**Neptunia** Lour, Fl. Cochinch. 2: 641, 653. 1790.

***N. oleracea*** Lour., Fl. Cochinch. 2: 654. 1790; Baker in Hook. f., Fl. Brit. India 2: 285. 1878. Perennial herb.

**Pithecellobium** Mart., Flora 20(2, Beibl.): 114. 1837 ('Pithecollobium'), *nom. & orth. cons.*

***P. dulce*** (Roxb.) Benth., London J. Bot. 3: 199. 1844 ('Pithecolobium'); Baker in Hook. f., Fl. Brit. India 2: 302. 1878. *Mimosa dulcis* Roxb., Pl. Coromandel 1: 67. t. 99. 1796. Tree. Cultivated throughout India, native to S America.

**Prosopis** L., Syst. Nat., ed. 12., 2: 282, 293. 1767.

***P. juliflora*** (Sw.) DC., Prodr. (DC.) 2: 447. 1825. *Mimosa juliflora* Sw., Prodr. 85. 1788. Shrub/Tree.

**Senegalia** Raf., Sylva Tellur. 119. 1838.

**1.** ***Senegalia catechu*** (L.f.) P. J. H. Hurter & Mabb., Mabberley's Pl.-Book 1021. 2008.

*Mimom catechu* L.f., Suppl. Pl. 439. 1781; Roxb., Pl. Coromandel 2: t 175. 1802. Tree.

**2.** ***Senegalia gageana*** (Craib) Maslin, Seigler & Ebinger, Blumea 58(1): 40. 2013.

*Acacia gageana* Craib, Bull. Misc. Inf. 1915; 409.1915: Calder & Narayanaswami, Rec. Bot. Surv. India 11: 1. 1926. Climbing shrub.

**3.** ***Senegalia lenticularis*** (Buch.-Ham ex Benth.) Ragupathy, Seigler, Ebinger & Maslin, Phytotaxa 162(3): 176.2014. Tree.

*Acacia lenticularis* Buch.-Ham. (in Wall., Numer. List no. No.5244. 1831-32, nom. nud) ex Benth. in Hook., London J. Bot. 1: 508. 1842; Baker in Hook. f., Fl. Brit. India 2:296.1878.

**4.** ***Senegalia modesta*** (Wall.) P. J. H. Hurter, Mabberley's Pl.-Book 1021. 2008.

*Acacia modesta* Wall., Pl. Asiat. Rar. 2: 27, t. 130. 1831; Baker in Hook.f., Fl. Brit. India 2: 296. 1878. Tree.

**5.** ***Senegalia torta*** (Roxb.) Maslin, Seigler & Ebinger, Blumea 58:42.2013

*Mimosa torta* Roxb., Fl. Ind 2: 566. 1832. Shrub.

**Vachellia** Wight & Arn., Prodr. Fl. Ind. Orient. 1: 272. 1834.

**1.** ***Vachellia farnesiana*** (L.) Wight & Arn., Prodr. Fl. Ind. Orient.1: 272, 1834. *Mimosa farnesiana* L., Sp. Pl. 1: 521. 1753. Shrub/Small tree.

**2.** ***Vachellia nilotica*** (L.) P. J. H. Hurter & Mabb. subsp. *indica* (Benth.) Kyal. & Boatwr., Bot. J. Linn. Soc. 172(4): 515. 2013. *Acacia arabica* (Lam.) Willd. var. *indica* Benth. in Hook., London J. Bot. 1: 500. 1842. Tree.

**3.** ***Vachellia pseudoeburnea*** (J.R. Drumm. ex Dunn) Ragupathy, Seigler, Ebinger & Maslin, Phytotaxa 162(3): 177.2014.

*Acacia pseudoeburnea* J. R. Drumm. ex Dunn, Bull. Misc. Inform. Kew 1922(6): 185.1922. Shrub/Small tree.

## *24.2.4 Leguminosae: Papilionoideae*

**Abrus** Adans., Fam. Pl. 2: 327, 511. 1763.

***A. precatorius*** L., Syst. Nat., ed. 12. 2: 472. 1767 ; Baker in Hook. f., Fl. Brit. India 2: 175. 1876. Climber.

**Aeschynomene** L., Sp. Pl. 2: 713. 1753.

**1.** ***A. aspera*** L., Sp. Pl. 2: 713. 1753; Baker in Hook. f., Fl. Brit. India 2: 152. 1878. Annual herb.

**2.** ***A. indica*** L., Sp. Pl. 2: 713. 1753; Baker in Hook. f., Fl. Brit. India 2: 151. 1878. Annual/Perennial herb.

**Alhagi** Gagnebin, Acta Helv. Phys.-Math. 2: 59. 1755.

**1. *A. maurorum*** Medik., Vorles. Churpfälz. Phys.-Öcon. Ges. 2: 397. 1787; Baker in Hook. f., Fl. Brit. India 2: 142. 1876 (‘*Alhagi maurorum* Desv.’). Perennial herb/Shrub.

**2. *A. nepalensis*** (D. Don) Shap., Sovietsk. Bot. 3-4: 170. 1933. *Manna nepalensis* D. Don, Prodr. Fl. Nepal. 247. 1825. Perennial herb/Shrub.

**Alysicarpus** Neck. ex Desv., J. Bot. Agric. 1: 120. 1813, *nom. cons.*

**1. *A. bupleurifolius*** (L.) DC., Prodr. 2: 352. 1825; Baker in Hook. f., Fl. Brit. India 2:158. 1876. *Hedysarum bupleurifolium* L., Sp. Pl. 2: 745. 1753. Annual herb.

**2. *A. hamosus*** Edgew., J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 21: 171. 1853; Baker in Hook. f., Fl. Brit. India 2:157. 1876. Annual herb, endemic to India.

**3. *A. heyneanus*** Wight & Arn., Prodr. Fl. Ind. Orient. 1: 234. 1834; Baker in Hook. f., Fl. Brit. India 2:159. 1876. var. ***heyneanus*.** Annual herb.

var. ***meeboldii*** (Schindl.) A. Pramanik & Thoth, J. Econ. Taxon. Bot. 12(2): 364. 1988.

*Alysicarpus meeboldii* Schindl., Repert. Spec. Nov. Regni Veg. 21: 13. 1925. Annual herb, endemic to India.

**4. *A. monilifer*** (L.) DC., Prodr. (DC.) 2: 353. 1825; Baker in Hook. f., Fl. Brit. India 2:157. 1876. *Hedysarum moniliferum* L., Mant. Pl. 102. 1767. Annual herb.

**5. *A. ovalifolius*** (Walp.) J. Léonard, Bull. Jard. Bot. État Bruxelles 24(1): 88. 1954. *Desmodium ovalifolium* Walp., Repert. Bot. Syst. 1: 737. 1842. Annual herb.

**6. *A. rugosus*** (Willd.) DC., Prodr. 2: 353. 1825; Baker in Hook. f., Fl. Brit. India 2:159. 1876. *Hedysarum rugosum* Willd., Sp. Pl., ed. 4, 3(2): 1172. 1802. Annual herb.

**7. *A. scariosus*** (Rottler ex Spreng.) Graham ex Thwaites, Enum. Pl. Zeyl. 2: 88. 1859. *Hedysarum scariosum* Rottler ex Spreng., Syst. Veg. ed. 16, 3: 319. 1826. Annual herb.

**8. *A. vaginalis*** (L.) DC., Prodr. 2: 353. 1825; Baker in Hook. f., Fl. Brit. India 2:158. 1876. *Hedysarum vaginale* L., Sp. Pl. 2: 746. 1753. var. ***vaginalis*.** Herb.

var. ***nummularifolius*** (DC.) Miq., Fl. Ned. Ind. 1(1): 232. 1855. *Alysicarpus nummularifolius* DC., Prodr. (DC.) 2: 353. 1825, p.p. Herb.

**Amphicarpaea** Elliott ex Nutt., Gen. N. Amer. Pl. 2: 113. 1818. (‘Amphicarp’) *nom.* et *orth. cons.*

***A. bracteata*** (L.) Fernald subsp. ***edgeworthii*** (Benth.) H. Ohashi in H. Hara, Fl. E. Himalaya 137. 1966. *Amphicarpaea edgeworthii* Benth. in Miq., Pl. Jungh. 2: 231. 1852; Baker in Hook. f., Fl. Brit. India 2:181. 1876. Perennial herb.

**Arachis** L., Sp. Pl. 2: 741. 1753.

***A. hypogaea*** L., Sp. Pl. 2: 741. 1753. Annual herb.

**Argyrolobium** Eckl. & Zeyher, Enum. Pl. Afric. Austral. 184. 1836, *nom. cons.*

**1.** ***A. flaccidum*** (Royle) Jaub. & Spach, Ill. Pl. Orient. 1: 115. 1843; Baker in Hook. f., Fl. Brit. India 2: 63. 1876. *Cytisus flaccidus* Royle, Ill. Bot. Himal. Mts. 197. 1835. Herb/Shrub.

**2.** ***A. roseum*** (Cambess.) Jaub. & Spach, Ill. Pl. Orient. 1: 116. 1843; Baker in Hook. f., Fl. Brit. India 2: 64. 1876. *Cytisus roseus* Cambess. in Jacquem., Voy. Inde 4(Bot.): 35. t. 40. 1844. subsp. ***roseum***. Perennial herb.

subsp. ***ornithopodiodes*** (Jaub. & Spach) Jafri & Ali, S. U. Sci. Res. J. 2: 4. 1966. *Argyrolobium ornithopodiodes* Jaub. & Spach, Ill. Pl. Orient. 1: 116. 1843. Perennial herb.

**3.** ***A. stenophyllum*** Boiss., Fl. Orient. 2: 32. 1872. Perennial herb.

**Astracantha** Podlech, Mitt. Bot. Staatssamml. München 19: 4. 1983.

***A. strobilifera*** (Royle) Podlech, Mitt. Bot. Staatssamml. München 19: 20. 1983. *Astragalus strobiliferus* Royle, Ill. Bot. Himal. Mts. 199. 1839; Baker in Hook. f., Fl. Brit. India 2: 135. 1876. Perennial herb.

**Astragalus** L., Sp. Pl. 2: 755. 1753.

**1.** ***A. amherstianus*** Royle, Ill. Bot. Himal. Mts. 199. 1835; Baker in Hook. f., Fl. Brit. India 2: 119. 1876. Annual herb.

**2.** ***A. anfractuosus*** Bunge, Mém. Acad. Imp. Sci. St Petersburg, Sér. 7, 11(16): 125. 1868. Herb.

**3.** ***A. arnoldii*** Hemsl. & H. Pearson, J. Linn. Soc., Bot. 35: 172. 1902. Herb.

**4.** ***A. bicuspis*** F. B. Fisch., Bull. Soc. Imp. Naturalistes Moscou 26(2): 406. 1853; Baker in Hook. f., Fl. Brit. India 2: 135. 1876. Shrub.

**5.** ***A. breviscapus*** B. Fedtsch., Trudy Imp. S.-Peterburgsk. Bot. Sada 24: 234. 1905. Shrub.

**6.** ***A. charguschanus*** Freyn, Bull. Herb. Boissier, Ser. 2. 4: 764. 1904. Perennial herb.

7. ***A. chlorostachys*** Lindl., Trans. Hort. Soc. London 7: 249. 1838; Baker in Hook. f., Fl. Brit. India 2: 128. 1876. Perennial herb.

**8.** ***A. coluteocarpus*** Boiss., Diagn. Pl. Orient., Ser. 1. 9: 65. 1849; Baker in Hook. f., Fl. Brit. India 2: 130. 1876. subsp. ***coluteocarpus***. Perennial herb.

subsp. ***chitralensis*** Wenn., Mitt. Bot. Staatssamml. München 30: 52. 1991. Perennial herb.

**9.** ***A. confertus*** Benth. ex Bunge, Mém. Acad. Imp. Sci. St.-Pétersbourg, Ser. 7. 11(16): 23. 1868; Baker in Hook. f., Fl. Brit. India 2: 123. 1876. Herb.

**10.** ***A. densiflorus*** Kar. & Kir., Bull. Soc. Imp. Naturalistes Moscou 15: 329-330. 1842 Baker in Hook. f., Fl. Brit. India 2: 125. 1876. Perennial herb.

**11.** ***A. drasianus*** H. J. Chowdhery, Uniyal & Balodi, Bull. Bot. Surv. India 34(1–4): 209 1997. Annual/Perennial herb, endemic to J&K.

**12.** ***A. falconeri*** Bunge, Mém. Acad. Imp. Sci. St.-Pétersbourg, Ser. 7. 11(16): 4. 1868; Baker in Hook. f., Fl. Brit. India 2: 120. 1876. Herb/Shrub.

**13.** ***A. frigidus*** (L.) A. Gray, Proc. Amer. Acad. Arts 6: 219. 1864; Baker in Hook. f., Fl. Brit. India 2: 130. 1876. *Phaca frigida* L., Syst. Nat., ed. 10. 2: 1173. 1759. Herb.

**14.** ***A. gilgitensis*** Ali, Phyton (Horn) 11: 135. 1966. Perennial herb.

**15.** ***A. gooraiensis*** L. B. Chaudhury, Novon 17(4): 417, f.1-2. 2007. Herb, endemic to J&K.

**16.** ***A. gracilipes*** Benth. ex Bunge, Mém. Acad. Imp. Sci. St.-Pétersburg, Ser. 7. 11(16): 15. 1868; Baker in Hook. f., Fl. Brit. India 2: 122. 1876. Annual herb.

**17.** ***A. grahamianus*** Benth. in Royle, Ill. Bot. Himal. Mts. 199. t. 36. f. 2. 1835. H erb/Shrub.

**18.** ***A. graveolens*** Buch.-Ham. ex Benth. in Royle Ill. Bot. Himal. Mts. 199. 1835; Baker in Hook. f., Fl. Brit. India 2: 131. 1876. Perennial herb.

**19.** ***A. hendersonii*** Baker in Hook. f., Fl. Brit. India 2: 120. 1876. Shrub.

**20.** ***A. heydei*** Baker in Hook. f., Fl. Brit. India 2: 118. 1876**.** Perennial herb.

**21.** ***A. himalayanus*** Klotzsch in Klotzsch & Garcke, Bot. Ergben. Reise Waldemar 160, t. 4. 1862; Baker in Hook. f., Fl. Brit. India 2: 126. 1876. Perennial herb.

**22.** ***A. hoffmeisteri*** (Klotzsch) Ali, Kew Bull. 13(2): 304. 1958. var. ***hoffmeisteri.*** Shrub.

var. ***pilosus*** Ali, Kew Bull. 1958(2): 304. Shrub; J&K and Pakistan.

**23.** ***A. imitensis*** Ali, Candollea 17: 90. f. 14. 1960 & Ali in Nasir & Ali, Fl. W. Pakistan 100:211.1977. Shrub. J&K and Pakistan

**24.** ***A. isabellae*** Dunn, Bull. Misc. Inform. Kew 1924: 384. 1924.

Habit & Distribution: Herb. India (Himachal Pradesh, Jammu & Kashmir), Pakistan.

**25.** ***A. kashmirensis*** Bunge, Mém. Acad. Imp. Sci. St.-Pétersbourg, Ser. 7. 11(16): 30. 1868; Baker in Hook. f., Fl. Brit. India 2: 127. 1876 ('cashmiriensis'). Perennial herb.

**26.** ***A. leucocephalus*** Bunge, Graham ex Benth. in Royle, Ill. Bot. Himal. Mts. 198. t. 33. f. 2. 1835; Baker in Hook. f., Fl. Brit. India 2: 128. 1876. Perennial herb

**27.** ***A. macropterus*** DC., Prodr. (DC.) 2: 283. 1825 ; Baker in Hook. f., Fl. Brit. India 2: 128. 1876. Perennial herb.

**28.** ***A. maxwellii*** Royle, Ill. Bot. Himal. Mts. 198. 1835. Perennial herb.

**29.** ***A. melanostachys*** Benth. ex Bunge, Mém. Acad. Imp. Sci. St.-Pétersburg, Ser.7. 11(16): 21. 1868; Baker in Hook. f., Fl. Brit. India 2: 125. 1876. Perennial herb.

**30.** ***A. multiceps*** Wall. ex Benth. in Royle, Ill. Bot. Himal. Mts. 199. 1835; Baker in Hook. f., Fl. Brit. India 2: 134. 1876. Shrub.

**31.** ***A. munroi*** Benth. ex Bunge, Mém. Acad. Imp. Sci. St.-Pétersburg, Ser. 7. 11(16): 30. 1868 ; Baker in Hook. f., Fl. Brit. India 2: 128. 1876. Perennial herb.

**32.** ***A. nivalis*** Kar. & Kir, Bull. Soc. Imp. Naturalistes Moscou 15: 341. 1842; Baker in Hook.f., Fl. Brit. India 2: 136. 1876. Perennial herb.

**33.** ***A. oplites*** Benth. ex R. Parker, Bull. Misc. Inform. Kew 1921: 270. 1921.

*Astragalus zanskarensis* Benth. ex Bunge subsp. *oplites* (Benth. ex R. Parker) I. Deml, Boissiera 21: 168. 1972. Perennial herb.

**34.** ***A. oxyodon*** Baker in Hook. f., Fl. Brit. India 2: 125. 1876. Perennial herb.

**35.** ***A. peduncularis*** Royle, Ill. Bot. Himal. Mts. 199. 1835; Baker in Hook.f., Fl. Brit. India 2: 136. 1876. Perennial herb.

**36.** ***A. polyacanthus*** Royle, Ill. Bot. Himal. Mts. 199. 1835; Baker in Hook. f., Fl. Brit. India 2: 134. 1876. Herb/Shrub.

**37.** ***A. pseudochlorostachy*s** Ali, Bot. Not. 118: 94. 1965; Ali in Nasir & Ali, Fl. W. Pakistan 100:174.1977. Perennial herb; J&K, Pakistan.

**38.** ***A. psilocentros*** Fischer, Bull. Soc. Imp. Naturalistes Moscou 26(2): 405. 1853.

var. ***psilocentros***. Shrub.

var. ***pilosus*** Benth ex R. Parker, Forest Fl. Punjab 140-141. 1924. Shrub.

**39.** ***A. pyrrhotrichus*** Boiss., Diagn. Pl. Orient., Ser. 1. 9: 73. 1849; Baker in Hook. f., Fl. Brit. India 2: 133. 1876. Perennial herb. H.P, J&K, Pakistan.

**40.** ***A. rhizanthus*** Benth. in Royle, Ill. Bot. Himal. Mts. 200. 1835; Baker in Hook. f., Fl. Brit. India 2: 131. 1876. subsp**. *rhizanthus***. Perennial herb.

subsp. ***candolleanus*** (Royle) Podlech, Mitt. Bot. Staatssamml. München 25(1): 184. 1988. *Astragalus candolleanus* Royle, Ill. Bot. Himal. Mts. 199. 1835; Baker in Hook. f., Fl. Brit. India 2: 132. 1876. Perennial herb.

subsp. ***hindukushensis*** (Wendelbo) Podlech, Mitt. Bot. Staatssamml. München 25(1): 402. 1988. *Astragalus hindukushensis* Wendelbo, Nytt. Mag. Bot. 1: 42. 1952. Perennial herb.

**41.** ***A. scorpiurus*** Bunge, Mém. Acad. Imp. Sci. St.-Pétersbourg, Ser. 7. 11(16): 5. 1868. Annual herb.

**42.** ***A. sherriffii*** Podlech, Sendtnera 7: 190. 2001. Perennial herb; endemic to J&K.

**43.** ***A. stewartii*** Baker in Hook. f., Fl. Brit. India 2: 129. 1876. Shrub.

**44.** ***A. strictus*** Graham ex Benth. in Royle, Ill. Bot. Himal. Mts. 198. 1835; Baker in Hook. f., Fl. Brit. India 2: 124. 1876. Perennial herb.

**45.** ***A. subuliformis*** DC., Astragalogia 107, 134. 1802. Perennial herb.

**46.** ***A. subumbellatus*** Koltzsch in Koltzsch & Garcke, Bot. Ergebn. Reise Waldemar 159. t. 3. 1862; Baker in Hook. f., Fl. Brit. India 2: 119. 1876. Annual herb.

**47.** ***A. tecti-mundi*** Freyn, Bull. Herb. Boissier, Ser. 2. 4: 456. 1904.

subsp. ***tecti-mundi*.** Annual herb.

subsp. ***orientalis*** Podlech, Sendtnera 7: 178. 2001. Herb.

**48.** ***A. thomsonii*** Podlech, Sendtnera 6: 140. 1999. Herb.

**49.** ***A. tibetanus*** Benth. ex Bunge, Mém. Acad. Imp. Sci. St.-Pétersbourg, Ser. 7. 11(16): 52. 1868 ; Baker in Hook. f., Fl. Brit. India 2: 124. 1876. Perennial herb.

**50.** ***A. tribulifolius*** Benth. ex Bunge, Mém. Acad. Imp. Sci. St.-Pétersbourg, Ser. 7. 11(16): 4. 1868. Perennial herb.

**51.** ***A. trichocarpus*** Graham ex Benth. in Royle, Ill. Bot. Himal. Mts. 199. 1835; Baker in Hook. f., Fl. Brit. India 2: 121. 1876. Shrub.

**52.** ***A. tulinovii*** B. Fedtsch. ex O. Fedtsch., Pl. Pamir 27. 1903. Herb.

**53.** ***A. verus*** Olivier, Voy. Emp. Othoman 3: t. 44. 1807. Shrub.

**54.** ***A. webbianus*** Graham ex Benth. in Royle, Ill. Bot. Himal. Mts. 199. 1835; Baker in Hook. f., Fl. Brit. India 2: 132. 1876. Perennial herb.

**55.** ***A. zanskarensis*** Benth. ex Bunge, Mém. Acad. Imp. Sci. St.-Pétersburg, Ser. 7. 11(16): 43. 1868; Baker in Hook. f., Fl. Brit. India 2: 134. 1876. Perennial herb.

**Butea** Roxb. ex Willd., Sp. Pl. 4, 3(2): 917. 1802, *nom. cons.*

***B. monosperma*** (Lam.) Taub. in Engl. & Prantl Nat. Pflanzenfam. 3(3): 366. f. 131M-N. 1894. Tree.

**Cajanus** Adans., Fam. Pl. 2: 326, 529. 1763 (‘Cajan’), *nom. et orth. cons.*

**1.** ***C. cajan*** (L.) Millsp., Publ. Field Columb. Mus., Bot. Ser. 2(1): 53. 1900. *Cytisus cajan* L., Sp. Pl. 2: 739. 1753. Shrub.

**2.** ***C. crassus*** (Prain & King) Maesen, Agric. Univ. Wageningen Pap. 85(4): 110. 1986. *Atylosia crassa* Prain & King, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 66: 45. 1897. Climbing shrub.

**3.** ***C. elongatus*** (Benth.) Maesen, Agric. Univ. Wageningen Pap. 85(4): 115. 1986. *Atylosia elongata* Benth. in Miq., Pl. Jungh. 2: 243. 1852. Climbing shrub.

**4.** ***C. mollis*** (Benth.) Maesen, Agric. Univ. Wageningen Pap. 85(4): 154. 1986. *Atylosia mollis* Benth. in Miq., Pl. Jungh. 2: 243. 1852, p. p. Climbing shrub.

**5.** ***C. platycarpus*** (Benth.) Maesen, Agric. Univ. Wageningen Pap. 85(4): 160. 1986. *Atylosia platycarpa* Benth. in Miq., Pl. Jungh. 2: 243. 1852; Baker in Hook. f., Fl. Brit. India 2: 216. 1876. Climber.

**6.** ***C. scarabaeoides*** (L.) Thouars ex Graham, Dict. Sci. Nat. 6: 617. 1817. *Dolichos scarabaeoides* L., Sp. Pl. 2: 726. 1753. Shrub.

**Campylotropis** Bunge, Pl. Mongholico-Chin. 6. 1835.

**1.** ***C. eriocarpa*** (DC.) Schindl., Repert. Spec. Nov. Regni Veg. 11: 347. 1912. *Lespedeza eriocarpa* DC., Ann. Sci. Nat. (Paris) 4: 102. 1825; Baker in Hook.f., Fl. Brit. India 2: 144. 1876. Shrub; endemic to India.

**2.** ***C. macrostyla*** (D. Don) Lindl. ex Miq., Fl. Ned. Ind. 1(1): 230. 1855. *Crotalaria macrostyla* D. Don, Prodr. Fl. Nepal. 242. 1825. Shrub.

**3.** ***C. meeboldii*** (Schindl.) Schindl., Repert. Spec. Nov. Regni Veg. 11: 424. 1912. *Lespedeza meeboldii* Schindl., Repert. Spec. Nov. Regni Veg. 9: 521. 1911. Shrub.

**4.** ***C. speciosa*** Schind., Repert. Spec. Nov. Regni Veg. 11: 425. 1912. Shrub.

**5.** ***C. stenocarpa*** (Klotzsch) Schindl., Repert. Spec. Nov. Regni Veg. 11: 345. 1912. *Oxyramphis stenocarpa* Klotzsch in Klotzsch & Garcke, Bot. Ergebn. Reise Waldemar 158. t. 1. f. 2. 1862. Shrub.

**Canavalia** Adans., Fam. Pl. 325, 531. 1763, *orth. cons*. ('Canavali').

**1.** ***C. africana*** Dunn, Bull. Misc. Inform. Kew 1922(4): 135. 1922. Climbing herb.

**2.** ***C. ensiformis*** (L.) DC., Prodr. 2: 404. 1825; Baker in Hook. f., Fl. Brit. India 2: 195. 1876. *Dolichos ensiformis* L., Sp. Pl. 2: 725. 1753. Climbing herb/Shrub.

**3.** ***C. gladiata*** (Jacq.) DC., Prodr. 2: 404. 1825. *Dolichos gladiatus* Jacq., Icon. Pl. Rar. 3: 13. t. 560. 1789. Climbing herb.

**Caragana** Fabr., Enum. ed. 2. 421. 1763.

**1.** ***C. brevifolia*** Kom., Trudy Imp. S.-Peterburgsk. Bot. Sada 29(2): 211. pl. 17. 1909. Shrub.

**2.** ***C. brevispina*** Benth. in Royle, Ill. Bot. Himal. Mts. 198. 1835; Baker in Hook. f., Fl. Brit. India 2: 116. 1876. Shrub.

**3.** ***C. conferta*** Benth. ex Baker in Hook. f., Fl. Brit. Ind. 2:116. 1876. Shrub.

**4.** ***C. decorticans*** Hemsl., Hooker's Icon. Pl. 18: t. 1825. 1887. Shrub.

**5.** ***C. gerardiana*** Benth. in Royle, Ill. Bot. Himal. Mts. 198. 1835; Baker in Hook. f., Fl. Brit. India 2: 116. 1876. Shrub.

**6. *C. polyacantha*** Royle, Ill. Bot. Himal. Mts. 198. 1835; Baker in Hook. f., Fl. Brit. India 2: 116. 1876. Shrub.

**7. *C. spinifera*** Kom., Trudy Imp. S.-Peterburgsk. Bot. Sada. 29(2): 267. 1909. Shrub.

**8. *C. tragacanthoides*** (Pall.) Poir. in Lam., Encycl. Suppl.2(1): 90. 1811.

var. ***tragacanthoides*.** Shrub.

var. ***himalaica*** Kom., Trudy Imp. S.-Peterburgsk. Bot. Sada 29(2): 272. 1909. Shrub.

**9. *C. versicolor*** Benth. in Royle, Ill. Bot. Himal. Mts. 198. t. 34. f. 2. a. 1835.

*Caragana pygmaea* auct. non (L.) DC., 1825; Baker in Hook. f., Fl. Brit. India 2: 116. 1876. Shrub.

**Chesneya** Lindl. ex Endl., Gen. Pl. 1275. 1840.

**1. *C. acaulis*** (Baker) Popov in Bull. Univ. Asiae Centr.15. Suppl. 2 :10. 1927.

*Caragana acaulis* Baker, J. Linn. Soc., Bot. 18: 44. 1880. Perennial herb.

**2. *C. crassipes*** A. Boriss., Acta Inst. Ac. Sci. URSS.ser. 1(3):207. 1936. Perennial herb.

**3. *C. cuneata*** (Benth.) Ali, Scientist (Karachi) 3: 3. 1959. *Gueldenstaedtia cuneata* Benth. in Royle, Ill. Bot. Himal. Mts. 200. 1835 ('Guldenstaedtia'). Perennial herb.

**4. *C. depressa*** (Oliv.) Popov, Bull. Univ. As. Centr. 15: Suppl. 11: 10. 1927. *Calophaca depressa* Oliv., Hooker's Icon. Pl. 24: 2304. 1894. Perennial herb; J&K, Pakistan.

**Christia** Moench, Suppl. Meth. 39. 1802 (ante Oct).

***C. vespertilionis*** (L. f.) Bakh. f., Reinwardtia 6(1): 90. 1961. *Hedysarum vespertilionis* L. f., Suppl. Pl. 331. 1782. Annual/Perennial herb.

**Cicer** L., Sp. Pl. 2: 738. 1753.

**1. *C. acanthophyllum*** Boriss., Novosti Sist. Vyssh. Rast. 6: 167. 1970. Perennial herb.

**2. *C. arietinum*** L., Sp. Pl. 2: 738. 1753; Baker in Hook. f., Fl. Brit. India 2: 176. 1876. Annual herb.

**3. *C. macracanthum*** Popov, Byull. Sredne-Aziatsk. Gosud. Univ. 15(Suppl): 16. 1927. Shrub.

**4. *C. microphyllum*** Benth. in Royle, Ill. Bot. Himal. Mts. 200. 1835. Shrub.

**5. *C. nuristanicum*** Kitam., Acta Phytotax. Geobot. 16: 136. 1956. Herb.

**Clitoria** L., Sp. Pl. 753. 1753.

***C. ternatea*** L., Sp. Pl. 753. 1753. Baker in Hook. f., Fl. Brit. Ind. 2:208.1876.

**Codariocalyx** Hassk., Flora 25(2) Beibl.: 48. 1842

***C. motorius*** (Houtt.) H. Ohashi, J. Jap. Bot. 40(12): 367. 1965. *Hedysarum motorium* Houtt., Nat. Hist. 2(10): 246. 1779. Perennial herb/Shrub.

**Colutea** L., Sp. Pl. 2: 723. 1753.

**1.** ***C. multiflora*** Shap. ex Ali, Bot. Not. 112: 491. 1959. Shrub.
**2.** ***C. nepalensis*** Sims, Bot. Mag. 53: t. 2622. 1826. Shrub.
**3.** ***C. paulsenii*** Freyn, Bull. Herb. Boissier, Ser. 2. 4: 47. 1904.
subsp. ***paulsenii*** Shrub.

subsp. ***mesantha*** (Shap. ex Ali) Ali, Fl. W. Pakistan 100: 93. 1977. *Colutea mesantha* Shap. ex Ali, Bot. Not. 112: 493. 1959. Shrub.

**Crotalaria** L., Sp. Pl. 2: 714. 1753, *nom. cons*.

**1.** ***C. albida*** B. Heyne ex Roth, Nov. Pl. Sp 333. 1821; Baker in Hook. f., Fl. Brit. India 2: 71. 1876. Perennial herb.

**2.** ***C. calycina*** Schrank, Pl. Rar. Hort. Monac. 1(2): t. 12. 1817; Baker in Hook. f., Fl. Brit. India 2: 72. 1876. Annual herb.

**3.** ***C. cytisoides*** Roxb. ex DC., Prodr. 2: 131. 1825. Perennial herb/Shrub.

**4.** ***C. hebecarpa*** (DC.) Rudd, Phytologia 54(1): 28. 1983. Goniogyna hebecarpa DC., Ann. Sci. Nat. Paris 4:92. Jan. 1825. Annual herb.

**5.** ***C. hirsuta*** Willd., Sp. Pl. 4, 3(2): 978. 1802; Baker in Hook. f., Fl. Brit. India 2: 68. 1876. Annual herb.

**6.** ***C. juncea*** L., Sp. Pl. 2: 714. 1753; Baker in Hook. f., Fl. Brit. India 2: 79. 1876. Herb/Shrub.

**7.** ***C. medicaginea*** Lam., Encycl. 2(1): 201. 1786; Baker in Hook. f., Fl. Brit. India 2: 81. 1876. var. ***medicaginea.*** Perennial herb.

var. ***luxurians*** (Benth.) Baker in Hook. f., Fl. Brit. India 2: 81. 1876. *Crotalaria luxurians* Benth., London J. Bot. 2: 578. 1843. Perennial herb.
var. ***neglecta*** (Wight & Arn.) Baker in Hook. f., Fl. Brit. India 2: 81.1876. *Crotalaria neglecta* Wight & Arn., Prodr. Fl. Ind. Orient. 1: 192. 1834. Annual herb.

**8.** ***C. pallida*** Aiton, Hortus Kew. 3: 20. 1789. Annual/Perennial herb.

**9.** ***C. prostrata*** Röttler ex Willd., Enum. Pl. 2: 747. 1809; Baker in Hook. f., Fl. Brit. India 2: 67. 1876. Annual/Perennial herb.

**10.** ***C. retusa*** L., Sp. Pl. 2: 715. 1753; Baker in Hook. f., Fl. Brit. India 2: 75. 1876. Annual herb.

**11.** ***C. spectabilis*** Roth, Nov. Pl. Sp. 341. 1821; Fl. Brit. India 2: 75. 1876. Shrub.

**12.** ***C. verrucosa*** L., Sp. Pl. 2: 715. 1753; Baker in Hook. f., Fl. Brit. India 2: 77. 1876. Annual herb.

**Cullen** Medik., Vorles. Churpfälz. Phys.-Öcon. Ges. 2: 381. 1787.

**1.** ***C. corylifolium*** (L.) Medik., Vorles. Churpfälz. Phys.-Öcon. Ges. 2: 380. 1787.

*Psoralea corylifolia* L., Sp. Pl. 2: 764. 1753; Baker in Hook. f., Fl. Brit. India 2: 103. 1876. Perennial herb.

**2.** ***C. drupaceum*** (Bunge) C.H. Stirt**.,** Bothalia 13(3–4): 317.1981. *Psoralea drupacea* Bunge, Arb. Naturf. Ver. Riga1: 221.1847.

**Dalbergia** L. f., Suppl. Pl. 52, 316. 1782, *nom. cons*.

**1.** ***D. lanceolaria*** L. f., Suppl. Pl. 316. 1781; Baker in Hook. f., Fl. Brit. India 2: 235. 1876. Tree.

**2.** ***D. sissoo*** Roxb. ex DC., Prodr. 2: 416. 1825; Baker in Hook. f., Fl. Brit. India 2: 231. 1876. Herb.

**Dendrolobium** (Wight & Arn.) Benth. in Miq., Pl. Jungh. 2: 215, 216. 1852.

***D. triangulare*** (Retz.) Schindl., Repert. Spec. Nov. Regni Veg. 20: 279. 1924. Hedysarum triangulare Retz., Obs. Bot. 3:40.1783. Shrub.

**Derris** Lour., Fl. Cochinch. 2: 423, 432. 1790, *nom. cons.*

***D. scandens*** (Roxb.) Benth., J. Proc. Linn. Soc., Bot. 4(Suppl.): 103. 1860; Baker in Hook. f., Fl. Brit. India 2: 240. 1878. *Dalbergia scandens* Roxb., Pl. Coromandel 2: 29. t. 192. 1805. Climbing shrub.

**Desmodium** Desv., J. Bot. Agric. 1: 122. 1813, *nom. cons.*

**1.** ***D. ospriostreblum*** Chiov., Ann. Bot. (Rome) 8: 428. 1908. Annual herb.

**2.** ***D. procumbens*** (Mill.) Hutch., Rep. (Annual) Missouri Bot. Gard. 4: 76. 1893. *Hedysarum procumbens* Mill., Gard. Dict., ed. 8. Hedysarum no. 10. 1768. Annual herb.

**3.** ***D. tortuosum*** (Sw.) DC., Prodr. 2: 332. 1825. *Hedysarum tortuosum* Sw., Prodr. 107. 1788. Herb/Undershrub.

**Dumasia** DC., Ann. Sci. Nat. (Paris) 4: 96. 1825.

***D. villosa*** DC., Ann. Sci. Nat. (Paris) 4: 97. 1825; Baker in Hook. f., Fl. Brit. India 2: 183. 1876. Climbing herb/Shrub.

**Ebenus** L., Sp. Pl. 2: 764. 1753.

**E. stellata** Boiss., Diagn. Pl. Orient. Ser. 1. 2: 100. 1843; Baker in Hook. f., Fl. Brit. India 2: 140. 1876. Shrub.

**Erythrina** L., Sp. Pl. 2: 706. 1753.

**1.** ***E. arborescens*** Roxb., Pl. Coromandel 3: 14. 219. 1811; Baker in Hook. f., Fl. Brit. India 2: 190. 1876. Tree.

**2.** ***E. stricta*** Roxb., Fl. Ind. 2, 3: 251. 1832 ; Baker in Hook. f., Fl. Brit. India 2: 189. 1876. Tree.

**3.** ***E. suberosa*** Roxb., Fl. Ind. 2, 3: 253. 1832; Baker in Hook. f., Fl. Brit. India 2: 189. 1876. Tree.

**4.** ***E. variegata*** L., Herb. Amboin. 10. 1754. Tree.

**Flemingia** Roxb. ex Aiton, Hortus Kew. ed. 2. 4: 349. 1812, *nom. cons.*

1. ***F. lineata*** (L.) Roxb. ex Aiton, Hortus Kew. ed. 2. 4: 350. 1812; Baker in Hook. f., Fl. Brit. India 2: 228. 1876. *Hedysarum lineatum* L., Syst. Nat., ed. 10. 2: 1170. 1759. Shrub.

**2.** ***F. macrophylla*** (Willd.) Kuntze ex Merr., Philipp. J. Sci., C. 5(2): 130. 1910. *Crotalaria macrophylla* Willd., Sp. Pl., ed. 4, 3(2): 982. 1802. Shrub.

**3. *F. procumbens*** Roxb., Fl. Ind. 2, 3: 338. 1832. Shrub.

**4. *F. strobilifera*** (L.) Aiton, Hortus Kew. ed. 2. 4: 350. 1812; Baker in Hook. f., Fl. Brit. India 2: 227. 1876. *Hedysarum strobiliferum* L., Sp. Pl. 2: 746. 1753. Trailing undershrub.

**Galactia** P. Br., Civ. Nat. Hist. Jamaica 298. 1756.

***G. striata*** (Jacq.) Urb., Symb. Antill. 2(2): 320. 1900. *Glycine striata* Jacq., Hort. Bot. Vindob. 1: 32, pl. 76. 1771. Perennial climbing herb.

**Gliricidia** Kunth in H. B. K., Nov. Gen. Sp. 6: ed. fol. 309. 1824; ed. qu. 393. 1824.

***G. sepium*** (Jacq.) Kunth in Walpers, Repert. Bot. Syst. 1(4): 679. 1842. *Robinia sepium* Jacq., Enum. Syst. Pl. 28. 1760. Tree.

**Glycine** Willd. Sp. Pl., ed. 4, 3(2): 1053. 1802, *nom. cons*.

***G. max*** (L.) Merr., Interpr. Herb. Amboin. 274. 1917. *Phaseolus max* L., Sp. Pl. 2: 725. 1753. Annual herb, cultivated.

**Glycyrrhiza** L., Sp. Pl. 2: 741. 1753.

***G. glabra*** L., Sp. Pl. 2: 742. 1753. Perennial herb.

**Grona** Lour., Fl. Cochinch. 2: 459. 1790.

**Grona heterocarpa** (L.) H.Ohashi & K.Ohashi, J. Jap. Bot. 93(2): 112. 2018.

*Hedysarum heterocarpon* L., Sp. Pl. 747.1753.

*Desmodium polycarpum* (Poir.) DC., Prodr. 2: 334. 1825; Baker in Hook. f., Fl. Brit. India 2: 171.1876 pro parte. Herb / Shrunb.

**Grona triflora** (L.) H.Ohashi & K.Ohashi, J. Jap. Bot. 93(2): 117. 2018.

*Hedysarum triflorum* L., Sp. Pl. 749. 1753, excl. vars.

*Desmodium triflorum* (L.) DC., Prodr. 2: 334. 1825; Baker in Hook.f., Fl. Brit. India 2: 173. 1876. Herb.

**Gueldenstaedtia** F. E. L. Fisch., Mém. Soc. Imp. Naturalistes Moscou 6: 171. 1823, *nom. cons. prop*.

***G. verna*** (Georgi) Boriss., Spisok Rast. Gerb. Fl. S.S.S.R. Bot. Inst. Vsesojuzn. Akad. Nauk 12(fasc. 75): 122. 1953. *Astragalus vernus* Georgi, Bemerk. Reise Russ. Reich. 1: 226. 1775. subsp. ***verna*.** Perennial herb.

subsp. ***multiflora*** (Bunge) H. P.Tsui, Fl. Reipubl. Popularis Sin. 42(2): 150.1998. ***Gueldenstaedtia multiflora*** Bunge, Enum. Pl. Chin. Bor. 18. 1833. Perennial herb.

**Hedysarum** L., Sp. Pl. 2: 745. 1753.

**1. *H. alpinum*** L., Sp. Pl. 2: 750. 1753. var. ***alpinum*.** Perennial herb.

var. ***laxiflorum*** (Benth. ex Baker) H. Ohashi & Tateishi, Fl. E. Himalaya 3rd. Rep. 367. 1975. *Hedysarum laxiflorum* Benth. ex Baker in Hook. f., Fl. Brit. India 2:146. 1876.
Perennial herb.

**2.** ***H. astragaloides*** Benth. ex Baker in Hook. f., Fl. Brit. India 2:146. 1876. Perennial herb.

**3.** ***H. cachemirianum*** Benth. ex Baker in Hook. f., Fl. Brit. India 2:146. 1876. Perennial herb.

**4.** ***H. falconeri*** Baker in Hook. f., Fl. Brit. India 2:146. 1876. Perennial herb.

**5.** ***H. laxiflorum*** Benth. Baker in Hook. f., Fl. Brit. India 2:146. 1876. Perennial herb.

**6.** ***H. microcalyx*** Baker in Hook. f., Fl. Brit. India 2:147. 1876. Perennial herb.

**7.** ***H. minjanense*** Rech.f., Biol. Skr. 9(3): 185-188. 1957. Perennial herb.

**8.** ***H. pseudomicrocalyx*** H.Ohashi & Tateishi, F. E. Himalaya 3rd. Rep. 385. 1975. Perennial herb.

**9.** ***H. tibeticum*** (Benth.) B. H. Choi & H. Ohashi, Taxon 52(3): 574. 2003.

*Stracheya tibetica* Benth., Hooker's J. Bot. Kew Gard. Misc. 5: 307. 1853. Perennial herb.

**Hylodesmum** H.Ohashi & R. R. Mill, Edinburgh J. Bot. 57(2): 178. 2000.

***H. podocarpum*** (DC.) H.Ohashi & R. R. Mill, Edinburgh J. Bot. 57(2): 181. 2000. *Desmodium podocarpum* DC., Ann. Sci. Nat. (Paris) 4: 102. 1825; Baker in Hook. f., Fl. Brit. India 2: 165. 1876. subsp. ***podocarpum*** . Perennial herb.

subsp. ***oxyphyllum*** (DC.) H.Ohashi & R. R. Mill, Edinburgh J. Bot. 57(2): 183. 2000.

*Desmodium oxyphyllum* DC., Ann. Sci. Nat. (Paris). 4: 102. 1825.

**Indigofera** L., Sp. Pl. 2: 751. 1753.

**1.** ***I. astragalina*** DC., Prodr. (DC.) 2: 228. 1825. Annual herb.

**2.** ***I. atropurpurea*** Buch.-Ham. ex Hornem., Suppl. Hort. Bot. Hafn. 152. 1819;Baker in Hook. f., Fl. Brit. India 2: 101. 1876. Shrub.

**3.** ***I. cassioides*** Röttler ex DC., Prodr. 2: 225. 1825. Shrub.

**4.** ***I. chitralensis*** Sanjappa, Bull. Bot. Surv. India 28(1-4): 228. f.2. 1988. Shrub; endemic to J&K.

**5.** ***I. colutea*** (Burm.f.) Merr., Philipp. J. Sci. 19(3): 355. 1921. *Galega colutea* Burm.f., Fl. Ind. 172. 1768. Herb/Subshrub.

**6.** ***I. cordifolia*** B. Heyne ex Roth, Nov. Pl. Sp. 357. 1821;Baker in Hook. f., Fl. Brit. India 2: 93. 1876. Annual herb.

**7.** ***I. dosua*** Buch.-Ham. ex D. Don, Prodr. Fl. Nepal. 244. 1825;Baker in

**8.** ***I. glandulosa*** J. C. Wendl., Bot. Boeb. 55. 1748. Shrub.

**9.** ***I. hamiltonii*** Graham ex Duthie & Prain, Ann. Roy. Bot. Gard. (Calcutta) 9: 22, t. 29. 1901. Shrub; endemic to India.

**10.** ***I. hebepetala*** Benth. ex Baker in Hook. f., Fl. Brit. India 2: 101. 1876.

var. ***hebepetala*.** Shrub.
var. ***glabra*** Ali, Bot. Not. 3: 572. 1958. Shrub.

**11.** ***I. heterantha*** Wall. ex Brandis, Forest Fl. N.W. India 135. 1874. Shrub.

**12.** ***I. himalayensis*** Ali, Bot. Not. 111: 574. 1958. Shrub.

**13.** ***I. linifolia*** (L. f.) Retz., Observ. Bot. 4: 29. 1786; Baker in Hook. f., Fl. Brit. India 2: 92. 1876. *Heysarum linifolium* L. f., Suppl. Pl. 331. 1782. Annual herb.

**14.** ***I. linnaei*** Ali, Bot. Not. 111: 549. 1958. Herb.

**15.** ***I. tinctoria*** L., Sp. Pl. 2: 751. 1753; Baker in Hook. f., Fl. Brit. India 2: 99. 1876. Shrub.

**16.** ***I. trifoliata*** L., Cent. Pl. II: 29. 1756; Baker in Hook. f., Fl. Brit. India 2: 96. 1876. Annual herb.

**17.** ***I. trita*** L. f., Suppl. Pl. 335. 1782; Baker in Hook. f., Fl. Brit. India 2: 96. 1876. Shrub.

**Lablab** Adans., Fam. Pl. 2: 325. 1763.

***L. purpureus*** (L.) Sweet, Hort. Brit. 1: 481. 1826. subsp. ***purpureus*.** *Dolichos purpureus* L., Sp. Pl., ed. 2. 2: 1021. 1763. Climbing herb/Shrub.

subsp. ***benghalensis*** (Jacq.) Verdc., Kew Bull. 24(3): 411. 1970. *Dolichos benghalensis* Jacq., Stapel. Hort. Vindob. Cult. 2: 57. 1809. Annual herb.

**Lathyrus** L., Sp. Pl. 2: 729. 1753, *nom. cons. des*.

**1.** ***L. aphaca*** L., Sp. Pl. 2: 729. 1753; Baker in Hook. f., Fl. Brit. India 2: 179. 1876. Annual herb.

**2.** ***L. emodi*** (Wall. ex Fritsch) Ali, Biologia (Lahore) 11(2): 4. 1965. *Orobus emodi* Wall. ex Fritsch, Denkschr. Kaiserl. Akad. Wiss., Wien. Math.-Naturwiss. Kl. 104: 489. 1895. Annual/Perennial herb.

**3.** ***L. himalayensis*** Cambess. in Jacquem., Voy. Inde 4(Bot.): 44. t. 53. 1844. Endemic to J&K.

**4.** ***L. hirsutus*** L., Sp. Pl. 2: 732. 1753. Annual herb.

**5.** ***L. humilis*** (Ser.) Fischer ex Spreng., Syst. Veg. ed. 16, 3: 263. 1826. *Orobus humilis* Ser., Prodr. 2: 378. 1825. Perennial herb.

**6.** ***L. inconspicuus*** L., Sp. Pl. 2: 730. 1753. Annual herb.

**Note:** In ILDIS database, its occurrence is reported from Punjab, based on Bamber (Plants of the Punjab—*a descriptive key to the Flora of the Punjab, North-West Frontier Province and Kashmir*, 1916). Bamber actually gives its distribution in Simla and Baluchistan.

**7.** ***L. luteus*** Peterm., *Fl. Deutschland 155. 1849*; Bamber, Pl. Punjab 1916.

Annual herb; Jammu & Kashmir.

**8.** ***L. odoratus*** L., Sp.Pl. 732. 1753. Annual herb; cultivated widely; native to Italy.

**9.** ***L. pratensis*** L., Sp. Pl. 2: 733. 1753. Herb.

**10.** ***L. sativus*** L., Sp. Pl. 2: 730. 1753. Annual herb.

**11.** ***L. sphaericus*** Retz., Observ. Bot. 3: 39. 1783. Annual herb.

**Lens** Mill., Gard. Dict. Abr., ed. 4. no. 765. 1754, *nom. cons*.

***L. culinaris*** Medik., Vorles. Churpfälz. Phys.-Öcon. Ges. 2: 361. 1787. Annual herb.

**Leptodesmia** (Benth.) Benth.in Benth. & Hook.f., Gen. Pl. 1: 522. 1865.

**Leptodesmia microphylla** (Thunb.) H.Ohashi & K.Ohashi, J. Jap. Bot. 93(3): 186. 2018.
*Hedysarum microphyllum* Thunb., Fl. Jap. 284.1784.Herb / Shrub.

**Lespedeza** Michx, Fl. Bor.-Amer. (Michaux) 2: 70. t. 39. 1803.

**1. *L. bicolor*** Turcz., Bull. Soc. Imp. Naturalistes Moscou 13: 69. 1840. Herb/Shrub.
**2. *L. elegans*** Cambess. in Jacquem., Voy. Inde 4(Bot): 43. t. 52. 1844; Baker in Hook. F., Fl. Brit. India 2: 143. 1876. Herb/Shrub.
**3. *L. floribunda*** Bunge, Pl. Mongholico-Chin. 1: 13. 1835. Shrub.
**4. *L. gerardiana*** Wall. ex Maxim., Trudy Imp. S.-Peterburgsk. Bot. Sada 2: 373. 1873; Baker in Hook. F., Fl. Brit. India 2: 142. 1876. Shrub.
**5. *L. hispida*** (Franch.) T. Nemoto & H. Ohashi, J. Jap. Bot. 84: 156-158, f. 6 & 7. 2009. Perennial herb/Undershrub.
**6. *L. juncea*** (L. f.) Pers., Syn. Pl. 2(2): 318. 1807. var. ***juncea*.** Shrub.
var. ***sericea*** (Thunb.) F. B. Forbes & Hemsl., J. Linn. Soc., Bot. 23(154): 181. 1887. Herb/Shrub.
var. ***variegata*** (Cambess.) Ali, Biologia (Lahore) 12(2): 41. 1966. Shrub; endemic to J&K, H. P. and Punjab.
**7. *L. tomentosa*** (Thunb.) Sieb. ex Maxim., Trudy Imp. S.-Peterburgsk. Bot. Sada 2: 376. 1873. Shrub.

**Lotus** L., Sp. Pl. 2: 773. 1753.

**1. *L. corniculatus*** L., Sp. Pl. 2: 775. 1753 ('corniculata'). subsp. ***corniculatus*** var. ***corniculatus*.** Herb.

var. ***japonicus*** Regel, Index Sem. (St. Petersburg) 23. 1864. Herb.

**2. *L. krylovii*** Schischkin & Serg., Sist. Zametki Mater. Gerb. Krylova Tomsk. Gosud. Univ. Kuybysheva 1932(7-8): 5. 1932. Perennial herb.

**Lupinus** L., Sp.Pl. 721. 1753.

**1. *L. albus*** L., Sp.Pl. 721. 1753.

India (cultivated), native to Mediterranian region.

**2. *L. hirsutus*** Linn., Sp.Pl. 721. 1753. Cultivated in India, native to N America.
**3. *L. polyphyllus*** Lindl., Bot. Reg.t. 1096. 1827. Cultivated in India; native to N America.

**Macrotyloma** (Wight & Arn.) Verdc., Kew Bull. 24 : 322.970.

***M. uniflorum*** (Lam.) Verdc., Kew Bull. 24(2): 322, 401. 1970. *Dolichos uniflorus* Lam., Encycl. 2: 299. 1786. Climbing herb.

**Medicago** L., Sp. Pl. 2: 778. 1753, *nom. cons*.

**1.** ***M. edgeworthii*** Sirj., Oesterr. Bot. Z. 87: 123. 1938. Annual herb.

**2.** ***M. falcata*** L., Sp. Pl. 2: 779. 1753; Baker in Hook. f., Fl. Brit. India 2: 89. 1876. Perennial herb.

**3.** ***M. laciniata*** (L.) Mill., Gard. Dict., ed. 8. Medicago no. 5. 1768. Annual herb.

**4.** ***M. lupulina*** L., Sp. Pl. 2: 779. 1753. Annual/Perennial herb.

**5.** ***M. minima*** (L.) Bartal., Cat. Piant. Siena 61. 1776; Baker in Hook. f., Fl. Brit. India 2: 91. 1876; *Medicago polymorpha* var. *minima* L., Sp. Pl. 2: 780. 1753. Annual herb.

**6.** ***M. monantha*** (C. A. Mey.) Trautv., Bull. Sci. Acad. Imp. Sci. St. Petersburg 8: 272. 1841.*Trigonella monantha* C. A. Mey., Verz. Pfl. Casp. Meer. 137. 1831. Annual herb.

**7.** ***M. orbicularis*** (L.) Bartal., Cat. Piant. Siena 60. 1776. *Medicago polymorpha* var. *orbicularis* L., Sp. Pl. 2: 779. 1753. Annual herb.

**8.** ***M. polymorpha*** L., Sp. Pl. 2: 779. 1753. Annual herb.

**9.** ***M. sativa*** L., Sp. Pl. 2: 778. 1753. Perennial herb.

**Meizotropis** Voigt, Hort. Suburb. Calcutt. 239. 1845.

***M. buteiformis*** Voigt, Hort. Suburb. Calcutt. 239. 1845 (‘buteaeformis’). Shrub.

**Melilotus** (L.) Mill., Gard. Dict. Abr., ed. 4. 876. 1754.

**1.** ***M. albus*** Medik., Vorles. Churpfälz. Phys.-Öcon. Ges. 2: 382. 1787. Annual/Perennial herb.

**2.** ***M. indicus*** (L.) All., Fl. Pedem. 1: 308. 1785. Annual herb.

**3.** ***M. officinalis*** (L.) Lam., Fl. Franc. 2: 594. 1779. *Trifolium officinale* L., Sp. Pl. 2: 765. 1753 (‘M. officinale’). Annual/Perennial herb.

**4.** ***M. suaveolens*** Ledeb., Enum. Pl. Horti Bot. Dorpat. Suppl. 2: 5. 1824. Annual herb.

**Millettia** Wight & Arn., Prodr. Fl. Ind. Orient. 1: 263. 1834, *nom. cons*.

**1.** ***M. extensa*** (Benth.) Benth. ex Baker in Hook. f., Fl. Brit. India 2: 109. 1876. *Otosema extensa* Benth. in Miq., Pl. Jungh. 2: 249. 1852. Shrub.

**2.** ***M. pinnata*** (L.) Panigrahi in Panigrahi & S. K. Murti, Fl. Bilaspur Dist. 1: 210. 1989. *Cytisus pinnatus* L., Sp. Pl. 2: 741. 1753. Tree.

**Mucuna** Adans., Fam. Pl. 2: 325, 579. 1763, *nom. cons*.

**1.** ***M. nigricans*** (Lour.), Steud., Nomencl.Bot.cd. 2(2):163. 1841. *Citta nigricans* Lour., Fl.Cochinch. 456. 1790.

**2.** ***M. pruriens*** (L.) DC., Prodr. 2: 405. 1825. var. ***pruriens*.** Climber.

var. ***utilis*** (Wall. ex Wight) Baker ex Burck, Ann. Jard. Bot. Buitenzorg 11: 187. 1893.

*Mucuna utilis* Wall. ex Wight, Icon. Pl. Ind. Orient. 1: t. 280. 1840. Climber.
**Ohwia** H. Ohashi, Sci. Rep. Tohoku Imp. Univ., Ser. 4. Biol. 40(3): 243. 1999.

***O. caudata*** (Thunb.) H. Ohashi, Sci. Rep. Tohoku Imp. Univ., Ser. 4. Biol. 40(3): 243. 1999. Shrub.

**Onobrychis** Mill., Gard. Dict. Abr., ed. 4. 1754.

**1. *O. laxiflora*** Baker, J. Linn. Soc., Bot. 19: 159. 1882; Sanjappa, Legum.India 221.1992. Herb.
**2. *O. stewartii*** Baker in Hook.f., Fl. Brit. India 2: 141. 1876. Annual herb.

**Ononis** L., Sp. Pl. 2: 716. 1753.

***O. spinosa*** L., Sp. Pl. 2: 716. 1753. subsp. ***spinosa*.** Herb/Shrub.

subsp. ***antiquorum*** (L.) Briq., Prodr. Fl. Corse. 2: 247. 1913. *Ononis antiquorum* L., Sp. Pl., ed. 2. 2: 1006. 1763. Herb/Shrub.
subsp. ***arvensis*** (L.) Greuter & Burdet, Willdenowia 19(1): 33. 1989. *Ononis arvensis* L., Syst. Nat., ed. 10. 2: 1159. 1759. Herb/Shrub.
**Ophiocarpus** (Bunge) S. S. Ikonnikov, Novosti Sist. Vyssh. Rast. 14: 232. 1977

***O. aitchisonii*** (Baker) Podtech, Sendtnera 2: 162. 1994.
*Astragalus aitchisoni* Baker in Hook. f., Fl. Brit. India 2: 121. 1876. Annual herb.
**Ougeinia** Roxb.
***O. oojeinensis*** (Roxb.) Hochr., Annuaire Conserv. Jard. Bot. Geneve 13-14: 51. 1909. *Dalbergia oojeinensis* Roxb., Fl. Ind.2, 3: 220. 1832 **.** Tree..

**Ototropis** Nees, Index Seminum 1838: 3, 1839.

**Ototropis elegans** (DC.) H.Ohashi & K.Ohashi, J. Jap. Bot. 87(2): 112. 2012.
*Desmodium elegans* DC., Ann. Sci. Nat. 4: 100. Jan. 1825; H.Ohashi in H.Hara et al., Enum. Fl. Pl. Nepal 2: 117. 1979. Shrub.

**Ototropis multiflora** (DC.) H.Ohashi & K.Ohashi, J. Jap. Bot. 87(2): 111. 2012.
*Desmodium elegans* DC., Ann. Sci. Nat 4: 101. Jan. 1825; H.Ohashi, Univ. Tokyo Bull. 2:272. Shrub.

**Oxytropis** DC., Astragalogia 24, ed. 4: 66. f. 53. 1802, *nom. cons.*

**1. *O. birirensis*** Ali in Kew Bull. 28(2):306.1973 & in Nasir & Ali, Fl. W. Pakistan 100: 115.1977. Perennial herb; endemic to (occupied) Kashmir.
**2. *O. cachemiriana*** Cambess. in Jacquem., Voy. Inde 4(Bot.): 38. t. 4. 1844 (‘cachemirica’).
**3. *O. chiliophylla*** Royle ex Benth., Ill. Bot. Himal. Mts. 198. 1835. Perennial herb; endemic to Punjab, HP and J&K.
**4. *O. chitralensis*** Ali, Phyton. 8:50. 1959, 11:102.1964. Perennial herb; endemic to (occupied) Kashmir.
**5. *O. crassiuscula*** Boriss., Not. Syst. Herb. Inst. Bot. Acad. Sci. URSS. 7:237.t.2. 1938. Perennial herb**.**

**6. *O. densa*** Benth. ex Bunge, Mém. Acad. Imp. Sci. St.-Pétersburg, Ser. 7. 22: 24. 1874. Perennial herb.

**7. *O. glabra*** (Lam.) DC., Astragalogia 95. t. 8. 1802. *Astragalus glaber* Lam., Encycl. Suppl. 1: 525. 1811. Perennial herb.

**8. *O. gloriosa*** Ali in Phyton. 11:104. 1964; Kew Bull. 28(2): 306.1973. Perennial herb endemic to (occupied) Kashmir.

**9. *O. humifusa*** Kar. & Kir., Bull. Soc. Imp. Naturalistes Moscou 15: 535. 1842. Perennial herb.

**10. *O. hypoglottoides*** (Baker) Ali, Kew Bull. 28(2): 306. 1973. *Astragalus hypoglottoides* Baker in Hook. f., Fl. Brit. India 2: 124. 1876. Perennial herb.

**11. *O. immersa*** (Baker) B. Fedtsch., Beih. Bot. Centralbl. xxii. II. 212.1907.

var. ***jinaliensis*** Ali, Kew Bull. 28(2):308.1973. Perennial herb; endemic to (occupied) Kashmir.

**12. *O. lapponica*** (Wahlenb.) Gay, Corresp. Flora Helv. 10: 30. 1827. *Phaca lapponica* Wahlenb., Veg. Clim. Helv. Sept. 131. 1813. Perennial herb.

**13. *O. meinshauseni*** Schrenk, Bull. Sci. Acad. Imp. Sci. St. Petersburg 10: 254. 1842. Perennial herb.

**14. *O. microphylla*** (Pall.) DC., Prodr. 2: 279. 1825. *Phaca microphylla* Pall., Reise Russ. Reich. 3: 744. 1776. Perennial herb.

**15. *O. mollis*** Benth. in Royle, Ill. Bot. Himal. Mts. 198. 1835. Perennial herb.

**16. *O. savellanica*** Bunge ex Boiss., Fl. Orient.2: 503. 1872. Perennial herb.

**17. *O. shivae*** Aswal, Goel & Mehrotra, Indian J. Forest 13(3): 257. 1990 ('shivai'). Perennial herb; endemic to J&K.

**18. *O. stracheyana*** Bunge in Mem. Acad. Imp. Sci. St. Petersb. Ser. 7. 22 (1):62. 1874.

**19. *O. tatarica*** Baker in Hook. f., Fl. Brit. India 2: 138. 1876 non Hook. f. & Thomson ex Bunge, 1874. Perennial herb; endemic to J&K and HP.

**Parochetus** Buch.-Ham. ex D. Don, Prodr. Fl. Nepal. 240. 1825.

***P. communis*** Buch.-Ham. ex D. Don, Prodr. Fl. Nepal. 240. 1825. Perennial herb.

**Phaseolus** L., Sp. Pl. 2: 723. 1753.

**1. *P. lunatus*** L., Sp. Pl. 2: 724. 1753. Perennial climber.

**2. *P. vulgaris*** L., Sp. Pl. 2: 723. 1753. Annual herb; cultivated, native to Mexico.

**Phyllodium** Desv., J. Bot. Agric. 1: 123. t. 5. f. 24. 1813.

***P. pulchellum*** (L.) Desv., J. Bot. Agric. 1: 124. t. 5. f. 24. 1813. *Hedysarum pulchellum* L., Sp. Pl. 2: 747. 1753. Shrub.

**Piptanthus** Sweet, Brit. Fl. Gard. 3: ad t. 264. 1828.

***P. nepalensis*** (Hook.) Sweet, Brit. Fl. Gard. 3: t. 264. 1828. *Baptisia nepalensis* Hook., Exot. Fl. 2: t. 131. 1824. Shrub.

**Pisum** L., Sp. Pl. 2: 727. 1753.

***P. sativum*** L., Sp. Pl. 2: 727. 1753. Annual herb; cultivated throughout world.

**Pleurolobus** J.St.-Hil., Nouv. Bull. Soc. Philom. 3: 192. 1812.

**Pleurolobus gangeticus** (L.) J.St.-Hil., Nouv. Bull. Soc. Philom.3: 192. 1812.

*Hedysarum gangeticum* L., Sp. Pl. 746. 1753.
*Desmodium gangeticum* (L.) DC., Prodr. 2: 327. 1825; Baker in Hook.f., Fl. Brit. India 2: 168. 1876. Shrub.

**Podolotus** Benth. in Royle, Ill. Bot. Himal. Mts. 198. 1835.

***P. hosackioides*** Benth. in Royle, Ill. Bot. Himal. Mts. 198. 1835. Perennial herb.

**Polhillides** H. Ohashi & K. Ohashi, J.Jap. Bot. 94(2): 65. 2019.

**Polhillides velutina** (Willd.) H. Ohashi & K. Ohashi, J.Jap. Bot. 94(2): 2019.

*Hedysarum velutinum* Willd., Sp. Pl. 3: 117. 1803.
*Desmodium latifolium* (Roxb.) DC., Prodr. 2: 327. 1825; Wight & Arn., Prodr. Fl. Ind. Orient. 1: 225. 1834 incl. vars.; Baker in Hook.f., Fl. Brit. India 2: 168. 1876. Shrub.
subsp. **longibracteata** (Schindl.) H. Ohashi & K. Ohashi, J.Jap. Bot. 94(2): 2019.
*Desmodium longibracteatum* Schindl., Fedde Rep. Beih.49: 296. 1928. Shrub.

**Pueraria** DC., Ann. Sci. Nat. (Paris) 4: 97. 1825.

***P. tuberosa*** (Roxb. ex Willd.) DC., Ann. Sci. Nat. (Paris) 4: 97. 1825. *Hedysarum tuberosum* Roxb. ex Willd., Sp. Pl., ed. 4, 3(2): 1197. 1803. Woody climber.

**Pycnospora** R. Br. ex Wight & Arn., Prodr. Fl. Ind. Orient. 1: 197. 1834.

***P. lutescens*** (Poir.) Schindl., J. Bot. 64: 145. 1926. *Hedysarum lutescens* Poir., Encycl. 6(2): 417. 1805. Perennial herb.

**Rhynchosia** Lour., Fl. Cochinch. 2: 425, 460. 1790, *nom. cons*.

**1.** ***R. capitata*** (B. Heyne ex Roth) DC., Prodr. (DC.) 2: 386. 1825. *Glycine capitata* B. Heyne ex Roth, Nov. Pl. Sp. 346. 1821. Climbing herb.
**2.** ***R. himalensis*** Benth. ex Baker in Hook. f., Fl. Brit. India 2: 225. 1876. Climbing herb..
**3.** ***R. minima*** (L.) DC., Prodr. (DC.) 2: 385. 1825. *Dolichos minimus* L., Sp. Pl. 2: 726. 1753. var. ***minima.*** Herb.

var. ***laxiflora*** (Cambess.) Baker in Hook. f., Fl. Brit. India 2: 223. 1876. *Rhynchosia laxiflora* Cambess. in Jacquem., Voy. Inde 4(Bot.): 44. t. 54. 1844. Climbing herb.

**4.** ***R. pseudocajan*** Cambess. in Jacquem., Voy. Inde 4(Bot.): 45. t. 55. 1844. Shrub.
**5.** ***R. rothii*** Benth. ex Aitch., Cat. Pl. Punjab Sindh 50. 1869. Herb/Shrub.

**Robinia** L., Sp. Pl. 2: 722. 1753.

***R. pseudoacacia*** L., Sp. Pl. 2: 722. 1753. Tree.

**Rothia** Pers., Syn. Pl. 2(2): 638. 1807, *nom. cons*.

***R. indica*** (L.) Druce, Rep. Bot. Exch. Club Soc. Brit. Isles 3(4): 423. 1914..*Trigonella indica* L., Sp. Pl. 2: 778. 1753. Annual herb.

**Sesbania** Scop., Introd. Hist. Nat. 308-309. 1777*, nom. cons*.

**1.** ***S. bispinosa*** (Jacq.) W. Wight, U.S.D.A. Bur. Pl. Industr. Bull. 137: 15. 1909.

*Aeschynomene bispinosa* Jacq., Icon. Pl. Rar. 3(8): t. 564. 1792; 3(16): 13. 1795. Herb/Shrub.

**2.** ***S. concolor*** J. B. Gillett, Kew Bull. 17(1): 142-143. 1963. Shrub.

**3.** ***S. grandiflora*** (L.) Pers., Syn. Pl. 2(2): 316. 1807. *Robinia grandiflora* L., Sp. Pl. 2: 722. 1753. Shrub/Tree; cultivated in tropical areas, native to Indonesia.

**4.** ***S. sesban*** (L.) Merr., Philip. J. Sci., Bot. 7:235. 1912. *Aeschynomene sesban* L., Sp. Pl. 714. 1753. Cultivated, especially in tropical areas.

**Shuteria** Wight & Arn., Prodr. Fl. Nov. Orient. 1: 207. 1834, *nom. cons*.

***S. involucrata*** (Wall.) Wight & Arn., Prodr. Fl. Ind. Orient. 1: 207. 1834. *Glycine involucrata* Wall., Pl. Asiat. Rar. 3: 22. t. 241. 1832. var. ***involucrata*****.** Annual/Perennial herb.

var. ***glabrata*** (Wight & Arn.) H. Ohashi, J. Jap. Bot. 50(10): 305. 1975. *Shuteria glabrata* Wight & Arn., Prodr. Fl. Ind. Orient. 1: 207. 1834. Climbing herb.

**Smithia** Aiton, Hortus Kew. 3: 496. 1789, *nom. cons*.

**1.** ***S. ciliata*** Royle, Ill. Bot. Himal. Mts. 201. t. 35. f. 2. 1835. Annual herb.

**2.** ***S. conferta*** Sm., Cycl. (Rees) 33: Smithia no. 2. 1816. Annual herb.

**3.** ***S. sensitiva*** Aiton, Hortus Kew. 3: 496. 1789. Annual herb.

**Sohmaea** H. Ohashi & K. Ohashi, J. Jap. Bot. 93(3): 159. 2018.

**Sohmaea laxiflora** (DC.) H. Ohashi & K. Ohashi, J. Jap. Bot. 93(3): 162. 2018 *Desmodium laxiflorum* DC., Ann. Sci. Nat Paris 4: 100. Jan. 1825; Prodr. 2:335. Nov. 1825; Baker in Hook.f., Fl. Brit. India 2:164.1876. Shrub.

**Sophora** L., Sp. Pl. 1: 373. 1753, *nom. cons*.

**1.** ***S. alopecuroides*** L., Sp. Pl. 1: 373. 1753. Perennial herb.

**2.** ***S. mollis*** (Benth.) Graham ex Baker in Hook.f., Fl. Brit. India 2: 251. 1878 non Span, 1841. *Edwardsia mollis* Benth. in Royle, Ill. Bot. Himal. Mts. 196. t. 32. f. 2. 1835.

subsp. ***mollis*****.** Shrub.

subsp. ***duthiei*** (Prain) Ali in Nasir & Ali, Fl. W. Pakistan 100 :28.1977. *Sophora mollis* var. *duthiei* Prain, J. Asiat. Soc. Bengal Part 2, Nat. Hist. 66(2): 467. 1897. Endemic to Chitral (occupied Kashmir).

subsp. ***griffithii*** (Stocks) Ali, Fl. W. Pakistan 100: 27. 1977. *Sophora griffithii* Stocks in Hooker's J. Bot. Kew Gard. Misc. 4: 147. 1852.

**3. *S. moorcroftiana*** (Benth.) Baker in Hook. f., Fl. Brit. India 2: 249. 1878. *Astragalus moorcroftiana* Benth. in Wall., Numer. List no. 5933. 1831–1832 ('moorcroftianus'). Shrub.

**Spartium** L., Sp. Pl. 2: 708. 1753.

***S. junceum*** L., Sp. Pl. 2: 708. 1753. Shrub.

**Spatholobus** Hassk., Flora 25(2, Beibl.): 52. 1842.

***S. parviflorus*** (Roxb. ex DC.) Kuntze, Revis. Gen. Pl. 1: 205. 1891. *Butea parviflora* Roxb. ex DC., Prodr. (DC.) 2: 415. 1825. Woody climber.

**Spongiocarpella** Yakovlev & N. Ulziykh., Bot. Zhurn. (Moscow & Leningrad) 72(2): 250. 1987.

***S. nubigena*** (D. Don) Yakovlev, Bot. Zhurn. (Moscow & Leningrad) 72(2): 252. 1987. *Astragalus nubigenus* D. Don, Prodr. Fl. Nepal. 245. 1825. Herb.

**Tadehagi** H. Ohashi, Ginkgoana 1: 280. 1973.

***T. triquetrum*** (L.) H.Ohashi subsp. ***pseudotriquetrum*** (DC.) H.Ohashi, Ginkgoana 1: 295. 1973. *Desmodium pseudotriquetrum* DC., Ann. Sci. Nat. (Paris) 4: 100. 1825. Herb/Shrub.

**Tateishia H.Ohashi** & K.Ohashi, J. Jap. Bot. 93(3): 178. 2018.

**Tateishia concinna** (DC.) H.Ohashi & K.Ohashi, J. Jap. Bot. 93(3): 179. 2018.
*Desmodium concinnum* DC., Ann. Sci. Nat. 4: 101. Jan. 1825;Baker in Hook.f., Fl. Brit. India 2: 170. 1876 pro parte. Shrub.

var. **nutans** (Hook.) H.Ohashi & K.Ohashi, J. Jap. Bot. 87(2): 114. 2012.
*Hedysarum nutans* Hook. in Bot. Mag. 55: t. 2867. 1828.

**Taverniera** DC., Prodr. 2 1825.

***T. cuneifolia*** (Roth) Arn, Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 18(1): 332. 1836. *Hedysarum cuneifolium* Roth, Nov. Pl. Sp. 357. 1821.

**Tephrosia** Pers., Syn. Pl. (Persoon) 2(2): 328. 1807, *nom. cons*.

**1. *T. pumila*** (Lam.) Pers., Syn. Pl. 2(2): 330. 1807. *Galega pumila* Lam., Encycl. 2: 599. 1788. Annual/Perennial herb.
**2. *T. purpurea*** (L.) Pers., Syn. Pl. 2(2): 329. 1807. *Cracca purpurea* L., Sp. Pl. 2: 752. 1753. Herb.
**3. *T. strigosa*** (Dalzell) Santapau & Maheshw., J. Bombay Nat. Hist. Soc. 54(3): 805. 1957. *Macronyx strigosus* Dalzell, Hooker's J. Bot. Kew Gard. Misc. 2: 35. 1850. Herb.
**4. *T. villosa*** (L.) Pers., Syn. Pl. 2(2): 329. 1807. *Cracca villosa* L., Sp. Pl. 2: 752. 1753. Herb.

**Teramnus** P. Browne, Civ. Nat. Hist. Jamaica 290. 1756.

**1. *T. labialis*** (L. f.) Spreng., Syst. Veg. ed. 16, 3: 235. 1826. *Glycine labialis* L. f., Suppl. Pl. 325. 1782. Herb.

**2. *T. mollis*** (Wight & Arn.) Benth., J. Linn. Soc., Bot. 8: 265. 1865.

*Glycine mollis* Wight & Arn., Prodr. Fl. Ind. Orient. 1: 209. 1834. Climbing shrub.

**Thermopsis** R. Br. ex Aiton, Hortus Kew. ed. 2. 3: 3. 1811.

**1. *T. barbata*** Benth. in Royle, Ill. Bot. Himal. Mts. 196. t. 32. f. 1. 1835. Herb.

**2. *T. inflata*** Cambess. in Jacquem., Voy. Inde 4(Bot.): 34. t. 39. 1844. Herb.

**Trifolium** L., Sp. Pl. 2: 764. 1753.

**1. *T. alexandrinum*** L., Cent. Pl. I: 25. 1755. Herb.

**2. *T. campestre*** Schreb., Deutschl. Fl. (Sturm), Abt. I, Phanerog. 1: 16. 1804. Herb.

**3. *T. cernuum*** Brot., Phytogr. Lusitan. Select. 1: 150. 1816. Herb.

**4. *T. dubium*** Sibth., Fl. Oxon. 231. 1794. Herb.

**5. *T. fragiferum*** L., Sp. Pl. 2: 772. 1753. Herb.

**6. *T. incarnatum*** L., Sp. Pl. 2: 769. 1753. Cultivated, or as an escape; native to Europe.

**7. *T. pratense*** L., Sp. Pl. 2: 768. 1753. Herb.

**8. *T. repens*** L., Sp. Pl. 2: 767. 1753. Herb.

**9. *T. resupinatum*** L., Sp. Pl. 2: 771. 1753. Herb.

**10. *T. tomentosum*** L., Sp. Pl. 2: 771. 1753. Herb.

**Trigonella** L., Sp. Pl. 2: 776. 1753.

**1. *T. corniculata*** (L.) L., Syst. Nat., ed. 10. 2: 1180. 1759. *Trifolium corniculatum* L., Sp. Pl. 2: 766. 1753 ('M. corniculata'). Herb.

**2. *T. cachemiriana*** Cambess. in Jacquem., Voy. Inde 4(Bot.): 36. t. 41. 1844. Herb.

**3. *T. emodi*** Benth. in Royle, Ill. Bot. Himal. Mts. 197. 1835. Herb.

**4. *T. fimbriata*** Royle, Ill. Bot. Himal. Mts. 197. 1835. Herb.

**5. *T. foenum-graecum*** L., Sp. Pl. 2: 777. 1753. Herb; cultivated.

**6. *T. gharuensis*** Rech. f. in Biol. Skr. Dan. Vid. Selsk. 9 : 12. 1958.

**7. *T. gracilis*** Benth. in Royle, Ill. Bot. Himal. Mts. 197. 1835. Herb.

**8. *T. griffithii*** Boiss., Fl. Orient. 2: 88. 1972.

**9. *T. podperae*** (Sirj.) Vassilcz., Trudy Bot. Inst. Akad. Nauk S.S.S.R., Ser. 1, Fl. Sist. Vyssh. Rast.10: 163. 1953. *Trigonella emodi* var. *podperae* Sirj., Spisy Prir. Fak. Masarykovy Univ. 102: 21. 1928. Herb; J&K and Pakistan.

**Uraria** Desv., J. Bot. Agric. 1: 122. 1813.

**1. *U. picta*** (Jacq.) Desv. ex DC., Prodr. 2: 324. 1825. *Hedysarum pictum* Jacq., Collectanea 2: 262-263. 1789. Shrub.

**2. *U. rufescens*** (DC.) Schindl., Repert. Spec. Nov. Regni Veg. 21: 14. 1925. *Desmodium rufescens* DC., Ann. Sci. Nat. (Paris) 4: 101. 1825. Perennial herb/ Shrub.

**Vicia** L., Sp. Pl. 2: 734. 1753.

**1.** ***V. bakeri*** Ali, Bot. Not. 120: 52. 1967. Herb.

**2.** ***V. faba*** L., Sp. Pl. 2: 737. 1753. Herb.

**3.** ***V. hirsuta*** (L.) Gray, Nat. Arr. Brit. Pl. 2: 614. 1821. *Ervum hirsutum* L., Sp. Pl. 2: 738. 1753. Herb.

**4.** ***V. mollis*** Boiss., Fl. Orient. 2: 576.1872. Herb.

**5.** ***V. monantha*** Retz., Observ. Bot. 3: 39. 1783. Herb.

**6.** ***V. narbonensis*** L., Sp. Pl. 2: 737. 1753. Herb.

**7.** ***V. rigidula*** Benth. in Royle, Ill. Bot. Himal. Mts. 200. 1835. Herb.

**8.** ***V. sativa*** L., Sp. Pl. 2: 736. 1753. Herb.

**9.** ***V. sepium*** L., Sp. Pl. 2: 737. 1753. Herb.

Note: In ILDIS database, its occurrence is reported in Punjab based on Bamber (Plants of the Punjab-*a descriptive key to the Flora of the Punjab, North-West Frontier Province and Kashmir*, 1916). Bamber actually gives distribution in Kashmir.

**10.** ***V. tenera*** Wall. ex Benth. in Royle, Ill. Bot. Himal. Mts. 200. 1835. Perennial herb; endemic to Punjab, Uttarakhand, HP, and J&K.

**11.** ***V. tenuifolia*** Roth, Tent. Fl. Germ. 1: 309. 1788. Herb.

**Table 24.1** Numerical analysis of legumes in Jammu and Kashmir state compared with that of India and the world

| | No. of genera | | | No. of species | | |
|---|---|---|---|---|---|---|
| Family/ subfamily/tribe | World | India | J&K | World | India | J&K |
| **LEGUMINOSAE, *Nom. alt*. FABACEAE** (Tribes 36) | 727 | 207 | 106 | 19616 | 1272 | 399 |
| **1A. CAESALPINIOIDEAE** (Tribes 4) | | | **11** | | | **33** |
| [a]T1. Cercideae | 12 | 01 | 02 | 348 | 31 | 07 |
| T2. Detariea | 82 | 18 | 01 | 766 | 43 | 01 |
| T3. Cassieae | 21 | 05 | 03 | 735 | 59 | 16 |
| T4. Caesalpinieae | 56 | 11 | 05 | 444 | 42 | 09 |
| **1B. MIMOSOIDEAE** (Tribes 4) | | | **09** | | | **28** |
| T1. Mimoseae | 40 | 13 | 05 | 899 | 33 | 07 |
| T2. Mimozygantheae | 01 | – | – | 01 | – | – |
| T3. Acacieae | 01 | 02 | 01 | 1450 | 94 | 12 |
| T4. Ingeae | 36 | 07 | 03 | 966 | 40 | 09 |
| **1C. PAPILIONOIDEAE** (Tribes 28) | | | **86** | | | **338** |
| T1. Swartzieae | 17 | 01 | – | 228 | 01 | – |
| T2. Sophoreae | 45 | 09 | 01 | 398 | 21 | 03 |
| T3. Diptenygeae | 03 | – | – | 022 | – | – |
| T4. Brongniartieae | 10 | 01 | – | 152 | 01 | – |
| T5. Euchresteae | 01 | 01 | – | 04 | 01 | – |
| T6. Thermopsideae | 06 | 02 | 02 | 47 | 03 | 03 |
| T7. Podalyrieae | 08 | 01 | – | 125 | 01 | – |
| T8. Crotalarieae | 11 | 02 | 02 | 1204 | 98 | 13 |

(continued)

**Table 24.1** (continued)

| Family/ subfamily/tribe | No. of genera | | | No. of species | | |
|---|---|---|---|---|---|---|
| | World | India | J&K | World | India | J&K |
| T9. Genisteae | 25 | 08 | 03 | 572 | 15 | 06 |
| T10. Amorpheae | 08 | 01 | – | 248 | 01 | – |
| T11. Dalbergieae | 49 | 04 | 05 | 1331 | 42 | 09 |
| T12. Hypocalypteae | 01 | 0 | – | 03 | 0 | – |
| T13. Mirbelieae | 25 | 03 | – | 689 | 03 | – |
| T14. Bossiaeeae | 06 | 01 | – | 72 | 01 | – |
| T15. Indigofereae | 07 | 03 | 01 | 768 | 62 | 17 |
| T16. Millettieae | 45 | 10 | 04 | 914 | 71 | 08 |
| T17. Abreae | 01 | 01 | 01 | 17 | 03 | 01 |
| T18. Phaseoleae | 89 | 43 | 22 | 1580 | 209 | 48 |
| T19. Desmodieae | 30 | 18 | 14 | 530 | 102 | 44 |
| T20. Psoraleeae | 09 | 03 | 01 | 185 | 07 | 02 |
| T21. Sesbanieae | 01 | 07 | 01 | 60 | 32 | 04 |
| T22. Loteae | 22 | 01 | 02 | 282 | 02 | 03 |
| T23. Robinieae | 11 | 03 | 02 | 72 | 12 | 02 |
| T24. Galegeae | 24 | 09 | 09 | 3183 | 125 | 84 |
| T25. Hedysareae | 12 | 05 | 05 | 453 | 12 | 23 |
| T26. Cicereae | 01 | 01 | 01 | 43 | 03 | 07 |
| T27. Trifolieae | 06 | 06 | 06 | 485 | 39 | 34 |
| T28. Fabeae | 05 | 04 | 04 | 330 | 29 | 25 |

[a]*T* tribe, '–' means the taxon is absent or not represented

**Table 24.2** Comparative species' richness in the genera of three legume subfamilies in Jammu & Kashmir and in India

| Name of the taxon | No. of species in India | No. of species in J&K |
|---|---|---|
| **LEGUMINOSAE** | | |
| **CAESALPINIOIDEAE** | | |
| 1. *Bauhinia*[a] | 38 | 06 |
| 2. *Caesalpinia*[a] | 20 | 04 |
| 3. *Cassia*[a] | 09 | 01 |
| 4. *Cercis*[a] | 01 | 01 |
| 5. *Chamaecrista* | 11 | 04 |
| 6. *Delonix*[a] | 02 | 02 |
| 7. *Guilandina* | 01 | 01 |
| 8. *Parkinsonia*[a] | 01 | 01 |
| 9. *Peltophorum*[a] | 05 | 01 |
| 10. *Senna* | 36 | 11 |
| 11. *Tamarindus*[a] | 01 | 01 |
| Sub-total: | – | **33** |

(continued)

**Table 24.2** (continued)

| Name of the taxon | No. of species in India | No. of species in J&K |
|---|---|---|
| **MIMOSOIDEAE** | | |
| 1. *Acacia*[a] | 95 | 12 |
| 2. *Albizia* | 20 | 05 |
| 3. *Calliandra*[a] | 09 | 03 |
| 4. *Desmanthus*[a] | 01 | 01 |
| 5. *Leucaena*[a] | 02 | 01 |
| 6. *Mimosa* | 10 | 03 |
| 7. *Neptunia* | 03 | 01 |
| 8. *Pithecellobium*[a] | 02 | 01 |
| 9. *Prosopis*[a] | 05 | 01 |
| Sub-total: | – | **28** |
| **PAPILIONOIDEAE** | | |
| 1. *Abrus* | 03 | 01 |
| 2. *Aeschynomene* | 03 | 02 |
| 3. *Alhagi* | 02 | 02 |
| 4. *Alysicarpus* | 18 | 08 |
| 5. *Amphicarpaea* | 01 | 01 |
| 6. *Arachis*[a] | 01 | 01 |
| 7. *Argyrolobium* | 03 | 03 |
| 8. *Astracantha* | 01 | 01 |
| 9. *Astragalus* | 85 | 55 |
| 10. *Butea* | 02 | 01 |
| 11. *Cajanus* | 16 | 06 |
| 12. *Campylotropis* | 10 | 05 |
| 13. *Canavalia* | 07 | 03 |
| 14. *Caragana* | 12 | 09 |
| 15. *Chesneya* | 04 | 04 |
| 16. *Christia*[a] | 02 | 01 |
| 17. *Cicer*[a] | 05 | 05 |
| 18. *Clitoria* | 04 | 01 |
| 19. *Codariocalyx* | 02 | 01 |
| 20. *Colutea* | 02 | 03 |
| 21. *Crotalaria* | 97 | 12 |
| 22. *Cullen* | 03 | 02 |
| 23. *Dalbergia* | 33 | 02 |
| 24. *Dendrolobium* | 02 | 01 |
| 25. *Derris* | 22 | 01 |
| 26. *Desmodium* | 42 | 13 |
| 27. *Dumasia* | 02 | 01 |
| 28. *Ebenus* | 01 | 01 |
| 29. *Erythrina*[a] | 20 | 04 |

(continued)

**Table 24.2** (continued)

| Name of the taxon | No. of species in India | No. of species in J&K |
|---|---|---|
| 30. *Flemingia* | 27 | 04 |
| 31. *Galactia* | 02 | 01 |
| 32. *Gliricidia* | 01 | 01 |
| 33. *Glycine*[a] | 01 | 01 |
| 34. *Glycirrhiza*[a] | 01 | 01 |
| 35. *Gueldenstaedtia* | 02 | 01 |
| 36. *Hedysarum* | 07 | 09 |
| 37. *Hylodesmum* | 01 | 01 |
| 38. *Indigofera* | 62 | 17 |
| 39. *Lablab*[a] | 01 | 01 |
| 40. *Lathyrus*[a] | 11 | 11 |
| 41. *Lens* | 01 | 01 |
| 42. *Lespedza* | 09 | 07 |
| 43. *Lotus* | 02 | 02 |
| 44. *Lupinus*[a] | 03 | 03 |
| 45. *Macrotyloma*[a] | 03 | 01 |
| 46. *Medicago*[a] | 09 | 09 |
| 47. *Meizotropis* | 02 | 01 |
| 48. *Melilotus*[a] | 04 | 04 |
| 49. *Millettia* | 10 | 02 |
| 50. *Mucuna* | 09 | 02 |
| 51. *Ohwia* | 01 | 01 |
| 52. *Onobrychis* | 02 | 02 |
| 53. *Ononis* | 02 | 01 |
| 54. *Ophiocarpus* | 01 | 01 |
| 55. *Ougenia* | 01 | 01 |
| 56. *Oxytropis* | 20 | 19 |
| 57. *Parochetus* | ? | 01 |
| 58. *Phaseolus* | 04 | 02 |
| 59. *Phyllodium* | 02 | 01 |
| 60. *Piptanthus* | 01 | 01 |
| 61. *Pisum*[a] | 02 | 01 |
| 62. *Podolotus* | 01 | 01 |
| 63. *Pueraria* | 13 | 01 |
| 64. *Pycnospora* | 01 | 01 |
| 65. *Rhynchosia* | 26 | 05 |
| 66. *Robinia*[a] | 01 | 01 |
| 67. *Rothia* | 01 | 01 |
| 68. *Sesbania*[a] | 10 | 04 |
| 69. *Shuteria* | 04 | 01 |
| 70. *Smithia* | 18 | 03 |

(continued)

**Table 24.2** (continued)

| Name of the taxon | No. of species in India | No. of species in J&K |
|---|---|---|
| 71. *Sophora*[a] | 10 | 03 |
| 72. *Spartium*[a] | 01 | 01 |
| 73. *Spatholobus* | 06 | 01 |
| 74. *Spongiocarpella* | 02 | 01 |
| 75. *Tadehagi* | 01 | 01 |
| 76. *Taverniera* | 01 | 01 |
| 77. *Tephrosia* | 28 | 04 |
| 78. *Teramnus* | 05 | 02 |
| 79. *Thermopsis* | 02 | 02 |
| 80. *Trifolium*[a] | 12 | 10 |
| 81. *Trigonella*[a] | 12 | 09 |
| 82. *Uraria* | 08 | 02 |
| 83. *Vicia* | 16 | 12 |
| 84. *Vigna*[a] | 26 | 08 |
| 85. *Wisteria*[a] | 01 | 01 |
| 86. *Zornia* | 03 | 01 |
| Sub-total: | – | **338** |
| Grand-total in 3 sub-families | – | **399** |

[a]Includes some or all cultivated and naturalized species or their escapes.

**Table 24.3** Legume taxa from Jammu and Kashmir state included in the IUCN Red List

| S. No. | Name of the species/ssp/variety | Distribution |
|---|---|---|
| 1 | *Alysicarpus heyneanus* var. *meeboldii* (Schindl.) A. Pramanik & Thoth | Jammu & Kashmir |
| 2 | *Amphicarpaea bracteata* ssp. *edgeworthii* (Benth.) H. Ohashi | Jammu & Kashmir |
| 3 | *Astragalus rhizanthus* Benth. | Jammu & Kashmir |
| 4 | *Astragalus stewartii* Baker | Jammu & Kashmir |
| 5 | *Astragalus kashmirensis* Bunge | Jammu & Kashmir |
| 6 | *Astragalus maxwellii* Benth. | Jammu & Kashmir, Himachal Pradesh |
| 7 | *Hedysarum astragaloides* Benth. ex Baker | Jammu & Kashmir, Himachal Pradesh |
| 8 | *Hedysarum cachemirianum* Baker | Jammu & Kashmir |
| 9 | *Indigofera cedrorum* Dunn | Jammu & Kashmir, Himachal Pradesh |
| 10 | *Oxytropis shivae* Aswal, Goel & Mehrotra | Jammu & Kashmir |
| 11 | *Thermopsis inflata* Cambess. | Jammu & Kashmir, Himachal Pradesh |
| 12 | *Vicia mollis* Boiss. | Jammu & Kashmir |

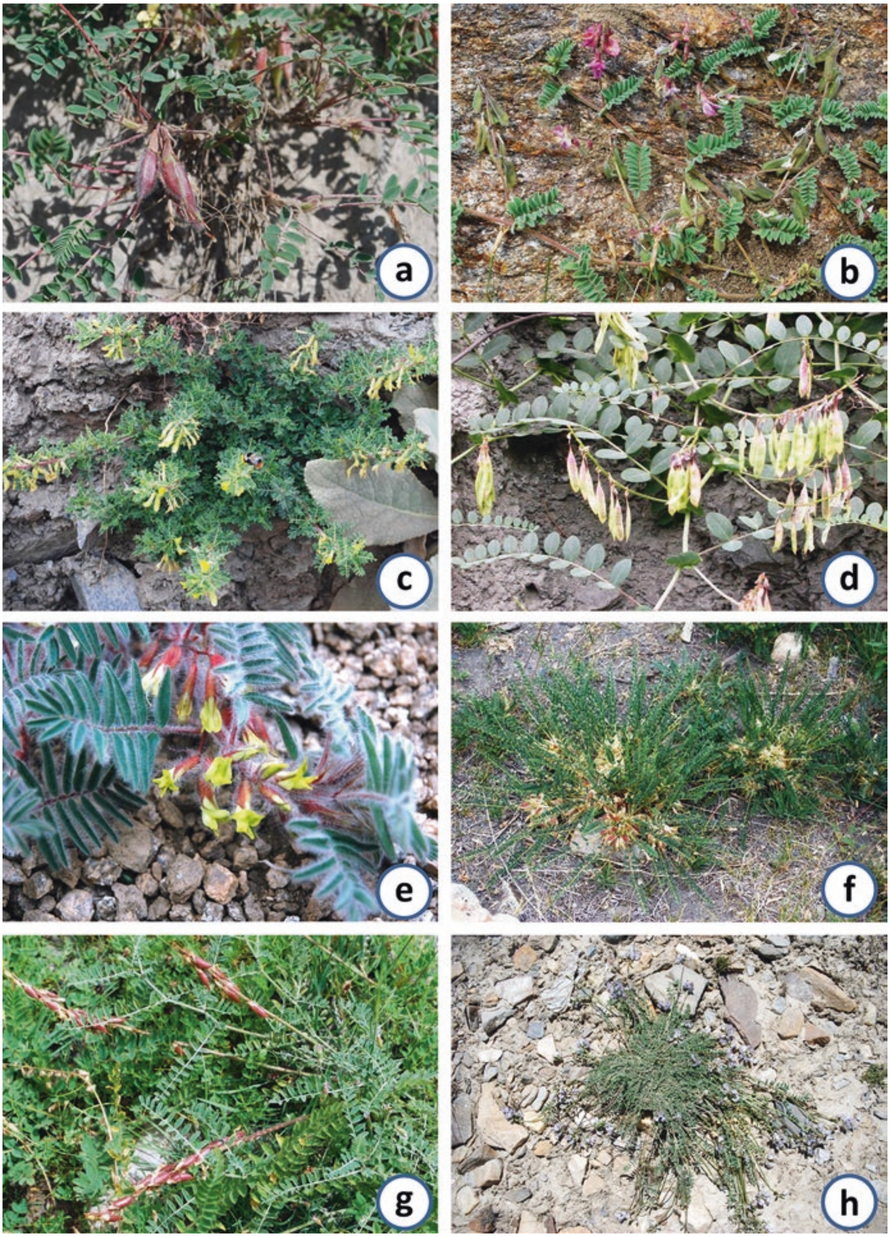


**Plate 24.1** (**a**) – *Astragalus candolleanus* (**b**) – *Astragalus falconeri* (**c**) – *Astragalus multiceps* (**d**) – *Astragalus graveolens* (**e**) – *Astragalus* (**f**) – *Astragalus oplites* (**g**) – *Astragalus peduncularis* (**h**) – *Astragalus strictus*

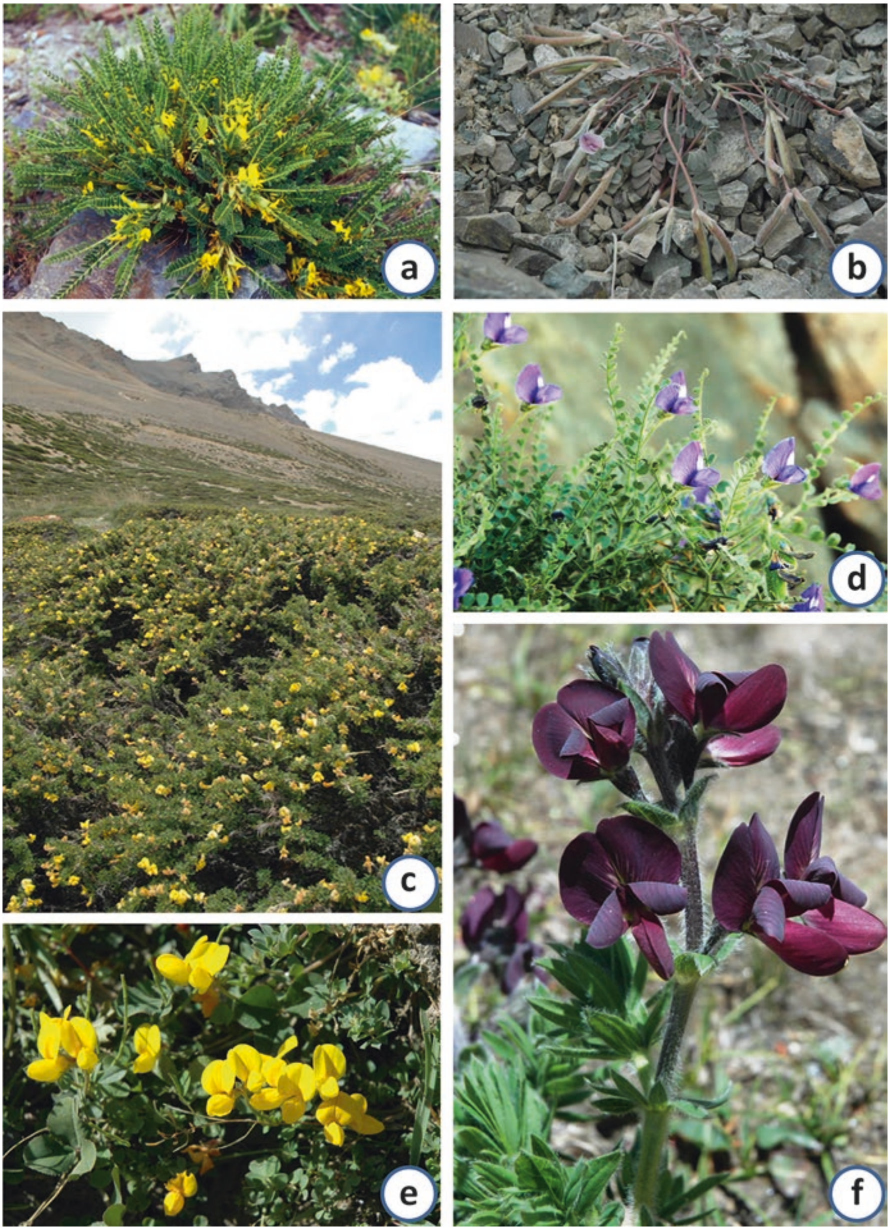


**Plate 24.2** (**a**) – *Astragalus webbianus,* (**b**) – *Caragana versicolor,* (**c**) – *Chesneya cuneata,* (**d**) – *Cicer microphyllum,* (**e**) – *Lotus corniculatus,* (**f**) – *Thermopsis barbata*

**12.** ***V. tetrasperma*** (L.) Schreb., Spic. Fl. Lips. 26. 1771. *Ervum tetraspermum* L., Sp. Pl. 2: 738. 1753. Herb.

**Vigna** Savi, Nuovo Giorn. Lett. 8: 113. 1824, *nom. cons*.

**1.** ***V. aconitifolia*** (Jacq.) Marechal, Bull. Jard. Bot. Natl. Belg. 39(2): 160. 1969. *Phaseolus aconitifolius* Jacq., Observ. Bot. 3: 2. t. 52. 1768. Herb/Shrub.

**2.** ***V. adenantha*** (G. Mey.) Marechal, Mascherpa & Stainier, Taxon 27(2/3): 202. 1978. *Phaseolus adenanthus* G. Mey., Prim. Fl. Esseq. 239. 1818. Herb.

**3.** ***V. mungo*** (L.) Hepper, Kew Bull. 11(1): 128. 1956. *Phaseolus mungo* L., Mant. Pl. 101. 1767. Herb.

**4.** ***V. radiata*** (L.) R. Wilczek, Fl. Congo Belge 6: 386. 1954. *Phaseolus radiatus* L., Sp. Pl. 2: 725. 1753. Herb.

**5.** ***V. trilobata*** (L.) Verdc., Taxon 17(2): 172. 1968. *Dolichos trilobatus* L., Mant. Pl. 101. 1767. Herb.

**6.** ***V. umbellata*** (Thunb.) Ohwi & H.Ohashi, J. Jap. Bot. 44: 31. 1969. *Dolichos umbellatus* Thunb., Trans. Linn. Soc. London 2: 339. 1794. Herb.

**7.** ***V. unguiculata*** (L.) Walp., Repert. Bot. Syst. 1(5): 779. 1842. *Dolichos unguiculatus* L., Sp. Pl. 2: 725. 1753. subsp. ***unguiculata*****.** Herb.

subsp. ***cylindrica*** (L.) Verdc., Kew Bull. 24(3): 544. 1970. *Phaseolus cylindricus* L., Amoen. Acad., ed. 4: 132. 1759. Herb.

**8.** ***V. vexillata*** (L.) A. Rich., Hist. Fis. Cuba 10: 191. 1845. *Phaseolus vexillatus* L., Sp. Pl. 2: 724. 1753. Herb.

**Wisteria** Nutt., Gen. N. Amer. Pl. 2: 115. 1818, *nom. cons*.

***W. sinensis*** (Sims) Sweet, Hort. Brit. 121. 1826. *Glycine sinensis* Sims, Bot. Mag. 46: t. 2083. 1819. Climber.

**Zornia** J. F. Gmel., Syst. Nat., ed. 13, 2(2): 1076, 1096. 1791

***Z. gibbosa*** Span., Linnaea 15: 192. 1841. Herb.

## 24.3 Numerical analysis

The numerical analysis of legumes in Jammu & Kashmir state at subfamily, tribe, genus and species levels is compared with that of India and the world in Table 24.1; whereas in Table 24.2 is presented a comparison in number of species for each genus in J&K state with that of India. (The tables are as per the Polhil and Raven (1981) classification of subfamilies and tribes). The last minute changes made in the checklist could not be made here in tables. There are many recent changes in generic concepts in tribe *Caesalpineae* and genus *Desmodium*.

Although only 3 legume species (*Hedysarum astragaloides, H. cashmirianum, H. microcalyx*) of 24 species of flowering plants are included in the Red Data Book of Indian Plants, 12 legume taxa are listed in the IUCN Red List (Table 24.3) (Plates 24.1 and 24.2).

**Acknowledgements** We are thankful to Dr. S. K. Srivastava, BSD; Dr. P. Pusalkar, BSD; and Dr. L. B. Chaudhury, LWG, for providing photos of which the selected ones are included here. M. Sanjappa thanks Dr. Sringeshwara and Prof. M.D. Rajanna, Botanic Garden, University of Agricultural Sciences, GKVK, Bengaluru, for their help in preparing the plates and for extending the facilities for this work, respectively.

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# Chapter 25
# Poisonous Plants of the Kashmir Himalaya: A Checklist

**Mudasir Ahmad, Mohammad Yaseen Shah, and Abdul Rashid Naqshi**

**Abstract** Being part of the Himalayan biodiversity hotspot, Kashmir Himalaya is a rich repository of plant wealth. For quite a long time, this floral diversity with the enchanting topography of the region, has enticed people throughout the globe. However, the region has equally generated a wide research interest in various fields of plant science. The present study aimed to prepare a checklist of poisonous plants of the Kashmir Himalaya. The checklist was compiled after a thorough exploration of floristically diverse pockets of the region, together with extensive literature survey. Various traditional naturopaths were consulted in order to gain knowledge about toxic effects and medicinal uses of these plants. In total, 152 species of poisonous plants, belonging to 127 genera in 59 families are reported from the region.

**Keywords** Poisonous plants · Plant toxicity · Kashmir Himalaya · Ladakh

## 25.1 Introduction

Humans have made use of plants since time immemorial, mainly to fulfil their need for food, fodder, timber and healthcare. In searching for these plants, they also came across many varieties that are harmful to humans, as well as to the domestic animals. A poisonous plant is one which, by means of toxic substances that it contains, produces adverse effects in humans or economic animals such as livestock, in laboratory animals, pets, wild animals, birds, fish and bees (Wagstaff 2008). Of the

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_25

300,000 or so identified species of plants in the world, roughly 700 are known to be poisonous (Abid Askari 2011). A good number of such plants are present in our gardens as backyard flowers, decorative trees, house plants and weeds.

Poisonous plants form the third largest category of poisons known globally (Bhatia et al. 2013). Their toxicity is due to the presence of chemicals such as alkaloids, cyanogens, glucosides, toxalbumins, saponins, tannins, essential oils, and other secondary metabolites that are produced by plants perhaps as a protection against herbivores that may consume them (Habermehl 1998). Plant poisoning occurs due to ingestion of or exposure to a plant for nutritional, therapeutic or recreational intention and, sometimes, due to experimental or spiteful purposes. Very often, such poisoning is accidental, as many poisonous plants resemble edible herbs and also those used for medicinal purposes. Livestock deaths caused due to ingestion of poisonous herbs result in huge economic losses (Nielson et al. 1988). In the United States alone, the annual economic loss due to plant poisoning in livestock amounts to a quarter of a billion dollars (Tisserand and Balacs 1995). Toxic plants can affect the entire spectrum of organ systems, and the effect may depend on the condition, growth stage or part of the plant, the amount consumed and the species and susceptibility of the victim (Botha and Penrith 2008).

Although poisonous plants cause huge losses to life and economy, they have also been put to use by humans for various beneficial purposes. Apart from their role in therapeutics, they are used as insect-repellants and pesticides (Orozco and Lentz 2005), as well as in fishing (Neuwinger 2004). Many such plants have been used from ancient times in traditional therapeutic practices in different parts of the globe. As per the World Health Organisation (WHO) estimates, 80% people in the developing world still depend on traditional medicines for their primary healthcare requirements (De Silva 1997). However, the general belief that herbal drugs are devoid of any side effects has ceased to be valid. Despite the benefits derived from these plants, many of them have side effects related to overdoses and toxic principles that may lead to acute toxicity and even death of patients.

Kashmir Himalaya (in the present study includes Kashmir valley and Ladakh), being part of the Himalayan biodiversity hotspot, is a rich repository of plant wealth (see Stewart 1972, Dar et al. 1995). This rich plant diversity has long enticed people mainly for its aesthetic and economic attributes. These plants encompass a large number of useful plants, including the ones used as food, fodder, timber and medicinal herbs. Furthermore, the region harbours a good variety of poisonous plants. This chapter deals with the diversity of poisonous plants in Kashmir Himalaya.

## 25.2 Materials and Methods

The chapter is the result of eight years' study (2005–2013) in the Kashmir Himalaya. Several exploratory trips were carried out to different parts of the Kashmir valley and Ladakh region. The places visited include Gulmarg, Lidder Valley, Aharbal, Uri, Kishenganga Valley, Sonmarg and Zoji La in Kashmir; and Suru Valley, Zanskar Valley, Leh, Khardung La, Batallik, and Drass in the Ladakh cold desert.

Poisonous plants collected from various habitats were identified using relevant literature, including *Flora of British India* (Hooker 1872–1897) and *Flora of Pakistan* (Nasir and Ali/Ali and Nasir/Ali and Qaiser 1970 to date), as well as the online identification source—www.efloras.org. In addition, extensive literature survey was conducted in the compilation of the present inventory; these literature sources include a wide variety of national and international publications and some specialized online resources.

## 25.3 Results and Discussion

In the present work, 152 taxa of seed plants in the region have been found to be poisonous. These species belong to 127 genera in 59 families. Grouped in their respective families, each poisonous plant species is provided with its correct scientific name, habit (life-form), altitudinal range, region of occurrence, and its actual poisonous part (Table 25.1). The families that contain the highest number of poisonous species are Asteraceae and Ranunculaceae (with 18 spp. each), Solanaceae (11 spp.), and Fabaceae (10 spp.). *Artemisia*, *Euphorbia*, *Narcissus*, *Papaver*, *Ranunculus* and *Solanum* are the largest poisonous genera in the region, with three species each.

In their habit, the poisonous plants range from small annual herbs to gigantic trees; and have been grouped into herbs (annual, biennial and perennials), subshrubs (deciduous and evergreen), shrubs (deciduous and evergreen), trees (deciduous and evergreen), climbers, lianas, parasites, and aquatics. Perennial herbs are the most abundant, followed by annual herbs (Fig. 25.1). The majority (38%) of toxic plants are distributed in the temperate zone, followed by 31% in the montane zone; few species (22%) being found in the subalpine and even fewer species (9%) in the alpine zone (Fig. 25.2).

The poisoning is caused either by the whole plant or its part(s), viz. roots, underground stems (rhizome, corm, bulb, tuber), aerial stems, leaves, flowers, fruits, seeds or bark; in most of the cases (34%) the whole plant is poisonous, followed by the ones where aerial shoot, leaves, seeds and fruits possess the poisoning property. Poisonous plants affect various organs and organ systems in humans and livestock, with many of the poisonings being fatal and resulting in enormous loss to human and animal life, as well as to the economy.

The major causes of plant poisoning in humans include accidental ingestion, misidentification, or sometimes misuse of herbs. In livestock, however, poisoning usually occurs due to scarcity of forage plants. As revealed in the present study, the poisonous plants cause toxicity mainly in the form of gastro-intestinal-tract (GIT) poisoning, skin inflammatory reaction, nervous system toxicity, photosensitization, cardiac disorders, liver toxicity, kidney disorders, and eye problems (Fig. 25.3). It was found that the majority of these plants cause gastrointestinal-tract poisoning.

**Table 25.1** List of poisonous plants that occur in the Kashmir Himalaya

| Family/Name of species | Life-form | Altitude (m, asl) | Region of occurrence | Poisonous part(s) |
|---|---|---|---|---|
| **Alismataceae** | | | | |
| *Alisma plantago-aquatica* L. | Aq | 1600–1800 | K | Whole plant |
| *Sagittaria sagittifolia* L. | Aq | 1600–1800 | K | Whole plant |
| **Amaryllidaceae** | | | | |
| *Narcissus poeticus* L. | HP | 2000–2700 | K | Underground stem |
| *Narcissus pseudo-narcissus* L. | HP | 1600–2200 | K | Underground stem, Leaves |
| *Narcissus tazetta* L. | HP | 1600–2500 | K | Underground stem |
| **Anacardiaceae** | | | | |
| *Rhus succedanea* L. | TD | 1700–2300 | K | Leaves, Flowers |
| **Apiaceae** | | | | |
| *Angelica archangelica* L. | HP | 2400–3000 | K | Whole plant |
| *Conium maculatum* L. | HB | 1600–2400 | K | Whole plant |
| *Daucus carota* L. | HB | 1600–3100 | KL | Whole plant |
| *Ferula jaeschkeana* Vatke | HP | 2800–3500 | KL | Whole plant |
| *Prangos pabularia* Lindl. | HP | 2300–3200 | KL | Whole plant |
| **Apocynaceae** | | | | |
| *Nerium oleander* L. | SE | 1600–1700 | K | Whole plant |
| *Vinca major* L. | SSE | 1600–1700 | K | Whole plant |
| **Araceae** | | | | |
| *Acorus calamus* L. | HP | 1600–1800 | K | Roots |
| *Arisaema jacquemontii* Blume | HP | 2700–3200 | K | Underground stem; Fruits |
| *Arisaema propinquum* Schott. | HP | 2400–3600 | K | Underground stem |
| **Araliaceae** | | | | |
| *Hedera nepalensis* K. Koch | Li | 1600–2600 | K | Leaves, Fruits |
| **Asclepiadaceae** | | | | |
| *Vincetoxicum hirundinaria* Medic. | HP | 2400–3000 | KL | Whole plant |
| **Asteraceae** | | | | |
| *Achillea millefolium L.* | HP | 1600–3100 | K | Whole plant |
| *Anthemis cotula* L. | HB | 1600–2800 | K | Aerial parts |
| *Arctium lappa* L. | HP | 1600–3200 | KL | Roots, Flowers |
| *Artemisia absinthium L.* | SSD | 1800–3000 | K | Whole plant |
| *Artemisia maritima* L. | HP | 2500–3000 | KL | Whole plant |
| *Artemisia vulgaris* L. | SSD | 1800–2600 | K | Whole plant |
| *Chrysanthemum cinerariaefolium* Vis. | HP | 1600–1800 | K | Aerial parts |
| *Cichorium intybus* L. | HP | 1600–2500 | K | Roots |
| *Conyza Canadensis* Cronq. | HB | 1600–2500 | K | Aerial parts |
| *Inula royleana* DC. | HP | 2800–3400 | K | Roots |

(continued)

**Table 25.1** (continued)

| Family/Name of species | Life-form | Altitude (m, asl) | Region of occurrence | Poisonous part(s) |
|---|---|---|---|---|
| *Leucanthemum vulgare* Lam. | HP | 2000–2700 | K | Aerial parts |
| *Parthenium hysterophorus* L. | HA | 1600–1700 | K | Seeds, Aerial parts |
| *Senecio jacquemontianus* Benth. | HP | 3000–3900 | KL | Roots |
| *Senecio vulgaris* L. | HA | 1600–2000 | K | Whole plant |
| *Silybum marianum* Gaertn. | HA | 1600–1800 | K | Whole plant |
| *Tagetes minuta* L. | HP | 2000–2800 | K | Whole plant |
| *Tussilago farfara* L. | HP | 1800–2600 | K | Flowers |
| *Xanthium strumarium* L. | HA | 1600–2100 | K | Aerial parts |
| **Brassicaceae** | | | | |
| *Capsella bursa-pastoris* Medik. | HA | 1600–3000 | KL | Whole plant |
| *Thlaspi arvense* L. | HA | 1700–3000 | KL | Whole plant |
| **Buxaceae** | | | | |
| *Buxus wallichiana* Baill. | SE | 1600–1700 | K | Whole plant |
| **Bignoniaceae** | | | | |
| *Campsis radicans* Seem. | Li | 1600–1700 | K | Whole plant |
| *Catalpa bignonioides* Walt. | TD | 1600–1700 | K | Roots, Flowers |
| **Cannabaceae** | | | | |
| *Cannabis sativa* L. | HA | 1600–2400 | K | Leaves, Flowers |
| *Humulus lupulus* L. | Cl | 1600–2500 | K | Leaves, Flowers |
| **Ceratophyllaceae** | | | | |
| *Ceratophyllum demersum* L. | Aq | 1600–2100 | K | Whole plant |
| **Chenopodiaceae** | | | | |
| *Chenopodium album* L. | HA | 1600–2900 | KL | Aerial parts |
| *Chenopodium ambrosioides* L. | HA | 1700–2100 | K | Whole plant |
| *Kochia scoparia* Schrad | HA | 1600–2000 | K | Whole plant |
| *Salsola kali* L. | HP | 3200–4000 | L | Whole plant |
| **Convolvulaceae** | | | | |
| *Convolvulus arvensis* L. | HP | 1600–3100 | KL | Whole plant |
| *Ipomoea purpurea* Roth. | Cl | 1700–2100 | K | Seeds |
| **Coriariaceae** | | | | |
| *Coriaria nepalensis* Wall. | SD | 1600–2500 | K | Fruits |
| **Cucurbitaceae** | | | | |
| *Momordica charantia* L. | Cl | 1600–1800 | K | Seeds, Fruits |
| **Cupressaceae** | | | | |
| *Platycladus orientalis* L. | SE | 1600–2500 | K | Leaves |
| **Cuscutaceae** | | | | |
| *Cuscuta europaea* L. | Pa | 1700–2500 | K | Whole plant |
| *Cuscuta reflexa* Roxb. | Pa | 1800–2600 | K | Whole plant |

(continued)

**Table 25.1** (continued)

| Family/Name of species | Life-form | Altitude (m, asl) | Region of occurrence | Poisonous part(s) |
|---|---|---|---|---|
| **Ephedraceae** | | | | |
| *Ephedra gerardiana* Wall. | SE | 2700–4200 | KL | Whole plant |
| **Equisetaceae** | | | | |
| *Equisetum arvense* L. | HP | 1600–2200 | K | Aerial parts |
| **Ericaceae** | | | | |
| *Rhododendron campanulatum* D.Don | SE | 2800–3300 | KL | Leaves |
| **Euphorbiaceae** | | | | |
| *Euphorbia helioscopia* L. | HA | 1600–2500 | K | Aerial parts |
| *Euphorbia peplus* L. | HA | 1700–2100 | K | Aerial parts |
| *Euphorbia thomsoniana* Boiss. | HA | 2500–3300 | KL | Aerial parts |
| *Ricinus communis* L. | SSD | 1600–1800 | K | Seeds |
| **Fabaceae** | | | | |
| *Lathyrus sativus* L. | HA | 2500–4000 | L | Fruits, Seeds |
| *Lotus corniculatus* L. | HP | 1600–2800 | KL | Whole plant |
| *Lupinus polyphyllus* Lindl. | HP | 1600–2800 | K | Whole plant |
| *Medicago sativa* L. | HB | 1600–3000 | KL | Whole plant |
| *Robinia pseudo-acacia* L. | TD | 1600–2200 | K | Bark, Seeds, Leaves |
| *Trifolium pratense* L. | HP | 1600–3000 | K | Whole plant |
| *Trifolium repens* L. | HP | 1600–3400 | KL | Whole plant |
| *Vicia faba* L. | HA | 1600–3100 | KL | Seeds |
| *Vicia sativa* L. | HA | 1600–1800 | K | Seeds |
| *Wisteria sinensis* DC. | Li | 1600–1700 | K | Seeds, Bark |
| **Fagaceae** | | | | |
| *Quercus robur* L. | TD | 1600–1900 | K | Fruits, Leaves |
| **Ginkgoaceae** | | | | |
| *Ginkgo biloba* | TE | 1600–1700 | K | Seeds |
| **Hippocastanaceae** | | | | |
| *Aesculus indica* Hook.f. | TD | 1600–2600 | K | Fruits |
| **Hypericaceae** | | | | |
| *Hypericum perforatum* L. | HP | 1600–2900 | K | Whole plant |
| **Iridadeae** | | | | |
| *Iris germanica* L. | HP | 1600–2400 | K | Underground stem, Leaves |
| **Juncaginaceae** | | | | |
| *Triglochin maritima* L. | HP | 3000–3600 | KL | Whole plant |
| **Lamiaceae** | | | | |
| *Leonurus cardiaca* L. | HP | 1700–2800 | K | Leaves |
| *Mentha longifolia* L. | HP | 1800–3700 | KL | Aerial parts |

(continued)

**Table 25.1** (continued)

| Family/Name of species | Life-form | Altitude (m, asl) | Region of occurrence | Poisonous part(s) |
|---|---|---|---|---|
| **Lilliaceae** | | | | |
| *Asparagus officinalis* L. | SSE | 1800–2600 | K | Aerial parts |
| *Colchicum luteum* Baker | HP | 1600–3200 | KL | Underground stem |
| *Fritillaria imperialis* L. | HP | 1600–2200 | K | Underground stem |
| *Ornithogalum umbellatum* L. | HP | 1600–2200 | K | Underground stem |
| **Loranthaceae** | | | | |
| *Viscum album* L. | Pa | 1600–2500 | K | Whole plant |
| **Meliaceae** | | | | |
| *Melia azedarach* L. | TD | 1600–1700 | K | Fruits, Bark, Leaves |
| **Moraceae** | | | | |
| *Ficus carica* L. | TD | 1600–1900 | K | Fruits, Aerial parts |
| **Oleaceae** | | | | |
| *Fraxinus excelsior* L. | TD | 2200–2400 | K | Leaves, Fruits |
| **Oxalidaceae** | | | | |
| *Oxalis acetosella* L. | HP | 2000–2800 | K | Whole plant |
| *Oxalis corniculata* L. | HP | 1600–2500 | K | Whole plant |
| **Paeoniaceae** | | | | |
| *Paeonia emodii* Wall. | HP | 2000–3000 | K | Roots, Seeds |
| **Papaveraceae** | | | | |
| *Argemone Mexicana* L. | HA | 1600–1700 | K | Seeds |
| *Meconopsis aculeata* Royle | HP | 2800–4000 | KL | Roots |
| *Papaver nudicaule* L. | HA | 3600–4500 | L | Whole plant |
| *Papaver rhoeas* L. | HA | 1700–2300 | K | Whole plant |
| *Papaver somniferum* L. | HA | 1600–1800 | K | Fruits, Aerial parts |
| **Phytolaccaceae** | | | | |
| *Phytolacca latbenia* Walter | HP | 2200–3000 | K | Whole plant |
| **Pinaceae** | | | | |
| *Cedrus deodara* G.Don | TE | 1700–3200 | K | Flowers, Bark |
| *Pinus roxburghii* Sar. | TE | 1600–2800 | K | Leaves, Aerial parts |
| **Poaceae** | | | | |
| *Cynodon dactylon* Pers. | HP | 1600–2500 | K | Aerial parts |
| *Sorghum halepense* Pers. | HP | 1600–2700 | K | Aerial parts |
| *Stipa sibirica* Lam. | HP | 2000–3200 | K | Aerial parts |
| **Podophyllaceae** | | | | |
| *Podophyllum hexandrum* Royle | HP | 2500–3600 | KL | Underground stem |
| **Polygonaceae** | | | | |
| *Fagopyrum esculentum* Moench | HA | 1900–3200 | KL | Seeds |
| *Polygonum hydropiper* L. | HA | 1600–3000 | K | Whole plant |
| *Rheum australe* D.Don | HP | 2800–4200 | KL | Whole plant |

(continued)

**Table 25.1** (continued)

| Family/Name of species | Life-form | Altitude (m, asl) | Region of occurrence | Poisonous part(s) |
|---|---|---|---|---|
| **Polypodiaceae** | | | | |
| *Dryopteris filix-mas* Schott | HP | 2300–3000 | K | Underground stem |
| **Primulaceae** | | | | |
| *Anagallis arvensis* L. | HA | 1600–2800 | K | Whole plant |
| **Ranunculaceae** | | | | |
| *Aconitum rotundifolium* Kar. et Kir. | HP | 3000–3600 | KL | Whole plant |
| *Aconitum violaceum* Jacqeum. | HP | 3000–4000 | KL | Whole plant |
| *Actaea spicata* L. | HP | 2500–3100 | K | Roots |
| *Adonis aestivalis* L. | HA | 1900–2400 | K | Whole plant |
| *Anemone obtusiloba* D.Don. | HP | 2200–3200 | K | Roots, Seeds |
| *Aquilegia fragrans* Benth. | HP | 2500–3500 | KL | Whole plant |
| *Caltha alba* Camb. | HP | 1800–2800 | K | Whole plant |
| *Cimicifuga foetida* L. | HP | 2100–3600 | K | Roots |
| *Clematis gouriana* Roxb. | Cl | 1600–1800 | K | Aerial parts |
| *Clematis orientalis* L. | Li | 2100–4200 | KL | Aerial parts |
| *Delphinium ajacis* L. | HA | 1600–2800 | K | Leaves, Seeds |
| *Delphinium brunonianum* Royle | HP | 4000–4800 | L | Whole plant |
| *Nigella sativa* L. | HA | 1600–2000 | K | Seeds |
| *Ranunculus arvensis* L. | HA | 1600–3200 | K | Whole plant |
| *Ranunculus lingua* L. | Aq | 1700–2300 | K | Whole plant |
| *Ranunculus scleratus* L. | HA | 1600–2300 | K | Whole plant |
| *Thallictrum foliosum* DC. | HP | 1700–2500 | K | Whole plant |
| *Thallictrum minus* L. | HP | 1700–2400 | K | Whole plant |
| **Rosaceae** | | | | |
| *Eriobotrya japonica* Lindl. | TD | 1600–1700 | K | Seeds |
| *Malus pumila* Mill. | TD | 1600–1800 | K | Seeds |
| **Rutaceae** | | | | |
| *Dictamnus albus* L. | SD | 2300–3500 | K | Aerial parts |
| *Skimmia laureola* Sieb & Zucc. | SE | 1800–3200 | K | Leaves |
| **Sambucaceae** | | | | |
| *Sambucus wightiana* Wall. | HP | 2200–3000 | KL | Whole plant |
| **Sapindaceae** | | | | |
| *Cardiospermum helicacabum* L. | Cl | 1600–1700 | K | Whole plant |
| **Scrophulariaceae** | | | | |
| *Digitalis purpurea* L. | HB | 2000–2500 | K | Leaves |
| *Verbascum Thapsus* L. | HB | 1600–3500 | K | Whole plant |

(continued)

**Table 25.1** (continued)

| Family/Name of species | Life-form | Altitude (m, asl) | Region of occurrence | Poisonous part(s) |
|---|---|---|---|---|
| **Simaroubaceae** | | | | |
| *Ailanthus altissima* Swingle | TD | 1600–3100 | K | Flowers, Leaves, Bark |
| **Solanaceae** | | | | |
| *Atropa acuminata* Royle | HP | 2000–3000 | K | Leaves, Fruits |
| *Capsicum annuum* L. | HA | 1600–1700 | KL | Fruits, Seeds |
| *Capsicum frutescens* L. | HA | 1600–1700 | K | Fruits, Seeds |
| *Datura stramonium* L. | HA | 1600–2700 | KL | Whole plant |
| *Hyoscyamus niger* L. | HB | 1800–2900 | KL | Whole plant |
| *Lycopersicon esculentum* Mill. | HA | 1600–2200 | KL | Fruits, Leaves |
| *Physalis alkekengi* L. | HP | 1800–3500 | KL | Underground stem, Fruits |
| *Physochlaina praealta* Miers | HP | 3200–3800 | L | Whole plant |
| *Solanum nigrum* L. | HA | 1600–2500 | K | Fruits, Leaves |
| *Solanum pseudo-capsicum* L. | SD | 1600–2400 | K | Fruits, Leaves |
| *Solanum tuberosum* L. | HA | 1600–3000 | KL | Underground stem |
| **Taxaceae** | | | | |
| *Taxus wallichiana* Zucc. | TE | 2100–2600 | K | Leaves, Fruits |
| **Thymelaeaceae** | | | | |
| *Daphne mucronata* Royle | SE | 1400–2300 | K | Whole plant |
| **Urticaceae** | | | | |
| *Urtica dioica* L. | HP | 1600–3000 | K | Aerial parts |
| *Urtica hyperborea* Jacq. | HP | 3000–4200 | L | Aerial parts |
| **Zygophyllaceae** | | | | |
| *Peganum harmala* L. | HP | 1700–3500 | KL | Whole plant |
| *Tribulus terrestris* L. | HA | 1900–3000 | KL | Whole plant |

**Life-forms –** *Aq* aquatic, *Cl* climber, *HA* annual herb, *HB* biennial herb, *HP* perennial herb, *Li* liana, *Pa* parasite, *SD* deciduous shrub, *SE* evergreen shrub, *SSD* deciduous sub-shrub, *SSE* evergreen sub-shrub, *TD* deciduous tree, *TE* evergreen tree
**Region –** *K* Kashmir, *L* Ladakh

GIT responds to a number of toxic substances in the form of pain, vomiting, dysentery and diarrhoea.

### *25.3.1 Poisonous Plants in Our Neighbourhood*

Among the 152 taxa of poisonous plants present in the Kashmir Himalaya, almost 50% are present in our surroundings in the form of weeds, ornamentals, and food and fodder plants. These pose a serious threat to both humans and domestic animals. Children and livestock in particular are at a greater risk of toxicity from such plants.

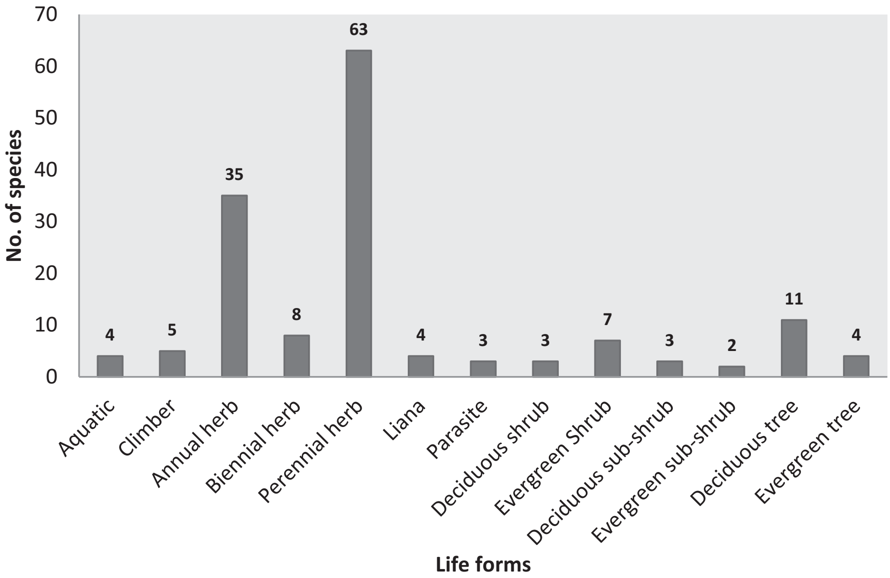
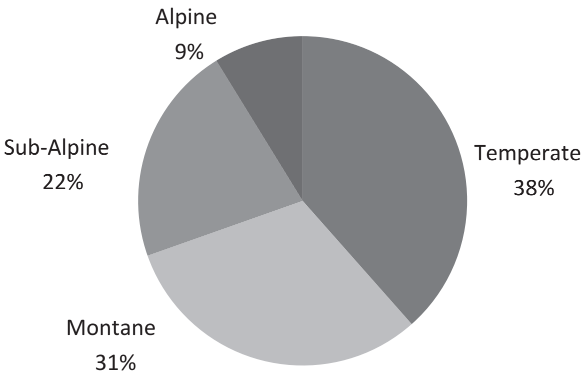



**Fig. 25.1** Number of different life-forms of poisonous plants in the Kashmir Himalaya

**Fig. 25.2** Altitudinal distribution of poisonous plants in the Kashmir Himalaya




Ornamental poisonous plants grown in the region include *Aesculus indica*, *Ailanthus altissima*, *Buxus wallichiana*, *Campsis radicans*, *Cardiospermum helicacabum*, *Catalpa bignonioides*, *Chrysanthemum cinerariaefolium*, *Coriaria nepalensis*, *Delphinium ajacis*, *Eriobotrya japonica*, *Frittilaria imperialis*, *Hedera nepalensis*, *Humulus lupulus*, *Ipomoea purpurea*, *Iris germanica*, *Narcissus poeticus*, *N. pseudo-narcissus*, *N. tazetta*, *Nerium oleander*, *Nigella sativa*, *Papaver somniferum*, *Ricinus communis*, *Platycladus orientalis*, *Vinca major* and *Wisteria sinensis*.

The common weed and wasteland plants that are potentially toxic are *Achillea millefolium, Anagallis arvensis, Anthemis cotula, Arctium lappa, Artemisia* sp., *Cichorium intybus, Conium maculatum, Conyza canadensis, Cannabis sativa,*

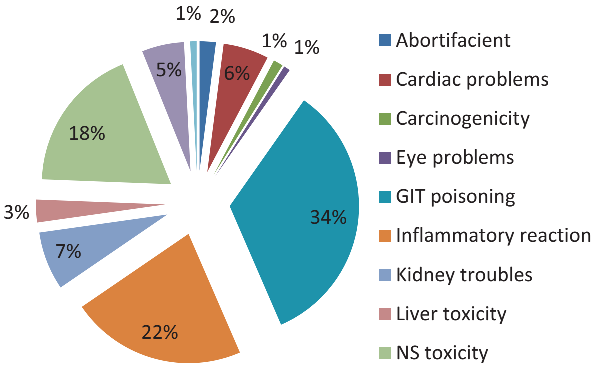



**Fig. 25.3** Different forms of toxicity (in percentage) caused by poisonous plants in the Kashmir Himalaya

*Chenopodium album, Convolvulus arvensis, Cynodon dactylon, Datura stramonium, Daucus carota, Euphorbia helioscopia, Hypericum perforatum, Lotus corniculatus, Kochia scoparia, Medicago sativa, Mentha longifolia, Polygonum hydropiper, Ranunculus sceleratus, Senecio vulgaris, Solanum nigrum, Sorghum halepense, Tribulus terrestris, Trifolium pratense, T. repens, Urtica dioica,* and *Xanthium strumarium. Capsicum anuum, C. frutescens, Eriobotrya japonica, Fagopyrum esculentum, Ficus carica, Lycopersicon esculentum, Malus pumila, Momordica charantia, Solanum tuberosum* and *Vicia faba* are the plants grown for food, but these have some poisoning effects too. This information assumes immense importance as it can help people remain aware about the potential hazards of plants occurring in their lawns, kitchen gardens, and cultivated fields.

### *25.3.2 Poisonous Plants in Healthcare*

Although poisonous plants cause huge loss of life and economy, they have also been put to use for various beneficial purposes. In fact, it is difficult to draw a distinct line between a poisonous and a medicinal plant. Poisonous plants often contain active compounds with useful biological activities. Pharmacology and toxicology are deeply interrelated, as therapeutic efficacy occurs at lower dose, while overdose may induce poisoning (Botha and Penrith 2008). The search for highly specific potent drugs for therapeutic use and, more precisely, as an investigation tool in biological research has been quite productive in toxic plants. A large number of important compounds now used in research have been derived from toxic plants (Williamson et al. 1996).

Since most poisonous plants contain active secondary metabolites, they are used in specific doses to cure and control different diseases. Many poisonous plants in this region are already being harvested to cure various ailments. *Podophyllum hexandrum*, *Atropa acuminata* and *Hyoscyamus niger* are but a few examples. The people of both Kashmir and Ladakh provinces rely greatly on traditional healthcare practices, the ethno-medicinal treatments being almost entirely dependent on their

**Table 25.2** Toxic plants of the Kashmir Himalaya that are commonly used in local ethno-medicine

| Name of species | Toxic effect in humans and/or livestock | Ethno-medicinal use |
|---|---|---|
| *Achillea millefolium* | Inflammatory reaction | Stomach problems, Dysentery, vomiting (Ballabh and Chaurasia 2009); Toothache (Ganie et al. 2012) |
| *Aconitum violaceum* | GIT poisoning | Febrifuge, gastric problems (Gairola 2014); Toothache (Kapahi et al. 1993) |
| *Acorus calamus* | Carcinogenic | Respiratory disorders (Naqshi et al. 1992) |
| *Angelica archangelica* | Inflammatory reaction | Expectorant (Kapahi et al. 1993) |
| *Arisaema jacquemontii* | Inflammatory reaction | Respiratory disorders (Naqshi et al. 1992) |
| *Artemisia absinthium* | GIT Poisoning; Nervous system toxicity | Menstrual problems (Ballabh and Chaurasia 2011); Anthelmintic (Malik et al. 2011) |
| *Atropa acuminata* | Nervous system toxicity; Eye problems | Analgesic, sedative (Kapahi et al. 1993) |
| *Cannabis sativa* | Nervous system toxicity; Inflammatory reaction | Menstrual problems (Khan et al. 2004; Diarrhoea (Mir and John 2014) |
| *Chenopodium album* | Photosensitization; GIT poisoning; Nervous system poisoning | Stomach problems, Diuretic (Buth and Navchoo 1988) |
| *Colchicum luteum* | Inflammatory reaction | Cough, dandruff, fever (Gairola et al. 2014) |
| *Datura stramonium* | Nervous system toxicity | Rheumatism (Ganie et al. 2012) Antispasmodic, anti-asthmatic (Gairola et al. 2014) |
| *Digitalis purpurea* | Cardiac disorders | Heart tonic; Epilepsy (Kumari et al. 2013) |
| *Ephedra gerardiana* | Cardiac disorders; GIT poisoning | Respiratory troubles; Liver problems (Buth and Navchoo 1988) |
| *Euphorbia helioscopia* | GIT poisoning; Nervous system toxicity | Boils (Mir and John 2014) |
| *Hyoscyamus niger* | GIT poisoning; Nervous system toxicity | Toothache (Malik et al. 2011). |
| *Mentha longifolia* | Nervous system toxicity; Inflammatory reaction | Dysentery; Vomiting (Ballabh and Chaurasia 2009) |
| *Papaver somniferum* | Nervous system toxicity; GIT poisoning | Cough (Ganie et al. 2012) |
| *Peganum harmala* | Cardiac disorders; Nervous system toxicity | Impotency; Menstrual problems (Ballabh and Chaurasia 2011) |
| *Phytolacca acinosa* | Nervous system toxicity; Inflammatory reaction | Joint pain, Blood purifier (Naqshi et al. 1992) |
| *Podophyllum hexandrum* | Cardiac disorders; GIT poisoning | Tonic; Liver ailments(Naqshi et al. 1992; Kapahi et al. 1993) |

(continued)

**Table 25.2** (continued)

| Name of species | Toxic effect in humans and/or livestock | Ethno-medicinal use |
|---|---|---|
| *Sambucus wightiana* | GIT poisoning | Stomach problems (Malik et al. 2011) |
| *Tribulus terrestris* | Cardiac disorders; Nervous system toxicity Photosensitization | Aphrodisiac, impotency (Ballabh and Chaurasia 2011) Kidney stone (Gairola 2014) |
| *Urtica dioica* | Inflammatory reaction | Joint pain; corns (Malik et al. 2011) |
| *Verbascum Thapsus* | Inflammatory reaction | Burns, wounds, infections (Gairola et al. 2014) |
| *Viscum album* | Cardiac disorders; GIT poisoning | Laxative; Bone fractures (Khan et al. 2004) |

herbal wealth. In both regions, a big chunk of medicinal preparations are derived from poisonous plants. Of these plants, those which are commonly used in medicinal preparations by traditional herbal healers are listed, with their toxic effect and ethno-medicinal usage, in Table 25.2.

### *25.3.3 Problems with Traditional Herbal Preparations*

Traditional herbal medicine has been practiced since ages, and as per the WHO estimates, around 80% of people in the developing world still rely on ethno-medicine for their primary healthcare needs. However, these ancient therapeutic practices have their own drawbacks. Many traditional plant preparations are found to cause toxicities of varying degrees and fatalities. This is mostly due to the fact that many such preparations contain intolerable proportions of poisonous plants or their parts. Recently available toxicity testing has revealed that many plants used in traditional medicine are potentially toxic, mutagenic and carcinogenic (Schimmer et al. 1994; Higashimoto et al. 1993; De Sa Ferrira and Ferrao Vargas 1999). This has been the case with *Momordica charantia,* traditionally used as anti-diabetic (Raman and Lau 1996; Basch et al. 2003) and *Urtica dioica* used as anti-diuretic and anti-hypersensitive (Tahri et al. 2000). This raises severe concern about the safety of these ethno-medicinal plants. It is estimated that in South Africa alone, the mortality due to acute poisoning by traditional medicines varies widely from 8000 to 20,000 per annum (Thomson 2000); 43% of poisoning cases recorded in a forensic database for Johannesburg are caused by traditional plant medicines (Stewart et al. 1999). However, many cases of poisoning remain unrecorded, and mortality from traditional plant medicines may be higher than currently known (Thomson 2000; Popat et al. 2001).

Intoxication from herbal preparations is often due to misidentification or misuse of a particular herb. The use of a wrongly identified plant is common, and so is the substitution of different plants for the same indication. Many food and medicinal plants have deadly relatives in their neighbourhood, and it is difficult for an ordinary herb healer to make the difference. Since most of herbs used in traditional medicine in the region are harvested from the wild, the chances of misidentification are very high. Adulteration is another cause of ethno-medicinal toxicities. Because of over-exploitation, the herbal treasures are shrinking, and this leads to intentional adulteration of herbal formulations. Many such adulterants come from poisonous plants, thereby causing toxicities. Such negative implications of traditional herbal medicines are mainly due to the fact that no proper regulatory standards in terms of efficacy and safety are in practice with regard to traditional healthcare.

### *25.3.4 Livestock Poisoning and Exotic Plants*

Livestock are the chief animals that suffer great loss due to poisoning. Deaths due to plant poisoning cause annual loss worth millions of rupees. A number of factors contribute to the intoxication of livestock. Many toxic plants are not palatable, so livestock avoid their ingestion if other good-quality forage is available. But ingestion of toxic plants is much more likely during periods of forage scarcity. There are geographical differences with regard to the distribution of poisonous plants. Plants that are associated with intoxications in a particular geographical region are not found in other regions (Poppenga 2010). However, a number of poisonous plants have been introduced into non-native areas where they thrive more efficiently. In the absence of natural herbivores and insect pests in these non-native areas, many such poisonous plant species can grow to the extent of becoming invasive. Such poisonous plants are more detrimental as the local livestock have no evolutionary defences against them. Because of lack of previous exposure, animals take risks in ingesting these alien plants. An ample number of poisonous plants in our region have their origin outside the Indian subcontinent. Most of these alien plants are found in the immediate surroundings of domestic animals, thereby posing a great threat.

## 25.4 Concluding Remarks

Poisonous plants, unlike venomous animals, lack distinct morphological features and warning signals. They affect the entire spectrum of organ systems, both in humans and domestic livestock. Many of these have caused much accidental toxicity due to unintentional addition of poisonous plant components and toxic adulterations. In order to avoid such toxicities, proper regulatory standards must be in place, particularly in terms of their safety. Therefore, the key to avoiding problems caused by such plants is their proper identification. Identifying poisonous plants is as important as knowing edible and other useful plants. Since the successful use of plants depends on positive identification, therefore recognition of poisonous plants will help minimize the potential toxicities and hazards associated with them. Proper identification will not only be beneficial in terms of avoiding toxicities, but also in making suitable and non-toxic herbal preparations.

In the Kashmir Himalaya, however, information about poisonous plants is negligible and restricted only to few scattered individual case reports. Extensive research in this field is the need of the hour, both in terms of creating poisonous-plant awareness as well as in drug development from such potent raw material. The inventory of poisonous plant species provided here will serve as a checklist for familiarization of these plants to researchers as well to common people who happen to deal with them, particularly farmers and livestock holders of the region.

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# Chapter 26
# Flora of Ladakh: An Annotated Inventory of Flowering Plants

**Achuta Nand Shukla and S. K. Srivastava**

**Abstract** The flora of Ladakh is influenced broadly by altitude and climate; more significantly by the soil, drainage, and microclimate. The present work is based on more than 20,000 plant specimens collected from Ladakh region of Jammu and Kashmir State, since 1975. Critical study of these collections has revealed presence of 1085 species of flowering plants from the Ladakh region. These species belong to 370 genera in 74 families. Of these, 808 species under 283 genera and 62 families belong to dicots, while 277 species under 87 genera and 12 families belong to monocots. Poaceae is the most dominant family and is represented by 184 species, followed by Asteraceae with 122 species, Fabaceae and Brassicaceae with 77 species each, Cyperaceae with 51 species, Scrophulariaceae with 43 species, Lamiaceae and Ranunculaceae with 40 species each, etc. At the generic level, *Astragalus* comprises the maximum number of 35 species, followed by *Carex* with 28 species, *Poa* with 27 species, *Nepeta* with 24 species, *Corydalis* with 20 species, etc. Herbs account for 1010 species, shrubs 48 species, trees 13 species, under-shrubs 11 species, whereas climbers and twiners have 2 and 1 species, respectively.

**Keywords** Flora · Ladakh · Jammu and Kashmir State · Inventory · Flowering plants

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_26

## 26.1 Introduction

In India, the Trans-Himalayan zone lies in the rain shadow of the main Himalayan range and is usually described as a 'High Altitude Cold Desert'. It is more extensive outside the Indian territory adjoining Tibet, covering only about 2% of the total land surface in India (Murti, 2001). The area encompasses the south-western-most extension of the high-level Tibetan Plateau including several basins without external drainage, and its rim towards the high mountain ranges of the Inner Himalaya, parts of the 'Leh' (Upper Indus Valley), 'Zanskar' and 'Rupshu' regions respectively as defined by Dickoré (1995). Altitude in the study area ranges from 3000 m at the bottom of the Indus Valley to 6622 m at Chhamser Kangri peak (Kapadia 1999). Flowering plants were found up to 5970 m. There is no climatic station located in the study area. However, data from a broader region (Dickoré and Miehe 2002; Hartmann 1997, 1999; Miehe et al. 2001) show that the study area is generally arid. It is rarely affected by monsoonal precipitation, which usually fails to cross the high crest of the main Himalayan range (Bhattacharyya 1989).

The vegetation of Ladakh as a whole is often referred to by local authorities as desert (Negi 1995; Srivastava 2010), or cold desert (Chowdhery and Rao 1990). There are few and very small permanent settlements on the plains situated at about 4550 m and large mountainous areas are uninhabited (Negi 1995). Barley and, less often, oat are cultivated on a small scale up to 4700 m. Steppe and alpine turf vegetation is grazed by sheep, Dzo, goats and yaks up to 5600 m. Synanthropic vegetation types include plant assemblages developed in villages and by stables of domestic stock up to 5400 m, and weed communities occur in arable fields up to 4700 m. The grazing effect of wild ungulates seems to be negligible due to the low densities of most species (Fox et al. 1991; Mallon 1991). During recent decades, the area has been experiencing continuous overgrazing due to large numbers of domestic sheep, goats and yaks (Jina 1995; Holzner and Kriechbaum 1998).

## 26.2 Materials and Methods

### *26.2.1 Study Area*

Ladakh, 'the land of high-rising passes', located in the State of Jammu and Kashmir, is a high-altitude desert as the Himalaya creates a rain shadow preventing entry of monsoon clouds. It lies between 32°59′57″- 34°10′12″ N latitude and 76°46′29″-8°41′34″ E longitude, covering more than 82,665 km$^2$ geographical area of the state. Commonly referred to as the land of the Lama, the high mountain land, a piece of land between earth and sky, etc., it remains landlocked for 6–7 months every year, when the temperature touches below −30 °C to −70 °C at various locations (Brazel and Marcus 1991; Frank et al. 1977). Based on location, river sites and geographical conditions, the Ladakh region can be divided into five different valleys, viz. Indus, Nubra, Changthang, Zanskar and Suru Valley (Chaurasia 1996–2001). It is bounded on the north and east by China, in the north-west by Gilgit and Skardu (Pakistan); whereas Bandipora, Ganderbal, Anantnag and Khistwar districts of the state lie at its west, and the Himachal Pradesh touches its southern borders. Siachen is the largest glacier located in the extreme northwest of Ladakh. The barren mountain landscape of Ladakh is broken by a series of rivers, notably the Indus and its tributaries, including Zanskar, Markha, Shyok, Nubra and Suru. The high altitude and harsh natural environment of Ladakh is characterized by extreme temperature, high radiation, strong winds, low precipitation, low humidity, desert-like extensive barren landscape, rugged topography, steep and vertical glaciated slopes, minimal forest cover, and few pasture lands at high elevations (Chaurasia and Singh 1996; Kumar et al. 2009).

### *26.2.2 Botanical Exploration in Ladakh*

The history of botanical exploration in Kashmir dates back to 1831, when V. Jacquemont (1801–1832) collected plants from Kashmir. His collections were studied and published by J. Cambessedes and F. Decaisne in 1845. Jacquemont was followed by Baron Von Huegel (1835) and Godfrey Thomas Vigne (1835–1836), who explored the Kashmir valley. Vigne collected plants from Kashmir and Deosai Plains in 1835. Hugh Falconer joined Vigne in Skardu in 1837 and made collections in Drass and Baltistan. W. Moorcroft collected specimens in the Ladakh region and sent his collections to Wallich and Royle. He also made collections in Niti Pass area. Falconer also obtained plants from Kashmir probably in the year 1839. Royle made extensive collections in Bashahr and Kinnaur around 1830 and sent collectors to Kashmir during 1833–1839. Thomas Thomson was another pioneer collector who collected in Kashmir during 1848. Schlagintweit (1855–1857), William Hay (1862), J. L. Stewart (1868), and Henderson and Hume (1873) also explored different areas of Kashmir. C. B. Clarke visited Kashmir in 1876 and crossed Deosai on his journey to Karakoram. He also visited Kishanganga valley. J. F. Duthie explored Baltistan and Gilgit during 1892–1893. He visited Deosai while travelling from Dras to Skardu and Astor. W. Gollam and Inayat, as Duthie's collectors, made collections in Kashmir in 1889 and 1891, respectively. G. A. Gammie surveyed and collected plants in Kashmir in the years 1891 and 1893.

In the first half of the twentieth century, several notable explorers and collectors visited this region. Keshavanand collected in Kashmir from 1906 to 1909, especially in the Kishanganga valley. Filippo De Filippi of the Abruzzi Expedition to the Karakoram Mountains in 1909 published a list of plants which he collected from Deosai. W. Koelz collected in Kashmir from 1931 to 1936. He visited Deosai and surrounding areas in Kashmir. R. R. Stewart collected plants in Deosai in 1940 and 1946 and explored Gilgit, Drass, Baltistan, Tilel, and Kamri Pass, etc. The other collectors during this period were R. N. Parker, N. L. Bor, S. R. Kashyap, Thakur Roopchand, Klimes, etc.

After re-organisation of the Botanical Survey of India (BSI) in 1954, the scientists of Northern Circle of B.S.I., Dehradun made systematic and extensive survey of Ladakh area. Notable among these were M. A. Rau, T. A. Rao, N. C. Nair, U. C. Bhattacharyya, B. M. Wadhwa, M. V. Viswanathan, P. K. Hajra, B. D. Naithani, B. P. Uniyal, H. J. Chowdhery, S. K. Murty, S. K. Srivastava, etc. In 1955, Grady Webster and E. Nasir explored Satpura La, Skardu and Deosai to Chillam. Scientists from Universities and Regional Research Laboratories of Kashmir and Jammu, like A. R. Naqshi, Gurcharan Singh, Uppeandra Dhar, B. L. Sapru, A. K. Kaul, R. N. Gohil, Y. K. Sarin, B. K. Kapahi, S. P. Sethi, B. M. Sharma, M. Y. Malla and G. H. Dar were also engaged in exploration of these areas independently.

The findings in this chapter are based on scrutiny of the literature available on floristics of Ladakh, including that of Stewart 1916–1917, Singh and Gohil 1972, Kachroo et al. 1977, Sapru and Kachroo 1979, Srivastava et al. 1981, Balapure 1982, Misri 1982, Dhar and Kachroo 1983, Kaul 1983, Whili 1983, Seybold and Kull 1985, Jain and Chandra 1986, Navchoo and Butt 1987, Naqshi et al. 1989, Murti 2001, Singh et al. 2002, Klimeš and Dickoré 2005, Rawat and Adhikari 2005, and Srivastava and Shukla 2013.

## 26.3 Floristic Analysis

A total of 1085 species of angiosperms are recorded in the present study. These are distributed over 370 genera in 74 families (Fig. 26.1), and listed in Table 26.1. An analysis of overall flora indicates that out of the total 74 families represented in the

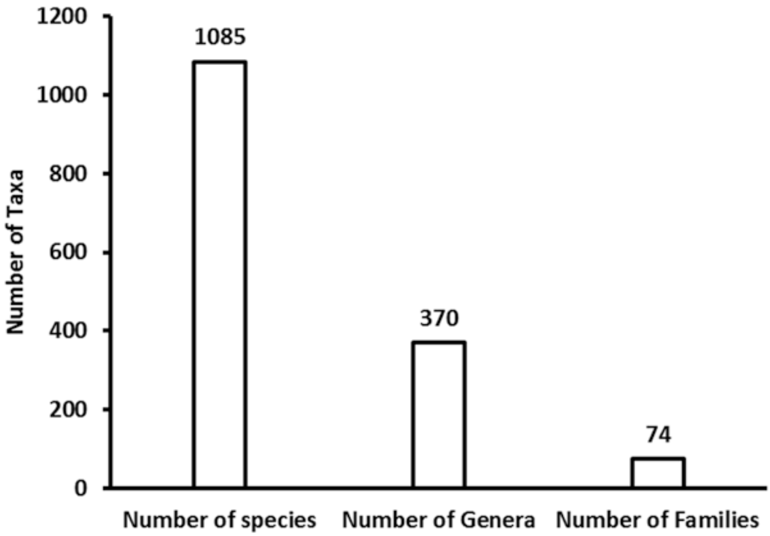


**Fig. 26.1** Number of species, genera and families in the angiosperm-flora of Ladakh

**Table 26.1** List of flowering plant species in the flora of Ladakh, Jammu and Kashmir State

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 1. | **Aconitum deinorrhizum** Stapf | Ranunculaceae | H | B | 3400–3600 |
| 2. | **Aconitum heterophyllum** Wall. ex Royle | Ranunculaceae | H | A | 3000 |
| 3. | **Aconitum moschatum** (Bruehl) Stapf | Ranunculaceae | H | P | 3500 |
| 4. | **Aconitum soongaricum** Stapf | Ranunculaceae | H | B | – |
| 5. | **Aconitum violaceum** Jacquem. ex Stapf | Ranunculaceae | H | B | – |
| 6. | **Adonis chrysocyathus** Hook.f. & Thomson | Ranunculaceae | H | P | 3000–4000 |
| 7. | **Anemone rivularis** Buch.-Ham. | Ranunculaceae | H | P | – |
| 8. | **Anemone rupicola** Cambess | Ranunculaceae | H | P | 3000–4500 |
| 9. | **Anemone tetrasepala** Royle | Ranunculaceae | H | P | 2000–3600 |
| 10. | **Aquilegia moorcroftiana** Wall. ex Royle | Ranunculaceae | H | P | 3000–4800 |
| 11. | **Aquilegia nivalis** (Baker) Bruehl | Ranunculaceae | H | P | 3000–4000 |
| 12. | **Callianthemum anemonoides** (J. Zahlbr.) Endl. ex Heynh. | Ranunculaceae | H | P | – |
| 13. | **Callianthemum pimpinelloides** (D. Don ex Royle) Hook.f. & Thomson | Ranunculaceae | H | P | 2700–4000 |
| 14. | **Cimicifuga foetida** L. | Ranunculaceae | H | P | 2400–3600 |
| 15. | **Clematis barbellata** Edgew. | Ranunculaceae | H | P | 2100–4000 |
| 16. | **Clematis grata** Wall. | Ranunculaceae | H | P | 1800–4000 |
| 17. | **Clematis orientalis** L. | Ranunculaceae | H | P | – |
| 18. | **Consolida schlagintweitii** (Huth) Munz | Ranunculaceae | H | P | 2200–2500 |
| 19. | **Delphinium brunonianum** Royle | Ranunculaceae | H | P | 4000–6000 |
| 20. | **Delphinium cashmerianum** Royle | Ranunculaceae | H | P | 2700–4300 |
| 21. | **Delphinium nordhagenii** Wendelbo | Ranunculaceae | H | P | 4500–5200 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 22. | **Delphinium pyramidale** Royle | Ranunculaceae | H | P | 3000–3900 |
| 23. | **Delphinium roylei** Munz. | Ranunculaceae | H | P | 4000 |
| 24. | **Delphinium vestitum** Wall. ex Royle | Ranunculaceae | H | P | 2700–4300 |
| 25. | **Isopyrum anemonoides** Kar. & Kir. | Ranunculaceae | H | A | – |
| 26. | **Oxygraphis endlicheri** (Walp.) Bennet & Veena Chandra | Ranunculaceae | H | P | 3300–5000 |
| 27. | **Pulsatilla wallichiana** (Royle) Ulbrich | Ranunculaceae | H | A | 3600–4500 |
| 28. | **Ranunculus aucheri** Boiss. | Ranunculaceae | H | P | 2500–3800 |
| 29. | **Ranunculus brotherusii** Freyn | Ranunculaceae | H | P | 3300–5500 |
| 30. | **Ranunculus hyperboreus** Rottb. | Ranunculaceae | H | P | 3600–5100 |
| 31. | **Ranunculus laetus** Wall. ex D. Don | Ranunculaceae | H | P | – |
| 32. | **Ranunculus pulchellus** C.A. Mey. | Ranunculaceae | H | P | 3500–4500 |
| 33. | **Ranunculus rufosephalus** Franch. | Ranunculaceae | H | P | – |
| 34. | **Ranunculus sphaerospermus** Boiss. & Blanche | Ranunculaceae | H | A | – |
| 35. | **Thalictrum alpinum** L. | Ranunculaceae | H | P | 3000–4800 |
| 36. | **Thalictrum cultratum** Wall. | Ranunculaceae | H | P | 3000–4200 |
| 37. | **Thalictrum minus** L. var. **majus** (Jacq.) Hook.f. & Thomson | Ranunculaceae | H | P | 3000–4500 |
| 38. | **Thalictrum platycarpum** Edgew. | Ranunculaceae | H | P | 3000–4800 |
| 39. | **Thalictrum rutifolium** Hook.f. & Thomson | Ranunculaceae | H | P | 3600–4800 |
| 40. | **Trollius acaulis** Lindl. | Ranunculaceae | H | P | 3000–4300 |
| 41. | **Meconopsis aculeata** Royle | Papaveraceae | H | P | 3000–4500 |
| 42. | **Meconopsis latifolia** (Prain) Prain | Papaveraceae | H | P | – |
| 43. | **Berberis jaeschkeana** C.K. Schneid. | Berberidaceae | S | P | 3000–4000 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 44. | **Berberis ulicina** Hook.f. & Thomson | Berberidaceae | S | P | 4000–5000 |
| 45. | **Podophyllum hexandrum** Royle | Podophyllaceae | H | P | – |
| 46. | **Corydalis adiantifolia** Hook.f. & Thomson | Fumariaceae | H | P | 4000–5000 |
| 47. | **Corydalis adiantifolia** var. **heterocarpa** Jafri | Fumariaceae | H | P | 3000–3100 |
| 48. | **Corydalis clarkei** Prain | Fumariaceae | H | P | – |
| 49. | **Corydalis cornuta** Royle | Fumariaceae | H | P | 3000–4000 |
| 50. | **Corydalis crassifolia** Royle | Fumariaceae | H | P | 3300–4800 |
| 51. | **Corydalis crithmifolia** Royle | Fumariaceae | H | P | 3500–5000 |
| 52. | **Corydalis diphylla** Wall. | Fumariaceae | H | P | 3500–4800 |
| 53. | **Corydalis falconeri** Hook.f. | Fumariaceae | H | P | 3500–4000 |
| 54. | **Corydalis filiformis** Royle | Fumariaceae | H | A | 2500–4000 |
| 55. | **Corydalis flabellata** Edgew. | Fumariaceae | H | P | 3000–4500 |
| 56. | **Corydalis gortschakovii** Schrenk | Fumariaceae | H | P | 3000–4800 |
| 57. | **Corydalis govaniana** var. **malukiana** Jafri | Fumariaceae | H | P | – |
| 58. | **Corydalis hendersonii** Hemsley | Fumariaceae | H | P | 5000–5500 |
| 59. | **Corydalis meifolia** Wall. | Fumariaceae | H | P | 4000–5500 |
| 60. | **Corydalis pseudocrithmifolia** Jafri | Fumariaceae | H | P | 4000–5000 |
| 61. | **Corydalis schelesnowiana** Regel & Schmalh. ex Regel | Fumariaceae | H | P | 3500–5000 |
| 62. | **Corydalis stewartii** Feddes | Fumariaceae | H | A | 3000–4500 |
| 63. | **Corydalis stricta** DC. | Fumariaceae | H | P | 3000–5800 |
| 64. | **Corydalis thyrsiflora** Prain | Fumariaceae | H | P | 3000–4500 |
| 65. | **Corydalis tibetica** Hook.f. & Thomson | Fumariaceae | H | P | 4000–5500 |
| 66. | **Alyssum desertorum** Stapf | Brassicaceae | H | A | 3000–4000 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 67. | **Aphragmus oxycarpus** (Hook.f. & Thomson) Jafri | Brassicaceae | H | A | 3600–5500 |
| 68. | **Arabidopsis himalaica** (Edgew.) O. Schulz | Brassicaceae | H | A | 3000–4200 |
| 69. | **Arabidopsis mollissima** (C. Meyer) N. Busch | Brassicaceae | H | A | 3000-4500 |
| 70. | **Arabidopsis pumilla** (Stephan) N. Busch | Brassicaceae | H | A | – |
| 71. | **Arabidopsis thaliana** (L.) Heynh. | Brassicaceae | H | P | 3000–4800 |
| 72. | **Arabidopsis wallichii** (Hook.f. & Thomson) N. Busch. | Brassicaceae | H | A | 800–3500 |
| 73. | **Arabis saxicola** Edgew. | Brassicaceae | H | B | 3600–4500 |
| 74. | **Arabis tenuirostris** O. Schulz | Brassicaceae | H | B | 3000–4500 |
| 75. | **Arabis tibetica** Hook.f. & Thomson | Brassicaceae | H | B | 3500–4800 |
| 76. | **Atelanthera perpusilla** Hook.f. & Thomson | Brassicaceae | H | A | 3000–4000 |
| 77. | **Barbarea vulgaris** R. Br. | Brassicaceae | H | B | 3000–4000 |
| 78. | **Brassica campestris** L. | Brassicaceae | H | B | – |
| 79. | **Braya rosea** (Turez.) Bunge | Brassicaceae | H | A | – |
| 80. | **Braya tibetica** Hook.f. & Thomson | Brassicaceae | H | A | 3500–5500 |
| 81. | **Capsella bursa-pastoris** (L.) Medicus | Brassicaceae | H | A | – |
| 82. | **Cardamine macrophylla** Willd. | Brassicaceae | H | P | – |
| 83. | **Chorispora macropoda** Trautv. | Brassicaceae | H | P | 3500–5000 |
| 84. | **Chorispora sabulosa** Cambess. | Brassicaceae | H | P | – |
| 85. | **Chorispora sibirica** (L.) DC. | Brassicaceae | H | A | 3600–4800 |
| 86. | **Chorispora tenella** (Pallas) DC. | Brassicaceae | H | A | 3800–5000 |
| 87. | **Christolea crassifolia** Cambess. | Brassicaceae | H | A | 3500–4800 |
| 88. | **Christolea himalayensis** (Cambess.) Jafri | Brassicaceae | H | A | 4000 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 89. | **Christolea lanuginosa** (Hook.f. & Thomson) Ovez. | Brassicaceae | H | A | 5000 |
| 90. | **Christolea parkeri** (O.E. Schulz) Jafri | Brassicaceae | H | A | 3500–5000 |
| 91. | **Christolea pumila** (Kurz) Jafri | Brassicaceae | H | A | 5000 |
| 92. | **Christolea scaposa** Jafri | Brassicaceae | H | P | 4900 |
| 93. | **Christolea stewartii** (T. Anderson ) Jafri | Brassicaceae | H | P | 3800 |
| 94. | **Conringia planisiliqua** Fischer & Meyer | Brassicaceae | H | A | 3000–4500 |
| 95. | **Crambe cordifolia** Steven subsp. **kotschyana** (Boiss.) Jafri | Brassicaceae | H | P | – |
| 96. | **Descurainia sophia** (L.) Webb ex Prantl | Brassicaceae | H | A | – |
| 97. | **Dilophila salsa** Thomson | Brassicaceae | H | P | – |
| 98. | **Draba affghanica** Boiss. | Brassicaceae | H | P | 4000–5100 |
| 99. | **Draba altaica** (C.A. Mey.) Bunge | Brassicaceae | H | P | 4000–5000 |
| 100. | **Draba cachemerica** Gand. | Brassicaceae | H | P | 4000 |
| 101. | **Draba ellipsoidea** Hook.f. & Thomson | Brassicaceae | H | A | – |
| 102. | **Draba falconeri** O.E. Schulz | Brassicaceae | H | P | – |
| 103. | **Draba glomerata** Royle | Brassicaceae | H | P | – |
| 104. | **Draba korschinskyi** (O. Fedtsch.) Pohle | Brassicaceae | H | P | – |
| 105. | **Draba lasiophylla** Royle | Brassicaceae | H | P | 4000–4800 |
| 106. | **Draba ludlowiana** Jafri | Brassicaceae | H | P | 4800 |
| 107. | **Draba olgae** Regel & Schmalh. | Brassicaceae | H | P | 4500–5000 |
| 108. | **Draba oreades** Schrenk | Brassicaceae | H | P | – |
| 109. | **Draba stenocarpa** Hook.f. & Thomson | Brassicaceae | H | P | – |
| 110. | **Draba tibetica** Hook.f. & Thomson | Brassicaceae | H | P | 4000–5000 |
| 111. | **Erysimum aitchinsonii** O. E. Schulz | Brassicaceae | H | P | – |
| 112. | **Erysimum altaicum** C.A. Mey. | Brassicaceae | H | P | 4000 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 113. | **Erysimum cachemiricum** O. Schulz | Brassicaceae | H | P | 3300–4500 |
| 114. | **Erysimum hieraciifolium** L. | Brassicaceae | H | P | – |
| 115. | **Erysimum melicentae** Dunn | Brassicaceae | H | A | – |
| 116. | **Erysimum repandum** L. | Brassicaceae | H | A | – |
| 117. | **Hedinia tibetica** (Thomson) Ostenf. | Brassicaceae | H | P | – |
| 118. | **Hymenolobus procumbens** (L.) Nutt. ex Torry & Gray | Brassicaceae | H | A | – |
| 119. | **Lepidium apetalum** Willd. | Brassicaceae | H | B | – |
| 120. | **Lepidium capitatum** Hook.f. & Thomson | Brassicaceae | H | A | – |
| 121. | **Lepidium latifolium** L. | Brassicaceae | H | P | – |
| 122. | **Malcolmia africana** (L.) R. Br. | Brassicaceae | H | A | – |
| 123. | **Malcolmia strigosa** Boiss. | Brassicaceae | H | A | – |
| 124. | **Matthiola flavida** Boiss. | Brassicaceae | H | P | – |
| 125. | **Megacarpaea bifida** Benth. | Brassicaceae | H | P | – |
| 126. | **Megacarpaea polyandra** Benth. | Brassicaceae | H | P | 3500–4500 |
| 127. | **Parrya exscapa** Ledeb. | Brassicaceae | H | P | 4000–5500 |
| 128. | **Parrya minjanensis** Rech. f. | Brassicaceae | H | P | 3600–4800 |
| 129. | **Parrya nudicaulis** (L.) Regel | Brassicaceae | H | P | 4800–5500 |
| 130. | **Pagaeophyton scapiflorum** (Hook.f. & Thomson) Marquand & Shaw | Brassicaceae | H | P | 4800–5200 |
| 131. | **Phaeonychium albiflorum** (T. Anderson) Jafri | Brassicaceae | H | A | 3600–4800 |
| 132. | **Phaeonychium parryoides** (Hook.f. & T. Anderson) O. Schulz | Brassicaceae | H | A | 3000–3700 |
| 133. | **Ptilotrichum canescens** (DC.) C.A. Mey. | Brassicaceae | H | P | 4500–5200 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 134. | **Pycnoplinthus uniflorus** (Hook.f. & Thomson) O. Schulz | Brassicaceae | H | P | 4500–5400 |
| 135. | **Sisymbrium brassiciforme** C. Meyer | Brassicaceae | H | P | – |
| 136. | **Sisymbrium loeselii** L. | Brassicaceae | H | A | – |
| 137. | **Sisymbrium orientale** L. | Brassicaceae | H | A | – |
| 138. | **Tauscheria lasiocarpa** Fischer ex DC. | Brassicaceae | H | A | 3000–4500 |
| 139. | **Thlaspi arvense** L. | Brassicaceae | H | A | – |
| 140. | **Thlaspi septigerum** (Bunge) Jafri | Brassicaceae | H | A | 4500–5000 |
| 141. | **Torularia humilis** (C.A. Mey.) O. Schulz. ex Limpricht | Brassicaceae | H | A | – |
| 142. | **Turritis glabra** L. | Brassicaceae | H | P | – |
| 143. | **Capparis spinosa** L. | Capparaceae | Under shrubs | P | – |
| 144. | **Viola betonicifolia** J. Smith | Violaceae | H | P | – |
| 145. | **Viola biflora** L. | Violaceae | H | P | – |
| 146. | **Viola kunawarensis** Royle | Violaceae | H | P | – |
| 147. | **Arenaria bryophylla** Fernald | Caryophyllaceae | H | P | 4200–6100 |
| 148. | **Arenaria festucoides** Royle | Caryophyllaceae | H | P | 3500–4500 |
| 149. | **Arenaria griffithii** Boiss. | Caryophyllaceae | H | P | 2500–3500 |
| 150. | **Arenaria neilgherrensis** Wight & Arn. | Caryophyllaceae | H | A | – |
| 151. | **Arenaria serpyllifolia** L. | Caryophyllaceae | H | A | – |
| 152. | **Arenaria stracheyi** Edgew. | Caryophyllaceae | H | P | 3500–4800 |
| 153. | **Cerastium alpinum** L. | Caryophyllaceae | H | P | – |
| 154. | **Cerastium cerastoides** (L.) Britton | Caryophyllaceae | H | P | – |
| 155. | **Cerastium fontanum** subsp. **trivale** (Link) Jalas | Caryophyllaceae | H | P | – |
| 156. | **Cerastium glomeratum** Thuill. | Caryophyllaceae | H | A | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 157. | **Cerastium pusillum** Ser. | Caryophyllaceae | H | P | – |
| 158. | **Dianthus angulatus** Royle ex Benth. | Caryophyllaceae | H | P | – |
| 159. | **Dianthus anatolicus** Boiss. | Caryophyllaceae | H | P | – |
| 160. | **Dianthus chinensis** L. | Caryophyllaceae | H | P | – |
| 161. | **Dianthus crinitus** Smith | Caryophyllaceae | H | P | – |
| 162. | **Dianthus deltoides** L. | Caryophyllaceae | H | P | – |
| 163. | **Dianthus jacquemontii** Edgew. | Caryophyllaceae | H | P | – |
| 164. | **Gypsophila sedifolia** Kurz | Caryophyllaceae | H | P | – |
| 165. | **Holosteum umbellatum** L. | Caryophyllaceae | H | P | – |
| 166. | **Lepyrodiclis holosteoides** (C.A. Mey.) Fischer & C.A. Mey. | Caryophyllaceae | H | P | – |
| 167. | **Minuartia biflora** (L.) Schinz & Thell. | Caryophyllaceae | H | P | – |
| 168. | **Minuartia kashmirica** (Edgew.) Mattf. | Caryophyllaceae | H | P | – |
| 169. | **Myosoton aquaticum** (L.) Moench | Caryophyllaceae | H | P | – |
| 170. | **Sagina saginoides** (L.) Karsten | Caryophyllaceae | H | P | – |
| 171. | **Silene amoena** L. | Caryophyllaceae | H | P | – |
| 172. | **Silene caespitella** F. Williams | Caryophyllaceae | H | P | – |
| 173. | **Silene conoidea** L. | Caryophyllaceae | H | A | – |
| 174. | **Silene gonosperma** (Rupr.) Bocq. subsp. **himalayensis** (Rohrb.) Bocq. var. **himalayensis** Bocq. | Caryophyllaceae | H | P | – |
| 175. | **Silene indica** Roxb. ex Otth | Caryophyllaceae | H | P | – |
| 176. | **Silene madens** Majumdar | Caryophyllaceae | H | P | – |
| 177. | **Silene moorcroftiana** Wall. ex Benth. | Caryophyllaceae | H | P | – |
| 178. | **Silene rechingeri** Bocq. | Caryophyllaceae | H | P | – |
| 179. | **Silene songarica** (Fischer, C. Meyer & Ave–Lall.) Bocq. | Caryophyllaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 180. | **Silene vulgaris** (Moench) Garcke | Caryophyllaceae | H | P | – |
| 181. | **Stellaria decumbens** Edgew. | Caryophyllaceae | H | P | – |
| 182. | **Stellaria graminea** L. | Caryophyllaceae | H | P | – |
| 183. | **Stellaria media** (L.) Vill. | Caryophyllaceae | H | A | – |
| 184. | **Stellaria monosperma** Buch.–Ham. ex D. Don | Caryophyllaceae | H | P | – |
| 185. | **Stellaria subumbellata** Edgew. & Hook.f. | Caryophyllaceae | H | A | – |
| 186. | **Stellaria tibetica** Kurz | Caryophyllaceae | H | A | – |
| 187. | **Stellaria uliginosa** Murray | Caryophyllaceae | H | P | – |
| 188. | **Thylacospermum caespitosum** (Cambess) Schischkin | Caryophyllaceae | H | P | – |
| 189. | **Vaccaria pyramidata** Medikus | Caryophyllaceae | H | A | – |
| 190. | **Myricaria albiflora** Grierson & Long | Tamaricaceae | S | P | 4100 |
| 191. | **Myricaria dahurica** (Willd.) Ehrenb. | Tamaricaceae | S | P | 4000 |
| 192. | **Myricaria germanica** (L.) Desv. subsp. **alopecuroides** (Schrenk) Kitam. | Tamaricaceae | S | P | – |
| 193. | **Myricaria prostrata** Hook.f. & Thomson ex Benth. & Hook.f. | Tamaricaceae | US | P | – |
| 194. | **Myricaria squamosa** Desv. | Tamaricaceae | S | P | – |
| 195. | **Myrtama elegans** (Royle) Ovez. & Kinz. | Tamaricaceae | S | P | 3000–4500 |
| 196. | **Tamarix dioica** Roxb. ex Roth | Tamaricaceae | S | P | – |
| 197. | **Tamarix indica** Willd. | Tamaricaceae | S | P | – |
| 198. | **Hypericum perforatum** L. | Hypericaceae | H | P | – |
| 199. | **Malva parviflora** L. | Malvaceae | H | A | – |
| 200. | **Malva verticellata** L. var. **rafiqii** S. Abedin | Malvaceae | H | A | – |
| 201. | **Linum perenne** L. | Linaceae | H | P | – |
| 202. | **Peganum harmala** L. | Zygophyllaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 203. | **Biebersteinia odora** Stephen ex Fischer | Biebersteiniaceae | H | P | – |
| 204. | **Erodium stephanianum** Willd. | Geraniaceae | H | A | – |
| 205. | **Erodium tibetanum** Edgew. & Hook.f. | Geraniaceae | H | A | – |
| 206. | **Geranium collinum** Stephan ex Willd. | Geraniaceae | H | P | – |
| 207. | **Geranium himalayense** Klotzsch | Geraniaceae | H | P | – |
| 208. | **Geranium lambertii** Sweet. | Geraniaceae | H | P | – |
| 209. | **Geranium nepalense** Sweet | Geraniaceae | H | P | – |
| 210. | **Geranium ocellatum** Cambess | Geraniaceae | H | P | – |
| 211. | **Geranium pratense** L. | Geraniaceae | H | P | – |
| 212. | **Geranium sibiricum** L. | Geraniaceae | H | P | – |
| 213. | **Geranium tuberaria** Cambess. | Geraniaceae | H | P | – |
| 214. | **Impatiens bicornuta** Wall. | Balsaminaceae | H | A | – |
| 215. | **Impatiens brachycentra** Kar. & Kir. | Balsaminaceae | H | A | – |
| 216. | **Impatiens scabrida** DC. | Balsaminaceae | H | A | – |
| 217. | **Impatiens thomsonii** Hook.f. | Balsaminaceae | H | A | – |
| 218. | **Dictamus albus** L. | Rutaceae | H | P | – |
| 219. | **Rhamnus triquetra** (Wall.) Brandis | Rhamnaceae | S | P | – |
| 220. | **Astragalus arnoldii** Hemsley & Pearson | Fabaceae | H | P | – |
| 221. | **Astragalus candollenanus** Royle ex Benth. | Fabaceae | S | P | – |
| 222. | **Astragalus coluteocarpus** Boiss. | Fabaceae | H | P | – |
| 223. | **Astragalus confertus** Benth. ex Bunge | Fabaceae | H | P | – |
| 224. | **Astragalus densiflorus** Kar. & Kir. | Fabaceae | H | P | – |
| 225. | **Astragalus drasianus** H.J. Chowdhery, Uniyal & Balodi | Fabaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 226. | **Astragalus falconeri** Bunge | Fabaceae | H | P | – |
| 227. | **Astragalus frigidus** (L.) A Gray | Fabaceae | H | P | – |
| 228. | **Astragalus gracilipes** Benth. ex Bunge | Fabaceae | H | A | – |
| 229. | **Astragalus grahmianus** Royle ex Benth. | Fabaceae | H | P | – |
| 230. | **Astragalus heydei** Baker | Fabaceae | H | P | – |
| 231. | **Astragalus himalayanus** Klotz. | Fabaceae | H | A | – |
| 232. | **Astragalus hoffmeisteri** (Klotz.) Ali | Fabaceae | H | P | – |
| 233. | **Astragalus ladakhense** R.R. Rao & Balodi | Fabaceae | H | P | – |
| 234. | **Astragalus ladakensis** N.P. Balakr. | Fabaceae | H | P | – |
| 235. | **Astragalus leucocephalus** Grah. ex Benth. | Fabaceae | US | P | – |
| 236. | **Astragalus macropterus** DC. | Fabaceae | US | P | – |
| 237. | **Astragalus malacophyllus** Benth. ex Bugne | Fabaceae | H | P | – |
| 238. | **Astragalus maxwelli** Royle ex Benth. | Fabaceae | H | P | – |
| 239. | **Astragalus melanostachys** Benth. ex Bunge | Fabaceae | H | P | – |
| 240. | **Astragalus multiceps** Wall. ex Benth. | Fabaceae | H | P | – |
| 241. | **Astragalus munroi** Benth. ex Bunge | Fabaceae | H | P | – |
| 242. | **Astragalus nivalis** Kar. & Kir. | Fabaceae | H | P | – |
| 243. | **Astragalus ophiocarpus** Benth. ex Bunge | Fabaceae | H | P | – |
| 244. | **Astragalus oplites** Benth. ex Parker | Fabaceae | S | P | – |
| 245. | **Astragalus oxyodon** Baker | Fabaceae | H | P | – |
| 246. | **Astragalus peduncularis** Royle ex Benth. | Fabaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 247. | **Astragalus polyacanthus** Royle ex Benth. | Fabaceae | US | P | – |
| 248. | **Astragalus rhizanthus** Royle ex Benth. | Fabaceae | H | P | – |
| 249. | **Astragalus subuliformis** DC. | Fabaceae | H | P | – |
| 250. | **Astragalus subumbellatus** Klotz. | Fabaceae | H | P | – |
| 251. | **Astragalus tibetanus** Benth. ex Bunge | Fabaceae | H | P | – |
| 252. | **Astragalus tribulifolius** Benth. ex Bunge | Fabaceae | H | P | – |
| 253. | **Astragalus webbianus** Grah. ex Benth. | Fabaceae | H | P | – |
| 254. | **Astragalus zanskarensis** Benth. ex Bunge | Fabaceae | US | P | – |
| 255. | **Caragana brevifolia** Komarov | Fabaceae | S | P | – |
| 256. | **Caragana gerardiana** Royle ex Benth. | Fabaceae | S | P | – |
| 257. | **Caragana versicolor** (Wall.) Benth | Fabaceae | S | P | – |
| 258. | **Chesneya cuneata** (Benth.) Ali | Fabaceae | H | P | – |
| 259. | **Cicer microphyllum** Benth. | Fabaceae | H | P | – |
| 260. | **Colutea nepalensis** Sims. | Fabaceae | S | P | – |
| 261. | **Indigofera heterantha** Wall. ex Brandis | Fabaceae | S | P | – |
| 262. | **Lathyrus sativus** L. | Fabaceae | H | A | – |
| 263. | **Lens culinaris** Medik. | Fabaceae | H | A | – |
| 264. | **Lotus corniculatus** L. | Fabaceae | H | P | – |
| 265. | **Medicago falcata** L. | Fabaceae | H | P | – |
| 266. | **Medicago lupulina** L. | Fabaceae | H | P | – |
| 267. | **Medicago polymorpha** L. | Fabaceae | H | A | – |
| 268. | **Medicago sativa** L. | Fabaceae | H | P | – |
| 269. | **Medicago x varia** Martyn | Fabaceae | H | P | – |
| 270. | **Melilotus alba** Medik. ex Desr. | Fabaceae | H | A | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 271. | **Melilotus officinalis** (L.) Pall. | Fabaceae | H | A | – |
| 272. | **Oxytropis cachemiriana** Cambess. | Fabaceae | H | P | – |
| 273. | **Oxytropis chiliophylla** Royle ex Benth. | Fabaceae | H | P | – |
| 274. | **Oxytropis densa** Benth. ex Bunge | Fabaceae | H | P | – |
| 275. | **Oxytropis humifusa** Kar. & Kir. | Fabaceae | H | P | – |
| 276. | **Oxytropis hypoglottoides** (Baker) Ali | Fabaceae | H | P | – |
| 277. | **Oxytropis lapponica** (Wahl.) Gay. | Fabaceae | H | P | – |
| 278. | **Oxytropis microphylla** (Pallas) DC. | Fabaceae | H | P | – |
| 279. | **Oxytropis mollis** Royle ex Benth. | Fabaceae | H | P | – |
| 280. | **Oxytropis shivai** Aswal, Goel and Mehrotra | Fabaceae | H | P | – |
| 281. | **Oxytropis tatarica** Cambess ex Bunge. | Fabaceae | H | P | – |
| 282. | **Pisum sativum** L. var. **arvense** (L.) Poir. | Fabaceae | H | A | – |
| 283. | **Robina pseudoacacia** L. | Fabaceae | T | P | – |
| 284. | **Sophora alopecuroides** L. | Fabaceae | US | P | – |
| 285. | **Sophora moorcroftiana** (Benth.) Baker | Fabaceae | S | P | – |
| 286. | **Stracheya tibetica** Benth. | Fabaceae | H | P | – |
| 287. | **Thermopsis barbata** Royle | Fabaceae | H | P | – |
| 288. | **Thermopsis inflata** Cambess | Fabaceae | H | P | – |
| 289. | **Trifolium pratense** L. | Fabaceae | H | P | – |
| 290. | **Trifolium repens** L. | Fabaceae | H | P | – |
| 291. | **Trigonella cachemiriana** Cambess. | Fabaceae | H | P | – |
| 292. | **Trigonella corniculata** (L.) L. | Fabaceae | H | P | – |
| 293. | **Trigonella emodi** Benth. | Fabaceae | H | A | – |
| 294. | **Vicia faba** L. | Fabaceae | H | A | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 295. | **Vicia sativa** L. | Fabaceae | H | A | – |
| 296. | **Vicia tenuifolia** Roth | Fabaceae | C | P | – |
| 297. | **Agrimonia pilosa** Ledeb. subsp. **japonica** Hara | Rosaceae | H | A | – |
| 298. | **Chamaerhodos sabulosa** Bunge | Rosaceae | H | P | 3700–4300 |
| 299. | **Cotoneaster gilgitensis** Klotz. | Rosaceae | S | P | 3000–3450 |
| 300. | **Filipendula vestita** (Wall. ex G. Don) Maxim. | Rosaceae | H | P | 3400–3600 |
| 301. | **Potentilla anserina** L. | Rosaceae | H | P | 3800–3900 |
| 302. | **Potentilla arbuscula** D.Don var. **pumila** (Hook. f.) Hand.–Mazz. | Rosaceae | S | P | 4000–4800 |
| 303. | **Potentilla atrosanguinea** Lodd. | Rosaceae | H | P | 4200 |
| 304. | **Potentilla bifurca** L. subsp. **moorcroftii** (Wall. ex Lehm.) Sojak ex Panigrahi | Rosaceae | H | P | 4100–4800 |
| 305. | **Potentilla curviseta** Hook.f. | Rosaceae | H | P | 3500–4100 |
| 306. | **Potentilla desertorum** Bunge | Rosaceae | H | P | 3600–4700 |
| 307. | **Potentilla gelida** C.A.Mey. | Rosaceae | H | P | 3500–5200 |
| 308. | **Potentilla gerardiana** Lindl. ex Lehm. | Rosaceae | H | P | 3100–4100 |
| 309. | **Potentilla multifida** L. | Rosaceae | H | P | 2600–3900 |
| 310. | **Potentilla nivea** L. | Rosaceae | H | P | 4800 |
| 311. | **Potentilla salesoviana** Stephan | Rosaceae | S | P | 3600–4200 |
| 312. | **Potentilla sericea** L. | Rosaceae | H | P | 4300–4500 |
| 313. | **Prunus armeniaca** L. | Rosaceae | T | P | 3000–3100 |
| 314. | **Rosa brunonii** Lindl. | Rosaceae | C | P | 3500 |
| 315. | **Rosa macrophylla** Lindl. | Rosaceae | S | P | 3400 |
| 316. | **Rosa webbiana** Wall. ex Royle | Rosaceae | S | P | 3400–3500 |
| 317. | **Rubus saxatilis** L. | Rosaceae | H | P | 3400–3570 |
| 318. | **Sibbaldia parviflora** Willd. | Rosaceae | H | P | 3500 |

(continued)

Table 26.1 (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 319. | **Sibbaldia tetrandra** Bunge | Rosaceae | H | P | 6000 |
| 320. | **Bergenia ciliata** Sternb. | Saxifragaceae | H | P | 3450 |
| 321. | **Bergenia stracheyi** (Hook.f. & Thomson) Engl. | Saxifragaceae | H | P | 3800 |
| 322. | **Saxifraga cernua** L. | Saxifragaceae | H | P | 6000 |
| 323. | **Saxifraga flagellaris** Willd. | Saxifragaceae | H | P | 4200–4500 |
| 324. | **Saxifraga hirculus** L. | Saxifragaceae | H | P | 4800 |
| 325. | **Saxifraga jacquemontiana** Decne. | Saxifragaceae | H | P | 5200 |
| 326. | **Saxifraga oppositifolia** L. | Saxifragaceae | H | P | 3800 |
| 327. | **Saxifraga pulvinaria** H.Sm. | Saxifragaceae | H | A | 3600–5000 |
| 328. | **Saxifraga sibirica** L. | Saxifragaceae | H | A | 3500–4100 |
| 329. | **Parnassia laxmanni** Pall. ex Schult. | Parnassiaceae | H | A | 3500–4200 |
| 330. | **Parnassia palustris** L. | Parnassiaceae | H | A | 4000 |
| 331. | **Ribes alpestre** Wall. ex Decne. | Grossulariaceae | S | P | 3800 |
| 332. | **Ribes glaciale** Wall. | Grossulariaceae | S | P | 2500 |
| 333. | **Ribes orientale** Desf. | Grossulariaceae | S | P | – |
| 334. | **Hylotelephium ewersii** (Ledeb.) Ohba | Crassulaceae | H | P | 4000 |
| 335. | **Orostachys thyrsiflora** Fisch. | Crassulaceae | H | B | 4000 |
| 336. | **Pseudosedum lievenii** (Ledeb.) A. Berger | Crassulaceae | H | P | 3720–3950 |
| 337. | **Rhodiola fastigiata** (Hook.f. & Thomson) S.H. Fu | Crassulaceae | H | P | – |
| 338. | **Rhodiola heterodonta** (Hook.f. & Thomson) A. Bor. | Crassulaceae | H | P | 4000–4500 |
| 339. | **Rhodiola imbricata** Edgew. | Crassulaceae | H | P | 4500–5100 |
| 340. | **Rhodiola quadrifida** (Pall.) Schrenk | Crassulaceae | H | P | – |
| 341. | **Rhodiola tibetica** (Hook.f. & Thomson) Fu | Crassulaceae | H | P | 4200–4560 |
| 342. | **Rhodiola wallichiana** (Hook.) S.H. Fu | Crassulaceae | H | P | 4500 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 343. | **Rosularia alpestris** (Kar. & Kir.) A. Bor. | Crassulaceae | H | P | 3200–4100 |
| 344. | **Sedum fischeri** Raym.–Hamet | Crassulaceae | H | A | – |
| 345. | **Hippuris vulgaris** L. | Hippuridaceae | H | P | – |
| 346. | **Callitriche palustris** L. | Callitrichaceae | H | P | – |
| 347. | **Callitriche stagnalis** Scop. | Callitrichaceae | H | P | – |
| 348. | **Epilobium amurense** Hausskn. | Onagraceae | H | P | 3700 |
| 349. | **Epilobium anagallidifolium** Lam. | Onagraceae | H | P | 3400–3975 |
| 350. | **Epilobium angustifolium** L. | Onagraceae | H | P | 2600–4000 |
| 351. | **Epilobium brevifolium** D. Don | Onagraceae | H | P | 2900–3400 |
| 352. | **Epilobium chitralense** Raven | Onagraceae | H | P | – |
| 353. | **Epilobium cylindricum** D. Don | Onagraceae | H | P | 4000 |
| 354. | **Epilobium glaciale** P.H. Raven | Onagraceae | H | P | – |
| 355. | **Epilobium hirsutum** L. | Onagraceae | H | P | 3600 |
| 356. | **Epilobium ladakhianum** T.K. Paul | Onagraceae | H | P | – |
| 357. | **Epilobium latifolium** L. | Onagraceae | H | P | 4000 |
| 358. | **Epilobium latifolium** L. subsp. **speciosum** (Decne.) Raven | Onagraceae | H | P | 4000 |
| 359. | **Epilobium leiophyllum** Hausskn. | Onagraceae | H | P | 3330–4100 |
| 360. | **Epilobium minutiflorum** Hausskn | Onagraceae | H | P | 4000 |
| 361. | **Epilobium palustre** L. | Onagraceae | H | P | 4200 |
| 362. | **Epilobium parviflorum** Schreber | Onagraceae | H | P | – |
| 363. | **Epilobium roseum** Schreb. | Onagraceae | H | P | 3375–4200 |
| 364. | **Epilobium royleanum** Hausskn. | Onagraceae | H | P | 3100–3750 |
| 365. | **Epilobium tibetanum** Hausskn. | Onagraceae | H | P | 4500 |
| 366. | **Bupleurum falcatum** L. | Apiaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 367. | **Bupleurum gracillimum** Klotzsch | Apiaceae | H | P | 3950 |
| 368. | **Bupleurum hamiltonii** Balakr. | Apiaceae | H | P | – |
| 369. | **Bupleurum jucundum** Kurz | Apiaceae | H | P | 3100–3500 |
| 370. | **Bupleurum longicaule** DC. | Apiaceae | H | P | – |
| 371. | **Bupleurum subuniflorum** Boiss. & Heldr. | Apiaceae | H | A | 4000 |
| 372. | **Bupleurum thomsonii** C.B.Clarke | Apiaceae | H | P | – |
| 373. | **Carum carvi** L. | Apiaceae | H | B | 3700–4200 |
| 374. | **Chaerophyllum acuminatum** Lindl. | Apiaceae | H | A | 4200 |
| 375. | **Chaerophyllum villosum** Wall. ex DC. | Apiaceae | H | P | 3400 |
| 376. | **Eriocycla thomsonii** (C.B. Clarke) H. Wolff | Apiaceae | H | P | – |
| 377. | **Eryngium billardieri** Delar. | Apiaceae | H | P | – |
| 378. | **Ferula jaeschkeana** Vatke | Apiaceae | S | P | 3400–3500 |
| 379. | **Foeniculum vulgare** Mill. | Apiaceae | H | P | 2600 |
| 380. | **Heracleum candicans** Wall. ex DC. | Apiaceae | H | P | 3900 |
| 381. | **Heracleum pinnatum** C.B.Clarke | Apiaceae | H | P | 3000–3980 |
| 382. | **Heracleum thomsonii** C.B. Clarke | Apiaceae | H | P | 4400 |
| 383. | **Ligusticum elatum** (Edgew.) C.B. Clarke | Apiaceae | H | P | 3530–4300 |
| 384. | **Ligusticum thomsonii** C.B. Clarke | Apiaceae | H | P | 4800 |
| 385. | **Pleurospermum brunonis** (DC.) C.B. Clarke | Apiaceae | H | A | – |
| 386. | **Pleurospermum candollei** Benth. ex C.B. Clarke | Apiaceae | H | B | 4800–4250 |
| 387. | **Pleurospermum hookeri** C.B. Clarke | Apiaceae | H | A | 4200–5500 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 388. | **Pleurospermum lindleyanum** (Klotzsch & Garcke) B. Fedtsch. | Apiaceae | H | A | 3450–4800 |
| 389. | **Pleurospermum stellatum** (D. Don) Benth. ex C.B. Clarke | Apiaceae | H | B | 4200 |
| 390. | **Prangos pabularia** Lindl. | Apiaceae | H | P | 3250 |
| 391. | **Selinum vaginatum** (Edgew.) C.B. Clarke | Apiaceae | H | P | 3375–3700 |
| 392. | **Sium sisarum** L. | Apiaceae | H | P | 2900–3100 |
| 393. | **Trachydium roylei** Lindl. | Apiaceae | H | A | 3550 |
| 394. | **Vicatia coniifolia** DC. | Apiaceae | H | A | 3800 |
| 395. | **Lonicera asperifolia** (Decne.) Hook.f. & Thomson | Caprifoliaceae | S | P | 4050 |
| 396. | **Lonicera coerulea** L. var. **altaica** Sweat ex Dippal | Caprifoliaceae | S | P | 3310 |
| 397. | **Lonicera heterophylla** Decne. | Caprifoliaceae | S | P | 2650 |
| 398. | **Lonicera microphylla** Willd. ex Roem & Schult. | Caprifoliaceae | S | P | – |
| 399. | **Lonicera obovata** Royle ex Hook.f. & Thomson | Caprifoliaceae | S | P | – |
| 400. | **Lonicera purpurascens** (Decne.) Walp. | Caprifoliaceae | S | P | 4500 |
| 401. | **Lonicera semenovii** Regel | Caprifoliaceae | S | P | 4600 |
| 402. | **Lonicera spinosa** (Jacquem. ex Decne.) Walp. | Caprifoliaceae | S | P | 3975 |
| 403. | **Lonicera webbiana** Wall. ex DC. | Caprifoliaceae | S | P | 4400 |
| 404. | **Galium aparine** L. | Rubiaceae | H | A | 3150–3375 |
| 405. | **Galium boreale** L. | Rubiaceae | H | P | 2700 |
| 406. | **Galium serpylloides** Royle ex Hook.f. | Rubiaceae | H | P | 3600 |
| 407. | **Galium tibeticum** (Bunge) Aswal & Mehrotra | Rubiaceae | H | A | 3600–4350 |
| 408. | **Galium tricornutum** Dandy | Rubiaceae | H | A | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 409. | **Galium verum** L. | Rubiaceae | H | A | 4000 |
| 410. | **Rubia cordifolia** L. | Rubiaceae | H | P | 3200 |
| 411. | **Rubia tibetica** Hook.f. | Rubiaceae | H | P | 4000 |
| 412. | **Valeriana himalayana** Grubov | Valerianaceae | H | P | 4500 |
| 413. | **Valeriana jatamansi** Jones | Valerianaceae | H | P | – |
| 414. | **Valeriana stracheyi** C.B. Clarke | Valerianaceae | H | P | – |
| 415. | **Dipsacus mitis** D. Don | Dipsacaceae | H | P | – |
| 416. | **Morina coulteriana** Royle | Morinaceae | H | P | 3500 |
| 417. | **Achillea millefolium** L. | Asteraceae | H | P | 3500 |
| 418. | **Acroptilon repens** (L.) DC. | Asteraceae | H | P | 3500 |
| 419. | **Anaphalis contorta** (D. Don) Hook.f. | Asteraceae | H | A | 3100 |
| 420. | **Anaphalis nepalensis** (Spreng.) Hand.–Mazz. | Asteraceae | H | A | 4000 |
| 421. | **Anaphalis staintonii** Georgiadou | Asteraceae | H | P | 4500 |
| 422. | **Anaphalis triplinervis** (Sims.) C.B. Clarke | Asteraceae | H | P | 3200 |
| 423. | **Anaphalis virgata** Thomson ex C.B. Clarke | Asteraceae | H | P | 2500 |
| 424. | **Arctium lappa** L. | Asteraceae | H | P | 3100 |
| 425. | **Artemisia absinthium** L. | Asteraceae | H | P | 2900 |
| 426. | **Artemisia biennis** Willd. | Asteraceae | H | A | 4500 |
| 427. | **Artemisia capillaris** Thunb. | Asteraceae | H | A | 3110 |
| 428. | **Artemisia dracunculus** L. | Asteraceae | H | P | 4300 |
| 429. | **Artemisia dubia** Wall. ex Bess. var. **subdigitata** (Mattf.) Y.R. Ling | Asteraceae | H | P | 3800 |
| 430. | **Artemisia gmelinii** Weber ex Stechm. | Asteraceae | H | P | 3800 |
| 431. | **Artemisia japonica** Thunb. | Asteraceae | H | P | 3200 |
| 432. | **Artemisia macrocephala** Jacquem. ex Besser | Asteraceae | H | A | 3800 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 433. | **Artemisia maritima** L. var. **thomsoniana** C.B. Clarke | Asteraceae | H | P | 3800 |
| 434. | **Artemisia minor** Jacquem. ex Besser | Asteraceae | H | P | 5000 |
| 435. | **Artemisia persica** Boiss. | Asteraceae | H | P | 3200 |
| 436. | **Artemisia salsoloides** Willd. | Asteraceae | H | P | 3600 |
| 437. | **Artemisia sieversiana** Ehrh. | Asteraceae | H | A | 4200 |
| 438. | **Artemisia stracheyi** Hook.f. & Thomson ex C.B.Clarke | Asteraceae | H | P | – |
| 439. | **Artemisia stricta** Edgew. | Asteraceae | H | A | 3900 |
| 440. | **Artemisia tournefortiana** Rchb. | Asteraceae | H | A | 3200 |
| 441. | **Artemisia wallichiana** Bess. forma **nitida** (Pamp.) B.D. Naithani | Asteraceae | H | P | 4100 |
| 442. | **Aster altaicus** Willd. | Asteraceae | H | P | 3700 |
| 443. | **Aster diplostephioides** (DC.) C.B. Clarke | Asteraceae | H | P | 4000 |
| 444. | **Aster falconeri** (C.B. Clarke) Hutch. | Asteraceae | H | P | 3600 |
| 445. | **Aster flaccidus** Bunge | Asteraceae | H | P | 4050 |
| 446. | **Blumea bifoliata** (L.) DC. | Asteraceae | H | A | 3800 |
| 447. | **Brachyactis pubescens** (DC.) Aitch. & C.B. Clarke | Asteraceae | H | A | 4100 |
| 448. | **Brachyactis roylei** (DC.) Wendelbo | Asteraceae | H | A | 4000 |
| 449. | **Breea arvensis** (L.) Less. | Asteraceae | H | P | – |
| 450. | **Calendula officinalis** L. | Asteraceae | H | A | 3500 |
| 451. | **Carduus edelbergii** Rchb.f. | Asteraceae | H | B | – |
| 452. | **Centaurea cyanus** L. | Asteraceae | H | A | 3600 |
| 453. | **Centaurea depressa** M. Bieb. | Asteraceae | H | A | – |
| 454. | **Chrysanthemum pyrethroides** (Kar. & Kir.) B.Fedtsch–Rostit. | Asteraceae | H | P | 4000 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 455. | **Chrysanthemum stoliczkai** C.B. Clarke | Asteraceae | H | P | 4100 |
| 456. | **Chrysanthemum tibeticum** Hook.f. & Thomson ex C.B. Clarke | Asteraceae | H | P | 4500 |
| 457. | **Cichorium intybus** L. | Asteraceae | H | P | 2500 |
| 458. | **Cirsium wallichii** DC. | Asteraceae | H | P | 3900 |
| 459. | **Conyza bonariensis** (L.) Cronq. | Asteraceae | H | P | – |
| 460. | **Cousinia falconeri** Hook.f. | Asteraceae | H | P | 3600 |
| 461. | **Cousinia thomsonii** C.B. Clarke | Asteraceae | H | P | – |
| 462. | **Cremanthodium ellisii** (Hook.f.) Kitam. | Asteraceae | H | A | 4000 |
| 463. | **Crepis multicaulis** Ledeb. | Asteraceae | H | P | 4000 |
| 464. | **Crepis sancta** (L.) Babc. | Asteraceae | H | A | 4400–4500 |
| 465. | **Echinops niveus** Wall. ex DC. | Asteraceae | H | P | – |
| 466. | **Erigeron acer** L. var. **multicaulis** (Wall. ex DC.) C.B.Clarke | Asteraceae | H | A | 2800 |
| 467. | **Erigeron bellidioides** (Buch.–Ham. ex D. Don) Benth. ex C.B. Clarke | Asteraceae | H | P | – |
| 468. | **Erigeron multiradiatus** (Lindl. ex DC.) Benth. ex C.B. Clarke | Asteraceae | H | P | 3900 |
| 469. | **Filago hurdwarica** (Wall. ex DC.) Wagenitz | Asteraceae | H | A | 4000 |
| 470. | **Galinsoga parviflora** Cav. | Asteraceae | H | A | 2700 |
| 471. | **Gnaphalium hypoleucum** DC. | Asteraceae | H | P | – |
| 472. | **Gnaphalium leuteo–album** L. subsp. **affine** (D. Don) Koster | Asteraceae | H | P | 3800 |
| 473. | **Gnaphalium stewartii** C.B. Clarke ex Hook.f. | Asteraceae | H | P | 3500 |
| 474. | **Gnaphalium thomsonii** Hook.f. | Asteraceae | H | P | 3500 |
| 475. | **Heteropappus holohermaphroditus** Grierson | Asteraceae | H | P | 3500 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 476. | **Hieracium crocatum** Fries | Asteraceae | H | P | 3800 |
| 477. | **Hieracium umbellatum** L. | Asteraceae | H | P | 2700 |
| 478. | **Hieracium virosum** Pallas | Asteraceae | H | P | 2700 |
| 479. | **Hieracium vulgatum** Fries | Asteraceae | H | P | – |
| 480. | **Inula falconeri** Hook.f. | Asteraceae | H | A | 4200 |
| 481. | **Inula obtusifolia** Kern | Asteraceae | H | P | 2700 |
| 482. | **Inula rhizocephala** Schrenk. var. **rhizocephaloides** (C.B. Clarke) Kitam. | Asteraceae | H | P | – |
| 483. | **Inula royleana** DC. | Asteraceae | H | P | – |
| 484. | **Koelpinia linearis** Pall. | Asteraceae | H | A | 3110 |
| 485. | **Lactuca decipiens** C.B. Clarke | Asteraceae | H | P | 3100–3300 |
| 486. | **Lactuca dissecta** D. Don | Asteraceae | H | A | 3200 |
| 487. | **Lactuca dolichophylla** Kitam. | Asteraceae | H | A | 3200 |
| 488. | **Lactuca orientalis** (Boiss.) Boiss. | Asteraceae | H | P | – |
| 489. | **Lactuca sativa** L. | Asteraceae | H | A | 3250 |
| 490. | **Lactuca serriola** Tourner | Asteraceae | H | A | 2700 |
| 491. | **Lactuca tatarica** (L.) C.A. Mey. | Asteraceae | H | A | 4000 |
| 492. | **Leontopodium brachyactis** Gand. | Asteraceae | H | P | 4535 |
| 493. | **Leontopodium nanum** (Hook.f. & Thomson) Hand.–Mazz. | Asteraceae | H | P | 3600 |
| 494. | **Logfia arvensis** (L.) Holub | Asteraceae | H | A | 2900 |
| 495. | **Matricaria recutita** L. | Asteraceae | H | A | – |
| 496. | **Picris hieracioides** L. subsp. **kaimaensis** Kitam. | Asteraceae | H | A | 3000 |
| 497. | **Psychrogeton andryaloides** (DC.) Novopkr. ex Krqasch. | Asteraceae | H | P | 4500 |
| 498. | **Saussurea atkinsoni** C.B. Clarke | Asteraceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 499. | **Saussurea bracteata** Decne. | Asteraceae | H | P | 4700 |
| 500. | **Saussurea caespitosa** (DC.) Wall. ex Sch.–Bip. | Asteraceae | H | P | 4500 |
| 501. | **Saussurea ceratocarpa** Decne. | Asteraceae | H | A | – |
| 502. | **Saussurea depsangensis** Pamp. | Asteraceae | H | P | 4800–5200 |
| 503. | **Saussurea glacialis** Herd. | Asteraceae | H | P | 5500 |
| 504. | **Saussurea gnaphalodes** (Royle ex DC.) Sch.–Bip. | Asteraceae | H | P | 5000 |
| 505. | **Saussurea jacea** (Klotz.) C.B. Clarke | Asteraceae | H | P | 4100 |
| 506. | **Saussurea nana** (Pamp.) Pamp. | Asteraceae | H | A | – |
| 507. | **Saussurea subulata** C.B. Clarke | Asteraceae | H | P | – |
| 508. | **Saussurea thomsonii** C.B. Clarke | Asteraceae | H | P | – |
| 509. | **Scorzonera virgata** DC. | Asteraceae | H | P | 4000 |
| 510. | **Senecio desfontainei** Druce | Asteraceae | H | A | – |
| 511. | **Senecio dubitabilis** C. Jeffrey & Y.L. Chen | Asteraceae | H | A | 4500 |
| 512. | **Senecio krascheninnikovii** Schischk. | Asteraceae | H | A | 4000 |
| 513. | **Senecio ladakhensis** H.J. Chowdhery, B.P. Uniyal & R. Mathur | Asteraceae | H | A | 3500 |
| 514. | **Senecio laetus** Edgew. | Asteraceae | H | P | 3570 |
| 515. | **Senecio tibeticus** Hook.f. | Asteraceae | H | P | – |
| 516. | **Sonchus asper** (L.) Hill. | Asteraceae | H | A | – |
| 517. | **Sonchus oleraceous** L. | Asteraceae | H | A | 3000 |
| 518. | **Tanacetum artemisioides** Sch.–Bip. ex Hook.f. | Asteraceae | H | P | 4000 |
| 519. | **Tanacetum dolichophyllum** (Kitam.) Kitam. | Asteraceae | H | P | 4500 |
| 520. | **Tanacetum fruticulosum** Ledeb. | Asteraceae | H | P | 4850 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 521. | **Tanacetum gracile** Hook.f. & Thomson | Asteraceae | H | P | 3500 |
| 522. | **Tanacetum nanum** C.B. Clarke | Asteraceae | H | P | 3310–3800 |
| 523. | **Tanacetum tibeticum** Hook.f. & Thomson ex C.B. Clarke | Asteraceae | H | P | 4500 |
| 524. | **Tanacetum tomentosum** DC. | Asteraceae | H | P | 4500 |
| 525. | **Taraxacum leucanthum** (Ledeb.) Ledeb. | Asteraceae | H | P | 4600 |
| 526. | **Taraxacum officinale** Weber | Asteraceae | H | P | – |
| 527. | **Tragopogon dubius** Scop. | Asteraceae | H | P | 3700 |
| 528. | **Tragopogon sinuatus** Avé–Lall. | Asteraceae | H | P | – |
| 529. | **Tricholepis tibetica** Hook.f. & Thomson ex C.B. Clarke | Asteraceae | H | A | – |
| 530. | **Tussilago farfara** L. | Asteraceae | H | P | – |
| 531. | **Waldheimia glabra** (Decne.) Regel | Asteraceae | H | P | 4975 |
| 532. | **Waldheimia nivea** (Hook.f. & Thomson ex C.B. Clarke) Regel | Asteraceae | H | P | 4560 |
| 533. | **Waldheimia stoliczkae** (C.B. Clarke) Ostanf. | Asteraceae | H | P | 4350 |
| 534. | **Waldheimia tomentosa** (Decne.) Regel | Asteraceae | H | P | 4800 |
| 535. | **Waldheimia vestita** (Hook.f. & Thomson ex C.B. Clarke) Pamp. | Asteraceae | H | P | 4000 |
| 536. | **Xanthium indicum** Koenig | Asteraceae | H | P | 2700 |
| 537. | **Youngia glauca** Edgew. | Asteraceae | H | A | – |
| 538. | **Youngia tenuifolia** (Willd.) Bebc. & Stebbins. | Asteraceae | H | P | 4300 |
| 539. | **Campanula alsinoides** Hook.f. & Thomson | Campanulaceae | H | P | 2400 |
| 540. | **Campanula argyrotricha** Wall. ex A. DC. | Campanulaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 541. | **Campanula aristata** Wall. | Campanulaceae | H | P | 3425 |
| 542. | **Campanula cana** Wall. | Campanulaceae | H | P | 3500 |
| 543. | **Campanula cashmeriana** Royle | Campanulaceae | H | P | – |
| 544. | **Campanula pallida** Wall. | Campanulaceae | H | A | 3300–3400 |
| 545. | **Codonopsis ovata** Benth. | Campanulaceae | H | A | 3800–4100 |
| 546. | **Codonopsis rotundifolia** Benth. | Campanulaceae | H | P | 3300 |
| 547. | **Acantholimon lycopodioides** (Girard) Boiss. | Plumbaginaceae | S | P | 4400 |
| 548. | **Limonium macrorhabdon** (Boiss) O. Ktze. | Plumbaginaceae | H A | A | 3600 |
| 549. | **Anagallis arvensis** L. | Primulaceae | H | A | 3000–3100 |
| 550. | **Androsace aizoon** Duby | Primulaceae | H | A | 3330 |
| 551. | **Androsace mucronifolia** Watt | Primulaceae | H | P | 3500 |
| 552. | **Androsace rotundifolia** Hardw. | Primulaceae | H | P | 2900 |
| 553. | **Androsace sempervivoides** Jacq. ex Dyby | Primulaceae | H | P | 3950 |
| 554. | **Glaux maritima** L. | Primulaceae | H | P | 4600 |
| 555. | **Primula elliptica** Royle | Primulaceae | H | P | |
| 556. | **Primula macrophylla** D. Don | Primulaceae | H | P | 5000 |
| 557. | **Primula minutissima** Jacquem. ex Duby | Primulaceae | H | P | 3900 |
| 558. | **Primula nutans** Georgi | Primulaceae | H | A | 4000 |
| 559. | **Primula rosea** Royle | Primulaceae | H | P | 6000 |
| 560. | **Trachomitum venetum** (L.) Woodson | Apocynaceae | H | P | – |
| 561. | **Cynanchum acutum** L. | Asclepiadaceae | TW | P | 3000 |
| 562. | **Vincetoxicum hirundinaria** subsp. **hirundinaria** Medicusin | Asclepiadaceae | H | P | 2800 |
| 563. | **Vincetoxicum hirundinaria** Medicus subsp. **glaucum** (Wall. ex Wight) Hara | Asclepiadaceae | H | A | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 564. | **Centaurium meyeri** Druce | Gentianaceae | H | A | – |
| 565. | **Gentiana algida** Pall. var. **nubigena** (Edgew.) Kusn. | Gentianaceae | H | P | 4500 |
| 566. | **Gentiana aquatica** L. | Gentianaceae | H | A | 3500–3700 |
| 567. | **Gentiana aquatica** L. var. **pseudoaquatica** (Kusn.) S. Agrawal | Gentianaceae | H | A | 4200 |
| 568. | **Gentiana crassuloides** Bureau & Franch. | Gentianaceae | H | A | 3400 |
| 569. | **Gentiana marginata** (D. Don) Griseb. | Gentianaceae | H | A | 3110–4109 |
| 570. | **Gentiana marginata** (D. Don) Griseb. var. **hugelii** (Griseb.) S. Agrawal | Gentianaceae | H | A | – |
| 571. | **Gentiana prostrata** Haenke | Gentianaceae | H | A | 4600 |
| 572. | **Gentiana tianshanica** Rupr. | Gentianaceae | H | A | 3300–4200 |
| 573. | **Gentianella aurea** (L.) Harry Sm. ex Hyl. | Gentianaceae | H | A | 3250 |
| 574. | **Gentianella moorcroftiana** (Wall. ex G. Don) Airy Shaw | Gentianaceae | H | A | 3800 |
| 575. | **Gentianella tenella** (Rottb.) Börner | Gentianaceae | H | A | 3800–4000 |
| 576. | **Gentianella thomsonii** (C.B. Clarke) U.C. Bhattach. & S. Agrawal | Gentianaceae | H | P | 4600 |
| 577. | **Gentianopsis detonsa** (Rottb.) Ma | Gentianaceae | H | A | 3850–4100 |
| 578. | **Gentianopsis paludosa** (Munro ex Hook.f.) Ma | Gentianaceae | H | A | 3600–4500 |
| 579. | **Jaeschkea canaliculata** (Royle ex G. Don.) Knobl. | Gentianaceae | H | B | 3500 |
| 580. | **Jaeschkea oligosperma** (Griseb.) Knobl. | Gentianaceae | H | A | 3100–3500 |
| 581. | **Lomatogonium brachyantherum** (C.B. Clarke) Fernald | Gentianaceae | H | A | 3950–4600 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 582. | **Lomatogonium carinthiacum** (Wulfen) Rchb. | Gentianaceae | H | A | 4500 |
| 583. | **Lomatogonium spathulatum** (A. Kern.) Fernald | Gentianaceae | H | A | 3800 |
| 584. | **Swertia cordata** (Wall. ex G. Don) C.B. Clarke | Gentianaceae | H | A | 3800 |
| 585. | **Swertia petiolata** D. Don | Gentianaceae | H | P | 3300 |
| 586. | **Swertia thomsonii** C.B. Clarke | Gentianaceae | H | P | 2940 |
| 587. | **Actinocarya tibetica** Benth. | Boraginaceae | H | A | 4600 |
| 588. | **Anchusa arevnsis** subsp. **orientalis** (L.) Nordh. | Boraginaceae | H | A | 2800 |
| 589. | **Arnebia euchroma** (Royle ex Benth.) I.M. Johnst. | Boraginaceae | H | P | 4800 |
| 590. | **Arnebia euchroma** (Royle ex Benth.) I.M. Johnst. var. **grandis** (Bornm.) Kazmi | Boraginaceae | H | P | 4800 |
| 591. | **Arnebia guttata** Bunge | Boraginaceae | H | P | 3400–4000 |
| 592. | **Arnebia guttata** Bunge var. **thomsonii** (C.B.Clarke) Kazmi | Boraginaceae | H | P | 3800 |
| 593. | **Asperugo procumbens** L. | Boraginaceae | H | A | – |
| 594. | **Cynoglossum glochidiatum** Wall. ex Benth. | Boraginaceae | H | A | 2770 |
| 595. | **Cynoglossum zeylanicum** (Vahl.) Thunb. ex Lehm. | Boraginaceae | H | P | 3110–3225 |
| 596. | **Eritrichium canum** (Benth.) Kitam. | Boraginaceae | H | P | 4500 |
| 597. | **Eritrichium fruticulosum** Klotz. | Boraginaceae | H | P | 4000-4200 |
| 598. | **Eritrichium nanum** (Vill.) Schrad. subsp. **villosum** (Ledeb.) Brand | Boraginaceae | H | P | 4150 |
| 599. | **Eritrichium spathulatum** (Benth.) C.B. Clarke | Boraginaceae | H | P | 4800 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 600. | **Eritrichium spathulatum** (Benth.) C.B. Clarke var. **thomsoni** (C.B.Clarke) Kazmi | Boraginaceae | H | P | 5000 |
| 601. | **Hackelia deflexa** (Wahlenb.) Opiz | Boraginaceae | H | A | – |
| 602. | **Lappula barbata** (M.–Bieb.) Gurke var. **cariensis** (Boiss.) Brand | Boraginaceae | H | A | 3400–3950 |
| 603. | **Lappula patula** (Lehm.) Ascherson ex Gurke | Boraginaceae | H | A | 3110 |
| 604. | **Lasiocaryum diffusum** (Brand) I.M. Johnst. | Boraginaceae | H | A | 3900 |
| 605. | **Lindelofia longiflora** (Benth.) Baill. | Boraginaceae | H | P | 3100–4000 |
| 606. | **Lindelofia stylosa** (Kar. & Kir.) Brand | Boraginaceae | H | P | 3400 |
| 607. | **Mattiastrum thomsonii** (C.B. Clarke) Kazmi | Boraginaceae | H | P | 3000 |
| 608. | **Mattiastrum tibeticum** (C.B. Clarke) Brand. | Boraginaceae | H | A | 3800 |
| 609. | **Microula tibetica** Benth. & Hook.f. | Boraginaceae | H | P | 5000 |
| 610. | **Myosotis stricta** Link ex Roem. & Schult. | Boraginaceae | H | A | 3400–3570 |
| 611. | **Onosma hispidum** Wall. ex D. Don | Boraginaceae | H | P | – |
| 612. | **Pseudomertensia echioides** Reidl. | Boraginaceae | H | P | 3000–3900 |
| 613. | **Rochelia rectipes** Stock | Boraginaceae | H | A | – |
| 614. | **Rochelia stylaris** Boiss. | Boraginaceae | H | A | – |
| 615. | **Trigonotis rotundifolia** Benth. ex C.B. Clarke | Boraginaceae | H | P | 4000 |
| 616. | **Trigonotis tibetica** (C.B. Clarke) I.M. Johnst. | Boraginaceae | H | P | – |
| 617. | **Convolvulus arvensis** L. | Convolvulaceae | H | P | 4000 |
| 618. | **Cuscuta capitata** Roxb. | Cuscutaceae | H | A | – |
| 619. | **Cuscuta europaea** L. | Cuscutaceae | H | A | 4000 |
| 620. | **Datura stramonium** L. | Solanaceae | H | A | 2900 |
| 621. | **Hyoscyamus niger** L. | Solanaceae | H | B | 3200 |
| 622. | **Hyoscyamus pusillus** L. | Solanaceae | H | P | 4000 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 623. | **Lycium ruthenicum** Murray | Solanaceae | S | P | 3275 |
| 624. | **Nicotiana rustica** L. | Solanaceae | H | A | 2900–3000 |
| 625. | **Physochlaina praealta** (Decne.) Miers. | Solanaceae | H | B | – |
| 626. | **Solanum nigrum** L. | Solanaceae | H | A | 3000 |
| 627. | **Euphrasia alba** Pennell | Scrophulariaceae | H | A | 3400 |
| 628. | **Euphrasia flabellata** Pennell | Scrophulariaceae | H | A | 3100–4000 |
| 629. | **Euphrasia himalayica** Wettst. | Scrophulariaceae | H | A | 3200 |
| 630. | **Euphrasia jaeschkei** Wettst. | Scrophulariaceae | H | A | 3400–3500 |
| 631. | **Euphrasia laxa** Pennell | Scrophulariaceae | H | A | – |
| 632. | **Euphrasia paucifolia** Wettst. | Scrophulariaceae | H | A | 3500–4200 |
| 633. | **Euphrasia pectinata** Ten. | Scrophulariaceae | H | A | 3350-3900 |
| 634. | **Euphrasia platyphylla** Pennell | Scrophulariaceae | H | A | – |
| 635. | **Euphrasia remota** Pennell | Scrophulariaceae | H | A | 3200–3500 |
| 636. | **Euphrasia schlagintweitii** Wettst. | Scrophulariaceae | H | A | 3110 |
| 637. | **Lagotis cashmeriana** (Royle ex Benth.) Rupr. | Scrophulariaceae | H | P | 3800 |
| 638. | **Lagotis globosa** (Kurz.) Hook.f. | Scrophulariaceae | H | P | – |
| 639. | **Lagotis kunawurensis** (Royle ex Benth.) Rupr. | Scrophulariaceae | H | P | 3900 |
| 640. | **Lancea tibetica** Hook.f. & Thomson | Scrophulariaceae | H | A | 3500 |
| 641. | **Leptorhabdos parviflora** (Benth.) Benth. | Scrophulariaceae | H | P | 2800–4100 |
| 642. | **Limosella aquatica** L. | Scrophulariaceae | H | P | – |
| 643. | **Linaria dalmatica** (L.) Mill. | Scrophulariaceae | H | A | 2500 |
| 644. | **Pedicularis bicornuta** Klotzsch | Scrophulariaceae | H | A | 3900–4500 |
| 645. | **Pedicularis brevifolia** D. Don | Scrophulariaceae | H | A | 4400–4700 |
| 646. | **Pedicularis cheilanthifolia** Schrenk | Scrophulariaceae | H | A | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 647. | **Pedicularis cheilanthifolia** Schrenk var. **purpurea** (Pennell) Tsoong ex T. Husain & Agnihotri | Scrophulariaceae | H | A | 4500 |
| 648. | **Pedicularis cheilanthifolia** Schrenk var. albida (Pennel) Tsoong | Scrophulariaceae | H | A | 3400 |
| 649. | **Pedicularis gracilis** Wall. ex Benth. | Scrophulariaceae | H | A | 3200 |
| 650. | **Pedicularis heydei** Prain | Scrophulariaceae | H | A | 5900 |
| 651. | **Pedicularis longiflora** Rudolphvar. **tubiformis** (Klotzsch) Tsoong | Scrophulariaceae | H | P | 4500 |
| 652. | **Pedicularis mollis** Wall. ex Benth. | Scrophulariaceae | H | A | 4200 |
| 653. | **Pedicularis oederi** Vahl | Scrophulariaceae | H | P | – |
| 654. | **Pedicularis pectinata** Wall. ex Benth. | Scrophulariaceae | H | P | 3200 |
| 655. | **Pedicularis pectinata** Wall. ex Benth. subsp. bipinnatifid Pennel | Scrophulariaceae | H | P | 3200 |
| 656. | **Pedicularis punctata** Decne. | Scrophulariaceae | H | A | 3600 |
| 657. | **Pedicularis pycnantha** Boiss. subsp. **cuspidata** Pennell | Scrophulariaceae | H | A | – |
| 658. | **Pedicularis rhinanthoides** Schrenk ex Fisch. & C.A. Mey. | Scrophulariaceae | H | P | 3200–4200 |
| 659. | **Pedicularis siphonantha** D. Don | Scrophulariaceae | H | P | 3350 |
| 660. | **Scrophularia dentata** Royle ex Benth. | Scrophulariaceae | H | A | 4300–4560 |
| 661. | **Scrophularia koelzii** Pennell | Scrophulariaceae | H | P | 3500 |
| 662. | **Scrophularia nudata** Pennell | Scrophulariaceae | H | P | 3900 |
| 663. | **Scrophularia scabiosifolia** Benth. | Scrophulariaceae | H | P | 3850 |
| 664. | **Verbascum thapsus** L. | Scrophulariaceae | H | P | 3850 |
| 665. | **Veronica alpina** subsp. **pumila** (All.) Dostál | Scrophulariaceae | H | P | 3400–4500 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 666. | **Veronica anagallis–aquatica** L. | Scrophulariaceae | H | P | 3400 |
| 667. | **Veronica beccabunga** subsp. **muscosa** (Korsh.) Elenevsky | Scrophulariaceae | H | P | 3975 |
| 668. | **Veronica biloba** L. | Scrophulariaceae | H | A | 3110–4025 |
| 669. | **Veronica hispidula** Boiss. & A. Huet | Scrophulariaceae | H | A | – |
| 670. | **Veronica koelzii** Pennell | Scrophulariaceae | H | P | 3500 |
| 671. | **Veronica lanosa** Royle ex Benth. | Scrophulariaceae | H | P | 3200–3300 |
| 672. | **Veronica macrostemon** Bunge ex Ledeb. | Scrophulariaceae | H | P | – |
| 673. | **Veronica salina** Schur | Scrophulariaceae | H | A | 3000–3700 |
| 674. | **Veronica secunda** Pennell | Scrophulariaceae | H | A | – |
| 675. | **Veronica serpyllifolia** L., | Scrophulariaceae | H | P | – |
| 676. | **Orobanche alba** Stephon ex Willd. | Orobanchaceae | H | A | 3000 |
| 677. | **Orobanche cernua** Loefl. | Orobanchaceae | H | A | – |
| 678. | **Orobanche hansii** A. Kern. | Orobanchaceae | H | B | 4100 |
| 679. | **Utricularia aurea** Lour. | Lentibulariaceae | H | A | 3500 |
| 680. | **Utricularia australis** R. Br. | Lentibulariaceae | H | A | 3400 |
| 681. | **Utricularia minor** L. | Lentibulariaceae | H | A | 3200 |
| 682. | **Dracocephalum heterophyllum** Benth. | Lamiaceae | H | A | 4250–6000 |
| 683. | **Dracocephalum moldavica** L. | Lamiaceae | H | A | 3100 |
| 684. | **Dracocephalum nutans** L. | Lamiaceae | H | A | 2770 |
| 685. | **Dracocephalum stamineum** Kar. & Kir. | Lamiaceae | H | A | 4500 |
| 686. | **Elsholtzia ciliata** (Thunb.) Hyl. | Lamiaceae | H | A | 2800–3400 |
| 687. | **Elsholtzia densa** Benth. | Lamiaceae | H | A | 3500–3800 |
| 688. | **Elsholtzia eriostachya** (Benth.) Benth. | Lamiaceae | H | A | 4100 |
| 689. | **Lamium amplexicaule** L. | Lamiaceae | H | A | 3200–3600 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 690. | **Marrubium marrubiastrum** (Stephan) Hedge | Lamiaceae | H | A | 4600 |
| 691. | **Mentha longifolia** (L.) Huds. | Lamiaceae | H | A | 3600 |
| 692. | **Nepeta adenophyta** Hedge | Lamiaceae | H | A | – |
| 693. | **Nepeta annua** Pall. | Lamiaceae | H | A | 3800 |
| 694. | **Nepeta batalica** Reshi | Lamiaceae | H | P | – |
| 695. | **Nepeta clarkei** Hook.f. | Lamiaceae | H | P | – |
| 696. | **Nepeta coerulescens** Maxim. | Lamiaceae | H | A | 5000 |
| 697. | **Nepeta connata** Royle ex Benth. | Lamiaceae | H | A | 3100 |
| 698. | **Nepeta discolor** Royle ex Benth. | Lamiaceae | H | A | 4100–4800 |
| 699. | **Nepeta discolor** Royle ex Benth. var. **kargilica** Reshi | Lamiaceae | H | A | – |
| 700. | **Nepeta drassiana** Reshi | Lamiaceae | H | A | – |
| 701. | **Nepeta eriostachya** Benth. | Lamiaceae | H | A | 4300–5000 |
| 702. | **Nepeta floccosa** Benth. | Lamiaceae | H | A | 3400–3650 |
| 703. | **Nepeta floccosa** Benth. var. **densiflora** Reshi | Lamiaceae | H | A | – |
| 704. | **Nepeta glutinosa** Benth. | Lamiaceae | H | A | 3450–3500 |
| 705. | **Nepeta grata** Benth. | Lamiaceae | H | A | 4570 |
| 706. | **Nepeta laevigata** (D. Don) Hand.–Mazz. | Lamiaceae | H | A | 3400–4400 |
| 707. | **Nepeta lancefolia** Reshi | Lamiaceae | H | A | 3000 |
| 708. | **Nepeta leucolaena** Benth. ex Hook.f. | Lamiaceae | H | A | 3100 |
| 709. | **Nepeta linearis** Royle ex Benth. | Lamiaceae | H | A | 3200–3500 |
| 710. | **Nepeta longibracteata** Benth. | Lamiaceae | H | A | 4000–5000 |
| 711. | **Nepeta nervosa** Royle ex Benth. | Lamiaceae | H | A | – |
| 712. | **Nepeta padamica** Reshi | Lamiaceae | H | P | – |
| 713. | **Nepeta paucifolia** Mukerjee | Lamiaceae | H | P | – |
| 714. | **Nepeta podostachys** Benth. | Lamiaceae | H | A | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 715. | **Nepeta podostachys** Benth. var. **hypoluciphylla** Reshi | Lamiaceae | H | A | – |
| 716. | **Perovskia abrotanoides** Kar. | Lamiaceae | S | P | 3500 |
| 717. | **Prunella vulgaris** L. | Lamiaceae | H | P | 2200 |
| 718. | **Scutellaria heydei** Hook.f. | Lamiaceae | H | P | – |
| 719. | **Scutellaria prostrata** Jacq. ex Benth. | Lamiaceae | H | P | 2900 |
| 720. | **Stachys tibetica** Vatke | Lamiaceae | US | P | 3310–3200 |
| 721. | **Thymus linearis** Benth. | Lamiaceae | H | P | 2270–3500 |
| 722. | **Plantago depressa** Willd. | Plantaginaceae | H | A | 3400-4600 |
| 723. | **Plantago lanceolata** L. | Plantaginaceae | H | P | 3730 |
| 724. | **Plantago major** L. | Plantaginaceae | H | P | 3570–4075 |
| 725. | **Amaranthus caudatus** L. | Amaranthaceae | H | A | 3900–4400 |
| 726. | **Amaranthus lividus** L. | Amaranthaceae | H | A | 2700 |
| 727. | **Acroglochin persicarioides** (Poir.) Moq. | Chenopodiaceae | H | A | – |
| 728. | **Atriplex crassifolia** C.A. Mey. | Chenopodiaceae | H | A | 3700 |
| 729. | **Atriplex hortensis** L. | Chenopodiaceae | H | A | 5500 |
| 730. | **Atriplex rosea** L. | Chenopodiaceae | H | A | 3500–3560 |
| 731. | **Axyris amaranthoides** L. | Chenopodiaceae | H | A | 3500–3850 |
| 732. | **Bassia dasyphylla** (Fisch. & C.A. Mey.) Kuntze. | Chenopodiaceae | H | A | – |
| 733. | **Chenopodium album** L. | Chenopodiaceae | H | A | – |
| 734. | **Chenopodium botrys** L. | Chenopodiaceae | H | A | 3500–3800 |
| 735. | **Chenopodium foliosum** (Moench) Asch. | Chenopodiaceae | H | A | 2700–4300 |
| 736. | **Chenopodium glaucum** L. | Chenopodiaceae | H | A | 3100–4250 |
| 737. | **Chenopodium hybridum** L. | Chenopodiaceae | H | A | 3200 |
| 738. | **Chenopodium murale** L. | Chenopodiaceae | H | A | 3500 |
| 739. | **Chenopodium opulifolium** Schrad. ex W.D.J. Koch & Ziz. | Chenopodiaceae | H | A | 3200–3505 |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 740. | **Corispermum tibeticum** Iljin. | Chenopodiaceae | H | A | 4175 |
| 741. | **Halocharis sulphurea** (Moq.) Moq. | Chenopodiaceae | H | A | 3310 |
| 742. | **Halocharis violacea** Bunge | Chenopodiaceae | H | A | – |
| 743. | **Halogeton glomeratus** (M. Bieb.) C.A. Mey. | Chenopodiaceae | H | A | 3800 |
| 744. | **Halogeton kashmirianus** Grey–Wilson & Wadhwa | Chenopodiaceae | H | A | 3506 |
| 745. | **Haloxylon thomsonii** Iljin | Chenopodiaceae | S | P | 3400 |
| 746. | **Kochia indica** Wight | Chenopodiaceae | H | A | – |
| 747. | **Kochia prostrata** (L.) C. Schrad. | Chenopodiaceae | US | P | 4500 |
| 748. | **Microgynoecium tibeticum** Hook.f. | Chenopodiaceae | H | A | 4300–4500 |
| 749. | **Salsola collina** Pall. | Chenopodiaceae | H | A | 3700–4000 |
| 750. | **Salsola kali** L. | Chenopodiaceae | H | A | 3400 |
| 751. | **Suaeda fruticosa** Forssk. ex J.F. Gmel. | Chenopodiaceae | US | P | – |
| 752. | **Suaeda microsperma** (C.A. Mey.) Fenzl. | Chenopodiaceae | H | A | 5500 |
| 753. | **Fagopyrum tataricum** (L.) Gaertn. | Polygonaceae | H | A | 3400–3650 |
| 754. | **Fallopia convolvulus** (L.) Á. Löve | Polygonaceae | H | A | 4100 |
| 755. | **Koenigia islandica** L. | Polygonaceae | H | A | – |
| 756. | **Oxyria digyna** (L.) Hill | Polygonaceae | H | P | 3100–3800 |
| 757. | **Polygonum amplexicaule** D. Don | Polygonaceae | H | P | – |
| 758. | **Polygonum aviculare** L. | Polygonaceae | H | A | 2800–3250 |
| 759. | **Polygonum cognatum** Meisn. | Polygonaceae | H | P | 3200–4400 |
| 760. | **Polygonum delicatulum** Meisn. | Polygonaceae | H | A | 3500–4200 |
| 761. | **Polygonum glabrum** Willd. | Polygonaceae | H | A | 3000–3500 |
| 762. | **Polygonum glaciale** Hook.f. | Polygonaceae | H | A | – |
| 763. | **Polygonum lapathifolium** L. | Polygonaceae | H | A | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 764. | **Polygonum molliiforme** Boiss. | Polygonaceae | H | A | 4150–4700 |
| 765. | **Polygonum nepalense** Meisn. | Polygonaceae | H | A | 2700–3300 |
| 766. | **Polygonum paronychioides** C.A. Mey. ex Hohen. | Polygonaceae | H | P | 3480–3850 |
| 767. | **Polygonum persicaria** L. | Polygonaceae | H | A | – |
| 768. | **Polygonum plebeium** R. Br. | Polygonaceae | H | A | 3505–4000 |
| 769. | **Polygonum polycnemoides** Jaub. & Spach | Polygonaceae | H | A | – |
| 770. | **Polygonum rottboellioides** Jaub. & Spach | Polygonaceae | H | A | 3700 |
| 771. | **Polygonum rottboellioides** Jaub. & Spach var. **tibetica** (Hook.f.) R.R. Stewart | Polygonaceae | H | A | – |
| 772. | **Polygonum sibiricum** Laxm. | Polygonaceae | H | P | – |
| 773. | **Polygonum tortuosum** D. Don | Polygonaceae | US | P | 3800–4500 |
| 774. | **Rheum tibeticum** Maxim. ex Hook.f. | Polygonaceae | H | A | – |
| 775. | **Rheum webbianum** Royle | Polygonaceae | H | P | 4000 |
| 776. | **Rumex acetosa** L. | Polygonaceae | H | P | 3150 |
| 777. | **Rumex angulatus** Rech.f. | Polygonaceae | H | P | – |
| 778. | **Rumex nepalensis** Spreng. | Polygonaceae | H | P | 3200 |
| 779. | **Rumex patientia** L. | Polygonaceae | H | P | 3000–3600 |
| 780. | **Elaeagnus angustifolia** L. | Elaeagnaceae | T | P | – |
| 781. | **Thesium himalense** Royle ex Edgew. | Santalaceae | H | P | 3900–4250 |
| 782. | **Thesium hookeri** Hendrych | Santalaceae | H | P | – |
| 783. | **Euphorbia hispida** Boiss. | Euphorbiaceae | H | A | 3500 |
| 784. | **Euphorbia kanaorica** Boiss. | Euphorbiaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 785. | **Euphorbia thomsoniana** Boiss. | Euphorbiaceae | H | P | 2900 |
| 786. | **Euphorbia tibetica** Boiss. | Euphorbiaceae | H | P | 3200–4000 |
| 787. | **Parietaria serbica** Pančić | Urticaceae | H | A | – |
| 788. | **Urtica ardens** Link. | Urticaceae | H | P | – |
| 789. | **Urtica dioica** L. | Urticaceae | H | P | 3150–3800 |
| 790. | **Urtica hyperborea** Jacq. ex Wedd. | Urticaceae | H | P | 4000–4600 |
| 791. | **Morus alba** L. | Moraceae | T | P | 2700 |
| 792. | **Ulmus wallichiana** Planch. | Ulmaceae | T | P | – |
| 793. | **Juglans regia** L. | Juglandaceae | T | P | 2600 |
| 794. | **Betula utilis** D. Don | Betulaceae | T | P | 3700 |
| 795. | **Populus alba** L. | Salicaceae | T | P | – |
| 796. | **Populus ciliata** Wall. ex Royle | Salicaceae | T | P | 3500 |
| 797. | **Populus deltoides** W. Bartram ex Marshall | Salicaceae | T | P | – |
| 798. | **Populus euphratica** Oilvier | Salicaceae | T | P | – |
| 799. | **Salix alba** L. | Salicaceae | T | P | 3200 |
| 800. | **Salix caesia** Vill. | Salicaceae | S | P | 4500 |
| 801. | **Salix daphnoides** Vill. | Salicaceae | S | P | – |
| 802. | **Salix denticulata** Andersson | Salicaceae | S | P | 3800 |
| 803. | **Salix flabellaris** Andersson | Salicaceae | S | P | 4800 |
| 804. | **Salix pycnostachya** Andersson | Salicaceae | S | P | 4000 |
| 805. | **Salix sclerophylla** Andersson | Salicaceae | S | P | – |
| 806. | **Salix sericocarpa** Andersson | Salicaceae | S | P | 3200 |
| 807. | **Salix tetrasperma** Roxb. | Salicaceae | T | P | – |
| 808. | **Salix wilhelmsiana** M. Bieb. | Salicaceae | S | P | 3200 |
| 809. | **Dactylorhiza hatagirea** (D.Don) Soo | Orchidaceae | H | P | – |
| 810. | **Malaxis muscifera** (Lindl.) O.Ktz. | Orchidaceae | H | A | – |
| 811. | **Iris decora** Wall. | Iridaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 812. | **Iris spuria** L. | Iridaceae | H | P | – |
| 813. | **Colchium luteum** Baker | Liliaceae | H | A | – |
| 814. | **Eremurus himalaicus** Baker | Liliaceae | H | A | – |
| 815. | **Fritillaria roylei** Hook. | Liliaceae | H | P | – |
| 816. | **Gagea kunawarensis** (D.Don) Grenter | Liliaceae | H | P | – |
| 817. | **Lloydia serotina** (L.) Reichb. | Liliaceae | H | A | – |
| 818. | **Tulipa stellata** Hook. | Liliaceae | H | A | – |
| 819. | **Allium auriculatum** Kunth | Alliaceae | H | A | – |
| 820. | **Allium caesioides** Wendelbo | Alliaceae | H | A | – |
| 821. | **Allium carolinianum** DC. | Alliaceae | H | P | – |
| 822. | **Allium consanguineum** Kunth | Alliaceae | H | P | – |
| 823. | **Allium fedtschenkoanum** Regel | Alliaceae | H | A | – |
| 824. | **Allium humile** Kunth | Alliaceae | H | A | – |
| 825. | **Allium jacquemontii** Kunth | Alliaceae | H | A | – |
| 826. | **Allium loratum** Baker | Alliaceae | H | A | – |
| 827. | **Allium oreoprasum** Schrenk | Alliaceae | H | A | – |
| 828. | **Allium roylei** Stern | Alliaceae | H | A | – |
| 829. | **Allium schoenoprasum** L. | Alliaceae | H | A | – |
| 830. | **Allium stoliczki** Regal | Alliaceae | H | A | – |
| 831. | **Allium tenuicaule** Regel | Alliaceae | H | A | – |
| 832. | **Allium victorialis** L. | Alliaceae | H | A | – |
| 833. | **Milula spicata** Prain | Alliaceae | H | A | – |
| 834. | **Juncus articulates** L. | Juncaceae | H | A | – |
| 835. | **Juncus bafonius** L. | Juncaceae | H | A | – |
| 836. | **Juncus leucomelas** Royle ex D.Don | Juncaceae | H | P | – |
| 837. | **Juncus punctorius** L.f. | Juncaceae | H | P | – |
| 838. | **Juncus sphacelatus** Decne. | Juncaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 839. | **Juncus sphacelatus** Decne. var. **himalensis** (Klotzsch & Garcke) Jafri | Juncaceae | H | P | – |
| 840. | **Juncus thomsonii** | Juncaceae | H | P | – |
| 841. | **Juncus triglumis** L. | Juncaceae | H | P | – |
| 842. | **Lemna minor** L. | Lemnaceae | H | A | – |
| 843. | **Najas marina** L. | Najadaceae | H | A | – |
| 844. | **Triglochin maritima** L. | Juncaginaceae | H | P | – |
| 845. | **Triglochin palustris** L. | Juncaginaceae | H | P | – |
| 846. | **Potamogeton crispus** L. | Potamogetonaceae | H | P | – |
| 847. | **Potamogeton natans** L. | Potamogetonaceae | H | P | – |
| 848. | **Potamogeton nodosus** L. | Potamogetonaceae | H | P | – |
| 849. | **Potamogeton pectinatus** L. | Potamogetonaceae | H | P | – |
| 850. | **Zannichellia palustris** L. | Zannichelliaceae | H | P | – |
| 851. | **Baeothryon pumilum** (Vahl) T.Koyama | Cyperaceae | H | A | – |
| 852. | **Blysmus compressus** (L.) Panz. ex Link | Cyperaceae | H | P | – |
| 853. | **Carex borii** Nelmes | Cyperaceae | H | P | – |
| 854. | **Carex borii** Nelmes var. **lutea** Stewart | Cyperaceae | H | P | – |
| 855. | **Carex cruenta** Nees | Cyperaceae | H | P | – |
| 856. | **Carex curta** Gooden | Cyperaceae | H | P | – |
| 857. | **Carex diluta** M.Bieb. | Cyperaceae | H | P | – |
| 858. | **Carex haematostoma** Nees | Cyperaceae | H | P | – |
| 859. | **Carex haematostoma** Nees var. **submacrogyna** Kuekenth | Cyperaceae | H | P | – |
| 860. | **Carex heterostachya** Bunge | Cyperaceae | H | P | – |
| 861. | **Carex infuscata** Nees | Cyperaceae | H | P | – |
| 862. | **Carex karoi** Freyn. | Cyperaceae | H | P | – |
| 863. | **Carex melanantha** C.A. Mey | Cyperaceae | H | P | – |
| 864. | **Carex melanantha** C.A. Mey var. **moorcroftii** (Boott) Kuekenth. | Cyperaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 865. | **Carex microglochin** Wall. | Cyperaceae | H | P | – |
| 866. | **Carex nigerrima** Nelmes | Cyperaceae | H | P | – |
| 867. | **Carex nivalis** Boott | Cyperaceae | H | P | – |
| 868. | **Carex oligocarya** C.B.Clarke | Cyperaceae | H | P | – |
| 869. | **Carex orbicularis** Boott | Cyperaceae | H | P | – |
| 870. | **Carex pamirensis** C.B.Clarke | Cyperaceae | H | P | – |
| 871. | **Carex parva** Nees | Cyperaceae | H | P | – |
| 872. | **Carex plectobasis** V.Krecz. | Cyperaceae | H | P | – |
| 873. | **Carex pseudofoetida** Kuekenth | Cyperaceae | H | P | – |
| 874. | **Carex psychrophila** Nees | Cyperaceae | H | P | – |
| 875. | **Carex serotina** Merat | Cyperaceae | H | P | – |
| 876. | **Carex setosa** Boott | Cyperaceae | H | P | – |
| 877. | **Carex stenophylla** Wahl. | Cyperaceae | H | P | – |
| 878. | **Carex stenophylla** Wahl. var. **longipedicellata** (Boeck.) Kuekenth. | Cyperaceae | H | P | – |
| 879. | **Carex tristis** M.Bieb. | Cyperaceae | H | P | – |
| 880. | **Carex vulpinaris** Nees | Cyperaceae | H | P | – |
| 881. | **Elaeocarpus atropurpurea** (Retz.) J. & K. Presl | Cyperaceae | H | A | – |
| 882. | **Elaeocarpus mitracarpa** Steud. | Cyperaceae | H | P | – |
| 883. | **Elaeocarpus palustris** (L.) R.Br. | Cyperaceae | H | P | – |
| 884. | **Elaeocarpus quinquiflora** (F.X. Hartm.) O.Schwarz | Cyperaceae | H | P | – |
| 885. | **Elaeocarpus uniglumis** (Link.) Schult. | Cyperaceae | H | P | – |
| 886. | **Isolepis setacea** (L.) R.Br. | Cyperaceae | H | A | – |
| 887. | **Kobresia capillifolia** (Decne.) C.B. Clarke | Cyperaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 888. | **Kobresia cerostachys** (Franch.) C.B. Clarke | Cyperaceae | H | P | – |
| 889. | **Kobresia laxa** Nees | Cyperaceae | H | P | – |
| 890. | **Kobresia macrantha** Boeck. | Cyperaceae | H | P | – |
| 891. | **Kobresia nitens** C.B. Clarke | Cyperaceae | H | P | – |
| 892. | **Kobresia pygmaea** (C.B. Clarke) C.B. Clarke | Cyperaceae | H | P | – |
| 893. | **Kobresia royleana** (Nees) Boeck. | Cyperaceae | H | P | – |
| 894. | **Kobresia laxa** Nees var. **paniculata** (Regel) Kuekenth. | Cyperaceae | H | P | – |
| 895. | **Pycreus flavescens** (L.) Reichb. | Cyperaceae | H | A | – |
| 896. | **Pycreus flavidus** (Retz.) Koyama | Cyperaceae | H | A | – |
| 897. | **Pycreus sanguinolentus** (Vahl) Nees ex C.B. Clarke | Cyperaceae | H | P | – |
| 898. | **Schoenoplectus lacustris** (L.) Palla | Cyperaceae | H | P | – |
| 899. | **Schoenoplectus tabernaemontani** (C.C. Gmel.) Palla | Cyperaceae | H | P | – |
| 900. | **Schoenoplectus triqueter** (L.) Palla | Cyperaceae | H | P | – |
| 901. | **Scirpus rufus** Schrad. | Cyperaceae | H | P | – |
| 902. | **Agrostis gigantean** Roth. | Poaceae | H | A | – |
| 903. | **Agrostis munroana** Aitch. & Hemsl. | Poaceae | H | A | – |
| 904. | **Agrostis pilosula** Trin. | Poaceae | H | A | – |
| 905. | **Agrostis stolonifera** L. | Poaceae | H | A | – |
| 906. | **Agrostis vinealis** Schreb. | Poaceae | H | P | – |
| 907. | **Agrostis viridis** Gouan | Poaceae | H | P | – |
| 908. | **Alopecurus aequalis** Sobol. | Poaceae | H | P | – |
| 909. | **Alopecurus arundinaceus** Poir. | Poaceae | H | P | – |
| 910. | **Alopecurus himalaicus** Hook.f. | Poaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 911. | **Anthoxanthum odoratum** L. | Poaceae | H | P | – |
| 912. | **Aristida cyanantha** Nees ex Steud. | Poaceae | H | P | – |
| 913. | **Arundo donax** L. | Poaceae | H | P | – |
| 914. | **Avena barbata** Pett. ex Link | Poaceae | H | A | – |
| 915. | **Avena fatua** L. | Poaceae | H | A | – |
| 916. | **Avena sterilis** L. subsp. **ludoviciana** (Dur.) Gill & Magne | Poaceae | H | A | – |
| 917. | **Bothriochloa ischaemum** (L.) Keng | Poaceae | H | P | – |
| 918. | **Bothriochloa pertusa** (L.) A. Camus | Poaceae | H | P | – |
| 919. | **Brachypodium sylvaticum** (Huds.) P. Beauv. | Poaceae | H | P | – |
| 920. | **Briza media** L. | Poaceae | H | P | – |
| 921. | **Bromus confinis** Nees ex Steud. | Poaceae | H | P | – |
| 922. | **Bromus danthoniae** Trin. | Poaceae | H | A | – |
| 923. | **Bromus gracillimus** Bunge | Poaceae | H | A | – |
| 924. | **Bromus inermis** Leyss. | Poaceae | H | P | – |
| 925. | **Bromus japonicus** Thunb. ex Murr. | Poaceae | H | A | – |
| 926. | **Bromus lanceolatus** Roth | Poaceae | H | A | – |
| 927. | **Bromus oxyodon** Schrenk | Poaceae | H | A | – |
| 928. | **Bromus pectinatus** Thumb. | Poaceae | H | A | – |
| 929. | **Bromus ramosus** Huds. | Poaceae | H | P | – |
| 930. | **Bromus scoparius** L. | Poaceae | H | A | – |
| 931. | **Bromus tectorum** L. | Poaceae | H | A | – |
| 932. | **Calamagrostis decora** Hook.f. | Poaceae | H | P | – |
| 933. | **Calamagrostis emodensis** Griseb. | Poaceae | H | P | – |
| 934. | **Calamagrostis epigejos** (L.) Roth | Poaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 935. | **Calamagrostis garhwalensis** C.E. Hubbard & Bor | Poaceae | H | P | – |
| 936. | **Calamagrostis pseudophragmites** (Hall.f.) Koel. | Poaceae | H | P | – |
| 937. | **Calamagrostis pseudophragmites** (Hall.f.) Koel. subsp. **tartarica** (Hook.f.) Bor | Poaceae | H | P | – |
| 938. | **Calamagrostis scabrescens** Griseb. | Poaceae | H | P | – |
| 939. | **Calamagrostis stoliczkai** Hook.f. | Poaceae | H | P | – |
| 940. | **Catabrosa aquatic** (L.) P. Beauv. | Poaceae | H | P | – |
| 941. | **Chloris virgata** Sw. | Poaceae | H | A | – |
| 942. | **Chrysopogon gryllus** (L.) Trin. | Poaceae | H | P | – |
| 943. | **Chrysopogon gryllus** (L.) Trin. subsp. **echinulatus** (Nees) T.A. Cope | Poaceae | H | P | – |
| 944. | **Colpodium himalaicum** (Hook.f.) Bor | Poaceae | H | P | – |
| 945. | **Colpodium leucolepis** Nevski | Poaceae | H | P | – |
| 946. | **Colpodium nutahs** (Stapf) Bor | Poaceae | H | P | – |
| 947. | **Crypsis schoenoides** (L.) Lam. | Poaceae | H | A | – |
| 948. | **Cymbopogon jwarancusa** (Jones) Schult. | Poaceae | H | P | – |
| 949. | **Cymbopogon jwarancusa** (Jones) Schult. subsp. **olivieri** (Boiss.) Soenarko | Poaceae | H | P | – |
| 950. | **Cymbopogon pospischilii** (K. Schum.) C.E. Hubbard | Poaceae | H | P | – |
| 951. | **Dactylis glomerata** L. | Poaceae | H | P | – |
| 952. | **Danthonia cachemyriana** Jaub. & Spach. | Poaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 953. | **Danthonia schneideri** Pilger | Poaceae | H | P | – |
| 954. | **Deschampsia caespitosa** (L.) P. Beauv. | Poaceae | H | P | – |
| 955. | **Deschampsia koelerioides** Regel | Poaceae | H | P | – |
| 956. | **Digitaria ischaemum** (Schreb.) Schreb. ex Muhl. | Poaceae | H | A | – |
| 957. | **Digitaria sanguinalis** (L.) Scop. | Poaceae | H | A | – |
| 958. | **Digitaria stewartiana** Bor | Poaceae | H | A | – |
| 959. | **Duthiea bromoides** Hack. | Poaceae | H | P | – |
| 960. | **Echinochloa colona** (L.) Link | Poaceae | H | A | – |
| 961. | **Echinochloa crusgalli** (L.) P. Beauv. | Poaceae | H | A | – |
| 962. | **Elymus cognatus** (Hack.) T.A. Cope | Poaceae | H | P | – |
| 963. | **Elymus dahuricus** Turcz. ex Griseb. | Poaceae | H | P | – |
| 964. | **Elymus dentatus** (Hook. f.) T.A. Cope | Poaceae | H | P | – |
| 965. | **Elymus fedtschenkoi** Tzvelev | Poaceae | H | P | – |
| 966. | **Elymus hispidus** (Opiz) Meld. | Poaceae | H | P | – |
| 967. | **Elymus jacquemontii** (Hook.f.) T.A. Cope | Poaceae | H | P | – |
| 968. | **Elymus longi-aristatus** (Boiss.) Tzvelev subsp. **canaliculatus** (Nevski) Tzvelev | Poaceae | H | P | – |
| 969. | **Elymus nutans** Griseb. | Poaceae | H | P | – |
| 970. | **Elymus repens** (L.) Gould | Poaceae | H | P | – |
| 971. | **Elymus schrenkianus** (Fisch. & Mey.) Tzvelev | Poaceae | H | P | – |
| 972. | **Elymus schugnanicus** (Nevski) Tzvelev | Poaceae | H | P | – |
| 973. | **Elymus semicostatus** (Nees ex Steud.) Meld. | Poaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 974. | **Elymus stewartii** (Meld.) T.A. Cope | Poaceae | H | P | – |
| 975. | **Enneapogon persicus** Boiss. | Poaceae | H | P | – |
| 976. | **Eragrostis minor** Host | Poaceae | H | A | – |
| 977. | **Eragrostis pilosa** (L.) P. Beauv. | Poaceae | H | A | – |
| 978. | **Eremopoa altaica** (Trin.) Rosch. | Poaceae | H | A | – |
| 979. | **Eremopoa altaica** (Trin.) Rosch. subsp. **songarica** (Schrenk) Tzvelev | Poaceae | H | A | – |
| 980. | **Eremopoa persica** (Trin.) Rozhev. | Poaceae | H | A | – |
| 981. | **Festuca alaica** Drobov | Poaceae | H | P | – |
| 982. | **Festuca alatavica** (St. Yves) Rozhev. | Poaceae | H | P | – |
| 983. | **Festuca coelestic** (St.-Vyes) Krecz. & Bobrov | Poaceae | H | P | – |
| 984. | **Festuca hartmannii** (Markgr.-Dannenb.) Alexeev | Poaceae | H | P | – |
| 985. | **Festuca kashmiriana** Stapf | Poaceae | H | P | – |
| 986. | **Festuca nitidula** Stapf | Poaceae | H | P | – |
| 987. | **Festuca olgae** (Regel) Krivot. | Poaceae | H | P | – |
| 988. | **Festuca pamirica** Tzvelev | Poaceae | H | P | – |
| 989. | **Festuca polycolea** Stapf | Poaceae | H | P | – |
| 990. | **Festuca rubra** L. | Poaceae | H | P | – |
| 991. | **Festuca rubra** L. subsp. **arctica** (Hack.) Govar. | Poaceae | H | P | – |
| 992. | **Festuca tibetica** (Stapf) Alexeev | Poaceae | H | P | – |
| 993. | **Festuca valesiaca** Schleich. ex Gaud. | Poaceae | H | P | – |
| 994. | **Helictotrichon pratense** (L.) Pilger | Poaceae | H | P | – |
| 995. | **Hierochloe laxa** R.Br. ex Hook.f. | Poaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 996. | **Hordeum bogdani** Wilensky | Poaceae | H | P | – |
| 997. | **Hordeum brevisubulatum** (Trin.) Link | Poaceae | H | P | – |
| 998. | **Hordeum brevisubulatum** (Trin.) Link subsp. **turkestanicum** (Nevski) Tzevelve | Poaceae | H | P | – |
| 999. | **Kengia mutica** (Keng) Packer | Poaceae | H | P | – |
| 1000. | **Koeleria argentea** Griseb. | Poaceae | H | P | – |
| 1001. | **Koeleria macrantha** (Ledeb.) Schult. | Poaceae | H | P | – |
| 1002. | **Leymus secalinus** (Georgi) Tzvelev | Poaceae | H | P | – |
| 1003. | **Lolium perenne** L. | Poaceae | H | P | – |
| 1004. | **Melica persica** Kunth | Poaceae | H | P | – |
| 1005. | **Melica secunda** Regel | Poaceae | H | P | – |
| 1006. | **Milium effusum** L. | Poaceae | H | P | – |
| 1007. | **Muhlenbergia huegelii** Trin. | Poaceae | H | P | – |
| 1008. | **Orinus thoroldii** (Stapf ex Hemsl.) Bor | Poaceae | H | P | – |
| 1009. | **Oryzopsis aequiglumis** Duthie ex Hook. f. | Poaceae | H | P | – |
| 1010. | **Oryzopsis lateralis** Stapf | Poaceae | H | P | – |
| 1011. | **Oryzopsis munroi** Stapf | Poaceae | H | P | – |
| 1012. | **Oryzopsis wendelboi** Bor | Poaceae | H | P | – |
| 1013. | **Panicum miliaceum** L. | Poaceae | H | P | – |
| 1014. | **Pennisetum flaccidum** Griseb. | Poaceae | H | P | – |
| 1015. | **Pennisetum lanatum** Klotzsch | Poaceae | H | P | – |
| 1016. | **Pennisetum orientale** L.C. Rich | Poaceae | H | P | – |
| 1017. | **Phalaris arundinacea** L. | Poaceae | H | P | – |
| 1018. | **Phleum alpinum** L. | Poaceae | H | P | – |
| 1019. | **Phragmites australis** (Cav.) Trin. ex Steud. | Poaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 1020. | **Phragmites karka** (Retz.) Trin. ex Steud. | Poaceae | H | P | – |
| 1021. | **Poa alpina** L. | Poaceae | H | P | – |
| 1022. | **Poa annua** L. | Poaceae | H | P | – |
| 1023. | **Poa attenuata** Trin. | Poaceae | H | P | – |
| 1024. | **Poa bacteriana** Rozhev. | Poaceae | H | P | – |
| 1025. | **Poa bacteriana** Rozhev. subsp. **glabriflora** (Rozhev. ex Ovcz.) Tzvelev | Poaceae | H | P | – |
| 1026. | **Poa bulbosa** L. | Poaceae | H | P | – |
| 1027. | **Poa calliopsis** Litw. ex Ovcz. | Poaceae | H | P | – |
| 1028. | **Poa falconeri** Hook.f. | Poaceae | H | P | – |
| 1029. | **Poa glauca** Vahl subsp. **litwinowiana** (Ovcz.) Tzvelev | Poaceae | H | P | – |
| 1030. | **Poa infirma** H.B.K. | Poaceae | H | P | – |
| 1031. | **Poa koelzii** Bor | Poaceae | H | P | – |
| 1032. | **Poa ladakhensis** Hartm. | Poaceae | H | P | – |
| 1033. | **Poa markgrafii** Hartm. | Poaceae | H | P | – |
| 1034. | **Poa nemoralis** Bor | Poaceae | H | P | – |
| 1035. | **Poa nepalensis** Wall. ex Duthie | Poaceae | H | P | – |
| 1036. | **Poa pagophila** Bor | Poaceae | H | P | – |
| 1037. | **Poa pratensis** L. | Poaceae | H | P | – |
| 1038. | **Poa pratensis** L. subsp. **angustifolia** (L.) Gaud. | Poaceae | H | P | – |
| 1039. | **Poa sikkimensis** (Stapf) Bor | Poaceae | H | P | – |
| 1040. | **Poa stafiana** Bor | Poaceae | H | P | – |
| 1041. | **Poa sterilis** M.Bieb. | Poaceae | H | P | – |
| 1042. | **Poa stewartiana** Bor | Poaceae | H | A | – |
| 1043. | **Poa supina** Schrad. | Poaceae | H | P | – |
| 1044. | **Poa suruana** Hartm. | Poaceae | H | P | – |
| 1045. | **Poa tibetica** Munro ex Stapf | Poaceae | H | P | – |
| 1046. | **Poa trivialis** L. | Poaceae | H | P | – |
| 1047. | **Poa versicolor** Bess. subsp. **araratica** (Trautv.) Tzvelev | Poaceae | H | P | – |
| 1048. | **Polypogon fugax** Nees ex Steud. | Poaceae | H | A | – |
| 1049. | **Polypogon monspeliensis** (L.) Desf. | Poaceae | H | A | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 1050. | **Puccinellia distans** (Wahlb.) Parl. | Poaceae | H | P | – |
| 1051. | **Puccinellia himalaica** Tzvelev | Poaceae | H | P | – |
| 1052. | **Puccinellia kashmiriana** Bor | Poaceae | H | P | – |
| 1053. | **Puccinellia minuta** Bor | Poaceae | H | P | – |
| 1054. | **Puccinellia stapfiana** R.R. Stewart | Poaceae | H | P | – |
| 1055. | **Puccinellia tenuiflora** (Griseb.) Scribn. & Merr. | Poaceae | H | P | – |
| 1056. | **Puccinellia thomsonii** (Stapf) R.R. Stewart | Poaceae | H | P | – |
| 1057. | **Saccharum filifolium** Nees ex Steud. | Poaceae | H | P | – |
| 1058. | **Saccharum griffithii** Munro ex Boiss. | Poaceae | H | P | – |
| 1059. | **Saccharum ravennae** (L.) Murr. | Poaceae | H | P | – |
| 1060. | **Saccharum spontaneum** L. | Poaceae | H | P | – |
| 1061. | **Schismus arabicus** Nees | Poaceae | H | A | – |
| 1062. | **Schismus barbatus** (L.) Thell. | Poaceae | H | A | – |
| 1063. | **Setaria pumila** (Poir.) Roem. & Schult. | Poaceae | H | A | – |
| 1064. | **Setaria viridis** (L.) P.Beauv. | Poaceae | H | A | – |
| 1065. | **Stipa breviflora** Grisseb. | Poaceae | H | P | – |
| 1066. | **Stipa capillata** L. | Poaceae | H | P | – |
| 1067. | **Stipa caucasica** Schmalh. | Poaceae | H | P | – |
| 1068. | **Stipa consanguinea** Trin. & Rupr. | Poaceae | H | P | – |
| 1069. | **Stipa himalaica** Rozhev. | Poaceae | H | P | – |
| 1070. | **Stipa jacquemontii** Jaub. & Spach. | Poaceae | H | P | – |
| 1071. | **Stipa kirghisorum** P. Smim. | Poaceae | H | P | – |
| 1072. | **Stipa mongholica** Turcz. ex Trin. | Poaceae | H | P | – |
| 1073. | **Stipa orientalis** Trin. | Poaceae | H | P | – |
| 1074. | **Stipa purpurea** Griseb. | Poaceae | H | P | – |
| 1075. | **Stipa regeliana** Hack. | Poaceae | H | P | – |
| 1076. | **Stipa sibirica** (L.) Lam. | Poaceae | H | P | – |

(continued)

**Table 26.1** (continued)

| S. No. | Species | Family | Habit | Life form | Altitude |
|---|---|---|---|---|---|
| 1077. | **Stipa splendens** Trin. | Poaceae | H | P | – |
| 1078. | **Stipa subsessiliflora** (Rupr.) Rozhev. | Poaceae | H | P | – |
| 1079. | **Stipagrostis plumosa** (L.) Munro ex T. Anders. | Poaceae | H | P | – |
| 1080. | **Tetrapogon villosus** Desf. | Poaceae | H | P | – |
| 1081. | **Trikeraia hookeri** (Stapf) Bor | Poaceae | H | P | – |
| 1082. | **Tripogon filiformis** Nees ex Steud. | Poaceae | H | P | – |
| 1083. | **Trisetum clarkei** (Hook.f.) R.R. Stewart | Poaceae | H | P | – |
| 1084. | **Trisetum spicatum** (L.) Richt. | Poaceae | H | P | – |
| 1085. | **Vulpia myuros** (L.) C.C. | Poaceae | H | A | – |

Habit: *A* annual, B biennial, P perennial
Life Form: *H* herb, *C* climber, *S* shrub, *T* tree, *TW* twiner, *US* under-shrub

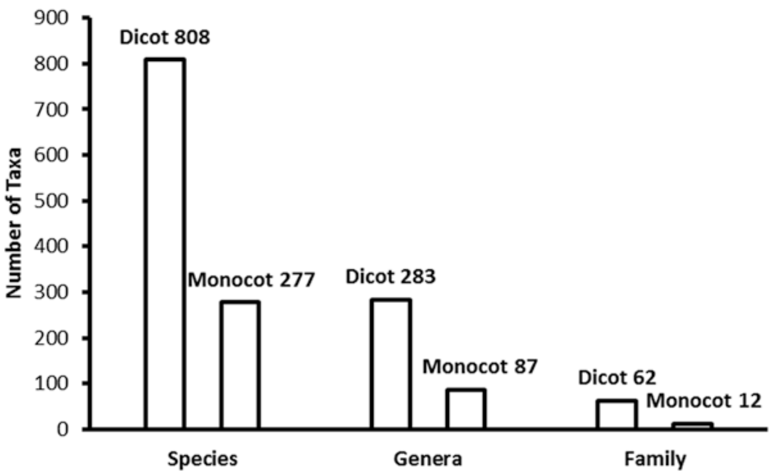


**Fig. 26.2** Contribution of dicots and monocots in species, genera and families of flowering plants in the flora of Ladakh

with the highest number of species in Ladakh flora are *Astragalus* (with 35 species), followed by *Carex* (28 species), *Poa* (27 species), *Nepeta* (24 species), *Corydalis* (20 species), *Epilobium* (18 species), and *Polygonum* and *Artemisia* (17 species each) (Fig. 26.6) (Plates 26.1 and 26.2).

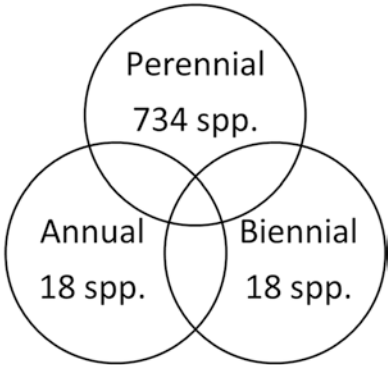


**Fig. 26.3** Extent of species in different life-forms in the angiosperm flora of Ladakh

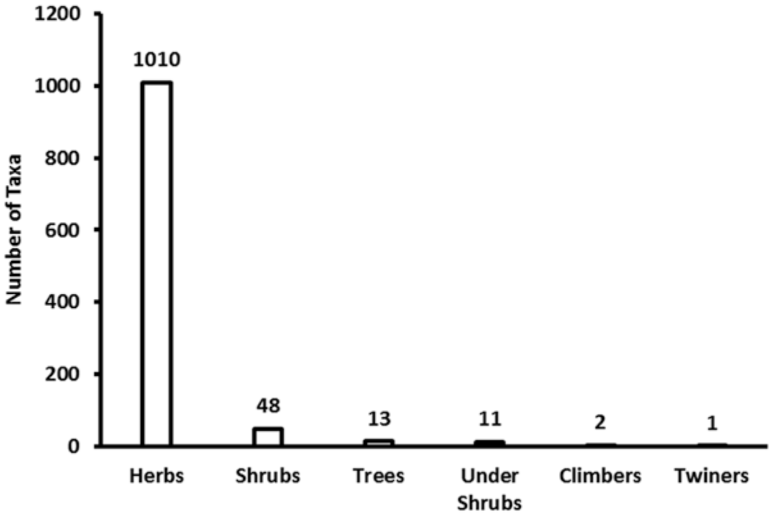


**Fig. 26.4** Habit-wise contribution of different forms in the angiosperm flora of Ladakh

Ladakh flora, 62 families belong to dicotyledons and 12 to monocotyledons. Out of the total 370 genera, 283 genera belong to dicotyledons and 87 to monocotyledons. Likewise, out of the total 1085 species, 808 species are from dicotyledons while 277 belong to monocotyledons (Fig. 26.2). Perennials comprise 734 species of the angiosperm flora of Ladakh, whereas 18 species each are annuals and biennials (Fig. 26.3). In habit-wise classification, herbs dominate with 1010 species, followed by shrubs (48 species), trees (13 species), under-shrubs (11 species), climbers (2 species) and twiners (1 species) (Fig. 26.4).

The families with the highest number of species are Poaceae (with 184 species), followed by Asteraceae (122 species), Fabaceae and Brassicaceae (77 species each), Cyperaceae (51 species), Scrophulariaceae (49 species), Caryophyllaceae (43 species), Lamiaceae and Ranunculaceae (40 species each), Boraginaceae (30 species), Apiaceae (29 species) and Chenopodiaceae (26 species) (Fig. 26.5). The genera

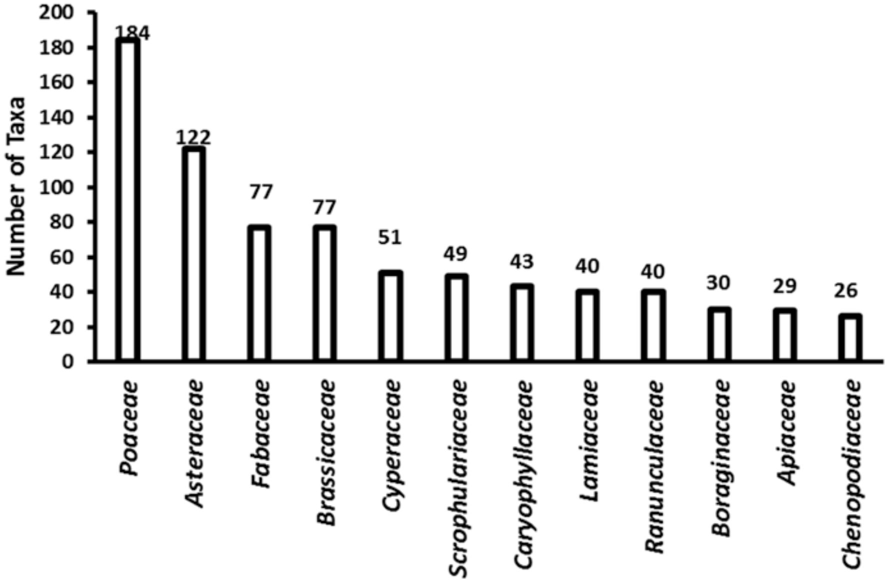


**Fig. 26.5** Twelve larger families (with 26 or more species each) in angiosperm flora of Ladakh

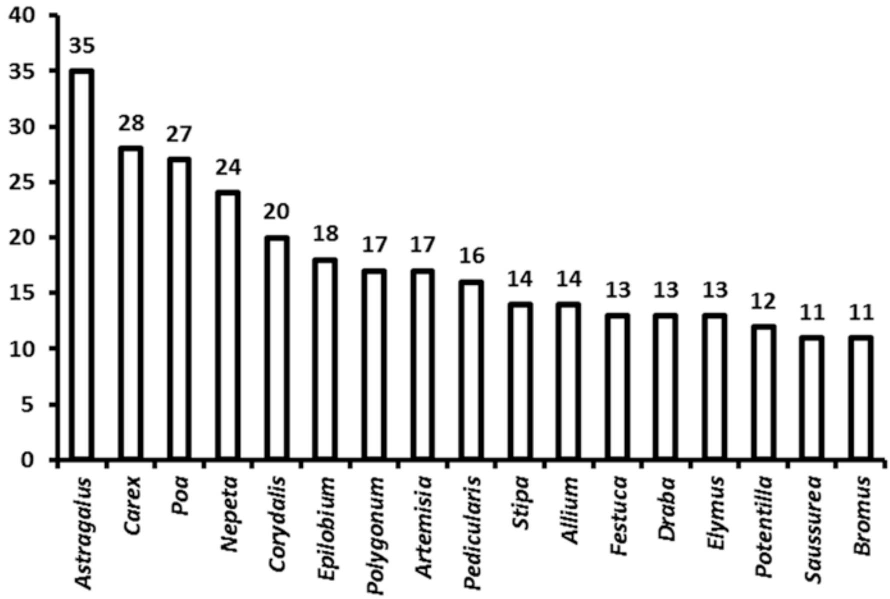


**Fig. 26.6** Seventeen larger genera (with 11 or more species each) in angiosperm-flora of Ladakh

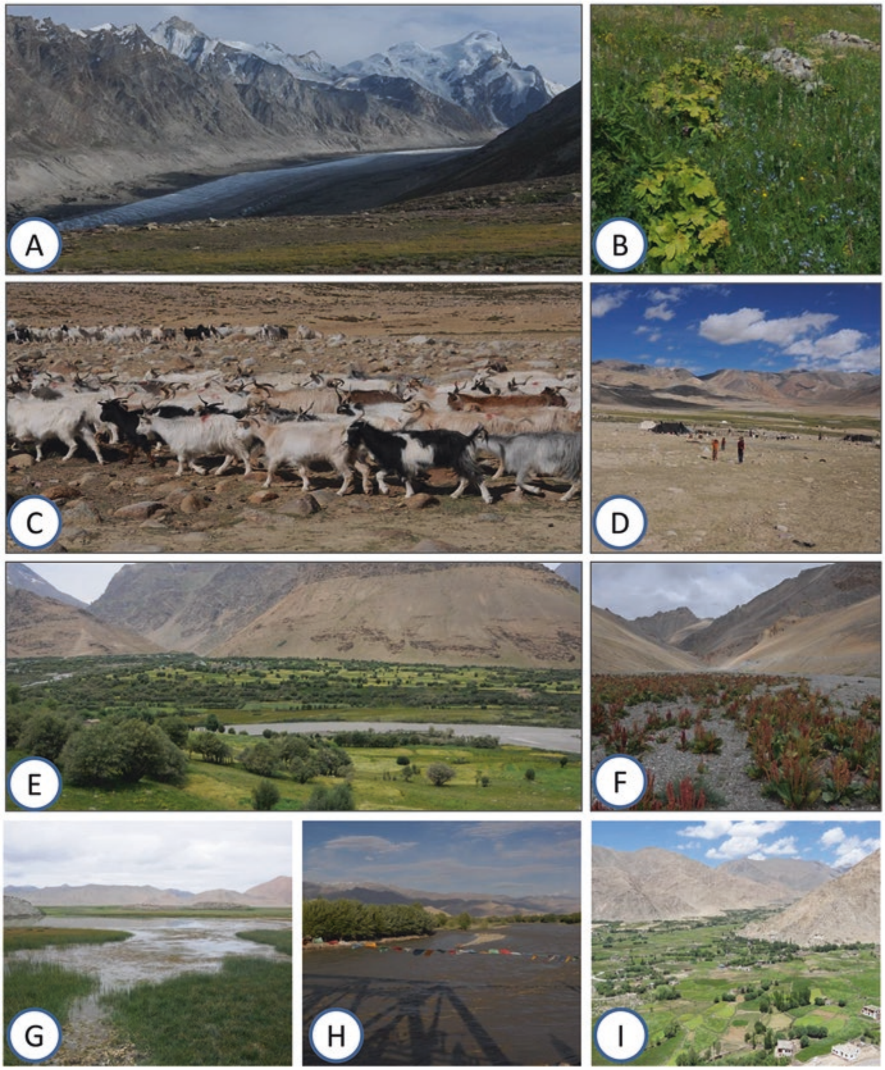


**Plate 26.1** (**a**) – Drang Drung Glacier in the Greater Himalaya Range in southern Ladakh, (**b**) – Population of *Podophyllum hexandrum* in wild at Suru Valley, Kargil, (**c**) – Overgrazing by domestic sheep, (**d**) – A Landscape of Changthang region characterised by undulations with rugged terrains, (**e**) – Irrigated fields in Ladakh, Suru valley, (**f**) – A Landscape of Pang, Ladakh, (**g**) – A view of Tsokar Lake, Changthang region, Ladakh, (**h**) – Vegetation along Indus river, Leh, Ladakh, (**i**) – Agriculture in the Indus Valley, Changthang Range Ladakh

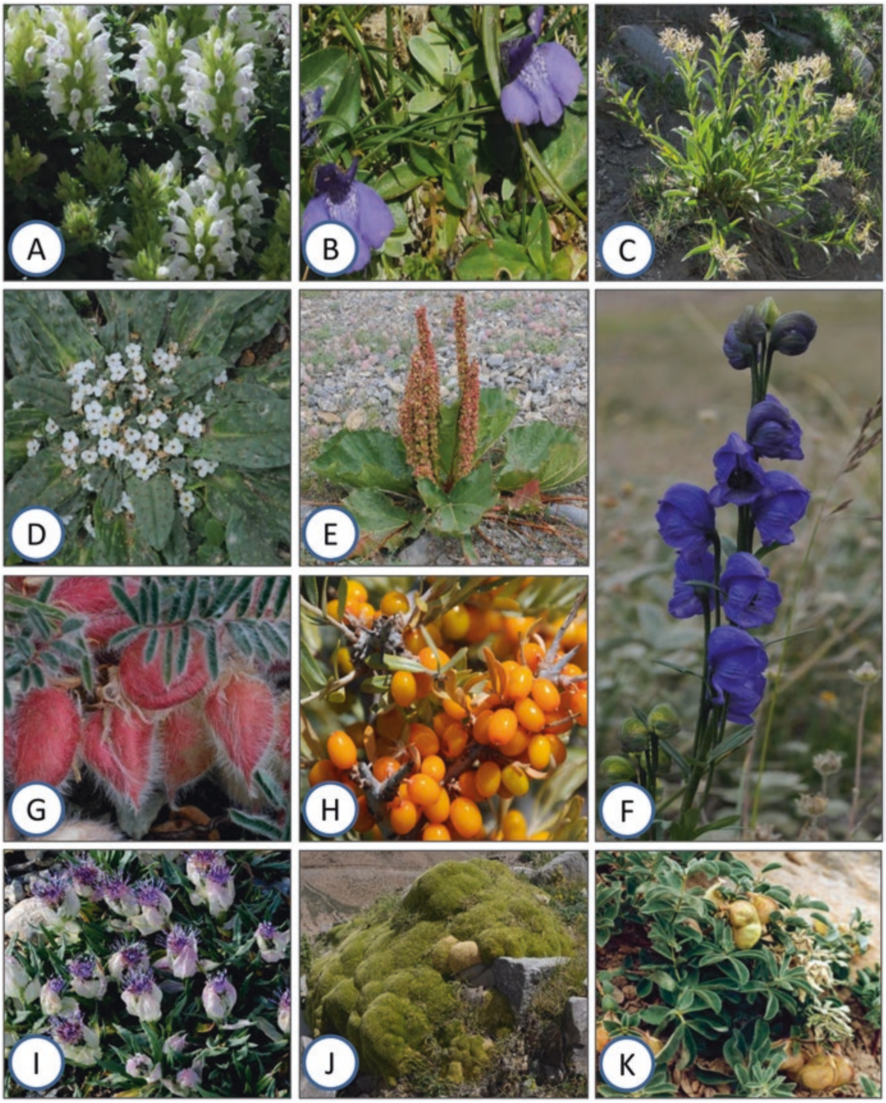


**Plate 26.2** (**a**) – *Dracocephalum heterophyllum* Benth., (**b**) – *Lancea tibetica* Hook.f. & Thomson, (**c**) – *Arnebia euchroma* (Royle ex Benth.) I.M. Johnston, (**d**) – *Microula tibetica* Benth., (**e**) – *Rheum spiciforme* Royle, (**f**) – *Aconitum violaceum* Jacquem. ex Stapf, (**g**) – *Astragalus munroi* Benth. ex Bunge, (**h**) – *Hippophae rhamnoides* L., (**i**) – *Saussurea nana* (Pamp.) Pamp., (**j**) – *Thylacospermum caespitosum* (Cambess.) Schischk., (**k**) – *Thermopsis inflata* Cambess

**Acknowledgement** Authors are thankful to Dr. Paramjit Singh, Ex-Director, Botanical Survey of India, Kolkata, for his encouragement and for providing facilities during the course of this study.

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# Part VI
# Biodiversity of Jammu and Kashmir State: Faunal Diversity

# Chapter 27
# Taxonomic Inventory of Ants (Hymenoptera: Formicidae) in Jammu and Kashmir State

**Aijaz Ahmad Wachkoo, Shahid Ali Akbar, Ulfat Jan, and Ghulam Mustafa Shah**

**Abstract** This chapter presents the first ever taxonomic inventory of ant species recorded from the Jammu and Kashmir State. The inventory is based on relevant scientific literature and museum collections, combined with data obtained from the field surveys since 2008. In total, there are 198 ant taxa (species and subspecies) representing 54 genera in 7 subfamilies recorded from Jammu and Kashmir. Looking ahead, the study clearly highlights that much research efforts are required to document the unknown ant diversity of this Himalayan region.

**Keywords** Ants · Formicidae · Hymenoptera · Distribution · Jammu and Kashmir State

## 27.1 Introduction

Ants are classified in a single family, Formicidae, within the order Hymenoptera; the latter also contains bees and wasps. The main morphological characteristics that delimit all adult ants from other Hymenoptera include: (i) the presence of a metapleural gland, unique to ants, above the hind pair of coxae (secondarily lacking in many males and in the queens and workers of some formicine groups, e.g. sugar ants); (ii) the presence of a wingless worker caste (secondarily lost in a few parasitic species that have queens and males only), wings of alate queens deciduous,

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_27

shed after mating; (iii) the possession of reduced second abdominal segment, forming a node or scale (the petiole), isolated from the mesosoma in front and the remaining abdominal segments behind, frequently the third abdominal segment is also reduced and isolated (postpetiole); (iv) and elbowed ('geniculate') antennae with 4–12 segments in queens and workers, with 9–13 segments in males. In general, living ants are mainly seen by a layperson as wingless, social insects, quickly resolving any doubt as to their identity (Hölldobler and Wilson 1990; Bolton 1994; Heterick 2009).

Ants like other groups of organisms have received little research attention, especially in India in general, and Jammu and Kashmir (J&K) in particular. The work carried out by Bingham (1903), about more than a century ago, stands outdated at present and needs comprehensive revision. Most of the species are insufficiently described outside the context of any revisionary work and largely without any comparative study. Although the ant fauna of J&K is highly diverse, the ant taxonomy in the State remains problematic with status of many taxa being dubious, since no detailed research efforts have ever been undertaken.

## 27.2 Materials and Methods

Jammu and Kashmir is biogeographically complex and diverse, the flora and fauna has passed through various stages during geomorphological evolution of this region. Historically, the region has been colonized at different times by Malayan, Afrotropical, Mediterranean, Central Asian and Temperate elements. Variable environment has further acted upon this mosaic of geographical forms leading to extinction of species, breaking up of dispersal barriers and extension of distributional ranges and eventually induction of genetic variations with or without speciation (Bharti 2008; Bharti et al. 2013a). The J&K State comprises of three regions: Jammu, Kashmir and Ladakh, housing different ant fauna (Table 27.1).

This chapter provides an updated taxonomic inventory of the ant species of J&K based on critical review of the literature and on the biological material collected during several field surveys conducted in the State during the last one decade. The species' inventory presented here includes the valid scientific names of all ant species with their occurrence record in the three regions, i.e. Jammu (J), Kashmir (K) and Ladakh (L) (Table 27.1). Nonetheless, some of the ant species recorded in literature (Bharti et al. 2013a) have been excluded due to their doubtful occurrence in the State. The names of the taxa presented are in agreement with the current Formicidae classification following AntWeb (Bolton 2017) (Plates 27.1 and 27.2).

## 27.3 Results

**Table 27.1** Inventory of ants in Jammu and Kashmir arranged by subfamily, genus and species

| S. No. | Species | J | K | L | Literature Source |
|---|---|---|---|---|---|
| **1. Subfamily Amblyoponinae Forel, 1893** | | | | | |
| 1. | *Prionopelta kraepelini* Forel, 1905 | + | – | – | Bharti and Wachkoo (2012a) and Bharti et al. (2017) |
| **2. Subfamily Dolichoderinae Forel, 1878** | | | | | |
| 2. | *Chronoxenus dalyi* (Forel, 1895) | – | + | – | Thapa (2000) |
| 3. | *Chronoxenus myops* (Forel, 1895) | + | + | – | Menozzi (1939) and Bharti et al. (2013a) |
| 4. | *Chronoxenus wroughtonii* (Forel, 1895) | + | + | – | Menozzi (1939) and Bharti et al. (2017) |
| 5. | *Dolichoderus taprobanae* (Smith, F., 1858) | + | – | – | Bharti et al. (2013a) |
| 6. | *Dolichoderus thoracius* (Smith, F., 1860) | + | – | – | Bharti et al. (2013a) |
| 7. | *Tapinoma himalaica* Bharti, Kumar and Dubovikoff, 2013b | + | – | – | Bharti et al. (2013b, 2017) |
| 8. | *Tapinoma melanocephalum* (Fabricius, 1793) | + | + | – | Bharti et al. (2013a, 2017) |
| 9. | *Tapinoma wroughtonii* Forel, 1904 | – | + | – | Forel (1906), Emery (1913, 1925), Chapman and Capco (1951), and Shattuck (1994) |
| 10. | *Technomyrmex albipes* (Smith, F., 1861) | + | – | – | Bharti et al. (2013a) |
| 11. | *Technomyrmex rector* Bolton, 2007 | + | – | – | Bharti et al. (2017) |
| **3. Subfamily Dorylinae Leach, 1815** | | | | | |
| 12. | *Aenictus aitkenii* Forel, 1901 | + | – | – | Bharti et al. (2013a) |
| 13. | *Aenictus ceylonicus* (Mayr, 1866) | + | – | – | Bharti et al. (2017) |
| 14. | *Aenictus doryloides* Wilson, 1964 | + | – | – | Bharti et al. (2013a) |
| 15. | *Aenictus pachycerus* (Smith, F., 1858) | + | – | – | Bharti et al. (2013a) |
| 16. | *Dorylus labiatus* Shuckard, 1840 | + | – | – | Bharti et al. (2013a) |
| 17. | *Dorylus orientalis* Westwood, 1835 | + | – | – | Bharti et al. (2013a, 2017) |
| 18. | *Ooceraea biroi* (Forel, 1907) | + | – | – | Bharti et al. (2013a, 2017) |
| 19. | *Lioponera longitarsus* Mayr, 1879 | + | – | – | Bharti et al. (2013a, 2017) |
| **4. Subfamily Formicinae Latreille, 1809** | | | | | |
| 20. | *Camponotus aethiops cachmiriensis* Emery, 1925 | – | + | – | Forel (1904, 1906) |
| 21. | *Camponotus buddhae* Forel, 1892 | – | – | + | AntWeb (2017) |

(continued)

**Table 27.1** (continued)

| S. No. | Species | J | K | L | Literature Source |
|---|---|---|---|---|---|
| 22. | *Camponotus compressus* (Fabricius, 1787) | + | – | – | Bharti et al. (2013a, 2017) |
| 23. | *Camponotus himalayanus* Forel, 1893 | + | – | – | Bharti et al. (2013a, 2017) |
| 24. | *Camponotus mitis* (Smith, 1858) | + | – | – | Bharti et al. (2017) |
| 25. | *Camponotus mutilarius* Emery, 1893 | + | – | – | Wachkoo (2015) and Bharti et al. (2017) |
| 26. | *Camponotus nirvanae* Forel, 1893 | + | – | – | Bharti et al. (2017) |
| 27. | *Camponotus oblongus binominatus* Forel, 1916 | + | – | – | Bharti et al. (2013a, 2017) |
| 28. | *Camponotus opaciventris* Mayr, 1879 | + | – | – | Wachkoo and Akbar (2016) and Bharti et al. (2017) |
| 29. | *Camponotus parius* Emery, 1889 | + | – | – | Bharti et al. (2013a, 2017) |
| 30. | *Camponotus socrates* Forel, 1904 | – | + | – | Forel (1906) and Menozzi (1939) |
| 31. | *Camponotus sylvaticus basalis* Smith, 1878 | – | + | + | Bingham (1903), Forel (1906), and Menozzi (1939) |
| 32. | *Camponotus sylvaticus paradichrous* Emery, 1925 | – | + | + | Menozzi (1939) and Mani and Singh (1962) |
| 33. | *Cataglyphis cugiai* Menozzi, 1939 | + | – | + | Menozzi (1939), Mani and Singh (1962), and Bharti et al. (2013a, 2014) |
| 34. | *Cataglyphis setipes* (Forel, 1894) | + | – | – | Wachkoo and Bharti (2015a) and Bharti et al. (2017) |
| 35. | *Formica candida* Smith, 1878 | – | – | + | Seifert (2004) |
| 36. | *Formica clara* Forel, 1886 | + | + | + | Bharti et al. (2013a) and Gul (2013) |
| 37. | *Formica cunicularia* Latreille, 1798 | + | + | – | Bharti et al. (2013a) and Gul (2013) |
| 38. | *Formica fusca* Linnaeus, 1758 | + | + | + | Menozzi (1939) and Bharti et al. (2013a) |
| 39. | *Formica gagates* Latreille, 1798 | – | + | – | Bharti et al. (2013a) and Gul (2013) |
| 40. | *Formica gagatoides* Ruzsky, 1904 | + | + | – | Bharti et al. (2013a) and Gul (2013) |
| 41. | *Formica kashmirica* Stärcke, 1935 | – | – | + | Stärcke (1935) and Seifert and Schultz (2009) |
| 42. | *Formica picea* Nylander, 1846 | – | + | + | Menozzi (1939) and Mani and Singh (1962) |
| 43. | *Formica rufibarbis* Fabricius, 1793 | – | + | – | Forel (1904) |
| 44. | *Formica sanguinea* Latreille, 1798 | + | + | – | Menozzi (1939), Bharti et al. (2013a), and Gul (2013) |
| 45. | *Formica truncorum* Fabricius, 1804 | + | + | – | Bharti et al. (2013a) and Gul (2013) |
| 46. | *Lasius alienoflavus* Bingham, 1903 | + | + | – | Collingwood (1982), Bharti et al. (2013a), and Bharti and Gul (2014) |
| 47. | *Lasius alienus* (Foerster, 1850) | + | + | + | Menozzi (1939), Collingwood (1982), Bharti et al. (2013a), and Gul (2013) |
| 48. | *Lasius bicornis* (Foerster, 1850) | – | + | – | Donisthorpe (1930), Wilson (1955), and Collingwood (1982) |

(continued)

**Table 27.1** (continued)

| S. No. | Species | J | K | L | Literature Source |
|---|---|---|---|---|---|
| 49. | *Lasius brunneus* (Latreille, 1798) | + | + | – | Bharti et al. (2013a) and Gul (2013) |
| 50. | *Lasius crinitus* (Smith, 1858) | – | + | – | Forel (1894, 1906), Bingham (1903), and Wilson (1955) |
| 51. | *Lasius himalayanus* Bingham, 1903 | – | + | – | Menozzi (1939) and Seifert (1992) |
| 52. | *Lasius lawarai* Seifert, 1992 | – | + | – | Gul (2013) |
| 53. | *Lasius niger* (Linnaeus, 1758) | + | + | + | Menozzi (1939), Collingwood (1982), and Bharti et al. (2013a) |
| 54. | *Lasius wittmeri* Seifert, 1992 | – | + | – | Seifert (1992) |
| 55. | *Lepisiota bipartita* (Smith, 1861) | + | + | – | Menozzi (1939); Bharti et al. (2017) |
| 56. | *Lepisiota capensis* (Mayr, 1862) | + | – | – | Bharti et al. (2013a) |
| 57. | *Lepisiota capensis lunaris* (Emery, 1893) | – | + | – | Forel (1904) and Menozzi (1939) |
| 58. | *Lepisiota frauenfeldi integra* (Forel, 1894) | + | – | – | Bharti et al. (2013a, 2017) |
| 59. | *Lepisiota modesta* (Forel, 1894) | + | – | – | Wachkoo (2017, personal collection) |
| 60. | *Lepisiota opaca* (Forel, 1892) | + | – | – | Bharti et al. (2013a) |
| 61. | *Lepisiota opaca pulchella* (Forel, 1892) | + | – | – | Bharti et al. (2013a, 2017) |
| 62. | *Lepisiota sericea* (Forel, 1892) | + | – | – | Bharti et al. (2017) |
| 63. | *Lepisiota simplex* (Forel, 1892) | + | – | – | Bharti et al. (2017) |
| 64. | *Nylanderia indica* (Forel, 1894) | – | + | – | AntWeb (2017) |
| 65. | *Nylanderia smythiesii* (Forel, 1894) | + | – | – | Wachkoo and Bharti (2014, 2015b) and Bharti et al. (2017) |
| 66. | *Nylanderia taylori* (Forel, 1894) | + | – | – | Bharti et al. (2013a) |
| 67. | *Oecophylla smaragdina* (Fabricius, 1775) | + | – | – | Bharti et al. (2013a, 2017) |
| 68. | *Paraparatrechina aseta* (Forel, 1902) | – | + | – | Bharti et al. (2013a) |
| 69. | *Paratrechina longicornis* (Latreille, 1802) | + | – | – | Bharti et al. (2013a, 2017) |
| 70. | *Plagiolepis balestrierii* Menozzi, 1939 | – | – | + | Menozzi (1939) and Mani and Singh (1962) |
| 71. | *Plagiolepis dichroa* Forel, 1902 | + | – | – | Bharti et al. (2013a, 2017) |
| 72. | *Plagiolepis jerdonii* Forel, 1894 | + | – | – | Bharti et al. (2013a, 2017) |
| 73. | *Polyrhachis exercita lucidiventris* Forel, 1907 | + | – | – | Bharti et al. (2013a) |
| 74. | *Polyrhachis illaudata* Walker, 1859 | + | – | – | Bharti et al. (2013a) |
| 75. | *Polyrhachis lacteipennis* Smith, F., 1858 | + | + | – | Bolton (1974) and Bharti et al. (2013a, 2017) |
| 76. | *Polyrhachis menelas* Forel, 1904 | + | – | – | Bharti et al. (2017) |
| 77. | *Polyrhachis punctillata smythiesii* Forel, 1895 | + | – | – | Bharti et al. (2013a, 2017) |

(continued)

**Table 27.1** (continued)

| S. No. | Species | J | K | L | Literature Source |
|---|---|---|---|---|---|
| 78. | *Prenolepis naoroji* Forel, 1902 | + | – | – | Bharti and Wachkoo (2012b) and Bharti et al. (2013a, 2017) |
| 79. | *Pseudolasius familiaris* (Smith, F., 1860) | + | – | – | Bharti et al. (2013a) |
| 80. | *Pseudolasius machhediensis* Bharti, Gul and Sharma, 2012a | + | – | – | Bharti et al. (2012a) |
| **5. Subfamily Myrmicinae Lepeletier de Saint-Fargeau, 1835** | | | | | |
| 81. | *Aphaenogaster beesoni* Donisthorpe, 1933 | + | – | – | Gul (2013) |
| 82. | *Aphaenogaster cristata* (Forel, 1902) | + | – | – | Bharti et al. (2013a) |
| 83. | *Aphaenogaster feae* Emery, 1899 | + | – | – | Bharti et al. (2013a) |
| 84. | *Aphaenogaster rothneyi* (Forel, 1902) | + | – | – | Bharti et al. (2013a) |
| 85. | *Aphaenogaster sagei* (Forel, 1902) | + | + | + | Menozzi (1939); Bharti et al. (2013a) |
| 86. | *Aphaenogaster sagei pachei* (Forel, 1906) | – | + | – | Bharti et al. (2013a) |
| 87. | *Aphaenogaster smythiesii* (Forel, 1902) | + | + | – | Menozzi (1939) and Bharti et al. (2013a) |
| 88. | *Aphaenogaster smythiesii prudens* (Forel, 1902) | + | – | – | Bharti et al. (2013a) |
| 89. | *Cardiocondyla wroughtonii* (Forel, 1890) | + | – | – | Bharti et al. (2013a, 2017) |
| 90. | *Carebara affinis* (Jerdon, 1851) | + | – | – | Bharti et al. (2013a, 2017) |
| 91. | *Carebara dentata* Bharti and Kumar, 2013 | + | – | – | Bharti and Kumar (2013) and Bharti et al. (2017) |
| 92. | *Carebara propomegata* Bharti and Kumar, 2013 | + | – | – | Bharti and Kumar (2013) and Bharti et al. (2017) |
| 93. | *Carebara rectangulata* Bharti and Kumar, 2013 | + | – | – | Bharti and Kumar (2013) and Bharti et al. (2017) |
| 94. | *Carebara spinata* Bharti and Kumar, 2013 | + | – | – | Bharti and Kumar (2013) and Bharti et al. (2017) |
| 95. | *Cataulacus taprobanae* Smith, F., 1853 | + | – | – | Bharti et al. (2013a, 2017) |
| 96. | *Crematogaster anthracina* Smith, F., 1857 | + | – | – | Bharti et al. (2013a, 2017) |
| 97. | *Crematogaster binghamii* Forel, 1904 | + | – | – | Bharti et al. (2017) |
| 98. | *Crematogaster biroi* Mayr, 1897 | + | – | – | Bharti et al. (2013a) |
| 99. | *Crematogaster biroi smythiesii* Forel, 1902 | + | – | – | Bharti et al. (2017) |
| 100. | *Crematogaster flava* Forel, 1886 | + | – | – | Bharti et al. (2013a) |
| 101. | *Crematogaster politula* Forel, 1902 | + | – | – | Bharti et al. (2013a) |

(continued)

**Table 27.1** (continued)

| S. No. | Species | J | K | L | Literature Source |
|---|---|---|---|---|---|
| 102. | *Crematogaster rogenhoferi* Mayr, 1879 | + | – | – | Bharti et al. (2013a) |
| 103. | *Crematogaster rothneyi* Mayr, 1879 | + | – | – | Bharti et al. (2017) |
| 104. | *Crematogaster sagei* Forel, 1902 | + | – | – | Bharti et al. (2013a, 2017) |
| 105. | *Crematogaster subnuda* Mayr, 1879 | + | – | – | Bharti et al. (2013a, 2017) |
| 106. | *Lophomyrmex ambiguus* Rigato, 1994 | + | – | – | Bharti et al. (2013a) |
| 107. | *Lophomyrmex bedoti* Emery, 1893 | + | – | – | Bharti et al. (2013a) |
| 108. | *Lophomyrmex quadrispinosus* (Jerdon, 1851) | + | – | – | Bharti et al. (2013a) |
| 109. | *Mayriella transfuga* Baroni Urbani, 1977 | + | – | – | Bharti et al. (2013a) |
| 110. | *Meranoplus bicolor* (Guerin-Meneville,1844) | + | – | – | Bharti et al. (2013a, 2017) |
| 111. | *Messor himalayanus* (Forel, 1902) | + | + | – | Forel (1902, 1903, 1904, 1906), Menozzi (1939), and Bharti et al. (2013a) |
| 112. | *Messor instabilis* (Smith, F., 1858) | + | + | – | Wheeler (1922), Menozzi (1939), and Bharti et al. (2013a) |
| 113. | *Messor semirufus* (Andre, 1883) | – | + | – | Forel (1886) |
| 114. | *Monomorium floricola* (Jerdon, 1851) | + | – | – | Bharti et al. (2013a) |
| 115. | *Monomorium indicum* Forel, 1902 | + | – | – | Bharti et al. (2013a, 2017) |
| 116. | *Monomorium luisae* Forel, 1904 | – | + | – | Ettershank (1966) |
| 117. | *Monomorium orientale* Mayr, 1879 | + | – | – | Bharti et al. (2013a, 2017) |
| 118. | *Monomorium pharaonis* (Linnaeus, 1758) | + | – | – | Bharti et al. (2013a, 2017) |
| 119. | *Monomorium sagei* Forel, 1902 | + | + | – | Menozzi (1939) and Bharti et al. (2013a, 2017) |
| 120. | *Myrmica aimonissabaudiae* Menozzi, 1939 | + | + | + | Menozzi (1939), Mani and Singh (1962), Radchenko and Elmes (2001), and Bharti et al. (2013a, 2016) |
| 121. | *Myrmica cachmiriensis* Forel, 1904 | + | + | + | Forel (1904), Radchenko and Elmes (2001), and Bharti et al. (2013a, 2016) |
| 122. | *Myrmica elmesi* Bharti and Sharma, 2011 | + | – | – | Bharti and Sharma (2011a) |
| 123. | *Myrmica ereptrix* Bolton, 1988 | – | + | – | Bolton (1988) and Radchenko and Elmes (2001) |
| 124. | *Myrmica fortior* Forel, 1904 | + | + | – | Radchenko and Elmes (2001) and Bharti et al. (2013a, 2016) |
| 125. | *Myrmica hecate* Weber, 1947 | – | + | – | Radchenko and Elmes (2001) and Bharti et al. (2016) |

(continued)

**Table 27.1** (continued)

| S. No. | Species | J | K | L | Literature Source |
|---|---|---|---|---|---|
| 126. | *Myrmica longisculpta* Bharti and Sharma, 2011 | + | + | – | Bharti and Sharma (2011b) |
| 127. | *Myrmica nitida* Radchenko and Elmes, 1999 | + | + | – | Radchenko and Elmes (1999, 2001) and Bharti et al. (2013a, 2016) |
| 128. | *Myrmica ordinaria* Radchenko and Elmes, 1999 | + | + | + | Radchenko and Elmes (1999, 2001) and Bharti et al. (2016) |
| 129. | *Myrmica petita* Radchenko and Elmes, 1999 | – | + | – | Radchenko and Elmes (1999, 2001) and Bharti et al. (2016) |
| 130. | *Myrmica radchenkoi* Bharti and Sharma, 2011 | + | – | – | Bharti and Sharma (2011c) |
| 131. | *Myrmica rhytida* Radchenko and Elmes, 1999 | + | + | – | Radchenko and Elmes (1999, 2001) and Bharti et al. (2013a, 2016) |
| 132. | *Myrmica rugosa* Mayr, 1865 | + | + | – | Radchenko and Elmes (2001) and Bharti et al. (2013a, 2016) |
| 133. | *Myrmica rupestris* Forel, 1902 | + | + | – | Radchenko and Elmes (2001) and Bharti et al. (2013a, 2016) |
| 134. | *Myrmica smythiesii* Forel, 1902 | + | + | – | Bharti et al. (2013a, 2016) |
| 135. | *Myrmica varisculpta* Radchenko and Rigato, 2009 | – | – | + | Radchenko and Elmes (2009) and Bharti et al. (2016) |
| 136. | *Myrmica wardi* Radchenko and Elmes, 1999 | + | + | + | Radchenko and Elmes (1999, 2001) and Bharti et al. (2013a, 2016) |
| 137. | *Myrmica williamsi* Radchenko and Elmes, 1999 | + | + | – | Radchenko and Elmes (1999, 2001) and Bharti et al. (2016) |
| 138. | *Myrmicaria brunnea* Saunders, 1842 | + | – | – | Bharti et al. (2013a, 2017) |
| 139. | *Pheidole binghamii* Forel, 1902 | + | – | – | Bharti et al. (2013a) |
| 140. | *Pheidole fervens* Smith, F., 1858 | + | – | – | Bharti et al. (2013a) |
| 141. | *Pheidole indica* Mayr, 1879 | + | + | – | Bingham (1903), Menozzi (1939), and Bharti et al. (2013a) |
| 142. | *Pheidole jucunda* Forel, 1885 | + | + | – | Bharti et al. (2013a) |
| 143. | *Pheidole jucunda fossulata* Forel, 1902 | + | – | – | Bharti et al. (2013a) |
| 144. | *Pheidole latinoda angustior* Forel, 1902 | + | – | – | Bharti et al. (2013a) |
| 145. | *Pheidole latinoda major* Forel, 1885 | + | – | – | Bharti et al. (2013a, 2017) |
| 146. | *Pheidole parva* Mayr, 1865 | + | – | – | Bharti et al. (2017) |
| 147. | *Pheidole sagei* Forel, 1902 | + | + | – | Menozzi (1939) and Bharti et al. (2013a) |
| 148. | *Pheidole sharpi* Forel, 1902 | + | – | – | Bharti et al. (2013a) |
| 149. | *Pheidole smythiesii* Forel, 1902 | + | – | – | Bharti et al. (2013a) |
| 150. | *Pheidole spathifera* Forel, 1902 | + | – | – | Bharti et al. (2013a) |
| 151. | *Pheidole spathifera aspatha* Forel, 1902 | + | – | – | Bharti et al. (2013a) |

(continued)

**Table 27.1** (continued)

| S. No. | Species | J | K | L | Literature Source |
|---|---|---|---|---|---|
| 152. | *Pheidole watsoni* Forel, 1902 | + | – | – | Bharti et al. (2013a) |
| 153. | *Pheidole woodmasoni* Forel, 1885 | + | – | – | Bharti et al. (2013a, 2017) |
| 154. | *Recurvidris recurvispinosa* (Forel, 1890) | + | – | – | Bharti et al. (2013a, 2017) |
| 155. | *Solenopsis geminata* (Fabricius, 1804) | + | – | – | Bharti et al. (2013a) |
| 156. | *Stenamma kashmirense* Baroni Urbani, 1977 | – | + | – | Baroni Urbani (1977), DuBois (1998), and Liu and Xu (2011) |
| 157. | *Strumigenys membranifera* Emery, 1869 | + | – | – | Bharti et al. (2017) |
| 158. | *Temnothorax desioi* (Menozzi, 1939) | + | + | + | Menozzi (1939), Bharti et al. (2013a), and Gul (2013) |
| 159. | *Temnothorax desioi melanicus* (Menozzi, 1939) | + | – | – | Bharti et al. (2013a) |
| 160. | *Temnothorax fultonii* (Forel, 1902) | + | + | – | Bharti et al. (2013a) and Gul (2013) |
| 161. | *Temnothorax himachalensis* Bharti, Gul and Schulz, 2012b | – | + | + | Bharti et al. (2012b) |
| 162. | *Temnothorax kashmirensis* Bharti, Gul and Schulz, 2012b | – | + | – | Bharti et al. (2012b) |
| 163. | *Temnothorax rothneyi* (Forel, 1902) | + | – | – | Bharti et al. (2013a) |
| 164. | *Temnothorax wroughtonii* (Forel, 1904) | – | + | – | Forel (1904, 1906) |
| 165. | *Tetramorium elisabethae* Forel, 1904 | – | + | – | Forel (1904) and Bolton (1977) |
| 166. | *Tetramorium lanuginosum* Mayr, 1870 | + | – | – | Bharti et al. (2013a, 2017) |
| 167. | *Tetramorium simillimum* (Smith, F., 1851) | + | – | – | Bharti et al. (2013a) |
| 168. | *Tetramorium smithi* Mayr, 1879 | + | – | – | Bharti et al. (2013a, 2017) |
| 169. | *Tetramorium walshi* (Forel, 1890) | + | – | – | Bharti et al. (2013a) |
| 170. | *Trichomyrmex aberrans* (Forel, 1902) | + | – | – | Bharti et al. (2013a, 2017) |
| 171. | *Trichomyrmex destructor* (Jerdon, 1851) | + | – | – | Bharti et al. (2013a, 2017) |
| 172. | *Trichomyrmex glaber* (André, 1883) | + | – | – | Bharti et al. (2013a) |
| 173. | *Trichomyrmex scabriceps* (Mayr, 1879) | + | – | – | Bharti et al. (2013a, 2017) |
| **6. Subfamily Ponerinae Lepeletier de Saint-Fargeau, 1835** | | | | | |
| 174. | *Anochetus cryptus* Bharti and Wachkoo, 2013 | + | – | – | Bharti and Wachkoo (2013a) and Bharti et al. (2017) |
| 175. | *Anochetus graeffei* Mayr, 1870 | + | – | – | Bharti et al. (2013a, 2017) |

(continued)

**Table 27.1** (continued)

| S. No. | Species | J | K | L | Literature Source |
|---|---|---|---|---|---|
| 176. | *Anochetus madaraszi* Mayr, 1897 | + | – | – | Bharti et al. (2017) |
| 177. | *Anochetus validus* Bharti and Wachkoo, 2013 | + | – | – | Bharti and Wachkoo (2013a) and Bharti et al. (2017) |
| 178. | *Brachyponera jerdonii* (Forel, 1900) | + | – | – | Bharti et al. (2017) |
| 179. | *Brachyponera luteipes* (Mayr, 1862) | + | – | – | Bharti et al. (2013a, 2017) |
| 180. | *Cryptopone subterranea* Bharti and Wachkoo, 2013 | + | – | – | Bharti and Wachkoo (2013b) and Bharti et al. (2017) |
| 181. | *Harpegnathos venator* (Smith, F., 1858) | + | – | – | Bharti et al. (2013a, 2017) |
| 182. | *Hypoponera assmuthi* (Forel, 1905) | + | – | – | Bharti et al. (2015, 2017) |
| 183. | *Hypoponera confinis* (Roger, 1860) | + | – | – | Bharti et al. (2013a, 2015, 2017) |
| 184. | *Hypoponera kashmirensis* Bharti, Akbar, Wachkoo and Singh, 2015 | – | + | – | Bharti et al. (2015) |
| 185. | *Hypoponera ragusai* (Emery, 1894) | + | – | – | Bharti et al. (2015, 2017) |
| 186. | *Leptogenys bhartii* Wachkoo, Maqbool, Akbar and Sharaf, 2018 | + | – | – | Wachkoo et al. (2018) |
| 187. | *Leptogenys chinensis* (Mayr, 1870) | + | – | – | Bharti et al. (2017) |
| 188. | *Leptogenys diminuta laeviceps* (Smith, 1857) | + | – | – | Bharti et al. (2017) |
| 189. | *Myopias shivalikensis* Bharti and Wachkoo, 2012 | + | – | – | Bharti and Wachkoo (2012c) and Bharti et al. (2017) |
| 190. | *Odontomachus monticola* Emery, 1892 | + | – | – | Bharti et al. (2013a) |
| 191. | *Odontomachus rixosus* Smith, F., 1857 | + | – | – | Bharti et al. (2013a) |
| 192. | *Odontoponera denticulata* (Smith, 1858) | + | – | – | Bharti et al. (2017) |
| 193. | *Platythyrea parallela* (Smith, 1859) | + | – | – | Bharti et al. (2017) |
| 194. | *Pseudoneoponera bispinosa* (Smith, F., 1858) | + | – | – | Bingham (1903) and Bharti et al. (2013a) |
| 195. | *Pseudoneoponera rufipes* (Jerdon, 1851) | + | – | – | Bingham (1903) and Bharti et al. (2013a, 2017) |
| **7. Subfamily Pseudomyrmecinae Smith, 1952** | | | | | |
| 196. | *Tetraponera allaborans* (Walker, 1859) | + | – | – | Bharti et al. (2013a, 2017) |
| 197. | *Tetraponera nigra* (Jerdon, 1851) | + | – | – | Bharti et al. (2013a, 2017) |
| 198. | *Tetraponera rufonigra* (Jerdon, 1851) | + | – | – | Bharti et al. (2013a, 2017) |

Abbreviations: *J* Jammu, *K* Kashmir, *L* Ladakh; presence of each species in these regions is marked with '+' whilst absence is marked with '–'


**Plate 27.1** **1–10** Habitus lateral view & head full-face view of some regional ants: **1–2** *Prionopelta kraepelini* Forel, 1905; **3–4** *Tapinoma melanocephalum* (Fabricius, 1793); **5–6** *Ooceraea biroi* (Forel, 1907); **7–8** *Stenamma kashmirense* Baroni Urbani, 1977; **9–10** *Temnothorax kashmirensis* Bharti, Gul & Schulz, 2012b. (Images courtesy AntWeb)

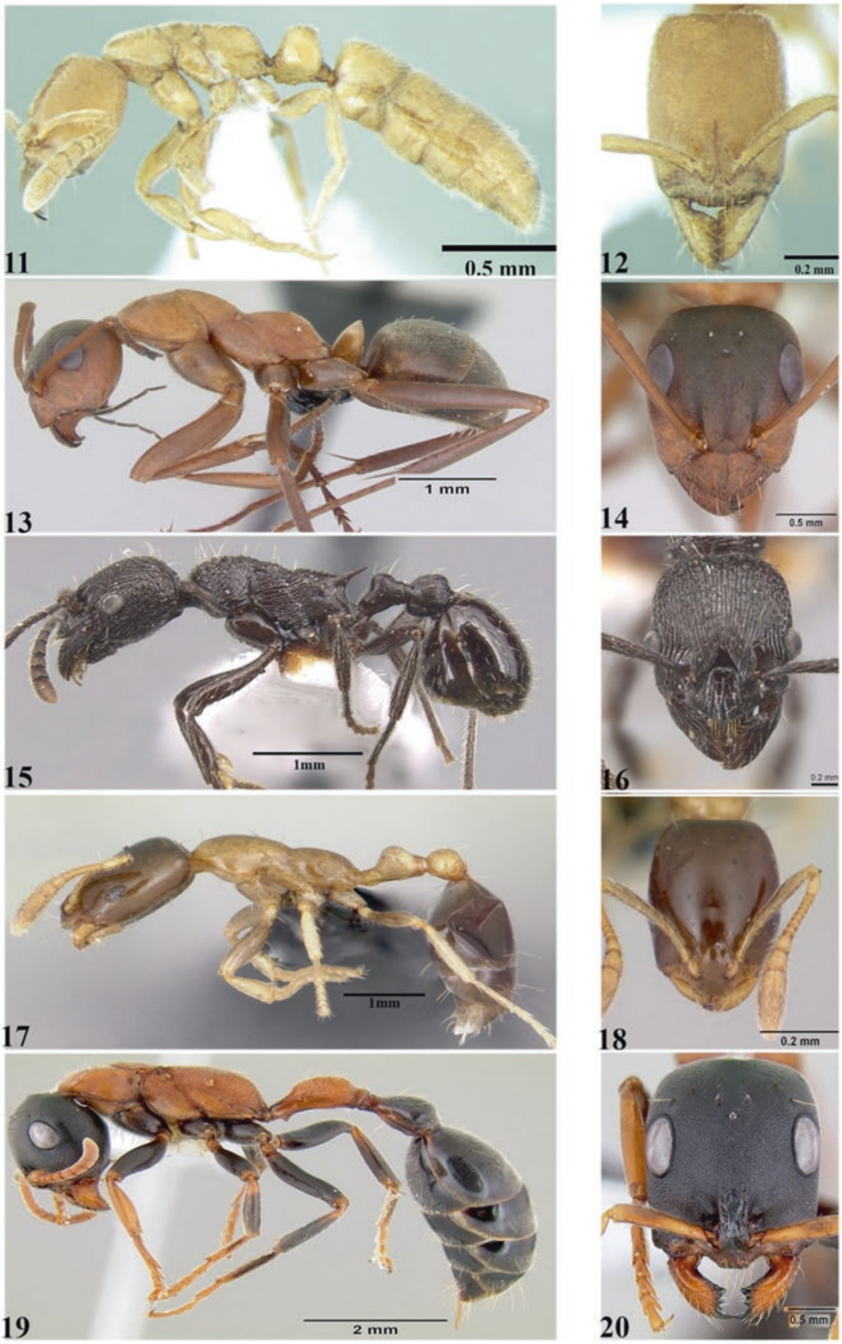


**Plate 27.2** **11–20** Habitus lateral view & head full-face view of some regional ants: **11–2** *Hypoponera kashmirensis* Bharti, Akbar, Wachkoo & Singh, 2015; **13–14** *Formica clara* Forel, 1886; **15–16** *Myrmica varisculpta* Radchenko & Rigato, 2009; **17–18** *Monomorium floricola* (Jerdon, 1851); **19–20** *Tetraponera rufonigra* (Jerdon, 1851). (Images courtesy AntWeb)

## 27.4 Concluding Remarks

This chapter documents a total of 198 ant taxa (i.e. species and subspecies) representing 54 genera and 7 subfamilies recorded from Jammu and Kashmir. Subfamily Myrmicinae is most diverse with 93 species followed by Formicinae with 61 species. Most diverse genera in terms of species' richness are *Myrmica* with 18 species followed by *Pheidole* (15 spp.); *Camponotus* (13 spp.); *Formica* (11 spp.) and *Crematogaster* (10 spp.). With respect to species' richness Jammu region harbours 164 species (82.83%), Kashmir 66 species (33.33%) and Ladakh 20 species (10.10%). The overall species' richness recorded across the three regions of Jammu and Kashmir is skewed towards Jammu, owing to the fact that most of the recent surveys were undertaken in this region (Bharti et al. 2017). Since most of the ant collection to date has been conducted in a small number of locations in Jammu and Kashmir, it is likely that many more species of the ants await discovery which can provide accurate species composition of the regions. This preset chapter constitutes a synthesis of what is known about the ants of Jammu and Kashmir. The intent of this work is to facilitate future research on ant fauna of the Jammu and Kashmir by providing the first comprehensive species' inventory. These studies are crucial to develop conservation strategies before local populations and endemic species are driven to extinction.

**Acknowledgements** Sincere thanks are due to Dr. Irfan Gul for providing the distributional records of some unpublished taxa in Jammu and Kashmir. We are also thankful to AntWeb (www.antweb.org), AntMaps (www.antmaps.org) and AntWiki (www.antwiki.org) for their immensely useful work.

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# Chapter 28
# Biodiversity of Butterflies (Lepidoptera: Rhopalocera) of Jammu and Kashmir State

**Aijaz Ahmad Qureshi**

**Abstract** The chapter reports butterfly fauna occurring in Jammu and Kashmir State. A total of 408 species belonging to 129 genera distributed under 25 subfamilies in 5 families are known to occur in the three distinct biogeographic regions of the State (Jammu, Kashmir, and Ladakh); these species account for ca. 27% of the India's butterfly fauna. Ladakh region harbors the highest number of species (317) followed by Kashmir (274) and Jammu (192). The highest number of genera (52) is represented by family Nymphalidae followed by Lycaenidae (38), Hesperiidae (20), Pieridae (15), and Papilionidae (4); while the family with highest number of species is Nymphalidae (166) followed by Papilionidae (81), Lycaenidae (80), Pieridae (50), and Hesperiidae (31). Biogeographically, 150 species are common to all the three regions, while 17, 50, and 116 species exclusively occur in Jammu, Kashmir, and Ladakh. In addition, 38 species of butterflies from the State have been included in the Wildlife (Protection) Act of India (1972). The present effort in documenting the butterfly fauna will form the baseline for undertaking future research, conservation and management strategies on butterfly biodiversity of this Himalayan State.

**Keywords** Biodiversity · Butterfly Fauna · Lepidoptera: Rhopalocera · Conservation · Jammu and Kashmir State

## 28.1 Introduction

Butterflies along with moths belong to insect order Lepidoptera and are perhaps the most conspicuous and colorful of insects (Kunte 2006). They undergo 'complete metamorphosis' and have four distinct stages in their life cycle (the egg, the larva, the pupa and the adult), and each stage of development takes its own time. Usually

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_28

the larval (caterpillar) stage is the longest, and the egg stage is the shortest. A number of factors, such as high species richness, occurrence across the world and variety of habitats (Kristensen et al. 2007), relatively easy to sample and identify with the help of field guides (Basset et al. 2011), highly sensitive to environmental changes (Spitzer et al. 1997), and above all being charismatic insects that attract the public attention, have made butterflies one of the most studied groups of organisms among the invertebrates (Varshney 1993; Spitzer et al. 1997) and qualified them to be considered as ideal candidates for indicator, umbrella and/or flagship species New 1997; Spitzer et al. 1997; Fleishman et al. 2000; Maes and Van Dyck 2001; Kristensen et al. 2007). Besides being used in biogeography, evolution and plant–insect interaction research, they play an important role in ecosystem functioning, including nutrient cycling and pollination. For instance, the association of blue caterpillars with ants is an astonishing case of coevolution (Kunte 2006). The habitats of butterflies are strictly terrestrial, and virtually all butterflies are associated with plants, and their occurrence depends on the presence of plants (Kunte 2006).

The total number of known species of Lepidoptera which makes up about 10% of the animal Kingdom, approaches 200,000 (Holloway et al. 1987) to 2,55,000 (Heppner 1991), most of which are moths (Heterocera) and only about 15,000 to 18,000 are butterflies (Rhopalocera) (Holloway et al. 1987; Shields 1989). India is also rich in butterfly fauna, and about 1400–1500 species (Bingham 1905, 1907; Talbot 1939, 1947; Wynter-Blyth 1957; Gaonkar 1996; Haribal 1992; Kunte 2006; Kehimkar 2008; Varshney and Smetacek 2015) have already been reported from the Indian subcontinent. The Jammu and Kashmir (J&K) State has also a unique and diverse butterfly fauna with respect to other parts of India. However, the information on butterfly fauna of this vital Himalayan region remains vague, erratic, scattered and poorly explored and documented. The present work is an attempt to document the butterfly diversity of this Himalayan State, and it is hoped that it will prove a baseline data for further studying these beautiful lifeforms.

## 28.2 Materials and Methods

The inventory data of the butterfly fauna was obtained from a comprehensive literature review. For compilation of the checklist, all the relevant scientific literature available has been perused. The earlier workers, prior to 1947, who have contributed to the information on butterfly fauna of the State include Kollar 1844; Horsfield and Moore 1857; Lang 1868; Moore 1874; Marshal and de Niceville 1883, 1886, 1889; Bingham 1905, 1907; Evans 1932; Thomas-Glover 1936; Home 1938; and Talbot 1939, 1947. Although these works remain relevant sources for developing the baseline data of butterfly wealth of J&K, many of these works, besides including Kashmir and Ladakh at that time, were covering whole of Indian subcontinent. Post 1947, during the last 70 years, a huge body of scientific literature has contributed to the knowledge base on butterflies of this biodiversity-rich region (Wynter-Blyth 1957; Das et al. 1964; Das and Verma 1965; Malik et al. 1972; Eisner 1978; Vis and

Coene 1987; Eisner and Weiss 1990; Jamdar 1991, 1992; Haribal 1992; Varshney 1993, 1994, 1997; Tshikolovets 2005; Kehimkar 2008; Khan et al. 2011a, b; Qureshi et al. 2012a, b, c; 2013a, b, c, d, e; 2014 Bala et al. 2014; Qureshi and Bhagat 2013, 2015) and Sondhi et al. 2017. For the present study, the classification scheme as proposed by Kunte (2012) and Varshney and Smetacek (2015) has been followed. The common names mostly as given in Evans (1932), Wynter-Blyth (1957), Varshney (1983), and Varshney and Smetacek (2015) have been followed. No attempt has been made to change the taxonomic position of a species, but at the same time, every effort has been made to put the species as per their valid taxonomic status.

## 28.3 Results and Discussion

A total of 408 species belonging to 5 families and distributed under 129 genera, which account for about 27% of the India's butterfly diversity, is reported from the J&K State (Table 28.1). Overall Ladakh region is reported to have the highest number of species (317) followed by Kashmir (274) and Jammu (192) regions. Family Nymphalidae is having highest number of species (166 spp.) which accounts for about 41% of the total butterfly fauna of the State, followed by Papilionidae (81 spp., 20%), Lycaenidae (80 spp., 19%), Pieridae (51 spp., 12%), and Hesperiidae (31 spp., 8%) (Table 28.1)**.** Some of the most diverse genera in terms of number of species include *Parnassius* having 58 species followed by *Hyponephele* (14 spp.), *Karanasa* (12 spp.), *Papilio* (12 spp.), *Argynnis* (11 spp.), *Colias* (11 spp.), *Polyommatus* (10 spp.), and *Ypthima* (10 spp.) (Table 28.1). The most diverse subfamily having the highest number of species is Satyrinae (76 spp.) followed by Parnassinae (58 spp.), Polyommatinae (48 spp.), Nymphalinae (33 spp.), Pierinae (27 spp.), Coliadinae (23 spp.), Papilioninae (23 spp.), Heliconinae (19 spp.), Pyrginae (16 spp.), Theclinae (16 spp.), Limenitinidae (14 spp.), Hesperiinae (13 spp.), and Lycaeninae (10 spp.) (Table 28.1; Fig. 28.1).

Biogeographically, 150 species (37%) are common to all the three regions, while 17 (4%), 50 (12%), and 116 (28%) species exclusively occur in Jammu, Kashmir, and Ladakh; and 24 (6%), 01 (0.25%), and 50 (12%) species are common between J&K, Jammu and Ladakh, and Kashmir and Ladakh regions, respectively (Fig. 28.2). Furthermore, 38 species belonging to 4 families, Nymphalidae (20 spp.), Pieridae (9 spp.), Lycaenidae (6 spp.), and Papilionidae (3 spp.), which account for 9% of the butterfly fauna of J&K have been included in the Wildlife (Protection) Act (WPA) of India (1972). Out of these, 6 species have been listed in the Schedule I and 31 species in the Schedule II of the Wildlife (Protection) Act of India (1972) (WPA), respectively (Table 28.1).

Despite being an important resource for socioeconomic development, the biodiversity of this Himalayan State which also includes butterfly wealth has suffered greatly due to varied anthropogenic pressures, more so in recent past. According to an estimate, about 40% of the endemic plant species in Kashmir Himalaya are cur-

**Table 28.1** Checklist of butterflies of J&K State

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| | **Family I: Hesperiidae** | | | |
| | **Subfamily: Coeliadinae** | | | |
| 1. | *Choaspes xanthopogan* (Kollar, [1844]) | Similar awlking | K | Varshney and Smetacek (2015) |
| | **Subfamily: Eudaminae** | | | |
| 2. | *Lobocla liliana* (Atkinson, 1871) | Marbled flat | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| | **Subfamily: Hesperiinae** | | | |
| 3. | *Actinor radians* (Moore, 1878) | Veined dart | JKL | Varshney and Smetacek (2015) |
| 4. | *Aeromachus stigmatus stigmatus* (Moore, 1878) | Veined scrub harper | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 5. | *Borbo bevani* (Moore, 1878) | Bevan's swift | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 6. | *Gegenes nostrodamus* (Fabricius, 1793) | Dingy swift | JKL | Varshney and Smetacek (2015) |
| 7. | *Hesperia comma comma* (Linnaeus, 1758) | Chequered darter | JKL | Kehimkar (2008) |
| 8. | *Hesperia comma dimila* (Moore, [1874]) | Garhwal chequered darter | JKL | Sondhi et al. (2017), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 9. | *Notocryta feisthameli* (Boisduval, 1832) | Spotted demon | JKL | Kehimkar (2008) |
| 10. | *Parnara bada* (Moore, 1878) | Ceylon swift | JKL | Varshney and Smetacek (2015) |
| 11. | *Parnara guttatus mangala* (Moore, [1866]) | Straight swift | JKL | Varshney and Smetacek (2015) |
| 12. | *Potanthus dara* (Kollar, [1844]) | Himalayan dart | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 13. | *Polytremis eltola* (Hewitson, 1869) | Yellow spot swift | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 14. | *Taractrocera danna* (Moore, 1865) | Himalayan grass dart | K | Dar et al. (2002), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 15. | *Taractrocera maevius sagara* (Moore [1866]) | Common grass dart | JKL | Khan et al. (2011a, b), Varshney and Smetacek (2015) |
| | **Subfamily: Pyrginae** | | | |
| 16. | *Calaenorrhinus leucocera* (Kollar, [1844]) | Common spotted flat | JKL | Dar et al. (2002), Kehimkar (2008), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 17. | *Celaenorrhinus munda* (Moore, [1884]) | Himalayan spotted flat | JKL | Varshney and Smetacek (2015) |
| 18. | *Celaenorrhinus pulomaya* (Moore, [1866]) | Multi-spotted flat | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 19. | *Carcharodus alceae* (Esper, 1780) | Plain marbled skipper | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 20. | *Carcharodus dravira* (Moore, [1875]) | Tufted marbled skipper | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 21. | *Pelopidas agna agna* (Moore, [1866]) | Obscure branded swift | JKL | Varshney and Smetacek (2015) |
| 22. | *Pelopidas mathias* (Fabricius, 1798) | Variable swift | K | Qureshi et al. (2012a, 2013c, d, e, 2014), Qureshi and Bhagat (2015), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 23. | *Pelopidas thrax thrax* (Huebner, [1821]) | Small branded swift | JKL | Varshney and Smetacek (2015) |
| 24. | *Polytremis discrete* (Elwes and Edwards, 1897) | Himalyan swift | JKL | Varshney and Smetacek (2015) |
| 25. | *Polytremis eltola* (Hewitson, 1869) | Yellow spot swift | JKL | Varshney and Smetacek (2015) |
| 26. | *Pyrgus alpinus* (Erschoff, 1874) | Mountain skipper | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 27. | *Pyrgus cashmirensis cashmirensis* (Moore, 1874) | Kashmir skipper | JKL | Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 28. | *Pyrgus cashmirensis pseudoalpinus* (Alberti, 1952) | Kashmir skipper | JKL | Varshney and Smetacek (2015) |
| 29. | *Seseria dohertyi* (Watson, 1893) | Himalayan white flat | JKL | Varshney and Smetacek (2015) |
| 30. | *Spialia orbifer* (Huebner, 1823) | Brick skipper | JKL | Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 31. | *Tagiades menaka* (Moore, [1866]) | Spotted snow flat | JKL | Dar et al. (2002), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| | **Family II: Lycaenidae** | | | |
| | **Subfamily: Aphaeinae** | | | |
| 32. | *Spindasis elima uniformis* (Moore, 1882) | Scarce Shot Silverline | K | Varshney and Smetacek (2015) |
| | **Subfamily: Curetinae** | | | |
| 33. | *Curetis thetis* (Drury, [1773]) | Indian Sunbeam | L | Varshney and Smetacek (2015) |
| | **Subfalimy: Lycaeninae** | | | |
| 34. | *Heliophorus androcles* (Westwood, 1851) | Green Sapphire | K | Evans (1932), Kehimkar (2008), Varshney (1994), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 35. | *Heliophorus bakeri* (Evans, 1927) | Western Blue Sapphire | K | Varshney and Smetacek (2015) |
| 36. | *Heliophorus moorei coruscans* (Moore, 1882) | Azure Sapphire | JKL | Varshney and Smetacek (2015) |
| 37. | *Heliophorus sena* (Kollar, 1844) | Sorrel Sapphire | JKL | Kehimkar (2008) |
| 38. | *Heliophorus tamu tamu* (Kollar, 1844) | Powdery Green Sapphire | JKL | Varshney and Smetacek (2015) |
| 39. | *Lycaena panava* (Westwood, 1852) | White-Bordered Copper | JKL | Dar et al. (2002), Evans (1932), Khan et al. (2011a, b), Kehimkar (2008), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 40. | *Lycaena phlaeas baralacha* (Moore, 1884) | Common Copper | JKL | Varshney and Smetacek (2015) Qureshi et al. (2014) |
| 41. | *Lycaena phlaeas phlaeas* (Linnaeus, 1761) | Common Copper | KL | Evans (1932), Khan et al. (2011a, b), Kehimkar (2008), Qureshi et al. (2012a, 2013c, d, e), Tshikolovets (2005), Qureshi and Bhagat (2015), Sondhi et al. (2017) andVarshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 42. | *Lycaena kasyapa* (Moore, 1865) | Green Copper | JKL | Khan et al. (2011b), Kehimkar (2008), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 43. | *Thersamonia aditya* (Moore, [1875]) | Ladakh Copper | L | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| | **Subfamily: Polyommatinae** | | | |
| 44. | *Acytolepis puspa gisca* (Fruhstorfer, 1910) | Common Hedge Blue | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 45. | *Albulina chitralensis chitralensis* (Tytler, 1926) | Chitral Green Underwing | L | Varshney and Smetacek (2015) |
| 46. | *Albulina chrysopis* (Grum-Grishimailo, 1888) | Golden Green Underwing | L | Varshney and Smetacek (2015) |
| 47. | *Albulina galathea depreei* (Tytler, 1926) | Large Green Underwing | L | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 48. | *Albulina galathea galathea* (Blanchard, [1844]) | Large Green Underwing | KL | Bingham (1907), Evans (1932), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 49. | *Albulina lehanus* (Moore, 1878) | Common Mountain Blue | KL | Bingham (1907), Khan et al. (2011b), Sondhi et al. (2017) and Varshney and Smetacek (2015) |
| 50. | *Albulina metallica metallica* (C & R Felder, [1865]) ## | Small Green Underwing | JKL | Khan et al. (2011b), Kehimkar (2008), Tshikolovets (2005) and Sondhi et al. (2017) |
| 51. | *Albulina omphisa* (Moore, [1875]) | Dusky Green Underwing | KL | Evans (1932), Khan et al. (2011b), Sondhi et al. (2017), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 52. | *Alpherakya devanica devanica* (Moore, [1875]) | Dusky Meadow Blue | KL | Bingham (1907), Evans (1932),Khan et al. (2011b), Sondhi et al. (2017), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 53. | *Alpherakya sarta gooraisica* (Tytler, 1927) | Brilliant Meadow Blue | KL | Varshney and Smetacek (2015) |
| 54. | *Agriades jaloka jaloka* (Moore, [1875]) ## | Greenish Mountain Blue | KL | Bingham (1907), Evans (1932), Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 55. | *Agriades jaloka leela* (de Niceville, [1884]) | Greenish Mountain Blue | L | Varshney and Smetacek (2015) |
| 56. | *Agriades jaloka marlane* (Heming, 1934) | Greenish Mountain Blue | K | Varshney and Smetacek (2015) |
| 57. | *Agriades pheretiades* (Eversmann, 1834) | Tien Shan Blue | L | Varshney and Smetacek (2015) |
| 58. | *Aricia agestis nazira* (Moore, 1865) | Orange-Bordered Argus | JKL | Bingham (1907), Evans (1932), Khan et al. (2011b), Kehimkar (2008), Qureshi et al. (2012a, 2013c, d, e, 2014), Qureshi and Bhagat (2015), Tshikolovets (2005), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 59. | *Aricia artaxerxes artaxerxes* (Obratzov, 1935) | Northern Brown Argus | L | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 60. | *Aricia astorica* (Evans, 1925) | Astor Argus | L | Varshney and Smetacek (2015) |
| 61. | *Celastrina argiolus kollari* Westwood, [1852]) | Hill Hedge Blue | JKL | Kehimkar (2008), Sondhi et al. (2017), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 62. | *Celastrina gigas* Westwood, [1852]) | Silvery Hedge Blue | JKL | Varshney and Smetacek (2015) |
| 63. | *Celastrina huegelii huegelii* (Moore, 1882) | Large Hedge Blue | JKL | Evans (1932), Haribal (1992), Khan et al. (2011b), Kehimkar (2008), Tshikolovets (2005), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 64. | *Cupido alainus* (Staudinger, 1887) | Staudinger's Cupid | L | Varshney and Smetacek (2015) |
| 65. | *Eumedonia eumedon* (Esper, 1780) | Streaked Argus | L | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 66. | *Everes argiades deporides* (Chapman, 1909) | Tailed/ Chapman's Cupid | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 67. | *Everes hugelii hugelii* (Gistel, 1857) | Dusky Blue Cupid | JKL | Varshney and Smetacek (2015) |
| 68. | *Farsia ashretha* (Evans, 1925) | Evan's Argus Blue | L | Varshney and Smetacek (2015) |
| 69. | *Farsia hanna* (Evans, 1932) | Jewel Argus Blue | L | Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 70. | *Iolana gigantea* (Grum Grishimalio, 1885) | Gilgit Mountain Blue | L | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 71. | *Kretania beani* (Balint & Johnson, 1997) | Beans's Jewel Blue | L | Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 72. | *Lampides boeticus (*Linnaeus, 1767) ## | Pea Blue | KL | Khan et al. (2011a, b), Malik et al. (1972), Qureshi et al. (2012a, 2013c, d, e, 2014), Qureshi and Bhagat (2015), Sondhi et al. (2017) and Tshikolovets (2005) |
| 73. | *Neopithecops zalmora zalmora* (Butler, [1881]) | Quaker | KL | Varshney and Smetacek (2015) |
| 74. | *Oreolyce vardhana vardhana* (Moore, [1875]) | Dusky Hedge Blue | JKL | Evans (1932), Kehimkar (2008) and Wynter-Blyth (1957) |
| 75. | *Polyommatus ariana* (Moore, 1865) | Lahaul Meadow Blue | KL | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 76. | *Polyommatus drasula* (Swinhoe, 1910) | Ladakh Meadow Blue | L | Varshney and Smetacek (2015) |
| 77. | *Polyommatus erigone* (Grum-Grshimailo, 1890) | Hunza Meadow Blue | L | Varshney and Smetacek (2015) |
| 78. | *Polyommatus hunza* (Grum-Grshimailo, 1890) | Hunza Meadow Blue | L | Varshney and Smetacek (2015) |
| 79. | *Polyommatus icadus* (Grum-Grshimailo, 1890) | Gilgit Meadow Blue | L | Varshney and Smetacek (2015) |
| 80. | *Polyommatus janatae* (Evans, 1927) | Janet's Meadow Blue | L | Varshney and Smetacek (2015) |
| 81. | *Polyommatus pulchellus* (Bernardi, 1951) | Bernardi's Meadow Blue | L | Varshney and Smetacek (2015) |
| 82. | *Polyommatus pseuderos* (Moore, 1879) | Kashmir Meadow Blue | KL | Varshney and Smetacek (2015) |
| 83. | *Polyommatus stoliczkanus stoliczkanus* (*C.* and R. Felder, [1865]) | Stoliczka's Meadow Blue | KL | Bingham (1907), Khan et al. (2011b), Sondhi et al. (2017), Tshikolovets (2005) and Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 84. | *Plebejidea loewii loewii* (Evans, 1932) | Large Jewel Blue | L | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 85. | *Plebejus samudra* (Moore, [1875]) | Ladakh Jewel Blue | KL | Khan et al. (2011b), Sondhi et al. (2017), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 86. | *Pseudozizeeria maha maha* (Kollar, [1844]) | Pale Grass Blue | JKL | Varshney and Smetacek (2015) |
| 87. | *Pseudophilotes vicrama vicrama* (Moore, 1865) | Chequered Blue | JKL | Khan et al. (2011b), Kehimkar (2008), Sondhi et al. (2017) and Tshikolovets (2005) |
| 88. | *Pseudophilotes vicrama cashmirensis* (Moore, 1874) | Eastern Baton Blue | KL | Varshney and Smetacek (2015) |
| 89. | *Tarucus hazara* (Evans, 1932) | Hazara Pierrot | K | Varshney and Smetacek (2015) |
| 90. | *Taracus venosus* (Moore, 1882) | Himalayan Pierrot | JKL | Varshney and Smetacek (2015) |
| 91. | *Turanana chitrali* (Charmeux & Pages, 2004) | Chitral Argus Blue | L | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| | **Subfamily: Riodininae** | | | |
| 92. | *Dodona durga* (Kollar, [1844]) | Common Punch | JKL | Bingham (1905), Khan et al. (2011b), and Kehimkar (2008) |
| 93. | *Dodona dipoea* (Hewitson, 1866) ## | Lesser Punch | JKL | Kehimkar (2008) |
| 94. | *Dodona egeon* (Westwood, [1851]) ## | Orange Punch | K | Bingham (1905) |
| 95. | *Dodona eugenes* (Bates, [1868]) | Tailed Punch | JKL | Kehimkar (2008) |
| | **Subfalimy: Theclinae** | | | |
| 96. | *Arhopala atrax* (Hewitson, 1862) | Indian Oakblue | JKL | Varshney and Smetacek (2015) |
| 97. | *Arhopala dodonea* (Moore, [1858]) | Pale Himalayan Oakblue | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 98. | *Arhopala ganesa ganesa* (Moore, [1858]) | Tailless Bushblue | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 99. | *Arhopala rama rama* (Kollar, [1844]) | Dark Himalayan Oakblue | JKL | Evans (1932), Kehimkar (2008), Tshikolovets (2005), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 100. | *Chaetoprocta odata odata* (Hewitson, 1865) | Walnut Blue | JKL | Khan et al. (2011b), Kehimkar (2008) and Tshikolovets (2005) |
| 101. | *Curetis thetis* (Drury, [1773]) | Indian Sunbeam | L | Varshney and Smetacek (2015) |
| 102. | *Deudorix epijarbus* (Moore, 1857) | Cornelian | JKL | Dar et al. (2002), Khan et al. (2011a, b) and Varshney and Smetacek (2015) |
| 103. | *Euaspa milionia* (Hewitson, 1869) | Water Hairstreak | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 104. | *Euaspa ziha* (Hewitson, [1865]) | White-spotted Hairstreak | JKL | Varshney and Smetacek (2015) |
| 105. | *Inomataozephyrus syla* (Kollar, [1844]) | Silver Hairstreak | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 106. | *Rapala iarbus sorya* (Kollar, [1884]) | Common Red Flash | JKL | Khan et al. (2011b) and Varshney and Smetacek (2015) |
| 107. | *Rapala nissa nissa* (Kollar, [1884]) | Common Flash | JKL | Evans (1932), Haribal (1992), Kehimkar (2008), Qureshi et al. (2012a, 2013c, d), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 108. | *Rapala selira* (Moore, 1874) | Himalayan Red Flash | K | Varshney and Smetacek (2015) |
| 109. | *Superflua deria* (Moore, 1865) | Moore's Hairstreak | K | Sondhi et al. (2017) and Varshney and Smetacek (2015) |
| 110. | *Thermozephyrus ataxus* (Westwood, 1851) ## | Wonderful Hairstreak | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 111. | *Virachola isocrates* (Fabricius, 1793) | Common Guava Blue/Anar Butterfly | JK | Dar et al. (2002), Khan et al. (2011a, b) and Malik et al. (1972) |
| | **Family III: Nymphalidae** | | | |
| | **Subfamily: Acraeinae** | | | |
| 112. | *Acraea violae* (Fabricius, 1793) | Tawny Coster | J | Viswanthan et al. (2004) |
| | **Subfamily: Apaturinae** | | | |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 113. | *Apatura ambica ambica* (Kollar, [1844]) | Indian Purple Emperor | JKL | Bingham (1905), Evans (1932), Khan et al. (2011b) and Kehimkar (2008) |
| 114. | *Diagora nicevillei nicevillei* (Moore, [1895])# | Scarce Siren | KL | Varshney and Smetacek (2015) |
| 115. | *Dilipa morgiana* (Westwood, [1850]) # | Golden Emperor | JKL | Dar et al. (2002), Evans (1932), Haribal (1992), Khan et al. (2011b), Kehimkar (2008), Varshney (1994) and Wynter-Blyth (1957) |
| 116. | *Hestina persimilis zella* (Butler, 1869) | Siren | JKL | Varshney and Smetacek (2015) |
| 117. | *Mimathyma chitralensis* (Evans, 1912) | Chitral Emperor | JKL | Varshney and Smetacek (2015) |
| 118. | *Sephisa dichroa* (Kollar, [1844]) | Western Courtier | JKL | Bingham (1905), Kehimkar (2008) and Varshney and Smetacek (2015) |
| | **Subfamily: Biblidinae** | | | Viswanthan et al. (2004) |
| 119. | *Ariadne aridnae* (Linnaeus, 1763) | Angled Castor | J | Khan et al. (2011a, b) and Viswanthan et al. (2004) |
| 120. | *Ariadne merione tapestrina* (Moore, 1884) | Common Castor | JK | Evans (1932), Khan et al. (2011b) and Varshney and Smetacek (2015) |
| | **Subfamily: Calinaginae** | | | |
| 121. | *Calinga buddha buddha* (Moore, 1857) | Freak | JKL | Varshney and Smetacek (2015) |
| | **Subfamily: Cyrestinae** | | | |
| 122. | *Cyrestis thyodamas ganesha* (Kollar, 1848) | Common Map | JKL | Dar et al. (2002), Evans (1932), Khan et al. (2011b), Kehimkar (2008), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| | **Subfalimy: Danainae** | | | |
| 123. | *Danaus chrysippus* (Linnaeus, 1758) | Plain Tiger | JK | Dar et al. (2002), Das and Verma (1965), Khan et al. (2011a, b), Qureshi et al. (2012a, 2013c, d, e, 2014), Qureshi and Bhagat (2015) and Wynter-Blyth (1957) |

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**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 124. | *Danaus genutia* (Crammer, [1779]) | Common Tiger | JK | Das and Verma (1965), Khan et al. (2011a, b), Qureshi et al. (2012a) and Wynter-Blyth (1957) |
| 125. | *Danaus liminiace* (Crammer, [1775]) | Blue Tiger | J | Varshney and Smetacek (2015) and Viswanthan et al. (2004) |
| 126. | *Danaus sita sita* (Kollar, [1884]) | Chestnut Tiger | JKL | Bingham (1905), Dar et al. (2002), Evans (1932), Haribal (1992), Khan et al. (2011b), Kehimkar (2008), Talbot (1947), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 127. | *Euploea core core* (Cramer, [1780]) | Indian Common Crow | J | Khan et al. (2011a, b) and Viswanthan et al. (2004) |
| 128. | *Euploea mulciber mulciber* (Cramer, [1777]) | Striped Blue Crow | JKL | Varshney and Smetacek (2015) |
| 129. | *Euploea sylvester* (Fabricius, 1793) | Double-branded Crow | J | Viswanthan et al. (2004) |
| 130. | *Parantica aglea aglea* (Stoll, [1782]) | Glassy Tiger | JK | Bingham (1905), Dar et al. (2002), Evans (1932), Haribal (1992), Talbot (1947) and Wynter-Blyth 1957 |
| 131. | *Parantica aglea melanoides* (Moore, 1883) | Himalayan Glassy Tiger | K | Varshney and Smetacek (2015) |
| | **Subfamily: Heliconinae** | | | |
| 132. | *Argynnis adippe pallida* (Moore) ## | Highbrown Silverstrip | JKL | Khan et al. (2011a) and Kehimkar (2008) |
| 133. | *Argynnis aglaja vitatha* (Moore, [1875]) | Dark-green Silverspot | JKL | Evans (1932), Khan et al. (2011b), Kehimkar (2008) and Varshney and Smetacek (2015) |
| 134. | *Argynnis andora pasargades* (Fruhstorfer, 1908) | Cardinal | L | Varshney and Smetacek (2015) |
| 135. | *Argynnis childreni childreni* (Gray, 1831) | Large Silverstripe | JKL | Bingham (1905), Khan et al. (2011a, b), Kehimkar (2008), Qureshi et al. (2012a, c, 2013c, d, e) and Qureshi and Bhagat (2015) |
| 136. | *Argynnis childreni sakontala* (Kollar, 1848) | Large Silverstripe | JKL | Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 137. | *Argynnis hyperbius hyperbius* (Linnaeus, 1763) | Indian Fritillary | JKL | Khan et al. (2003), Khan et al. (2004), Khan et al. (2011a, b), Kehimkar (2008), Marshal and de Niceville (1886), Qureshi et al. (2012a, 2013c, d, e, 2014), Qureshi and Bhagat (2015) and Varshney and Smetacek (2015) |
| 138. | *Argynnis jainadeva jainadeva* (Moore, 1864) | Highbrown Silverspot | JKL | Varshney and Smetacek (2015) |
| 139. | *Argynnis jainadeva persephone* Hemming, 1934 | Highbrown Silverspot | L | Khan et al. (2011b), Sondhi et al. (2017) and Varshney and Smetacek (2015) |
| 140. | *Argynnis kamala* (Moore, 1857) | Common Silverstrip | JKL | Bingham (1905), Khan et al. (2011b), Kehimkar (2008) and Varshney and Smetacek (2015) |
| 141. | *Argynnis pales sipora* (Moore, [1875]) | Straightwing Silverspot | KL | Bingham (1905), Evans (1932) and Khan et al. (2011b) |
| 142. | *Argynnis pandora pasargades* (Fruhstorfer, 1908) | Cardinal | L | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 143. | *Boloria erubescens* (Staudinger, 1901) | Whitespot Fritillary | L | Varshney and Smetacek (2015) |
| 144. | *Boloria generator* (Staudinger, 1901) | Hunza Fritillary | L | Varshney and Smetacek (2015) |
| 145. | *Boloria jerdoni jerdoni* (Lang, 1868) | Jerdon's Silverspot | KL | Bingham (1905), Dar et al. (2002), Evans (1932), Khan et al. (2011b) and Wynter-Blyth, 1957 |
| 146. | *Issoria gemmata gemmata* (Butler, 1881) | Gem Silverspot | K | Qureshi et al. (2012a, 2013c, d) |
| 147. | *Issoria isaea* (Gray, 1846) | Himalayan Queen Frtitillarry | L | Sondhi et al. (2017) |
| 148. | *Issoria lathonia isaaea* (Gray, 1846) | Queen of Spain Fritillary | JKL | Varshney and Smetacek (2015) |
| 149. | *Issoria lathonia lathonia* (Linnaeus, 1758) | Queen of Spain Fritillary | JKL | Das and Verma (1965), Das et al. (1964), Khan et al. (2011a, b), Kehimkar (2008), Qureshi et al. (2012a, 2013c, d, e, 2014), Qureshi and Bhagat (2015) and Marshal and de Niceville (1886) |
| 150. | *Phalanta phalanta* (Drury, [1773]) | Common Leopard | JK | Khan et al. (2011a, b) and Qureshi et al. (2012a, 2013c, d) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| | **Subfamily: Libytheinae** | | | |
| 151. | *Libythea celtis* (Laicharting, 1782) | European Beak | JKL | Khan et al. (2011a, b) and Kehimkar (2008) |
| 152. | *Libythea lepita lepita* (Moore, [1858]) ## | Common Beak | JKL | Bingham (1905), Dar et al. (2002), Haribal (1992), Kehimkar (2008), Marshal and de Niceville (1886), Qureshi et al. (2012a, 2013c, d, e, 2014), Qureshi and Bhagat (2015), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 153. | *Libythea lepita lepitoides* (Moore, 1901) | Common Beak | J | Viswanthan et al. (2004) |
| 154. | *LIbythea myrha* (Godart, 1819) | Club Beak | K | Haribal (1992) |
| | **Subfamily: Limenitinidae** | | | |
| 155. | *Athyma opalina opalina* (Kollar, [1844]) | Himalayan Sergeant | K | Dar et al. (2002), Evans (1932), Khan et al. (2011b), Kehimkar (2008) and Wynter-Blyth (1957) |
| 156. | *Euthalia aconthea* (Cramer, [1777]) | Common Baron | J | Viswanthan et al. (2004) |
| 157. | *Euthalia patala patala* (Kollar, [1844]) | Grand Duchess | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 158. | *Limenitis lepechini gilgitica* (Tytler, 1926) | Chitral White Admiral | L | Varshney and Smetacek (2015) |
| 159. | *Limenitis trivena hydaspes* (Moore, 1874) | Indian White Admiral | JKL | Varshney and Smetacek (2015) |
| 160. | *Limenitis trivena ligyes* (Hewitson, 1864) | Indian White Admiral | K | Khan et al. (2011b) and Varshney and Smetacek (2015) |
| 161. | *Limenitis trivena trivena* (Moore, 1864) | Indian White Admiral | JKL | Bingham (1905), Evans (1932), Kehimkar (2008), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 162. | *Neptis hylas* (Linnaeus, 1758) | Common Sailor | K | Bingham (1905), Haribal (1992), Khan et al. (2003), Khan et al. (2004), Khan et al. (2011a, b), Qureshi et al. (2012a, 2013c, d, e) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 163. | *Neptis mahendra mahendra* (Moore, 1872) | Himalayan Sailor | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 164. | *Neptis sappho* (Pallas, 1771) | Pallas Sailor | K | Qureshi and Bhagat (2015), Qureshi et al. (2014) and Varshney and Smetacek (2015) |
| 165. | *Neptis sankara sankara* Kollar, [1844]) | Broad-Banded Sailor | JKL | Dar et al. (2002), Khan et al. (2011a, b), Kehimkar (2008) and Varshney and Smetacek (2015) |
| 166. | *Neptis soma soma* (Moore, 1858) ## | Creamy Sailor | JKL | Evans (1932), Haribal (1992), Khan et al. (2011a, b), Kehimkar (2008) and Wynter-Blyth (1957) |
| 167. | *Neptis yerburii yerburii* (Butler, 1886) ## | Yurburi's Sailor | JKL | Bingham (1905), Evans (1932), Haribal (1992), Kehimkar (2008) and Wynter-Blyth (1957) |
| 168. | *Neptis zaida zaida* (Doubleday, [1848]) | Pale Green Sailer | JKL | Varshney and Smetacek (2015) |
| | **Subfamily: Nymphalinae** | | | |
| 169. | *Aglais cashmirensis aesis* (Frushtorfer, 1912) | Indian Tortoiseshell | K | Khan et al. (2011a, b) and Kehimkar (2008) |
| 170. | *Aglais cashmirensis cashmirensis* (Kollar, [1844]) | Indian Tortoiseshell | JKL | Bingham (1905), Dar et al. (2002), Evans (1932), Qureshi et al. (2012a, 2013b, c, d, e, 2014), Qureshi and Bhagat (2015), Malik et al. (1972), Sondhi et al. (2017), Varshney (1994) and Wynter-Blyth (1957) |
| 171. | *Aglais ladakensis* (Moore, 1878) ## | Ladakh Tortoiseshell | L | Varshney and Smetacek (2015) |
| 172. | *Aglais rizana* (Moore, 1872) | Mountain Tortoiseshell | JKL | Bingham (1905), Varshney (1994), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 173. | *Cynthia cardui* (Linnaeus, 1758) | Painted Lady | K | Khan et al. (2003, 2004, 2011a, b, Qureshi et al. (2012a, b, 2013a, c, d, e, 2014), Qureshi and Bhagat (2015), Sondhi et al. (2017) and Wynter-Blyth, 1957 |
| 174. | *Hypolimnas misippus* (Linnaeus, 1764) ## | Danaid Eggfly | K | Evans (1932), Khan et al. (2011a, b), Qureshi et al. (2012a, c, d, e, 2014), Qureshi and Bhagat (2015) Varshney (1994) and Wynter-Blyth (1957) |
| 175. | *Junonia almana* (Linnaeus, 1758) | Peacock Pansy | JK | Khan et al. (2011a, b) and Qureshi et al. (2012a) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 176. | *Junonia atlites* (Linnaeus, 1763) | Grey Pansy | JKL | Khan et al. (2011b) |
| 177. | *Junonia hierta* (Fabricius, 1798) | Yellow Pansy | JK | Khan et al. (2003) and Mathur and Srivastava (1967) |
| 178. | *Junonia iphita* (Crammer, [1779]) | Chocolate Pansy | K | Marshal and de Niceville (1886), Qureshi et al. (2012a, 2013c, e, 2014), Qureshi and Bhagat (2015) and Wynter-Blyth, 1957 |
| 179. | *Junonia lemonias persicaria* (Fruhstorfer, 1912) | Lemon Pansy | JK | Dar et al. (2002), Evans (1932), Khan et al. (2011a, b) and Wynter-Blyth (1957) |
| 180. | *Junonia orithya* (Linnaeus, 1758) | Blue Pansy | JK | Khan et al. (2003), (2011a, b), Qureshi et al. (2013c, d, e) and Qureshi and Bhagat (2015) |
| 181. | *Kallima inachus huegeli* (Kollar, [1844]) | Orange Oakleaf | K | Varshney and Smetacek (2015) |
| 182. | *Kallima inachus inachus* (Boisduval, 1846) | Orange Oakleaf | JKL | Bingham (1905), Dar et al. (2002), Evans (1932), Haribal (1992), Khan et al. (2011b), Kehimkar (2008) and Wynter-Blyth (1957) |
| 183. | *Kaniska canace canace* (Linnaeus, 1763) | Blue Admiral | JKL | Bingham (1905), Kehimkar (2008), Qureshi et al. (2012a, 2013c, d, e, 2014), Qureshi and Bhagat (2015) and Varshney and Smetacek (2015) |
| 184. | *Melitaea arcesia amoenula* (C. & R. Felder, [1867]) | Black Vein Fritillary | L | Khan et al. (2011b) and Sondhi et al. (2017) |
| 185. | *Melitaea arcesia sindura* (Moore, 1865) | Black Vein Fritillary | KL | Dar et al. (2002) and Khan et al. (2011b) |
| 186. | *Melitaea arcesia balbita* (Moore, 1874) | Kashmir Fritillary | KL | Varshney and Smetacek (2015) |
| 187. | *Melitaea balbina* (Tytler, 1926) | Pamir Fritillary | L | Varshney and Smetacek (2015) |
| 188. | *Melitaea fergana* (Staudinger, 1882) | Uzbek Fritillary | L | Varshney and Smetacek (2015) |
| 189. | *Melitaea nadezhdae* (Sheljuzhko, 1912) | Sheljuzhko's Fritillary | L | Varshney and Smetacek (2015) |
| 190. | *Melitaea shandura* (Evans, 1924) | Shandur Fritillary | L | Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 191. | *Nymphalis xanthomelas fervescens* (Stichel, [1908]) | Large Tortoiseshell | JKL | Bingham (1905), Khan et al. (2011b), Kehimkar (2008) and Varshney and Smetacek (2015) |
| 192. | *Polygonia c-album agnicula* (Moore, 1872) | Comma | L | Varshney and Smetacek (2015) |
| 193. | *Polygonia c-album cognata* (Moore, 1899) | Comma | K | Varshney and Smetacek (2015) |
| 194. | *Polygonia c-album kashmira* (Evans, 1932) | Comma | KL | Varshney and Smetacek (2015) |
| 195. | *Polygonia l-album* (Esper, 1781) ## | False Comma | KL | Varshney and Smetacek (2015) |
| 196. | *Polygonia undina* (Grum-Grshimailo, 1890) | Pamir Comma | L | Varshney and Smetacek (2015) |
| 197. | *Symbrenthia brabirasivokana* (Moore, 1899) | Himalayan Jester | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |
| 198. | *Symbrenthia hypselis cotanda* (Moore, [1875]) | Spotted Jester | JKL | Bingham (1905), Dar et al. (2002), Evans (1932), Haribal (1992) and Wynter-Blyth (1957) |
| 199. | *Symbrenthia niphanda hysudra* (Moore, 1874) | Blue-Tail Jester | K | Varshney and Smetacek (2015) |
| 200. | *Symbrenthia niphanda niphanda* (Moore, 1872) ## | Blue-Tail Jester | JKL | Evans (1932), Dar et al. (2002), Kehimkar (2008) and Wynter-Blyth (1957) |
| 201. | *Vanessa indica indica* (Herbst, 1794) | Indian Red Admiral | JKL | Dar et al. (2002), Haribal (1992), Khan et al. (2011a, b), Kehimkar (2008), Qureshi et al. (2012a, 2013c, d, e, 2014), Qureshi and Bhagat (2015), Sondhi et al. (2017) and Wynter-Blyth (1957) |
| | **Subfamily: Satyrinae** | | | |
| 202. | *Aulocera brahminus brahminus* (Blanchard, 1844) ## | Narrow-Banded Satyr | KL | Bingham (1905), Dar et al. (2002), Haribal (1992), Khan et al. (2011b), Qureshi et al. (2012a, 2013c, e), Varshney (1994), Sondhi et al. (2017) and Wynter-Blyth (1957) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 203. | *Aulocera brahminus tsukadai* (Sakai, 1978) | Narrow-Banded Satyr | JKL | Varshney and Smetacek (2015) |
| 204. | *Aulocera padma padma* (Kollar, [1844]) | Great Satyr | JKL | Evans (1932), Dar et al. (2002), Haribal (1992), Khan et al. (2011a, b), Kehimkar (2008), Qureshi et al. (2012a, 2013c, e), Talbot (1947) and Varshney (1994) |
| 205. | *Aulocera saraswati* (Kollar, [1844]) | Straited Satyr | JKL | Bingham (1905), Khan et al. (2011b), Kehimkar (2008) and Varshney (1994) |
| 206. | *Aulocera swaha garuna* (Fruhstosfer, 1911) | Common Satyr | L | Khan et al. (2011b), Sondhi et al. (2017), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 207. | *Aulocera swaha gilgitica* (Tytler, 1926) | Common Satyr | L | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 208. | *Aulocera swaha swaha* (Kollar, 1848) | Common Satyr | JKL | Bingham (1905), Evans (1932), Kehimkar (2008), Talbot (1947) and Wynter-Blyth (1957) |
| 209. | *Aulocera swaha tytleri* (Sakai, Aoki & Yamaguchi, 2001) | Common Satyr | L | Varshney and Smetacek (2015) |
| 210. | *Callerebia annada* (Moore, [1858]) ## | Ringed Argus | JKL | Bingham (1905), Dar et al. (2002), Evans (1932), Khan et al. (2011b), Kehimkar (2008), Talbot (1947) and Varshney (1994) |
| 211. | *Callerebia nirmala daksha* (Moore, 1874) | Common Argus | JKL | Dar et al. (2002), Khan et al. (2011a, b), Kehimkar (2008), Qureshi and Bhagat (2015) and Varshney and Smetacek (2015) |
| 212. | *Callerebia scanda scanda* (Kollar, [1844]) | Pallid Argus | JKL | Dar et al. (2002) and Kehimkar (2008) |
| 213. | *Cepora nerissa* (Fabricius, 1775) | Common Gull | JKL | Bala et al. (2014), Khan et al. (2011a, b) and Varshney and Smetacek (2015) |
| 214. | *Enmenis heydenreichi shandura* (Marshall, 1882) ## | Shandur Rockbrown | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 215. | *Hipparchia parisatis parsis* (Le Cerf, 1913) | White-Edged Rockbrown | L | Khan et al. (2011a, b) and Kehimkar (2008) |
| 216. | *Hipparchia parisatis shiva* (Le Cerf, 1913) | White-Edged Rockbrown | L | Khan et al. (2011b) and Varshney and Smetacek (2015) |
| 217. | *Hyponephele brevistigma* (Moore, 1893) | Short-branded Meadowbrown | L | Khan et al. (2011b), Sondhi et al. (2017) and Varshney and Smetacek (2015) |
| 218. | *Hyponephele carbonelli* (Lukhtanov, 1995) | Baltistan Meadow brown | L | Varshney and Smetacek (2015) |
| 219. | *Hyponephele cheena baltistana* (Eckweiler and Bozano, 2011) | Branded Meadowbrown | L | Varshney and Smetacek (2015) |
| 220. | *Hyponephele cheena cheena* (Moore, 1865) | Branded Meadowbrown | L | Varshney and Smetacek (2015) |
| 221. | *Hyponephele cheena kashmirica* (Moore, 1892) | Branded Meadowbrown | K | Khan et al. (2011b) and Varshney and Smetacek (2015) |
| 222. | *Hyponephele coenonympha* (C. and. R. Felder, 1867) | Spotted Meadowbrown | KL | Khan et al. (2011b) and Varshney and Smetacek (2015) |
| 223. | *Hyponephele davendra* (Moore, 1865) ## | White-ringed Meadowbrown | L | Khan et al. (2011b), |
| 224. | *Hyponephele pulchella* (C and R Felder, [1867]) | Tawny Meadowbrown | JKL | Dar et al. (2002), Khan et al. (2011b), Kehimkar (2008), Qureshi et al. (2012a, 2013c, e) and Sondhi et al. (2017) |
| 225. | *Hyponephele pulchra astorica* (Tytler, 1976) | Dusky Meadowbrown | L | Khan et al. (2011b) and Varshney and Smetacek (2015) |
| 226. | *Hyponephele pulchra baroghila* (Tytler, 1926) | Dusky Meadowbrown | L | Varshney and Smetacek (2015) |
| 227. | *Hyponephele pulchra neoza* (Lang, 1868) | Dusky Meadowbrown | KL | Varshney and Smetacek (2015) |
| 228. | *Hyponephele pulchra pulchra* (C. and R. Felder, [1867]) | Dusky Meadowbrown | KL | Dar et al. (2002) and Khan et al. (2011a, b) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 229. | *Hyponephele pulchra sylvia* (Hemming, 1933) | Dusky Meadowbrown | L | Varshney and Smetacek (2015) |
| 230. | *Hyponephele tenuistigma laspura* (Evans, 1932) | Lesser White-ringed Meadowbrown | L | Khan et al. (2011b) and Varshney and Smetacek (2015) |
| 231. | *Kanetisa digna* (Marshall, 1883) | Chitrali Satyr | KL | Varshney and Smetacek (2015) |
| 232. | *Karanasa alpherakyi* (Avinoff, 1910) | Avinoff's Satyr | L | Varshney and Smetacek (2015) |
| 233. | *Karanasa bolorica* (Grum-Grshimailo, 1888) | Turkestan Stayr | L | Varshney and Smetacek (2015) |
| 234. | *Karanasa cadesia* (Moore, [1875]) | Moore's Satyr | L | Varshney and Smetacek (2015) |
| 235. | *Karanasa huebneri astorica* (Tytler, 1926) | Tawny Satyr | L | Khan et al. (2011b) and Varshney and Smetacek (2015) |
| 236. | *Karanasa huebneri balti* (Tytler, 1926) | Tawny Satyr | L | Varshney and Smetacek (2015) |
| 237. | *Karanasa huebneri expressa* (Avinoff and Sweadner, 1951) | Tawny Satyr | L | Varshney and Smetacek (2015) |
| 238. | *Karanasa huebneri huebneri* (C. and R. Felder, [1867]) | Tawny Satyr | KL | Sondhi et al. (2017) and Varshney and Smetacek (2015) |
| 239. | *Karanasa leechi hunza* (Avinoff and Sweadner, 1951) | Leech's Satyr | L | Varshney and Smetacek (2015) |
| 240. | *Karanasa modesta gemina* (Avinoff and Sweadner, 1951) | Small Satyr | L | Khan et al. (2011b) and Varshney and Smetacek (2015) |
| 241. | *Karanasa modesta modesta* (Moore, 1893) | Small Satyr | L | Khan et al. (2011b) and Varshney and Smetacek (2015) |
| 242. | *Karanasa moorei dubia* (Avinoff and Sweadner, 1951) | Shandur Satyr | L | Varshney and Smetacek (2015) |
| 243. | *Karanasa moorei gilgitica* (Tytler, 1926) | Shandur Satyr | L | Khan et al. (2011b) and Varshney and Smetacek (2015) |
| 244. | *Lasiomata menava menava* (Moore, 1865) | Dark Wall | JKL | Dar et al. (2002), Khan et al. (2011b) and Kehimkar (2008) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 245. | *Lasiomata menava maeroides* (C. and R. Felder, 1868]) | Dark Wall | L | Khan et al. (2011b) and Varshney and Smetacek (2015) |
| 246. | *Lasiomata maerula maerula* (C. and R. Felder, [1867]) ## | Scarce Wall | JKL | Khan et al. (2011b), Kehimkar (2008) and Varshney and Smetacek (2015) |
| 247. | *Lasiomata schakra schakra* (Kollar, [1844]) | Common Wall | JKL | Dar et al. (2002), Khan et al. (2011a, b) and Kehimkar (2008) |
| 248. | *Lethe confusa* (Aurivillus, 1898) | Banded Treebrown | JK | Kehimkar (2008) |
| 249. | *Lethe rohria rohria* (Fabricius, 1787) | Common Treebrown | JKL | Dar et al. (2002), Khan et al. (2011b) and Kehimkar (2008) |
| 250. | *Lethe verma verma* (Kollar, [1844]) | Straight-Banded Treebrown | JKL | Dar et al. (2002), Khan et al. (2011b) and Kehimkar (2008) |
| 251. | *Melanitis phedima galkissa* (Fruhstorfer, 1911) | Dark Evening Brown | JKL | Dar et al. (2002), Khan et al. (2011b), Kehimkar (2008) and Qureshi et al. (2012a, 2013c, e) |
| 252. | *Melanitis phedima varaha* (Moore, 1856) | Dark Evening Brown | J | Viswanthan et al. (2004) |
| 253. | *Mycalesis mineus* (Linnaeus, 1785) ## | Dark-branded Bushbrown | J | Khan et al. (2011a, b) and Viswanthan et al. (2004) |
| 254. | *Oeneis buddha garhwalica* (Tytler, 1926) | Tibetan Satyr | JKL | Varshney and Smetacek (2015) |
| 255. | *Paralasa chitralicayasina* (Tytler, 1936) | Chitral Argus | L | Varshney and Smetacek (2015) |
| 256. | *Paralasa kalinda kalinda* (Moore, 1865) ## | Scarce Mountain Argus | KL | Khan et al. (2011b) and Sondhi et al. (2017) |
| 257. | *Paralasa kalinda kamriana* (Tytler, 1926) | Scarce Mountain Argus | K | Varshney and Smetacek (2015) |
| 258. | *Paralasa mani lorimeri* (Tytler, 1926) | Yellow Argus | L | Varshney and Smetacek (2015) |
| 259. | *Paralasa mani mani* (de Niceville, 1881) ## | Yellow Argus | KL | Kehimkar (2008), Qureshi et al. (2013c, e) and Sondhi et al. (2017) |
| 260. | *Paralasa shallada shallada* (Lang, 1881) | Mountain Argus | JKL | Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 261. | *Paroeneis pumilus bicolor* (Seitz, [1909]) | Mountain Satyr | K | Kehimkar (2008) |
| 262. | *Paroeneis pumilus pumilus* (C and R Felder, [1867]) | Mountain Satyr | JKL | Khan et al. (2011b), Kehimkar (2008), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 263. | *Pararge everesmanni cashmirensis* (Eversmann, 1847) ## | Yellow Wall | JKL | Khan et al. (2011b), Kehimkar (2008), Qureshi et al. (2012a, 2013c, e, 2014), and Qureshi and Bhagat (2015) |
| 264. | *Pseudochazara baldiva gilgitica* (Tytler, 1926) | Kashmir Rockbrown | L | Varshney and Smetacek (2015) |
| 265. | *Pseudochazara baldiva baltistana* (Holik, 1949) | Kashmir Rockbrown | L | Varshney and Smetacek (2015) |
| 266. | *Pseudochazara baldiva lehana* (Moore, 1878) | Kashmir Rockbrown | L | Varshney and Smetacek (2015) |
| 267. | *Pseudochazara droshica* (Tytler, 1926) | Tytler's Rockbrown | L | Varshney and Smetacek (2015) |
| 268. | *Satyrus pimpla pimpla* (C. and R. Felder, [1867]) | Black Stayr | KL | Varshney and Smetacek (2015) |
| 269. | *Ypthima avanta avanta* (Moore, [1875]) | Jewel Fourring | JKL | Dar et al. (2002) and Kehimkar (2008) |
| 270. | *Ypthima bolanica* (Marshall, 1882) ## | Desert Fourring | K | Varshney and Smetacek (2015) |
| 271. | *Ypthima ceylonica* (Hewitson, 1865) | Four Fourrring | JK | Varshney and Smetacek (2015) |
| 272. | *Ypthima huebneri* (Kirby, 1871) | Common Fourring | J | Khan et al. (2011a, b) and Viswanthan et al. (2004) |
| 273. | *Ypthima indecora* (Moore, 1882) | Western Fivering | K | Dar et al. (2002) |
| 274. | *Ypthima kasmira* (Moore, 1884) | Kashmir Fourring | JKL | Varshney and Smetacek (2015) |
| 275. | *Ypthima nareda* (Kollar, [1844]) | Large Threewing | JKL | Dar et al. (2002), Kehimkar (2008) and Varshney and Smetacek (2015) |
| 276. | *Ypthima nikaea* (Moore, [1875]) | Moore's Fivering | JKL | Varshney and Smetacek (2015) |
| 277. | *Ypthima sakra sakra* (Moore, 1857) | Himalayan Fivering | JKL | Kehimkar (2008) and Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| | **Family IV: Papilionidae** | | | |
| | **Subfamily: Papilioninae** | | | |
| 278. | *Atrophaneura dasarada dasarda* (Moore, 1858) | Great Windmill | K | Dar et al. (2002), Haribal (1992), Khan et al. (2011b) and Kehimkar (2008) |
| 279. | *Atrophaneura dasarada ravana* (Moore, 1858) | Great Windmill | K | Bingham (1907), Evans (1932), Haribal (1992), Talbot (1939), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 280. | *Atrophaneura latreillei latreillei* (Donovan, 1826) | Rose Windmill | JK | Varshney and Smetacek (2015) |
| 281. | *Atrophaneura polyeuctes letincius* (Fruhstorfer, 1908) | Common Windmill | KL | Varshney and Smetacek (2015) |
| 282. | *Atrophaneura polyeuctes polyeuctes* (Doubleday, 1842) | Common Windmill | K | Bingham (1907), Dar et al. (2002), Evans (1932), Haribal (1992), Kehimkar (2008) Talbot (1939) and Wynter-Blyth (1957) |
| 283. | *Graphium cloanthus cloanthus* (Westwood, 1841) | Glassy Bluebottle | JK | Bingham (1907), Dar et al. (2002), Evans (1932), Haribal (1992), Khan et al. (2011b), Kehimkar (2008), Talbot (1939), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 284. | *Graphium dososn* (C. and R. Felder, 1864) | Common Jay | JKL | Varshney and Smetacek (2015) |
| 285. | *Graphium eurous caschmirensis* (Rothschild, 1895) | Sixbar Swordtail | K | Dar et al. (2002), Evans (1932), Khan et al. (2011b), Kehimkar (2008), Talbot (1939) and Varshney and Smetacek (2015) |
| 286. | *Graphium eurous sikkimica* (Heron, 1899) | Sixbar Swordtail | JKL | Evans (1932), Haribal (1992) and Wynter-Blyth (1957) |
| 287. | *Graphium sarpedon serpedon* (Linnaeus, 1758) | Common Bluebottle | K | Evans (1932), Haribal (1992), Khan et al. (2011b), Talbot (1939), Wynter-Blyth (1957), Dar et al. (2002) and Kehimkar (2008) |
| 288. | *Graphium sarpedon sirkari* (Page and Treadaway, 2013) | Common Bluebottle | KL | Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 289. | *Papilio agestor agestor* (Gray, 1831) | Tawny Mime | K | Dar et al. (2002), Haribal (1992), Khan et al. (2011b) and Kehimkar (2008) |
| 290. | *Papilio agestor govindra* (Moore, 1864) | Tawny Mime | K | Bingham (1907), Evans (1932), Varshney and Smetacek (2015) |
| 291. | *Papilio arcturus arius* (Rothschild, 1908) | Blue Peacock | JK | Dar et al. (2002), Evans (1932), Haribal (1992), Khan et al. (2011b), Kehimkar (2008), Qureshi et al. (2012a, 2013c) and Marshall and De Niceville (1886) |
| 292. | *Papilio demoleus* (Linnaeus, 1758) | Lime Butterfly | JK | Bingham (1907) and Khan et al. (2011a, b), |
| 293. | *Papilio helenus* (Linnaeus, 1758) | Red Helen | JK | Khan et al. (2011a, b) |
| 294. | *Papilio machaon asiatica* (Menetries, 1855) | Common Yellow Swallowtail | KL | Khan et al. (2011a, b), Kehimkar (2008), Qureshi et al. (2012a, 2013c, d, e), Qureshi and Bhagat (2015), Talbot (1939), Tshikolovets (2005), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 295. | *Papilio machaon ladakensis* (Moore, 1884) | Common Yellow Swallowtail | L | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 296. | *Papilio machaon centralis* (Staudinger, 1886) | Common Yellow Swallowtail | L | Khan et al. (2011b) and Tshikolovets (2005) |
| 297. | *Papilio paris* (Linneaus, 1758) | Paris Peacock | J | Khan et al. (2011a, b) and Viswanthan et al. (2004) |
| 298. | *Papilio polyctor* (Boisduval, 1836) | Common Peacock | JK | Kehimkar (2008) |
| 299. | *Papilio polytes romulus* (Cramer, [1775]) | Common Mormon | J | Khan et al. (2011a, b) and Viswanthan et al. (2004) |
| 300. | *Papilio protenor euprotenor* (Fruhstorfer, 1908) | Spangle | K | Dar et al. (2002), Haribal (1992), Khan et al. (2011b) and Kehimkar (2008) |
| | **Subfamily: Parnassinae** | | | |
| 301. | *Parnassius acco acco* (gray, [1853]) | Varnished Apollo | L | Khan et al. (2011b), Kehimkar (2008) and Tshikolovets (2005) |
| 302. | *Parnassius acco baltorana* (Bang-Haas, 1937) | Varnished Apollo | JL | Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 303. | *Parnassius acco hampsoni* (Avinoff, 1916) | Varnished Apollo | JK | Varshney and Smetacek (2015) |
| 304. | *Parnassius acco tanglangi* (Bang-Hass, 1927) | Varnished Apollo | L | Varshney and Smetacek (2015) |
| 305. | *Parnassius acco transhimalayensis* (Eisner, 1938) | Varnished Apollo | L | Varshney and Smetacek (2015) |
| 306. | *Parnassius acdestis ladakensis* (Avinoff, 1916) | Dusky Apollo | L | Varshney and Smetacek (2015) |
| 307. | *Parnassius acdestis rupshuana* (Avinoff, 1916) | Dusky Apollo | L | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 308. | *Parnassius acdestis takedai* (Mikami and Sakaibara, 1988) | Dusky Apollo | L | Varshney and Smetacek (2015) |
| 309. | *Parnassius actius actius* (Eversmann, 1843) | Scarce Red Apollo | JKL | Khan et al. (2011b), Talbot (1939) and Tshikolovets (2005) |
| 310. | *Parnassius actius yelyangi* (Bang-Hass, 1934) | Scarce Red Apollo | K | Varshney and Smetacek (2015) |
| 311. | *Parnassius charltonius charltonius* (Gray, [1853]) ## | Regal Apollo | K | Eisner and Weiss (1990), Khan et al. (2011a, b), Kehimkar (2008), Talbot (1939) and Varshney and Smetacek (2015) |
| 312. | *Parnassius charltonius corporaali* (Bryk, 1935) | Regal Apollo | L | Varshney and Smetacek (2015) |
| 313. | *Parnassius charltonius deckerti* (Verity, 1927) | Regal Apollo | KL | Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 314. | *Parnassius charltonius eisnerianus* (Bryk, 1931) | Regal Apollo | L | Varshney and Smetacek (2015) |
| 315. | *Parnassius charltonius ella* (Bryk, 1931) | Regal Apollo | L | Varshney and Smetacek (2015) |
| 316. | *Parnassius charltonius otto* (Bryk and Eisner, 1932) | Regal Apollo | L | Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 317. | *Parnassius charltonius sakai* (Eisner, 1978) | Regal Apollo | L | Varshney and Smetacek (2015) |
| 318. | *Parnassius charltonius serenissimus* (Bryk, 1932) | Regal Apollo | KL | Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 319. | *Parnassius epaphus epaphus* (Oberthur 1879) | Common Red Apollo | L | Khan et al. (2011b), Talbot (1939) and Tshikolovets (2005) |
| 320. | *Parnassius epaphus gyaella* (Eisner, 1932) | Common Red Apollo | L | Varshney and Smetacek (2015) |
| 321. | *Parnassius epaphus puella* (Bryk, 1935) | Common Red Apollo | L | Varshney and Smetacek (2015) |
| 322. | *Parnassius epaphus rienki* (Eisner and Weiss, 1990) | Common Red Apollo | L | Varshney and Smetacek (2015) |
| 323. | *Parnassius epaphus sculptor* (Bryk and Eisner, 1939) | Common Red Apollo | L | Varshney and Smetacek (2015) |
| 324. | *Parnassius hardwickii hardwickii* (Gray, 1831) | Common Blue Apollo | KL | Khan et al. (2011b), Kehimkar (2008) and Tshikolovets (2005) |
| 325. | *Parnassius hunza hunza* Grum-(Grshimailo, 1888) | Karakoram Banded Apollo | L | Varshney and Smetacek (2015) |
| 326. | *Parnassius hunza shigarensis* (Bang-Haas, 1935) | Karakoram Banded Apollo | L | Varshney and Smetacek (2015) |
| 327. | *Parnassius jacquemontii jacquemontii* (Boisduval, 1836) ## | Keeled Apollo | KL | Bingham (1907), Evans (1932), Khan et al. (2011b), Talbot (1939) and Tshikolovets (2005) |
| 328. | *Parnassius jacquemontii hunzaica* (Tytler, 1926) | Keeled Apollo | L | Varshney and Smetacek (2015) |
| 329. | *Parnassius maharaja erici* (Hanus, Hanus and Manon, 1988) | Royal Apollo | L | Varshney and Smetacek (2015) |
| 330. | *Parnassius maharaja maharaja* (Avinoff, 1916) | Royal Apollo | JKL | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 331. | *Parnassius mamaievi affinis* (Peschkeand Eisner, 1934) | Scarce Banded Apollo | L | Varshney and Smetacek (2015) |
| 332. | *Parnassius mamaievi mamaievi* (Bang-Haas, 1915) | Scarce Banded Apollo | L | Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 333. | *Parnassius mamaievi workman* (Avinoff, 1916) | Scarce Banded Apollo | L | Varshney and Smetacek (2015) |
| 334. | *Parnassius simo chenrezi* (Wyatt, 1960) | Black-edged Apollo | KL | Varshney and Smetacek (2015) |
| 335. | *Parnassius simo colosseus* (Bang-Haas, 1935) | Black-edged Apollo | L | Varshney and Smetacek (2015) |
| 336. | *Parnassius simo ganymedes* (Bryk and Eisner, 1932) | Black-edged Apollo | L | Varshney and Smetacek (2015) |
| 337. | *Parnassius simo kangruensis* (Eisner and Weiss, 1990) | Black-edged Apollo | L | Varshney and Smetacek (2015) |
| 338. | *Parnassius simo lanaki* Bryk and (Eisner, 1932) | Black-edged Apollo | L | Varshney and Smetacek (2015) |
| 339. | *Parnassius simo lorimeri* (Tytler, 1926) | Black-edged Apollo | L | Varshney and Smetacek (2015) |
| 340. | *Parnassius simo saserensis* (Bang-Haas, 1937) | Black-edged Apollo | K | Talbot (1939) and Varshney and Smetacek (2015) |
| 341. | *Parnassius simo simo* (Gray, [1853]) | Black-edged Apollo | KL | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 342. | *Parnassius simo zarraensis* (Bang-Haas, 1935) | Black-edged Apollo | K | Talbot (1939) and Varshney and Smetacek (2015) |
| 343. | *Parnassius stenosemus atkinsoni* (Moore, [1902]) | Greater Banded Apollo | L | Khan et al. (2011b) and Tshikolovets (2005) |
| 344. | *Parnassius stenosemus divinus* (Bryk and Eisner, 1931) | Greater Banded Apollo | L | Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 345. | *Parnassius stenosemus nadiae* (Weiss and Michel, 1992) | Greater Banded Apollo | L | Varshney and Smetacek (2015) |
| 346. | *Parnassius stenosemus pensi* (Eisner and Weiss, 1990) | Greater Banded Apollo | L | Varshney and Smetacek (2015) |
| 347. | *Parnassius stenosemus rileyi* (Tytler, 1926) | Greater Banded Apollo | L | Varshney and Smetacek (2015) |
| 348. | *Parnassius stenosemus stenosemus* (Honrath, 1890) | Greater Banded Apollo | JKL | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 349. | *Parnassius stoliczkanus atkinsoni* (Moore, 1902) | Lesser Banded Apollo | KL | Talbot (1939) and Varshney and Smetacek (2015) |
| 350. | *Parnassius stoliczkanus beate* (Eisner, 1971) | Lesser Banded Apollo | L | Varshney and Smetacek (2015) |
| 351. | *Parnassius stoliczkanus davidi* (Eisner, 1971) | Lesser Banded Apollo | L | Varshney and Smetacek (2015) |
| 352. | *Parnassius stoliczkanus nicevillei* (Avinoff, 1916) | Lesser Banded Apollo | KL | Talbot (1939) and Varshney and Smetacek (2015) |
| 353. | *Parnassius stoliczkanus stoliczkanus* (C. and R. Felder, 1865) # | Lesser Banded Apollo | L | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 354. | *Parnassius stoliczkanus tenuis* (Bryk and Eisner 1865) | Lesser Banded Apollo | KL | Varshney and Smetacek (2015) |
| 355. | *Parnassius stoliczkanus thomas* (Eisner, 1939) | Lesser Banded Apollo | L | Varshney and Smetacek (2015) |
| 356. | *Parnassius stoliczkanus zanskarica* (Bang-Haas, 1935) | Lesser Banded Apollo | L | Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 357. | *Parnassius stoliczkanus zogilaica* (Tytler, 1926) | Lesser Banded Apollo | KL | Talbot (1939) and Varshney and Smetacek (2015) |
| 358. | *Parnassius tianschanica gilgitensis* (Bang-Haas, 1932) | Large Keeled Apollo | JKL | Varshney and Smetacek (2015) |
| | **Family V: Pieridae** | | | |
| | **Subfamily: Coliadinae** | | | |
| 359. | *Belenois aurota* (Fabricius, 1793) | Pioneer | JK | Bala et al. (2014), Bingham (1907), Khan et al. (2011a, b) and Qureshi et al. (2012b) |
| 360. | *Catopsilia crocale* (Cramer, 1775) | Lemon Emigrant | J | Khan et al. (2011a, b) and Viswanthan et al. (2004) |
| 361. | *Catopsilia pomona* (Fabricius, 1775) | Common Emigrant | K | Bala et al. (2014), Khan et al. (2011a, b), Qureshi and Bhagat (2013) and Talbot (1939) |
| 362. | *Catopsilia pyranthe* (Linnaeus, 1758) | Mottled Emigrant | JK | Das and Verma (1965), Das et al. (1964), Khan et al. (2011a, b), Qureshi et al. (2012a) and Qureshi and Bhagat (2013) |
| 363. | *Colias cocandica cocandica* (Erschoff, 1874) | Pamir Clouded Yellow | L | Kehimkar (2008) and Tshikolovets (2005) |
| 364. | *Colias eogene eogene* (C. and R. Felder, 1865) ## | Fiery Clouded Yellow | KL | Khan et al. (2011b), Kehimkar (2008), Qureshi et al. (2012b) and Talbot (1939) |
| 365. | *Colias eogene francesca* (Watkins, 1927) | Fiery Clouded Yellow | K | Bingham (1907), Evans (1932) and Varshney and Smetacek (2015) |
| 366. | *Colias fieldi* (Menetries, 1855) | Dark Clouded Yellow | KL | Dar et al. (2002), Das et al. (1964), Home (1938), Khan et al. (2011a, b), Qureshi et al. (2012a, 2013b c, d, e, 2014), Qureshi and Bhagat (2015), Thomas-Glover (1936), Tshikolovets (2005) and Varshney and Smetacek (2015) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 367. | *Colias erate* (Esper, 1805) | Pale Clouded Yellow | JKL | Bingham (1905), Dar et al. (2002), Das and Verma (1965), Das et al. (1964), Home (1938), Khan et al. (2011b), Kehimkar (2008), Qureshi et al. (2012a, 2013b, c, d, e, 2014), Qureshi and Bhagat (2015), Thomas-Glover (1936), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 368. | *Colias ladakensis* (C. and R. Felder, 1865) ## | Ladakh Clouded Yellow | KL | Bingham (1907), Khan et al. (2011b), Qureshi et al. (2013b), Talbot (1939) and Tshikolovets (2005) |
| 369. | *Colias leechi* (Grum-Grshimailo, 1893) | Glaucous Clouded Yellow | JKL | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 370. | *Colias marcopolo* (Grum-Grshimailo, 1883) | Marcopolo's Clouded Yellow | JKL | Varshney and Smetacek (2015) |
| 371. | *Colias stoliczkana stoliczkana* (Moore, 1878) | Orange Clouded Yellow | KL | Bingham (1907), Evans (1932), Khan et al. (2011b), Qureshi et al. (2013b), Talbot (1939) and Varshney (1993), |
| 372. | *Colias thrasibulus thrasibulus* (Fruhstorfer, 1903) # | Lemon Clouded Yellow | L | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 373. | *Colias wiskotti* (Staudinger, 1882) | Broad-bordered Clouded Yellow | L | Varshney and Smetacek (2015) |
| 374. | *Eurema andersoni* (Moore, 1866) | One Spot Grass Yellow | JKL | Khan et al. (2011b) |
| 375. | *Eurema blanda* (Boisduval, 1836) | Three Spot Grass Yellow | J | Viswanthan et al. (2004) |
| 376. | *Eurema brigitta* (Stoll, [1780]) | Small Grass Yellow | JKL | Khan et al. (2011a, b) |
| 377. | *Eurema hecabe* (Linnaeus, 1758) | Common Grass Yellow | JK | Bala et al. (2014), Khan et al. (2011a, b), Qureshi and Bhagat (2013) and Qureshi et al. (2012a, 2013c) |
| 378. | *Eurema laeta* (Boisduval, 1836) | Spotless Grass Yellow | JKL | Khan et al. (2011a, b) |
| 379. | *Gandaca harina* (Horsfield, [1829]) | Tree Yellow | J | Viswanthan et al. (2004) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 380. | *Gonepteryx mahaguru mahaguru* (Gistel, 1857) | Lesser Brimstone | K | Dar et al. (2002), Evans (1932), Khan et al. (2011b), Kehimkar (2008), Qureshi et al. (2013b), Talbot (1939), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 381. | *Gonepteryx rhamni nepalensis* (Doubleday, [1847]) | Common Brimstone | JKL | Bala et al. (2014), Khan et al. (2011a, b), Kehimkar (2008), Qureshi et al. (2012a, 2013c, d, e, 2014), Qureshi and Bhagat (2015), Tshikolovets (2005), Varshney (1993) and Varshney and Smetacek (2015) |
| | **Subfamily: Pierinae** | | | |
| 382. | *Aporia agathon phryxe* (Boisduval, [1836]) ## | Great Blackvein | K | Bingham (1907), Dar et al. (2002), Evans (1932), Haribal (1992), Khan et al. (2011b), Kehimkar (2008), Qureshi and Bhagat (2013), Talbot (1939) and Wynter-Blyth (1957) |
| 383. | *Aporia leucodice* (Eversmann, 1843) | Baluchi Blackvein | K | Bala et al. (2014), Bingham (1907), Evans (1932), Dar et al. (2002), Khan et al. (2011b), Qureshi and Bhagat (2013), Qureshi et al. (2013c), Qureshi et al. (2013e), Talbot (1939) and Wynter-Blyth (1957) |
| 384. | *Aporia nabellica nabellica* (Boisduval, [1836]) ## | Dusky Blackvein | KL | Bingham (1907), Dar et al. (2002), Evans (1932), Khan et al. (2011b), Talbot (1939), Tshikolovets (2005) and Wynter-Blyth (1957) |
| 385. | *Aporia soracta soracta* (Moore, 1857) | Himalayan Blackvein | JKL | Khan et al. (2011b), Kehimkar (2008), Qureshi et al. (2014), Qureshi and Bhagat (2015), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 386. | *Baltia butleri butleri* (Moore, 1882) ## | Butler's Dwarf | JKL | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 387. | *Baltia shawii shawii* (Bates, 1873) | Shaw's Dwarf | JKL | Khan et al. (2011b), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 388. | *Colotis etrida etrida* (Biosduval, 1876) | Little Orange Tip | JK | Bingham (1907) and Qureshi and Bhagat (2013) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 389. | *Delias sanaca* (Moore, 1857) # | Pale Jezabel | JKL | Kehimkar (2008), Qureshi and Bhagat (2013) and Wynter-Blyth (1957) |
| 390. | *Delias eucharis* (Drury, 1773) | Common Hezebel | J | Viswanthan et al. (2004) |
| 391. | *Delias belladonna horsfieldi* (Gray, 1831) | Hill Jezabel | K | Khan et al. (2011b) and Varshney and Smetacek (2015) |
| 392. | *Euchloe daphalis* (Moore, 1865) | Little White | JKL | Tshikolovets (2005) |
| 393. | *Hebomoia glaucippe* (Linnaeus, 1758) | Great Orange Tip | J | Viswanthan et al. (2004) |
| 394. | *Ixias marianne* (Crammer, [1779]) | White Orange Tip | JK | Bala et al. (2014) and Khan et al. (2011a, b) |
| 395. | *Ixias pyrene* (Linnaeus, 1764) | Yellow Orange Tip | JKL | Khan et al. (2011a, b) |
| 396. | *Pieris ajaka* (Moore, 1865) | Himalayan White | JKL | Varshney and Smetacek (2015) |
| 397. | *Pieris brassicae nepalensis* (Gray, 1846) | Large Cabbage White | JKL | Bala et al. (2014), Bhat et al. (2010), Bhat et al. (2011), Dar et al. (2002), Das and Verma (1965), Home (1938), Jamdar (1991, 1992), Khan et al. (2003), Khan et al. (2011a, b), Kehimkar (2008), Malik et al. (1972), Qureshi and Bhagat (2013), Qureshi et al. (2012a, 2013c, d, e, 2014), Qureshi and Bhagat (2015), Thomas-Glover (1936), Tshikolovets (2005), Varshney and Smetacek (2015) and Wynter-Blyth (1957) |
| 398. | *Pieris canidia indica* (Evans, 1926) | Indian Cabbage White | K | Bingham (1907), Khan et al. (2003), Khan et al. (2004), Khan et al. (2011a, b), Kehimkar (2008), Qureshi et al. (2012a), Qureshi and Bhagat (2013), Qureshi et al. (2013c), Qureshi et al (2014), and Qureshi and Bhagat (2015) |
| 399. | *Pieris canidia palaearctica* (Staudinger, 1886) | Indian Cabbage White | L | Khan et al. (2011b) and Tshikolovets (2005) |
| 400. | *Pieris deota deota* (de Niceville, [1884]) ## | Kashmir White | KL | Talbot (1939) and Tshikolovets (2005) |

(continued)

**Table 28.1** (continued)

| S. No. | Taxa | Common/ English name | Distribution | References |
|---|---|---|---|---|
| 401. | *Pieris krueperi devta* (de Niceville, [1884]) # | Kruepers's Small White/ Green Banded White | KL | Khan et al. (2011b), Kehimkar (2008), Talbot (1939) and Tshikolovets (2005) |
| 402. | *Pieris rapae rapae* (Linnaeus, 1758) | Small Cabbage White | JKL | Bhat et al. (2011), Dar et al. (2002), Khan et al. (2011a, b), Kehimkar (2008), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 403. | *Pontia callidice kalora* (Moore, 1865) | Lofty Bath White | JKL | Khan et al. (2011b), Kehimkar (2008), Tshikolovets (2005) and Varshney and Smetacek (2015) |
| 404. | *Pontia chloridice alpina* (Verity, 1911) ## | Peak White/ Small Bath White/Lesser Bath White | L | Varshney and Smetacek (2015) |
| 405. | *Pontia chloridice chloridice* (Hubner, [1813]) | Peak White/ Small Bath White | JKL | Khan et al. (2003), Khan et al. (2011b), Kehimkar (2008) and Tshikolovets (2005) |
| 406. | *Pontia daplidice daplidice* (Linnaeus, 1758) | Bath White | JKL | Bala et al. (2014), Bingham (1907), Bhat et al. (2011), Dar et al. (2002), Khan et al. (2003), Khan et al. (2011a, b), Kehimkar (2008), Qureshi et al. (2012a, 2013c, d, e, 2014), Qureshi and Bhagat (2015), Talbot (1939), Tshikolovets (2005) and Wynter-Blyth (1957) |
| 407. | *Pontia daplidice moorei* (Roeber, [1907]) | Bath White | JKL | Khan et al. (2011b) and Varshney and Smetacek (2015) |
| 408. | *Pontia glauconome* (Klug, 1829) | Desert Bath White | K | Malik et al. (1972) and Qureshi and Bhagat (2013) |

# species included in the Schedule-I of Wildlife (Protection) Act (1972), of India
## species included in the Schedule-II of Wildlife (Protection) Act (1972), of India

rently threatened (Dar et al. 2002), and just like other floral and faunal elements, butterflies are facing survival risks with many species already listed in Red Data books. Some of the identified threats to butterfly diversity include (i) habitat destruction, degradation and fragmentation, (ii) illegal trade, (iii) grazing, (iv) biotic pressure, (v) climate change, (vi) fires, (vii) application of chemical pesticides and weedicides in agricultural and urban ecosystems, and (viii) administrative and legal loopholes. In India, some of the areas where considerable butterfly trading goes on are in the Himalaya and in northeastern India (Kunte 2006). Although J&K State forms an important region of the Himalaya, its bio-wealth including butterflies is scientifically poorly reported and documented. There is still lack of basic informa-

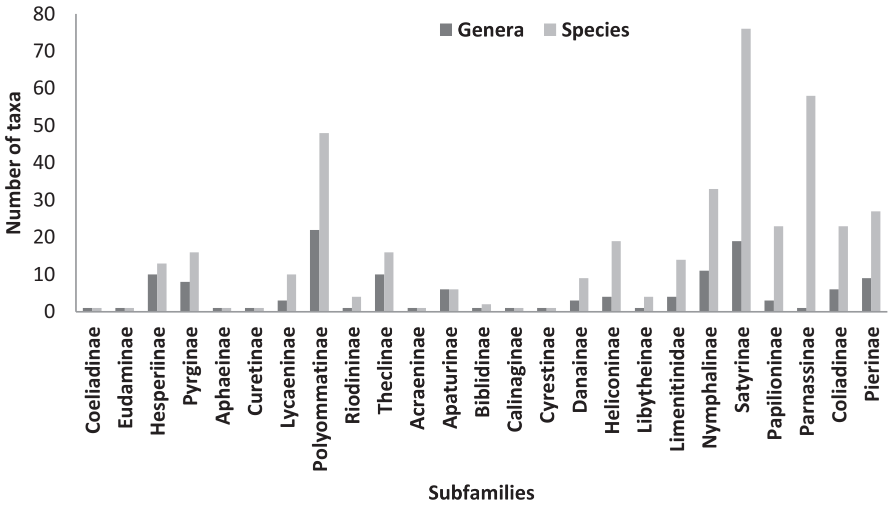


**Fig. 28.1** Subfamily-wise diversity in butterfly fauna of **J&K** State

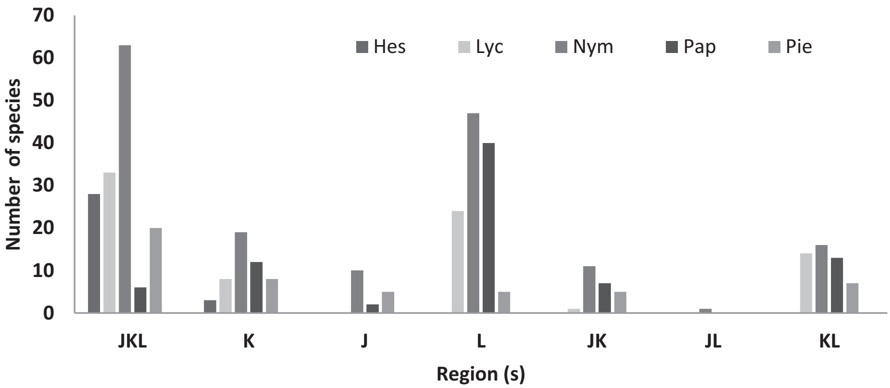


**Fig. 28.2** Region-wise diversity of butterflies in **J&K** State**.** (Hes = Hesperiidae; Lyc = Lycaenidae; Nym = Nymphalidae; Pap = Papilionidae; Pie = Pieridae)

tion on taxonomy, distributional records, status, biology, ecology, etc., for both widely distributed and endangered butterfly species (Plate 28.1).

## 28.4 Concluding Remarks

Butterflies are biological indicators of a healthy environment. In recent times, much emphasis is given to butterflies in the developed world and numerous and relatively small nature reserves have been set up to protect particular species or butterfly-rich


**Plate 28.1** Butterflies:(**A**) *Pieris brassicae* (**B**) *Gonepteryx rhamni* (**C**) *Junonia orithya* (**D**) *Colias electo* (**E**) *Aulocera padma* (**F**) *Vanessa indica ;* (**G**) *Cynthia cardui* (**H**) *Pontia daplidice* (**I**) *Lebithya lepita* (**J**) *Aglias cashmirensis* (**K**) *Argynnis childreni* (**L**). *Aulocera brahminus*

habitats. These allow the butterflies to prosper in areas threatened by human activities. Such conservation measures need to be undertaken in the developing world as well. In the J&K State, inspite of having its separate J&K Wildlife (Protection) Act, 1978 (JKWPA), to date no butterfly species has been listed. Thus, there is an urgent need to include the threatened butterflies in JKWPA, which will provide legal protection at the regional level. An enormous amount of organized research using new methodologies/technologies including molecular analysis (DNA barcoding), geospatial tools, information technology, etc., is required so that a reliable information base can be achieved for the conservation of butterfly and other biodiversity elements of J&K State. There is immense scope to popularize the concept of butterfly parks/gardens, which besides boosting ecotourism opportunities in the State shall pave way for the public awareness and participation in the conservation process. Further, there is need to promote research involving long-term monitoring, strict enforcement of laws, conservation education, citizen science among local communities, besides having a strong government support and political will for the overall documentation, conservation, and management of these beautiful creatures of nature. There are innumerable opportunities for entomologists, pollination biologists, policy makers, and other stakeholders to jointly put concerted efforts towards conservation of butterfly biodiversity of the State.

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# Chapter 29
# Select Brachycera Families (Diptera) in Jammu and Kashmir State

**Aijaz Ahmad Wachkoo, Shahid Ali Akbar, Ghulam Mustafa Shah, and Ulfat Jan**

**Abstract** The chapter presents an inventory of select dipteran families Bombyliidae (bee flies), Conopidae (thick-headed flies), Dryomyzidae (Dryomyzid flies), Megamerinidae (Megamerinid flies), Stratiomyidae (soldier flies), Syrphidae (hover flies), and Ulidiidae (picture-winged flies) recorded from Jammu and Kashmir State. Altogether 107 valid species have been reported from the State. Family Syrphidae is the most diverse with 88 species grouped in 33 genera followed by Bombyliidae with 7 species in 6 genera. Conopidae represents 6 species belonging to 4 genera, while Stratiomyidae is represented by 3 species placed in 3 genera. Dryomyzidae, Megamerinidae, and Ulidiidae each are represented by a single species. The inventory can serve as a baseline data for undertaking future studies on dipteran fauna in Jammu and Kashmir.

**Keywords** Diptera · Bee flies · Thick-headed flies · Soldier flies · Hover flies · Jammu and Kashmir State

## 29.1 Introduction

Dipterans (Order: Diptera) are a group of insects containing the two-winged or so-called true flies. They bear only one pair of functional wings. The reduced remnants of the second pair of wings are known as halteres and seem to function as stabilizers or as airspeed detectors. Globally, Diptera comprises more than 124,000 species and

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_29

constitutes about 12% of the planetary biota (Pape and Evenhuis 2013). Diptera includes two large suborders: Nematocera (antenna with more than six clearly defined segments, typically without style or arista, e.g., crane flies, midges, gnats, mosquitoes) and Brachycera (antennae with five or fewer segments, usually three, and bearing an arista or style, e.g, horse flies, robber flies, bee flies). Many flies are of major economic importance. A number of bloodsuckers are serious pests of humans and other animals, and some are important vectors of disease, whereas others are pests of cultivated plants. Flies are beneficial too, functioning as scavengers, predators, or parasites of certain insect pests, pollinators of plants, and biocontrol agents against obnoxious weeds.

Like the other insect groups, documentation of dipterans too has received little research attention in the developing countries, including India. Since Brunetti's (1920, 1923a, b) work about a century ago, no thorough studies have ever been undertaken. Here we provide the species list of seven Brachyceran families: Bombyliidae (bee flies), Conopidae (thick-headed flies), Dryomyzidae (Dryomyzid flies), Megamerinidae (Megamerinid flies), Stratiomyidae (soldier flies), Syrphidae (hover flies), and Ulidiidae (picture-winged flies) recorded from Jammu and Kashmir (Table 29.1), based on systematic screening of the published literature (e.g., Brunetti 1923a, b; Ghorpadé 1994; Evenhuis and Greathead 1999; Pape and Evenhuis 2013; Shah et al. 2014; Wachkoo et al. 2017). In total, these seven dipteran families represent 107 species and 49 genera from Jammu and Kashmir (Table 29.1; Plates 29.1 and 29.2).

## 29.2 Materials and Methods

Faunal diversity of Jammu and Kashmir is rich and diversified due to varied climatic conditions ranging from subtropical in Shivalik foothills to cold-arid in the Trans-Himalaya. There is dominance of Palaearctic and endemic fauna above timberline (above 3000 m) and Oriental and some Palaearctic and Ethiopian elements at middle and lower altitudes. Jammu (J), Kashmir (K), and Ladakh (L) represent the three distinct regions of Jammu and Kashmir State, which inhabit the different dipteran fauna and are listed accordingly in the present chapter.

The inventory is mostly based on the perusal of available literature. Most of the names of described species presented are in accordance with the recent Dipteran classification following Systema Dipterorum (Pape and Evenhuis 2013).

## 29.3 Results

**Table 29.1** Select Brachycera (Diptera) families in Jammu and Kashmir State

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| **Bee flies (Bombyliidae)** | | | | | |
| 1. | *Anastoechus kashmirensis* (Zaitzev, 1988) | – | + | – | Evenhuis and Greathead (1999) |
| 2. | *Systoechus socius* (Walker, 1852) | – | + | – | Evenhuis and Greathead (1999) |
| 3. | *Petrorossia orientalis* (Zaitzev, 1988) | – | + | – | Evenhuis and Greathead (1999) |
| 4. | *Phthiria gracilis* (Walker, 1852) | – | + | – | Evenhuis and Greathead (1999) |
| 5. | *Thyridanthrax keiseri* (François, 1968) | – | + | – | Evenhuis and Greathead (1999) |
| 6. | *Villa baluchiana* (Brunetti, 1920) | – | + | – | Evenhuis and Greathead (1999) |
| 7. | *Villa manifesta* (Walker, 1852) | – | + | – | Evenhuis and Greathead (1999) |
| **Thick-headed flies (Conopidae)** | | | | | |
| 8. | *Physocephala rufescens* (Brunetti, 1923) | – | + | – | Brunetti (1923b) |
| 9. | *Myopa confusa* (Stuke, 2004) | – | + | – | Stuke (2004) and Pape and Evenhuis (2013) |
| 10. | *Myopa nigriventris* (Brunetti, 1923) | – | + | – | Brunetti (1923b) |
| 11. | *Myopa testacea* (Linnaeus, 1767) | – | + | – | Brunetti (1923b) |
| 12. | *Sicus ferrugineus* (Linnaeus, 1761) | – | + | – | Pape and Evenhuis (2013) |
| 13. | *Zodion griseum* (Brunetti, 1923) | – | + | – | Pape and Evenhuis (2013) |
| **Dryomyzid flies (Dryomyzidae)** | | | | | |
| 14. | *Dryomyza pakistana* (Kurahashi, 1989) | – | + | – | Wachkoo et al. (2018a) |
| **Megamerinid flies (Megamerinidae)** | | | | | |
| 15. | *Megamerina dolium* (Fabricius, 1805) | – | + | – | Wachkoo et al. (2018b) |
| **Soldier flies (Stratiomyidae)** | | | | | |
| 16. | *Odontomyia kashmirensis* (Brunetti, 1920) | – | + | – | Brunetti (1920) and Wachkoo et al. (2017) |
| 17. | *Sargus mactans* (Walker, 1859) | – | + | – | Wachkoo (2017, personal collection) |
| 18. | *Stratiomys approximata* (Brunetti, 1923) | – | + | – | Brunetti (1923a) and Wachkoo et al. (2017) |
| **Hover flies (Syrphidae)** | | | | | |
| 19. | *Asarkina incisuralis* (Macquart, 1855) | + | – | – | Datta and Chakraborti (1984), Ghorpadé (2009), and Shah et al. (2014) |
| 20. | *Betasyrphus isaaci* (Bhatia, 1933) | + | + | – | Ghorpadé (2009) and Shah et al. (2014) |

(continued)

**Table 29.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 21. | *Ceriana brevis* (Brunetti, 1923) | – | + | – | Aslamkhan et al. (1997), Pape and Evenhuis (2013) and Shah et al. (2014) |
| 22. | *Ceriana dimidiatipennis* (Brunetti, 1923) | – | + | – | Aslamkhan et al. (1997) and Shah et al. (2014) |
| 23. | *Cheilosia songarea* (Becker, 1894) | – | + | + | Lambeck and Brink (1973) and Shah et al. (2014) |
| 24. | *Chrysotoxum baphyrum* (Walker, 1849) | + | + | – | Datta and Chakraborti (1984) and Shah et al. (2014) |
| 25. | *Chrysotoxum convexum* (Brunetti, 1915) | – | + | – | Ghorpadé (2014) |
| 26. | *Chrysotoxum fasciolatum* (De Geer, 1776) | + | + | – | Violovitsh (1974), Ghorpadé (1994) and Shah et al. (2014) |
| 27. | *Chrysotoxum intermedium* (Meigen, 1822) | + | + | + | Violovitsh (1974), Ghorpadé (1994, 2012), and Shah et al. (2014) |
| 28. | *Criorhina imitator* (Brunetti, 1915) | – | + | + | Brunetti (1923b), Aslamkhan et al. (1997), and Shah et al. (2014) |
| 29. | *Criorhina pallipilosa* (Hull, 1944) | – | + | – | Hull (1944) and Shah et al. (2014) |
| 30. | *Criorhina rubropilosa* (Hull, 1950) | – | + | – | Hull (1950) and Shah et al. (2014) |
| 31. | *Criorhina vivida* (Brunetti, 1923) | – | + | – | Brunetti (1923b), Aslamkhan et al. (1997), and Shah et al. (2014) |
| 32. | *Dasysyrphus darada* (Ghorpadé, 1994) | – | – | + | Ghorpadé (1994), and Shah et al. (2014) |
| 33. | *Dasysyrphus orsua* (Walker, 1852) | + | + | + | Ghorpadé (1994, 2009) and Shah et al. (2014) |
| 34. | *Dasysyrphus pandu* (Ghorpadé, 1994) | – | – | + | Ghorpadé (1994) and Shah et al. (2014) |
| 35. | *Didea vockerothi* (Ghorpadé, 1994) | – | + | – | Ghorpadé (1994) and Shah et al. (2014) |
| 36. | *Epistrophe griseocincta* (Brunetti, 1923) | – | + | – | Nayar (1968a); Ghorpadé (1994); Shah et al. (2014) |
| 37. | *Episyrphus balteatus* (De Geer, 1776) | + | + | – | Nayar (1968a), Lambeck and Brink (1973), Datta and Chakraborti (1984), Abrol (1993), and Shah et al. (2014) |
| 38. | *Eristalinus aeneus* (Scopoli, 1763) | + | + | – | Datta and Chakraborti (1984) and Shah et al. (2014) |
| 39. | *Eristalinus arvorum* (Fabricius, 1787) | + | + | – | Brunetti (1923b), Datta and Chakraborti (1984), and Shah et al. (2014) |
| 40. | *Eristalinus megacephalus* (Rossi, 1794) | + | + | – | Brunetti (1923b) and Shah et al. (2014) |
| 41. | *Eristalinus paria* (Bigot, 1880) | + | + | – | Nayar (1968b), Datta and Chakraborti (1984), and Shah et al. (2014) |
| 42. | *Eristalinus sepulchralis* (Linnaeus, 1758) | + | + | – | Brunetti (1923b), Aslamkhan et al. (1997), and Shah et al. (2014) |

(continued)

**Table 29.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 43. | *Eristalis arbustorum* (Linnaeus, 1758) | + | + | – | Brunetti (1923b), Aslamkhan et al. (1997), and Shah et al. (2014) |
| 44. | *Eristalis brevifacies* (Coe, 1964) | – | + | – | Coe (1964), Pape and Evenhuis (2013), and Shah et al. (2014) |
| 45. | *Eristalis cerealis* (Fabricius, 1805) | + | + | – | Nayar (1968b), Datta and Chakraborti (1984), and Shah et al. (2014) |
| 46. | *Eristalis himalayensis* (Brunetti, 1908) | + | + | – | Brunetti (1923b), Datta and Chakraborti (1984), and Shah et al. (2014) |
| 47. | *Eristalis tenax* (Linnaeus, 1758) | + | + | – | Lambeck and Brink (1973), Datta and Chakraborti (1984) and Shah et al. (2014) |
| 48. | *Eumerus albifrons* (Walker, 1852) | + | + | – | Brunetti (1923b), Abrol (1993) and Shah et al. (2014) |
| 49. | *Eumerus ammophilus* (Paramonov, 1926) | – | – | + | Doesburg (1955) and Shah et al. (2014) |
| 50. | *Eumerus aurifrons* (Wiedemann, 1824) | + | + | – | Brunetti (1923b) and Shah et al. (2014) |
| 51. | *Eumerus kashmerensis* (Kohli, Kapoor & Gupta, 1988) | + | + | – | Kohli et al. (1988) and Shah et al. (2014) |
| 52. | *Eumerus nepalensis* (Brunetti, 1908) | + | + | – | Abrol (1993) and Shah et al. (2014) |
| 53. | *Eumerus nicobarensis* (Schiner, 1868) | + | + | + | Brunetti (1923b), Ghorpadé (2014) and Shah et al. (2014) |
| 54. | *Eumerus pulverulentus* (Brunetti, 1923) | + | + | – | Brunetti (1923b), Shah et al. (2014), and Shah et al. (2014) |
| 55. | *Eupeodes bucculatus* (Rondani, 1857) | + | + | – | Ghorpadé (1994) and Shah et al. (2014) |
| 56. | *Eupeodes confrater* (Wiedemann, 1830) | + | + | – | Nayar (1968a), Abrol (1993) and Shah et al. (2014) |
| 57. | *Eupeodes corollae* (Fabricius, 1794) | + | + | – | Nayar (1968a), Lambeck and Brink (1973), Abrol (1993), and Shah et al. (2014) |
| 58. | *Eupeodes latifasciatus* (Macquart, 1829) | + | + | – | Nayar (1968a), Lambeck and Brink (1973), Datta and Chakraborti (1984), and Shah et al. (2014) |
| 59. | *Eupeodes nuba* (Wiedemann, 1830) | + | + | – | Nayar (1968a) and Shah et al. (2014) |
| 60. | *Ferdinandea isabella* (Hull, 1942) | – | + | – | Hull (1942), Coe (1964), and Shah et al. (2014) |
| 61. | *Ferdinandea montana* (Hull, 1942) | – | + | – | Hull (1942), Coe (1964), and Shah et al. (2014) |
| 62. | *Graptomyza brevirostris* (Wiedemann, 1820) | + | – | – | Datta and Chakraborti (1984) and Shah et al. (2014) |
| 63. | *Melangyna remota* (Brunetti, 1923) | – | + | – | Ghorpadé (2009) and Shah et al. (2014) |
| 64. | *Melanostoma orientale* (Wiedemann, 1824) | + | + | – | Lambeck and Brink (1973), Datta and Chakraborti (1984) and Shah et al. (2014) |

(continued)

**Table 29.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 65. | *Meliscaeva lefroyi* (Ghorpadé, 1994) | – | + | – | Ghorpadé (1994) and Shah et al. (2014) |
| 66. | *Orthonevra kozlovi* (Stackelberg, 1952) | – | + | – | Lambeck and Brink (1973) and Shah et al. (2014) |
| 67. | *Orthonevra nobilis* (Fallen, 1817) | – | – | + | Doesburg (1955) and Shah et al. (2014) |
| 68. | *Pararctophila oberthuri* (Herve-Bazin, 1914) | – | + | – | Ghorpadé (2014) |
| 69. | *Paragus annandalei* (Ghorpadé, 1992) | + | – | – | Thompson and Ghorpadé (1992) and Shah et al. (2014) |
| 70. | *Paragus bicolor* (Fabricius, 1794) | – | + | – | Thompson and Ghorpadé (1992) and Shah et al. (2014) |
| 71. | *Paragus politus* (Wiedemann, 1830) | + | + | – | Datta and Chakraborti (1984), Thompson and Ghorpadé (1992), and Shah et al. (2014) |
| 72. | *Paragus quadrifasciatus* (Meigen, 1822) | – | + | – | Datta and Chakraborti (1984), Thompson and Ghorpadé (1992), and Shah et al. (2014) |
| 73. | *Paragus rufocincta* (Brunetti, 1908) | – | + | – | Datta and Chakraborti (1984), Thompson and Ghorpadé (1992), and Shah et al. (2014) |
| 74. | *Paragus serratus* (Fabricius, 1805) | + | + | – | Datta and Chakraborti (1984), Thompson and Ghorpadé (1992), and Shah et al. (2014) |
| 75. | *Paragus tibialis* (Fallen, 1817) | + | + | – | Datta and Chakraborti (1984), Thompson and Ghorpadé (1992), and Shah et al. (2014) |
| 76. | *Parasyrphus kashmiricus* (Ghorpadé, 1994) | – | + | – | Ghorpadé (1994) and Shah et al. (2014) |
| 77. | *Parasyrphus thompsoni* (Ghorpadé, 1994) | – | + | – | Ghorpadé (1994) and Shah et al. (2014) |
| 78. | *Phytomia errans* (Fabricius, 1787) | + | – | – | Datta and Chakraborti (1984) and Shah et al. (2014) |
| 79. | *Platycheirus albimanus* (Fabricius, 1781) | – | + | – | Lambeck and Brink (1973) and Shah et al. (2014) |
| 80. | *Platycheirus ambiguus* (Fallen, 1817) | – | – | + | Sack (1935), Doesburg (1955), and Shah et al. (2014) |
| 81. | *Platycheirus angustatus* (Zetterstedt, 1843) | – | + | + | Sack (1935), Doesburg (1955), Lambeck and Brink (1973), and Shah et al. (2014) |
| 82. | *Platycheirus cryophilus* (Nielsen, 2007) | – | – | + | Nielsen (2007) and Shah et al. (2014) |
| 83. | *Platycheirus kashmiricus* (Nielsen, 2004) | – | – | + | Nielsen (2004) and Shah et al. (2014) |
| 84. | *Platycheirus peteri* (Doesburg, 1955) | – | – | + | Doesburg (1955) and Shah et al. (2014) |
| 85. | *Rohdendorfia dimorpha* (Smirnov, 1924) | – | – | + | Sack (1935), Doesburg (1955), and Shah et al. (2014) |
| 86. | *Scaeva albomaculata* (Macquart, 1842) | – | + | + | Sack (1935), Rahman (1940), Doesburg (1955), and Shah et al. (2014) |

(continued)

**Table 29.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 87. | *Scaeva latimaculata* (Brunetti, 1923) | + | + | – | Nayar (1968a), Ghorpadé (2009), and Shah et al. (2014) |
| 88. | *Scaeva pyrastri* (Linnaeus, 1758) | – | + | – | Ghorpadé (2014) |
| 89. | *Simosyrphus scutellaris* (Fabricius, 1805) | + | + | – | Datta and Chakraborti (1984), Abrol (1993), and Shah et al. (2014) |
| 90. | *Sphaerophoria bengalensis* (Macqaurt, 1842) | + | + | – | Lambeck and Brink (1973), Abrol (1993), and Shah et al. (2014) |
| 91. | *Sphaerophoria indiana* (Bigot, 1884) | + | + | – | Datta and Chakraborti (1984), Abrol (1993), and Shah et al. (2014) |
| 92. | *Sphaerophoria ladakhensis* (Ghorpadé, 1994) | – | – | + | Ghorpadé (1994) and Shah et al. (2014) |
| 93. | *Sphaerophoria rueppellii* (Wiedemann, 1830) | + | + | – | Ghorpadé (1994, 2009) and Shah et al. (2014) |
| 94. | *Sphaerophoria scripta* (Linnaeus, 1758) | + | + | – | Datta and Chakraborti (1984) and Shah et al. (2014) |
| 95. | *Sphaerophoria viridaenea* (Brunetti, 1915) | + | + | – | Nayar (1968a), Ghorpadé (1994), and Shah et al. (2014) |
| 96. | *Syritta pipiens* (Linnaeus, 1758) | + | + | – | Lambeck and Brink (1973), Datta and Chakraborti (1984), and Shah et al. (2014) |
| 97. | *Syrphus dalhousiae* (Ghorpadé, 1994) | – | + | – | Ghorpadé (1994) and Shah et al. (2014) |
| 98. | *Syrphus fulvifacies* (Brunetti, 1913) | – | + | – | Brunetti (1923b), Aslamkhan et al. (1997), and Shah et al. (2014) |
| 99. | *Syrphus howletti* (Ghorpadé, 1994) | – | + | – | Ghorpadé (1994) and Shah et al. (2014) |
| 100. | *Syrphus ribesii* (Linnaeus, 1758) | + | + | – | Nayar (1968a), Ghorpadé (1994), and Shah et al. (2014) |
| 101. | *Syrphus torvus* (Osten Sacken, 1875) | + | + | – | Ghorpadé (1994) and Shah et al. (2014) |
| 102. | *Syrphus vitripennis* (Meigen, 1822) | + | + | – | Ghorpadé (1994) and Shah et al. (2014) |
| 103. | *Tuberculanostoma solitarium* (Doesburg, 1955) | – | + | + | Doesburg (1955) and Shah et al. (2014) |
| 104. | *Volucella pellucens* (Linnaeus, 1758) | – | + | + | Ghorpadé (2014) |
| 105. | *Volucella ruficauda* (Brunetti, 1907) | – | + | + | Ghorpadé (2014) |
| 106. | *Volucella varipila* (Coe, 1964) | – | + | – | Coe (1964), Pape and Evenhuis (2013), and Shah et al. (2014) |
| **Picture-winged flies (Ulidiidae)** | | | | | |
| 107. | *Myennis octopunctata* (Coquebert, 1798) | – | + | – | Wachkoo et al. (2018b) |

Abbreviations: *J* Jammu, *K* Kashmir, *L* Ladakh; presence of each species in these regions is marked with "+" while absence is marked with "–")

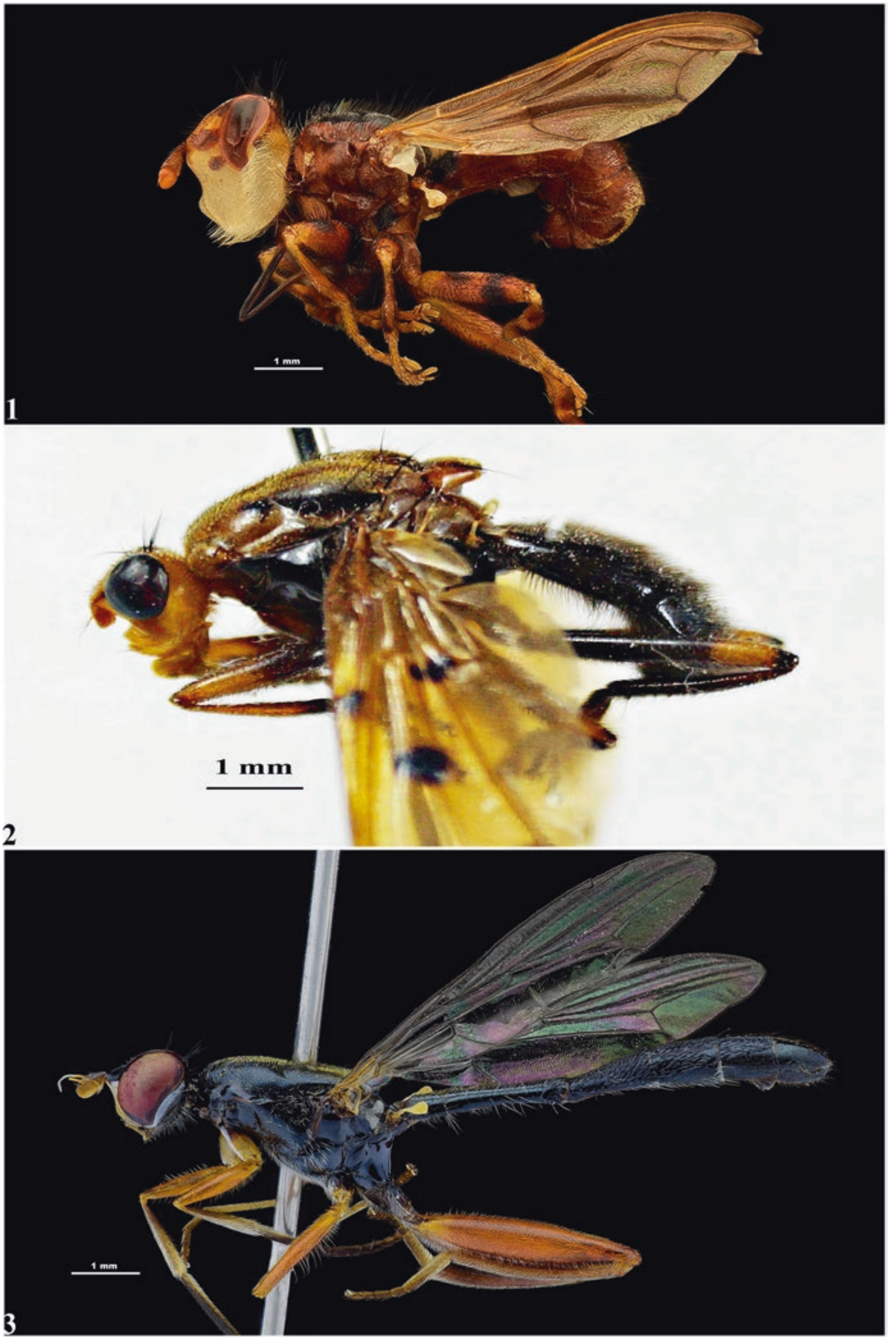


**Plate 29.1** **1–3** Habitus lateral view of some regional dipterans: **1** *Myopa testacea* (Linnaeus, 1767); **2** *Dryomyza pakistana* Kurahashi, 1989; **3** *Megamerina dolium* (Fabricius, 1805)

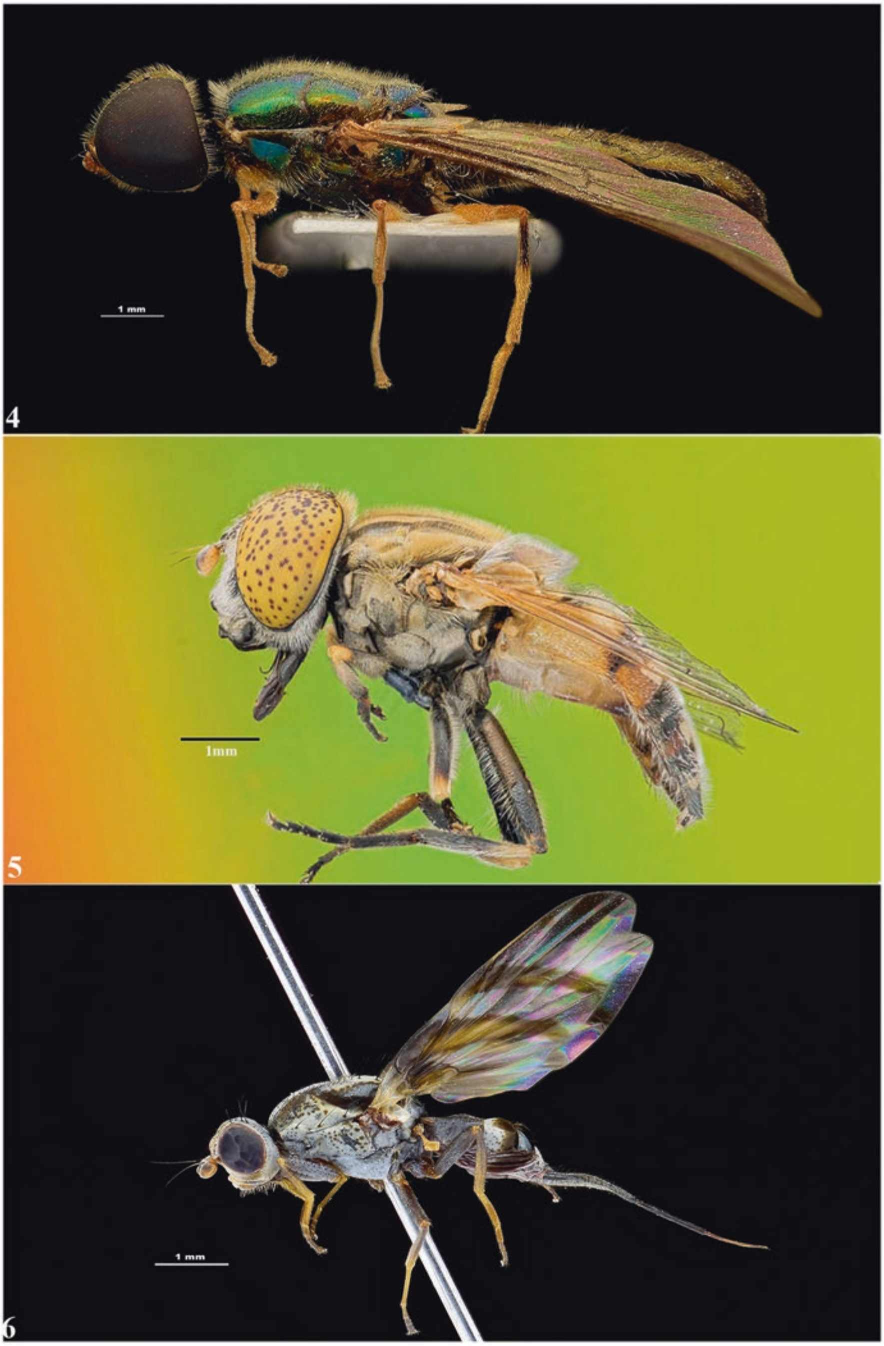


**Plate 29.2** **4–6** Habitus lateral view of some regional dipterans: **4** *Sargus mactans* Walker, 1859; **5** *Eristalinus megacephalus* (Rossi, 1794); **6** *Myennis octopunctata* (Coquebert, 1798)

## 29.4 Concluding Remarks

Flies are among the key components in most ecosystems and beneficial in many ways; they pollinate flowers, control arthropod pests, and provide food for other species, and of course some flies spread diseases. The present study of select dipteran families provides a synthesis of the taxonomical work carried out in Jammu and Kashmir until now and can serve as a baseline data for future biodiversity studies on dipterans. The current inventory reports 107 species of seven select dipteran families in 49 genera from Jammu and Kashmir. Species richness is highest in Kashmir with 93 species followed by 45 species in Jammu and 20 species in Ladakh. Since most of the previous surveys and sampling have been made from Kashmir region, coupled with the fact that a huge portion of the fly diversity has not yet been thoroughly described from any region of the State, true picture of species richness of dipterans in this Himalayan region as a whole remains to be ascertained. Considering the fact that most areas of the Jammu and Kashmir State are still unexplored for documenting the fly diversity, there is urgent need to undertake comprehensive survey of dipteran fauna in the region. Future research on regional diptera would have far-reaching economic benefits that would also encourage conservation efforts.

**Acknowledgments** Financial assistance to the first author rendered by the University Grants Commission, Government of India, New Delhi, under the D.S. Kothari Postdoctoral Fellowship (No. F.4-2/2006 (BSR)/BL/13-14/0148), is gratefully acknowledged. We thank our colleague Amir Maqbool for photographing dipteran specimens.

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# Chapter 30
# Diversity of Insects Infesting Medicinal and Aromatic Plants in the Kashmir Valley

**Nakeer Razak and Irfan Ahmad**

**Abstract** Little research attention has been paid toward the insect pests of Medicinal and Aromatic Plants (MAPs) and their insect biocontrol agents in Kashmir Valley. The present chapter provides baseline data regarding insects damaging MAPs in Kashmir Valley and future applications of insect biocontrol agents (parasitoids and predators) in the biocontrol programs to check these harmful insects. The data was collected from surveys conducted in various localities of cultivated and wild areas, falling under 8 districts of the Valley. As a result of field collection and laboratory rearing of immature stages, 91 insect species, including 1 new species under 5 orders and 36 families, were identified, which inflict various types and degrees of damage to leaves, stems, buds, flowers, fruits, roots, and seeds of the MAPs. In addition, 27 species of insect parasitoids including 5 new species and 11 species of insect predators, each under 5 families, were found to exert control over phytophagous insects. In total, 6 new species were described, 14 species reported for the first time from Kashmir Valley, 12 species for the first time from India, and 2 species new report to the Indian subcontinent. A total of 65 plant species under 35 families was recorded as hosts during the present study. These include 25 new host plant records and 51 new insect/host plant associations. Out of these 65 host plant records, 13 plant species (18.8%) fall under the category of threatened plants.

**Keywords** Insect diversity · Parasitoids · Host Plants · Medicinal and aromatic plants · Kashmir Valley

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_30

## 30.1 Introduction

Kashmir Valley is nestled within the northwestern folds of global biodiversity hotspot of the Himalaya (Mittermeier et al. 2005). Floristic diversity of the Valley includes a fairly good representation of medicinal and aromatic plants (MAPs). Kaul (1997) has listed 111 medicinal plants from Kashmir and Ladakh. Some of the important medicinal plants of Kashmir Valley include *Arnebia benthamii*, *Aconitum heterophyllum*, *Dioscorea deltoidea*, *Inula racemosa*, *Picrorhiza kurroa*, *Podophylum hexandrum*, etc., which grow in abundance in alpine areas of the region. The important aromatic plants growing in the wild include caraway (*Carum carvi*), siya zira (*Bunium persicum*), mint (*Mentha* sp.), etc. Besides these, a number of MAPs are cultivated in different localities of the Valley. Many of these plants are used in standardized plant extracts in modern medicine as drugs. About 40% of medicinal plants growing in Kashmir are used in the Indian pharmaceutical industries alone, some of them fetching high prices in the international market. A number of medicinal plants are illegally smuggled every year from the Valley, which has led to considerable population depletion of these prized plants, rendering them rare and threatened. Kaul (1997) lists 23 medicinal plants as Endangered in the Western Himalaya. Extensive documentation of therapeutic values and impressive record of safety and efficacy of these products/plants has been a major cause of global resurgence in herbal trade. The World Health Organization estimates that 75–80% of people in developing countries rely on plant-based medicines for primary health care. Over 25% of our common medicine contains at least some compounds isolated from plants (Duke 1997). Continued incursion of fatal diseases like cancer, AIDS, and nibbling disease including diabetes and arthritis, coupled with side effects of synthetic drugs, has generated interest of people globally from allopathic to natural system of medicine.

Like other plants, MAPs too have to bear the devastating attacks of injurious insect pests. Insects always strive to improve their energy gathering efficiency, while plants concurrently improve their defenses. The most common defensive method used by the plants includes production of toxic metabolites, gums, and minute hairlike hooks or thorns to prevent feeding by insects. But among herbivores, insects show greatest ability to overcome the toxic metabolites of plants. Due to their high reproductive potential and small generation time, insects rapidly evolve to overcome plant defenses. Insects have not only developed tolerance to the plant toxins but have also learned to locate these plants by their scent and exclusively feed on them. Chemical control of insect pests on medicinal plants involves risk of pesticide residues within extracted products (Debelyi and Troshko 1972, Zhang et al. 2000). Using chemical pesticides reduces the vitality and foraging efficiency of biocontrol agents (Gu and Waage 1990). Therefore, nowadays, biocontrol agents are being successfully utilized for control of major pests in different parts of world.

Notwithstanding the relatively high proportion of MAPs, few studies have been undertaken from Kashmir Valley regarding the insect pests of MAPs. Chopra et al. (1958) found *Agrotis flammatra* infesting *Atropa acuminata* in Kashmir Valley in dry months of June–July. They also reported larvae of tenebrionid *Gonocephalum* sp. causing considerable damage to roots. Zaka-ur-Rab (1981) reported first occurence of midge *Cystiphora taraxaci* Kieffer on the under surface of the leaves of *Taraxacum officinale* in Kashmir. Bhagat and Lone (1984) reported 17 species of aphidophagous predators belonging to 6 families, including a few predators of aphids attacking medicinal plants. Bali (1987) observed 18 species of coccinellids feeding on aphids from various ecological habitats on different host plants including medicinal plants. Based on detailed study on aphids and their parasitoids, Bhagat (1987) reported 16 species of aphids damaging 17 species of medicinal plants including 12 species of aphidiid parasitoids attacking these aphid species. Bhagat and Lone (1991) reported 7 species of thrips attacking flowers and leaves of *Senecio jacquemontiana*, *Artemisia absinthium*, and *Corydalis govaniana*. Bhagat and Lone (1991) recorded two species of scale insects *Coccus hesperidium* (L.) and *Eulecanium coryli* (L.) attacking *Rosa webbiana* and *Berberis* sp., respectively. Razak et al. (2011) reported *Chrysoesthia sexgutella*, as a supplement to Palearctic elements in the insect fauna of Kashmir infesting *Chenopodium album*. This was the first report of the genus from the Oriental region in general and the Indian region in particular. Saini et al. (2011) reported nine species of plants under nine genera and seven families as host plants of the insect *Poophilus costalis* Walker, in Kashmir Himalaya, including highly valued cash crop *Lavendula angustifolia* Mill. A new species of Lonchaeidae, *Silba lashkeri* (Macgowen et al. 2012) was described from specimens reared from figs in Jammu and Kashmir. Razak et al. (2013) reported the Mediterranean endophagous seed beetle, *Bruchidius tuberculatus* (Hochhut 1847) on *Centurea iberica* Trev. ex Spreng. Narendran et al. (2013) presented a taxonomic review of *Chrysocharis* forester hymenoptera: eulophidae of Indian subcontinent and reported five new species of *Chrysocharis* from Kashmir.

With this background, the present study was undertaken with the primary aim to generate baseline data regarding insects infesting medicinal and aromatic plants of Kashmir Valley. Additionally, the study attempts to explore the scope of insect bio-control agents (parasitoids and predators) in any future biological control programs against the harmful insects.

## 30.2 Materials and Methods

### *30.2.1 Field Surveys*

Extensive field surveys for the collection of various insects infesting MAPs were carried out in various districts of Kashmir Valley, viz., Anantnag, Pulwama, Shopian, Budgam, Ganderbal, Srinagar, Baramulla, and Bandipora from March 2007 to September 2010. The surveys were based on random sampling from time to time, covering different ecological habitats, in different wild and cultivated areas, both at low and high altitudes.

### 30.2.2 Insect Collection, Rearing, and Preservation

The insects infesting the MAPs were collected both as immature stages (eggs, larvae, pupae, maggots, grubs, nymphs, etc.) and as adults from their host plants. The immature stages were collected alive from field in collection jars, collection tubes, paper bags, or polythene bags, so as to carry them to laboratory for rearing out adults of insects and their biocontrol agents, if any. Various collection methods employed were handpicking, beating/jarring, aspiration, etc. Both laboratory and field rearing methods were employed as demanded by the study. Provision of fresh food material in cages was made by adding various parts of the host plants in the cages from time to time. Host plant material was carefully examined before it was placed in rearing containers to rule out the possibility of predators, parasites, and eggs being introduced accidentally. Care was taken to keep the cages at bay from ants. The adult stage of the insects was collected and preserved for identification. The predators, devouring insect-infesting MAPs, were raised by rearing their immature stages along with the host insects in the laboratory. In case of predators (coccinellids, syrphids, hemipterans, and neuropterans), fresh aphids on infested twigs were fed to the immatures till they entered pupal stage. Natural conditions under which the immatures were found were simulated as closely as possible in rearing cages. Rearing containers were monitored frequently for emergence of adult insects, pupae, and in some cases even eggs. Careful notes were taken throughout rearing so that all data relative to biology, host plant, and host insect is properly correlated. Larvae, pupae, or puparia were preserved with reared adults only after the association was positively established. Some coccinellids and hemipteran bugs were also collected as adults while they were preying on their host insects. Merely insect parasites/parasitoids raised during the mass rearing of immature stages of the pests are included in the data, and their collection is not based on sweeping. Both dry and liquid preservation methods were employed for preservation of insect specimens. Dry preservation was carried mostly of adult insects, except for soft-bodied insect like aphids, thrips, jassids, white flies, etc. Small soft-bodied insects, aphids, and jassids were preserved in 70–75% ethyl alcohol and thrips in alcohol/glycerin/acetic acid (AGA) solution. Larvae were preserved in kerosene/acetic acid/dioxone (KAAD) solution. Pampel's fluid was used to preserve gentalia for dissection.

### 30.2.3 Microscopy, Micro-morphometry, and Photography

Microscopic examination of the insects was made with the help of two types of microscopes:

(a) Stereoscopic dissection microscope (Make: Biomed C27), with lens combinations 4x x 10x and 2x x 10x.
(b) Binocular microscope (Make: Olympus Cx21) with lens combination of 3x, 4x, 5x, 7x, 10x, and 15x eye pieces and 10x, 2x, 4x, and 45x objectives.

Measurements of the specimens or their parts were taken with the help of an ocular micrometer, previously standardized with the stage micrometer. Field photography was done with the help of Olympus SP560, while as photomicrography was done by Olympus CX21 mounted on a trinocular microscope (Biomed C27).

## 30.3 Results and Discussion

During the course of present study, 91 insect species under 5 orders and 36 families were documented. Apart from this, 27 species of insect parasites/parasitoids and 11 species of insect predators, each under 5 families, were found. In all, six new species: *Silba lashkeri* (Macgowen et al. 2012), *Chrysocharis neoviridis* (Narendran et al. 2013), *Chrysocharis harithi* (Narendran et al. 2013), *Chrysocharis differentis* (Narendran et al. 2013), *Chrysocharis cuticisi* (Narendran et al. 2013), and *Chrysocharis neosunrosi* (Narendran et al. 2013) are recorded during the present study. Further, 14 species are reported for the first time from the Valley, 12 species for the first time from India, and 2 species are new to the Indian subcontinent (Tables 30.1 and 30.2).

### *30.3.1 Lepidoptera*

The Lepidoptera was found to be the largest Order in terms of species as well as the number of families, comprising of 35 species in 14 families (Table 30.1). Among lepidopterans, family Noctuidae was largest with species such as *Thysanoplusia orichalcea*, *Thysanoplusia nigrisigna*, and *Heliothis armigera* being dominant (Table 30.1). Most of these lepidopterans are defoliators. Species such as *Pleuroptya sabinusalis*, *Ulodemis trigrapha*, *Clepsis ruriana*, and *Pyrausta* sp. are leaf rollers; *Deudorix epijarbas*, *Helicoverpa armigera*, and *Lampides boeticus* are fruit borers, while *Chryoesthia sexgutella* and *Eteoryctis syngramma* are leaf miners. The genus *Chrysoesthia* (Gellichiidae) was reported for the first time from Indian subcontinent. The species such as *Callidrepana argenteola* and *Eteoryctis syngramma* are reported from Kashmir Valley for first time, with new host records. The genus *Agonopterix* is being reported for the second time from the Valley after a period of 100 years, with a new species.

### *30.3.2 Coleoptera*

The Order Coleoptera was found to be second only to Lepidoptera, both in terms of species and family number, with 20 species under 7 families. Most of the coleopterans recorded are florivores and leaf feeders while some being seed eaters and

**Table 30.1** Taxonomic inventory of insects and their host plants in the Kashmir Valley

| S. no. | Insect species | Family | Host plant species |
|---|---|---|---|
| **Order Lepidoptera** | | | |
| 1 | *Heliothis armiger* (Hubner, 1808) | Noctuidea | ∗*Salvia sclarea,* ∗ *Aquilegia nivalis,* ∗*Atropa acuminata* ∗*Inula racemosa,* ∗ *Sassurea costus,* ∗*Aralia cachemirica, Nepeta* sp., ∗*Rehum emodi, Hyoscyamus niger* |
| 2 | *Heliothis peltigera* (Dennis and Schiffermuller, 1775) | Noctuidea | *Hyoscyamus niger,* ∗*Inulu racemosa* |
| 3 | *Pyrrhia umbra* (Hufnagel, 1766) | Noctuidea | *Rhus scuccedanea* |
| 4 | *Thysanoplusia orichalcea* (Fabricius, 1775) | Noctuidea | ∗*Inula racemosa,* ∗*Salvia sclarea,* ∗*Arctium lappa,* ∗*Alcea rosea, Coriandrum sativum, Rehum emodi, Cannabis sativa, Mentha piperita,* ∗*Podophyllum hexandrum,* ∗*Atropa acuminata,* ∗*Aralia cachemirica,* ∗*Nepeta cataria,* #*Foeniculum vulgare* |
| 5 | *Trichoplusia nigrisigna* (Hubner, 1803) | Noctuidea | ∗*Inula racemosa,* ∗*Rehum emodi, Alcea rosea,* ∗*Arctium. lappa,* ∗*Nepeta cataria,* ∗*Podophyllum hexandrum,* #*Plantago major* |
| 6 | *Spodoptera exigua* (Hubner, 1808) | Noctuidea | ∗*Peganum harmala, Palantago major* |
| 7 | *Mamestra brassicae* (Linnaeus, 1758) | Noctuidea | ∗*Rehum emodi,* ∗*Atropa acuminata* |
| 8 | *Agrotis ipsilon* (Hufnagel, 1776) | Noctuidea | ∗*Picrorhiza kurroa* |
| 9 | *Xestia c-nigrum* (Linnaeus, 1758) | Noctuidea | ∗*Atropa acuminata* |
| 10 | *Mythimna sp.* | Noctuidea | *Rumex hastatus*, *Primula denticulata* |
| 11 | +*Cucilla verbasci* *(*Linnaeus, 1758) | Noctuidea | *Verbascum thapsus* |
| 12 | *Ascotis selenaria* (Dennis and Schiffermuller, 1775) | Geometridae | ∗*Atropa acuminata,* ∗*Aralia cachemirica* |
| 13 | *Ascotis imparata* *(*Walker, 1888) | Geometridae | *Cannabis sativa,* ∗*Berberis lycium* |
| 14 | *Triphosa dubiosta* (Walker, 1862) | Geometridae | *Berberis lycium* |
| 15 | *Spilosoma erythrozona* (Kollar, 1844) | Aractiidae | *Atropa acuminate* |
| 16 | *Spilarctia oblique* (Kollar, 1844) | Aractiidea | ∗*Rehum emodi,* ∗*Rumex hastatus,* ∗*Urtica diocia* |
| 17 | *Pyrausta* sp. | Crambidae | *Chenopodium album, Mentha longifolia* |

(continued)

**Table 30.1** (continued)

| S. no. | Insect species | Family | Host plant species |
|---|---|---|---|
| 18 | +*Pleuroptya sabinusalis* (Walker, 1859) | Crambidae | *Urtica diocia* |
| 19 | *Clepsis ruriana* Linnaeus 1758 | Totricidae | *Aconitum heterophyllum* |
| 20 | *Ulodemis trigrapha* Meyrick, 1907 | Totricidae | *Cannabis sativa* |
| 21 | *Euproctis scintillans* (Walker, 1856) | Lymantriidae | *Cannabis sativa* |
| 22 | *Agonopterix* sp. | Oecophoridae | *Sassurea costus* |
| 23 | +*Callidrepana argenteola* Moore, 1859 | Drepanidae | ∗*Rhus succedanea* |
| 24 | +*Eteoryctis syngramma* (Meyrick, 1914) | Gracillaridae | ∗*Rhus succedanea* |
| 25 | *Phyllonorycter* sp. | Gracillaridae | *Celtis australis* |
| 26 | ++*Chrysoesthia sexgutella* (Thunberg, 1974) | Gelechiidae | *Chenopodium album* |
| 27 | *Carcharodus alceae* Esper, 1780 | Hesperidae | *Althea rosea* |
| 28 | *Pieris brassicae* (Linnaeus, 1758) | Pieridae | *Nepeta* sp. |
| 29 | *Pontia daplidice* (Linnaeus, 1758) | Pieridae | ∗*Datura stramonium* |
| 30 | *Aglais kashmiriensis* (Kollar, 1848) | Nymphalidae | *Urtica diocia* |
| 31 | *Venessa indica* Herbst, 1794 | Nymphalidae | ∗*Centurea iberica, Urtica diocia,* ∗*Cynara cardunculus* |
| 32 | *Venessa cardui* (Linnaeus, 1758) | Nymphalidae | *Urtica diocia, Centurea iberica, Arctium lappa,* ∗*Sassurea costus,*∗*Arnebia benthamii,* #*Myosotis arvensis* |
| 33 | *Deudorix epijarbas* (Moore, 1857) | Lycaenidae | *Aesculus indica, Punica granatum* |
| 34 | *Lampides boeticus* (Linnaeus, 1767) | Lycaenidae | *Lupinus polyphyllus* |
| 35 | *Lycaena phlaeas* (Linnaeus, 1761) | Lycaenidae | *Rumex hastatus,* ∗*Rehum emodi* |
| **Order Coleoptera** | | | |
| 1 | *Altica* sp. | Chrysomelidae | *Rumex hastatus, Rehum emodi, Impatiens balsamina, Impatiens glandulifera* |
| 2 | +*Chrysolina coerallans bella* (Jacoby, 1890) | Chrysomelidae | *Mentha piperita, Mentha longifolia, Mentha officinalis, Salvia sclarea.* |
| 3 | *Psylloides brettinghami* Baly, 1862 | Chrysomelidae | *Atropa acuminata, Solanum nigrum* |

(continued)

**Table 30.1** (continued)

| S. no. | Insect species | Family | Host plant species |
|---|---|---|---|
| 4 | *Apthona nigrilabrus* Duvivier, 1892 | Chrysomelidae | *Verbascum Thapsus* |
| 5 | ++*Crioceris asparagi* (Linnaeus, 1758) | Chrysomelidae | *Asparagus filicinus* |
| 6 | *Protaetia neglecta* (Hope, 1831) | Scarabaeidae | *Berberis lycium, Alcea rosea, Aqullegia nivalis, Cynara cardunculus* |
| 7 | *Protaetia impavida* (Janson, 1878) | Scarabaeidae | *Alcea rosea, Berberis lycium* |
| 8 | *Hopila polita* Bates1891 | Scarabaeidae | *Sambucus wightiana* |
| 9 | +*Adoretus boops* Wiedemann, 1821) | Scarabaeidae | *Picrorhiza kurroa* |
| 10 | +*Euparea* sp. | Nitidulidae | *Achillea mellifolium, Dipsacus inermis* |
| 11 | +*Meligethes* sp. | Nitidulidae | *Atropa acuminata* |
| 12 | *Himalayrhynchites canus* (Faust, 1898) | Attelabidae | *Berberis lycium* |
| 13 | ++*Anthrenus picturatus* (Solskij, 1876) | Dermestidae | *Heracleum candicans, Rehum emodi, Daccus carrota* |
| 14 | ++*Anthrenus latefasciatus* (Reitter, 1892 | Dermestidae | *Heracleum candicans, Rehum emodi, Daccus carrota* |
| 15 | +*Rhinusa tetrum* (Fabricus, 1792) | Curculionidae | *Verbascum thapsus* |
| 16 | *Cionus hortulans* (Geoffroy, 1785) | Curculionidae | *Verbascum thapsus, Oenothera glazioviana* |
| 17 | *Myllocerus viridianus* (Fabricus, 1775) | Curculionidae | *Peganum harmala* |
| 18 | *Myllocerus* sp. | Curculionidae | *Aesculus. indica* |
| 19 | *Cyrtozemia dispar* (Pascoe, 1872) | Curculionidae | *Alcea rosea* |
| 20 | ++*Bruchidius tuberculatus* (Hochhut, 1847 | Bruchidae | *Centurea iberica* |
| **Order Hemiptera** | | | |
| 1 | *Lygus pratensis* (Linnaeus, 1758) | Miridae | ∗ *Achillea millefolium, Artemisia absinthium,* ∗*Celosia argentea,* ∗*Oscimum basilicum,* ∗*Peganum harmala* |
| 2 | +*Adelphocoris lineolatus* (Goeze, 1778) | Miridae | *Achillea millefolium, Artemisia absinthium, Celosia argentea, Oscimum basilicum, Peganum harmala,Verbascum thapsus* |
| 3 | *Nysius* sp. | Coreidae | *Bergenia ciliata, Origanum normale, Achillea mellefolium, Artemisia absinthium* |
| 4 | ++*Pyrrhocoris apterus* (Linnaeus, 1758) | Pyrrhocoridae | *Alcea rosea, Lavatera cachemiriana, Malva neglecta* |

(continued)

**Table 30.1** (continued)

| S. no. | Insect species | Family | Host plant species |
|---|---|---|---|
| 5 | ++*Corizus hyoscami* Linnaeus, 1758 | Rhopalidae | *Trigonella foenum-graceum,Verbascum thapsus* |
| 6 | *Liorhyssus rubicundus* (Signoret, 1859) | Rhopalidae | *Peganum harmala, Artemisia absinthium, Achillea mellifolium, Alcea rosea, Celosia argenteola* |
| 7 | +*Dictyla nassata* (Puton, 1874) | Tingidae | *∗Arnebia benthamii, Myosotis arvensis* |
| 8 | +*Poophilus costalis* (Walker, 1851) | Aphrophoridae | *Lavandulla angustifolia, Dipsacus inermis, Rumex hastatus, Cannabis sativa, Daucus carota, Cichorium intybus* |
| 9 | *Krisna* sp. | Cicadellidae | *Berberis lyceum* |
| 10 | *Leptocentrus* sp. | Membracidae | *Alcea rosea* |
| 11 | *Aphis nerri* (Boyer de Fonscolombe, 1841) | Aphididae | *Verbascum thapsus* |
| 12 | *Rhopalosiphum nymphaeae* (Linnaeus, 1761) | Aphididae | *Nymphaea alba* |
| 13 | *Macrosiphum rosae* (Linnaeus, 1758) | Aphididae | *Rosa webbiana* |
| 14 | *Cavariella* sp. | Aphididae | *Foeniculum vulgare* |
| 15 | *Aphis affinis* (del Guerico, 1911) | Aphididae | *Mentha longifolia* |
| 16 | *Uroleucon* sp. | Aphididae | *Sassurea costus* |
| 17 | *Macrosiphonella pseudoartemisae* (Shinji, 1933) | Aphididae | *Artemisia absinthium* |
| 18 | *Phordon cannabis* (Passerini, 1860) | Aphididae | *Cannabis sativa* |
| 19 | *Cavariella biswasi (*Del Guercio, 1911) | Aphididae | *Heracleum candicans* |
| 20 | *Brachyunguis harmalae* (Das, 1918) | Aphididae | *Peganum harmala* |
| 21 | *Aphis craccivora* (Koch, 1854) | Aphididae | *Solanum nigrum* |
| 22 | *Periphyllus aesculi* (Hille Rice Lambers, 1933) | Aphididae | *Aesculus indica* |
| 23 | +*Longistigma caryae* (Harris, 1841) | Aphididae | *Salix alba* |
| **Order Diptera** | | | |
| 1 | *Chromatomyia horticola* (Goureau, 1851) | Agromyzidae | *Alcea rosea, Arctium lappa, Artemisia absinthium, Cannabis sativa, Daucus carota, Malva neglecta, Mentha piperita, Mentha longifolia, Nepeta cataria, Papaver somniferum, Plantago major* |

(continued)

**Table 30.1** (continued)

| S. no. | Insect species | Family | Host plant species |
|---|---|---|---|
| 2 | ++*Pegomya solensis* (Meigen, 1826) | Anthomyiidae | *Rumex hastatus* |
| 3 | ++*Pegomya hyoscami* (Panzer, 1809) | Anthomyiidae | *Atropa acuminata* |
| 4 | ++*Pegomya canicularia* (Rondani, 1866) | Anthomyiidae | *Chenopodium album* |
| 5 | ++*Urophora quadrifasciata* (Meigen, 1826) | Tephritidae | *Centurea iberica* |
| 6 | +*Stemonocera cervicornis* (Brunetti, 1917) | Tephritidae | *Arctium lappa* |
| 7 | *Silba lashkeri* ∗∗ (Macgowen and Razak sp.nov) | Lonchaeidae | *Ficus carica* |
| **Order Thysanoptera** | | | |
| 1 | +*Coleothrips collaris* (Priesner, 1919) | Aeolothripidae | *Hypericum perforatum, Oraganum normale* |
| 2 | +*Coleothrips mongolicus* (Pelikán, 1985) | Aeolothripidae | *Hypericum perforatum, Oraganum normale* |
| 3 | *Thrips tabaci* (Lindeman, 1889) | Thripidae | *Peganum harmala, Hypericum perforatum, Achillea mellifolium* |
| 4 | *Thrips garuda (*Bhatti, 1980) | Thripidae | *Peganum harmala* |
| 5 | *Thrips flavus* (Schrank, 1776) | Thripidae | *Crocus sativus, Hypericum perforatum, Prunella vulgaris, Polygonum amplexicuale* |
| 6 | *Thrips alatus* (Bhatti, 1980) | Thripidae | *Hypericum perforatum, Verbascum thapsus* |

∗ (new host plant records), ∗∗(new species), + (new to Kashmir Valley), ++ (new to Indian region), # (new host plant record to India)

root feeders as well. Among the florivores are *Protetia impavida*, *Protetianeglecta*, *Hopila polita*, *Euparea* sp., *Meligethes* sp., *Rhinusa tetrum*, *Cionus hortulans*, *Anthrenus pictoratus*, and *Anthrenus latefasciatus*. Seed-feeding bruchid, *Bruchidius tuberculatus*, is a new record from Indian subcontinent, while florivorous dermestid beetles *Anthrenus pictoratus* and *Anthrenus latefasciatus* are new to India. Equally important among the coleopterans are leaf-eating beetles like *Altica* sp., *Chrysolina coerulans*, *Apthona nigrilabrus*, *Psylloides brethinghami*, and *Crioceris asparagi*, which cause severe damage to host plants including *Atropa acuminata*, *Solanum nigrum*, *Rheum emodi*, *Impatiens balsamina*, *I. glandulifera*, *Verbascum thapsus*, *Asparagus filicinus*, *Mentha longifolia*, and

**Table 30.2** An inventory of parasitoid host-insect interactions in the Kashmir Valley

| S.No. | Parasitoid species | Parasitoid family | Host insect | Host insect family |
|---|---|---|---|---|
| 1 | *Cotesia glomerata* (Linnaeus, 1758) | Braconidae | *Pieris brassicae* | Pieridae |
| 2 | *Cotesia ruficrus* (Haliday, 1834) | Braconidae | *Spodoptera exigua* | Noctuidae |
| 3 | *Cotesia* sp. | Braconidae | *Venessa cardui* | Nymphalidae |
| 4 | *Microgaster* sp. | Braconidae | *Venessa indica* | Nymphalidae |
| 5 | *Venanides* sp. | Braconidae | *Aglais kashmiriensis* | Nymphalidae |
| 6 | *Parapanteles* sp. | Braconidae | *Aglais kashmiriensis* | Nymphalidae |
| 7 | *Apanteles* sp. | Braconidae | *Pyrausta* sp. | Pyralidae |
| 9 | *Ephedrus* sp. | Braconidae | *Macrosiphonella pseudoartemisae* | Aphididae |
| 10 | *Bracon* sp. | Braconidae | *Chrysoesthia sexgutella* | Gellichiidae |
| 11 | *Gnamptodon* sp. | Braconidae | *Pegomya canicularia* | Anthomyiidae |
| 12 | *Charops* sp. | Ichneumonidae | *Callidrepana argenteola* | Drepanidae |
| 13 | *Netelia* sp. | Ichneumonidae | *Cucilla verbasci* | Noctuidae |
| 14 | *Ophion* sp. | Ichneumonidae | *Spodoptera exigua* | Noctuidae |
| 15 | *Eulophus* sp. | Eulophidae | *Thysanoplusia orichalcea* | Noctuidae |
| 16 | *Diglyphus guptai* (Subba Rao, 1957) | Eulophidae | *Chromatomyia horticola* | Agromyzidae |
| 17 | *Diglyphus isaea* (Walker, 1838) | Eulophidae | *Chromatomyia horticola* | Agromyzidae |
| 18 | *Chrysocharis neoviridis* (Narendran et al. 2013)** | Eulophidae | *Chromatomyia horticola* | Agromyzidae |
| 19 | *Chrysocharis harithi* (Narendran et al. 2013)** | Eulophidae | *Chromatomyia horticola* | Agromyzidae |
| 20 | *Chrysocharis differentis* (Narendran et al. 2013) ** | Eulophidae | *Chromatomyia horticola* | Agromyzidae |
| 21 | *Chrysocharis cuticisi* (Narendran et al. 2013)** | Eulophidae | *Chromatomyia horticola* | Agromyzidae |
| 22 | *Chrysocharis neosunrosi* (Narendran et al. 2013)** | Eulophidae | *Chromatomyia horticola* | Agromyzidae |
| 23 | *Chrysonotomyia* sp. | Eulophidae | *Chromatomyia horticola* | Agromyzidae |
| 24 | *Pediobius* sp. | Eulophidae | *Chromatomyia horticola* | Agromyzidae |
| 25 | *Omphalentedon* sp. | Eulophidae | *Chromatomyia horticola* | Agromyzidae |
| 26 | *Halticoptera* sp. | Pteromalidae | *Chromatomyia horticola* | Agromyzidae |

(continued)

**Table 30.2** (continued)

| S.No. | Parasitoid species | Parasitoid family | Host insect | Host insect family |
|---|---|---|---|---|
| 27 | *Capidosoma floridanum* (Ashmead, 1900) | Encyrtidae | *Trichoplusia nigrisigna* | Noctuidae |

∗ (new host plant records), ∗∗(new species), + (new to Kashmir Valley), ++ (new to Indian region), # (new host plant record to India)

*M. piperita*. Among chrysomelids, *Crioceris paragi* is being reported for the first time from India. New coleopterous records to the Kashmir Valley during the study include *Chrysolina coerulans*, *Adoretus boops*, *Euparea* sp., *Meligethes* sp., *Rhinusa tetrum*, and *Cionus hortulans*. White grubs of *Adoretus boops* caused devastation in *Picrorhiza kurroa* (Table 30.1).

### *30.3.3 Diptera*

Among dipterans, leaf miner fly *Chromatiomyza (Phytomyza) horticola* was most dominant. It was recorded on 11 host plants: *Papaver somniferum*, *Plantago major*, *Alcea rosea*, *Arctium lappa*, *Malva neglecta*, *Mentha piperita*, *M. longifolia*, *Nepeta cataria*, *Cannabis sativa*, *Daucus carota*, and *Artemisia absinthium*. Although showing narrow host spectrum, maggots of the genus *Pegomya* exhibited high incidence and formed blotch mines on the leaves of *Rumex hastatus*, *Chenopodium album*, and *Atropa acuminata*. The group is being reported for the first time from India. Detection of range extension of Mediterranean fig fly, *Silba* sp., to Indian subcontinent during the present study has sounded alarm to fig production in the region. A new species of the genus, *Silba lashkeri,* was found causing intensive damage to fig fruits. Fruit fly *Urophora quadrifasciata,* being a new report from Indian region, was encountered on *Centurea iberica*. Maggots of the fly feed on the developing endosperm of seeds and cause marked reduction in the seed production. *Stemonocera cervicornis* (Brunetti), new to Kashmir Valley, was found causing blotch mines on the leaves of *Arctium lappa*, a new host record for the species (Table 30.1).

### *30.3.4 Hemiptera*

Spittle bug, *Poophilus costalis* Walker (Hemiptera: Cercopoidea: Aphrophoridae) was detected as a constraint for commercial exploitation of *Lavendula augustifolia*. Though reported from various parts of India on rice, sugar cane, etc., the superfamily is being reported for the first time from the Valley. Most of the heteropterans recorded during the study are polyphagous, though a few like *Dictyla nassata* and *Pyrrhocoris apterus* are oligophagous and are economically more important. Among hemipterans the new records from India include *Adelphocoris lineolatus*, *Pyrrhocoris apterus*, and *Corizus hyoscami*, while the new records from the Valley include *Dictyla nassata*, *Poophilus costalis*, and *Longistigma caryae* (Table 30.1).

### *30.3.5 Thysanoptera*

Six species of thrips *Coleothrips collaris*, *C. mongolicus*, *Thrips tabaci*, *T. garuda*, *T. flavus*, and *T. alatus* were found infesting nine host plant species; and *Hypericum perforatum* was infested by all the six thrips species (Table 30.1).

### *30.3.6 Host Plants*

A total of 65 species under 35 families were recorded as host plants during the study. These include 25 new host records and 51 new insect-host plant associations. Out of these 65 host plant records, 13 (18.8 %) plant species fall under the threatened category (Kaul 1997). In terms of number of insect species infesting various plant families, the family Asteraceae was found to be highly infested, followed by Lamiaceae and Polygonaceae (Table 30.2). With regard to the number of plant species infested, family Lamiaceae was on top, followed by Asteraceae and then equally by Apiaceae and Solanaceae (Table 30.2). Among the host plants, few species like *Urtica diocia*, *Verbascum thapsus*, and *Centurea iberica*, despite their medicinal importance in various systems of medicine, are turning invasive because of their high seed banks and great power of dispersal. Various herbivorous insects recorded on these species during the current study may qualify as biocontrol agents to keep the population of these plants under check (Table 30.3).

### *30.3.7 Biocontrol Agents*

Laboratory rearing of immature stages of various insect species yielded 24 species of hymenopteran parasitoids falling under 5 families, neuropteran *Chrysoperla carnea*, and 3 species of coccinellids. Besides these, adults of 4 species of coccinellids, *Orius* sp., *Nabis* sp., and *Episyrphus balteatus* were found devouring various aphid and thrips species. Among biocontrol agents, parasitoids were dominant; and some of these cause heavy parasitism in their respective hosts and can have

**Table 30.3** Host plant-insect catalogue for the Kashmir Valley

| S.No | Host plant name | Family | Insect species |
|---|---|---|---|
| 1. | *Celosia argentea* L. | Amaranthaceae | *Lygus pratensis*, *Adelphocoris lineolatus*, *Liorhyssus rubicundus* |
| 2. | *Rhus succedanea* L. | Anacardiaceae | *Callidrepana argenteola, Eteoryctis syngramma, Pyrrhia umbra* |
| 3. | *Coriandrum sativum* L. *Daucus carota* L. *Foeniculum vulagare* Mill. *Heracleum candicans* Wall. | Apiaceae | *Thysanoplusia orichalcea* *Poophilus costalis, Chromatomyia horticola, Anthrenus picturatus, A. latefasciatus* *Cavariella* sp. *Thysanoplusia orichalcea* *Cavariella biswasi* *A. picturatus, A.latefasciatus* |
| 4. | *Aralia cachemirica* Lindl. | Araliaceae | *Ascotis selenaria* *T. orichalcea* |
| 5. | *Achillea millefolium* L. | Asteraceae | *Euparea* sp. *Thrips tabaci* *L. pratensis*, *A. lineolatus* *Nysius* sp. *Liorhyssus rubicundus* |
| 6. | *Aractium lappa* L. | Asteraceae | *Thysanoplusia orichalcea*, *T. orichalcea*, *Trichoplusia nigrisigna* *Venessa cardui* *C. horticola* *Stemonocera cervicornis* |
| 7. | *Artemisia absinthium* L. | Asteraceae | *L. pratensis*, *A.lineolatus* *Nysius* sp. *L. rubicundus* *C. horticola* *Macrosiphonella pseudoartemisae* |
| 8. | *Centurea iberica* (Trevir. and Spreng) | Asteraceae | *Bruchidius tuberculatus* *Venessa indica* *Urophora quadrifasciata* |
| 9. | *Cynara cardunculus* L. | Asteraceae | *Protaetia neglecta,* |
| 10. | *Inula racemosa*(Hook.f. 1881) | Asteraceae | *Helicoverpa armigera, H. peltigera* *T. orichalcea*, *T. nigrisigna* |
| 11. | *Sassurea costus* (Falc.) Lipsch. | Asteraceae | *H. armigera* *V. cardui* *Agonopterix pahalgami* *Uroleucon* sp., |
| 12. | *Cichorium intybus* L. | Asteraceae | *Poophilus costalis* |
| 13. | *Impatiens balsamina* L. | Balsaminaceae | *Altica* sp. |
| 14. | *Impatiens glandulifera* Royle. | Balsaminaceae | *Altica* sp. |
| 15. | *Berberis lycium* Royle. | Berberidaceae | *P. neglecta*, *P. impavida.* *Krisna sp.* *A. selenaria, Triphosa dubiosta* *Himalayrhynchites canus* |
| 16. | *Bergenia ciliata* (Haw.) Sternb. | Saxifragaceae | *Nysius* sp. |

(continued)

**Table 30.3** (continued)

| S.No | Host plant name | Family | Insect species |
|---|---|---|---|
| 17. | *Arnebia benthamii* (Wall. ex G.Don) | Borginaceae | *Dictyla nassata*<br>*V. cardui* |
| 18. | *Myosotis arvensis* (L.) Hill. | Borginaceae | *D. nassata*<br>*V. cardui* |
| 19. | *Cannabis sativa* L. | Cannabaceae | *Ascotis imparata*<br>*T. orichalcea*<br>*Ulodemis trigrapha*<br>*Euproctis scintillans*<br>*Phordon cannabis* |
| 20. | *Celtis australis* L. | Cannabaceae | *Phyllonorycter Spp.* |
| 21. | *Sambucus wightiana* (Wall. ex Wight & Arn). | Caprifoliaceae | *Hopila polita* |
| 22. | *Chenopodium album* L. | Chenopodiaceae | *Chrysoesthia sexgutella* |
| 23. | *Lupinus polyphyllus* (Lindl.) | Fabaceae | *Lampides boeticus* |
| 24. | *Trigonella foenum-graceum* L. | Fabaceae | *Corizus hyoscami* |
| 25. | *Aesculus indicus* (Wall. ex Camb.) Hook. | Hippocastanaceae | *Deudorix epijarbas*<br>*Myllocerus sp.*<br>*Periphyllus aesculi* |
| 26. | *Hypericum perforatum* L. | Hypericaceae | *Ceolothrips collaris*, *C. mongolicus*, *Thrips tabaci, T. flavus*, *T. alatus* |
| 27. | *Crocus sativus* L. | Irridaceae | *T. flavus* |
| 28. | *Lavendula angustifolia* Mill. | Lamiaceae | *Poophilus costalis* |
| 29. | *Melissa officinalis* L. | Lamiaceae | *Chrysolina coerulans bella* |
| 30. | *Mentha longifolia* (L.) Huds. | Lamiaceae | *Chrysolina coerulans bella*<br>*Pyrausta sp.,*<br>*C. horticola*<br>*Aphis aphis* |
| 31. | *Mentha piperita* L. | Lamiaceae | *Chrysolina coerulans bella*<br>Agr- *C. horticola*<br>Noc- *T. orichalcea, T. nigrisigna* |
| 32. | *Nepeta cataria* | Lamiaceae | *T. orichalcea, T. nigrisigna*<br>*C. horticola* |
| 33. | *Nepeta* sp. | Lamiaceae | *Pieris brassicae* |
| 34. | *Ocimum basilicum* L. | Lamiaceae | *L. pratensis, A. lineolatus* |
| 35. | *Origanum normale* D.Don. | Lamiaceae | *C. collaris*, *C. mongolicus*<br>*Nysius* sp. |
| 36. | *Prunella vulgaris* L. | Lamiaceae | *T.flavus* |
| 37. | *Salvia sclarea* L. | Lamiaceae | *Chrysolina coerulans bella*<br>*T. orichalcea, H. armigera* |
| 38. | *Asparagus filicinus* Buch.-Ham. ex D.Don | Liliaceae | *Crioceris asparagi* |

(continued)

**Table 30.3** (continued)

| S.No | Host plant name | Family | Insect species |
|---|---|---|---|
| 39. | *Alcea rosae* L. | Malvaceae | *P. impavida, P. neglecta*<br>*L. rubicundusPyrrhocoris apterus*<br>*Leptocentrus* sp.<br>*T. orichalcea, T. nigrisigna*<br>*Carcharodus alcea*<br>*C. horticola*<br>*Cyrtozemia dispar* |
| 40. | *Lavatera cachemiriana* (Cambess.) Kuntze | Malvaceae | *P. apterus* |
| 41. | *Malva neglecta* Wallr. | Malvaceae | *C. horticola* |
| 42. | *Ficus carica* L. | Moraceae | *Silba lashkeri* |
| 43. | *Nymphaea alba* L. | Nymphaeaceae | *Rhopalosiphum nymphaeae* |
| 44. | *Oenothgera glazioviana* Micheli. | Onagraceae | *Cionus hortulans* |
| 45. | *Papaver somniferum* L. | Papaveraceae | *C. horticola* |
| 46. | *Plantago major* L. | Plantaginaceae | *T. nigrisigna, Spodoptera exigua*<br>*C. horticola* |
| 47. | *Podophyllum hexandrum* Royle. | Podophyllaceae | *T. orichalcea, T. nigrisigna* |
| 48. | *Polygonum amplexicaule* D. Don. | Polygonaceae | *Thrips flavus* |
| 49. | *Rheum emodi* L. | Polygonaceae | *T. orichalcea, T. nigrisigna, H. armigera, Mamestra*<br>*brassicae, Mythimna* sp.,<br>*Spilarctia obliqua*<br>*Lycaena phlaeas*<br>*Altica* sp.<br>*A. picturatus, A.latefasciatus* |
| 50. | *Rumex hastatus* D. Don. | Polygonaceae | *Altica* sp.<br>*Spilarctia obliqua*<br>*Lycaena phlaeas*<br>*Pegomya solensi*<br>*Poophilus costalis* |
| 51. | *Primula denticulata* Sm. | Primulaceae | *Mythimna* sp. |
| 52. | *Punica granatum* L. | Punicaceae | *Deudorix epijarbus* |
| 53. | *Aconitum heterophyllum* Wall. ex Royle. | Rananculaceae | *Clepsis ruriana* |
| 54. | *Aquilegia nivalis* Falc. ex B.D.Jacks. | Rananculaceae | *H. armigera*<br>*P. neglecta* |
| 55. | *Dipsacus inermis* Wall. | Rananculaceae | *Euparea* sp.<br>*P. costalis* |
| 56. | *Rosa* sp. | Rosaceae | *Macrosiphum rosea* |
| 57. | *Salix alba* L. | Salicaceae | *Longistigma carynae* |
| 58. | *Picrorhiza kurroa* Royle ex Benth. | Scrophulariaceae | *Adoretus boops*<br>*Agrotis ipsilon* |

(continued)

**Table 30.3** (continued)

| S.No | Host plant name | Family | Insect species |
|---|---|---|---|
| 59. | *Verbascum thapsus* L. | Scrophulariaceae | *Cucilla verbasci*<br>*Aphis neri*<br>*Cionus hortulans*, *Rinusa tetrum*<br>*Corizus hyoscami*<br>*Apthona nigrilabrus*<br>*Thrips alatus*<br>*Adelphocoris lineolatus* |
| 60. | *Solanum nigrum* L. | Solanaceae | *Psylloides brettinghami*<br>*Aphis craccivora* |
| 61. | *Atropa accuminata* Royle ex Lindl. | Solanaceae | *P. brettinghami*<br>*Meligethes* sp.<br>*H. armigera*, *Xestia c-nigrum*,<br>*T. orchalea, Mammestrabrassicae*<br>*Ascotis selenaria*<br>*Spilosoma erythrozona*<br>*Pegomya hyoscami* |
| 62. | *Datura stramonium* L. | Solanaceae | *Pieris dapladice* |
| 63. | *Hyoscyamus niger* L. | Solanaceae | *H. armigera*, *H. peltigera* |
| 64. | *Urtica diocia* L. | Urticaceae | *Aglais kashmiriensis, V. cardui, V. indica*<br>*Pleuroptya sabinusalis*<br>*Spilarctia oblique* |
| 65. | *Peganum harmala* L. | Nitrariaceae | *Myllocerus viridianus*<br>*Thrips garuda, T. tabaci*<br>*A. lineolatus, L. pratensis*<br>*L. rubicundus*<br>*Spodoptera exigua*<br>*Brachyunguis harmalae* |

potential to suppress the insects damaging these economically important plants. These include eulophids (*Diglyphus isae*, *D. guptai*), ichneumonids (*Charops* sp., *Ophion* sp., *Netelia* sp.), and branconids (*Bracon* sp., *Cotesia glomerata*). Moderate level of parasitism was caused by eulophids (*Pediobius* sp., *Chrysocharis* sp.) and braconids (*Venanides* sp., *Microgaster* sp., *Cotesia* sp). The species found to cause low level of parasitism include eulophids (*Omphalentedon* sp., *Halticoptera* sp., *Chrysonotomyia* sp., *Chrysocharis viridis*) and braconids (*Parapanteles* sp., *Cotesia ruficrus*). It was revealed that out of 24 species of parasitoids bred from the host insects, 14 (58%) species infest the most dominating group, Lepidoptera. Among the Lepidoptera, the most important species observed, in terms of injury inflicted, were *Trichoplusia ni*, *Mamestra brassicae*, *Agrotis ipsilon*, *Helicoverpa armigera*, and *Diacrisia oblique* and did not suffer from parasitism, and on others like *Spodoptera exigua* and *Thysanoplusia orichalcea*, parasitism was least, i.e., 5%. In most of the lepidopterous larvae, parasitism was observed in the month of July when much of the damage was already suffered by the plants (Table 30.2).

## 30.4 Concluding Remarks

Major insect species inflicting damage to the plants of medicinal importance must be subjected to rigorous research, both in field and laboratory, to cover their biology and ecology under different agroecosystems, focusing on the predisposing factors affecting their population buildup. In the future, shortcomings and constraints observed in terms of low parasitic index and nonattendance of parasitization in the most destructive and rampant species demand to be worked out. Research needs to be carried out by conducting field trails in polyculture rather than monoculture. Since most of the insect species found inflicting damage during the study are polyphagous and oligophagous, taxonomic alliance must, therefore, be given due importance during the course of these research trials. Periodic entomological surveys must be carried out to assess changes in pest complex that often take place with the age of system due to an array of factors like changing agronomic practices, changing plant combinations, pesticidal sprays, anthropogenic activities, etc. Studies on insect physiology, genomics, and population genetics may enable us to understand plant-insect interactions in natural and agricultural ecosystems which can be beneficial to reduce the rate at which insects evolve tolerance to natural plant defenses (Plate 30.1).

The role of insect species in disease transmission among these economically important plants is yet another vast area for research. Last, but not the least, it may be emphasized that before taking up commercial exploitation of MAPs in Kashmir Valley, all the concerned agencies must seek expert advice from scientists in various fields like taxonomy, ecology, agronomy, entomology, pathology, and plant physiology.

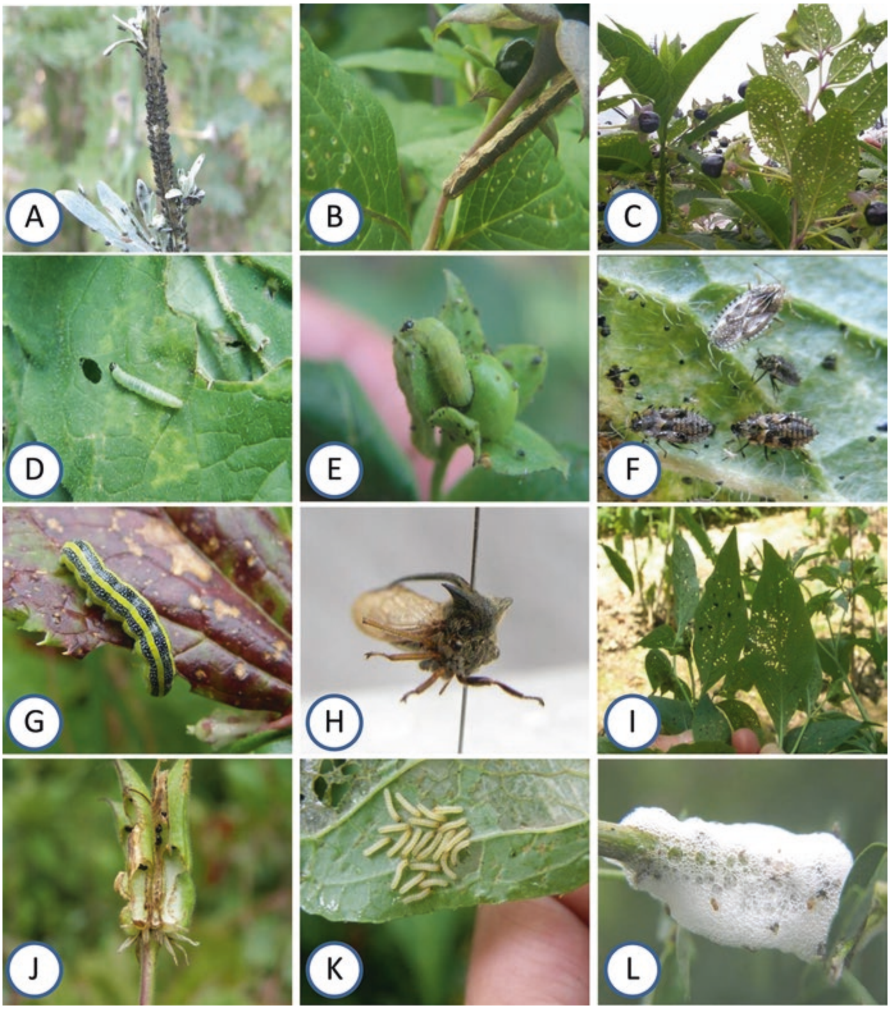


**Plate 30.1** (**a**) Encrustation of *M. pseudoartemisae* on *Artemisia absinthium* (**b**) Blotch leaf formed by *P. hyoscami* (**c**) Netting effect on *Atropa acuminata* by *P. brettinghami* (**d**) Larva of *Agonopterix* sp. on *Saussurea costus* (**e**) Larva of *H. armigera* boring into seed capsules of *Atropa acuminata* (**f**) Nymphs & adults of *D. nassata* (**g**) Noctuid larva defoliating *Podophyllum hexandrum* (**h**) Pin mount of *Leptocentrus* sp. (**i**) Netting effect on *Atropa acuminata* leaves by *P. brettinghami* (**j**) Damage to seeds of *Aquilegia nivalis* by *H. armigera* (**k**) Larvae of *S. erythrozona* on *Atropa acuminata* (**l**) Spit mass by nymphs *of P. costalis*

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# Chapter 31
# Moth (Lepidoptera) Fauna of Jammu and Kashmir State

**Mudasir Ahmad Dar, Shahid Ali Akbar, Aijaz Ahmad Wachkoo, and Mushtaq Ahmad Ganai**

**Abstract** The chapter provides a taxonomic overview of moths (Lepidoptera) of Jammu and Kashmir State. Based on the critical review of scientific literature, museum collections, and data generated from the field surveys since 2002, moth diversity of the State is represented by 461 species belonging to 23 families classified under 12 superfamilies. Noctuoidea (with 283 species) is the most diverse superfamily followed by Tortricoidea (74 spp.), Bombycoidea (50 spp.), and Geometroidea (29 spp.). Erebidae (with 152 species) is the most diverse family followed by Noctuidae (109 spp.), Tortricidae (74 spp.), Sphingidae (38 spp.), and Geometridae (29 spp.). The most diverse genera include *Cyana* (16 species), *Mythimna* (7 spp.), and *Callopistria, Choristoneura, Euxoa,* and *Lyclene* (6 spp. each). Jammu is the most moth speciose region with 392 species followed by Kashmir (332 spp.) and Ladakh region (136 spp.). Some of the species are reported to act as pests, causing considerable damage to major crops. The present study will provide baseline data and facilitate further research on this important group of insects in this Himalayan region.

**Keywords** Moth fauna · Lepidoptera · Distribution · Jammu and Kashmir State

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_31

## 31.1 Introduction

Lepidoptera is an order of insects that includes butterflies and moths, comprising about 10% of the total described species of living organisms (Heppner 2008). Order Lepidoptera is divided into four suborders, Zeugloptera, Aglossata, Heterobathmiina, and Glossata, consisting of about 46 superfamilies and 126 families, with estimated number of species in the world likely to exceed 60,000 (Mallet 2007). Phytophagous nature and high reproductive rate ascribe moths as serious pests throughout the world. Almost every kind of a cultivated plant has one or more pests belonging to this group. Besides their pest abilities, these insects are also known for their role in pollination and predation and constitute one of the well-studied insect groups. Hampson (1894) contributed greatly to Indian moths, and his major contribution "*Fauna of British India Moths, including Ceylon and Burma, Moths*" included description of 1415 species pertaining to 273 genera and 10 subfamilies. Since then, a lot of taxonomic changes and several contributions have been made on this group of insects. In fact, with their extraordinary evolutionary success, it is likely that the higher classification of these insects will remain complex and unstable. A number of rearrangements to the higher classification of the Lepidoptera group have already been and continue to be proposed by various eminent lepidopterists throughout the world (Lafontaine and Schmidt 2010; Zahiri et al. 2010, 2012, 2013). In the light of these recent changes, the present study provides a summary of moths (Lepidoptera) of Jammu and Kashmir State (Table 31.1) which will serve as baseline data and facilitate further research on this important group of insects.

## 31.2 Materials and Methods

In the present review, the three distinct regions of Jammu and Kashmir State are designated as Jammu (J), Kashmir (K), and Ladakh (L). In order to avoid confusion due to various proposed classification schemes and grouping and subgroupings, species arranged under superfamily and family are provided without any mention of their placement within suborders and clades. The arrangement followed here is after Zahiri et al. (2010) which supports six major, well-supported lineages interpreted as families.

## 31.3 Results

A total of 461 species of moths, belonging to 12 superfamilies consisting of 23 families, are known to occur across the Jammu and Kashmir State (Table 31.1). These 12 superfamilies including their respective number of families and species are summarized in Table 31.2. Noctuoidea with 283 species is the most diverse superfamily from the region followed by Tortricoidea (74), Bombycoidea (50 species), Geometroidea (29), and others. Likewise Erebidae with 152 species is the most

**Table 31.1** List of moths reported form the Jammu and Kashmir State

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| **1. Superfamily Bombycoidea**<br>**1a. Bombycidae Latreille, 1802** | | | | | |
| 1 | *Bombyx mori* (Linnaeus, 1758) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| **1b: Brahmaeidae Swinhoe, 1892** | | | | | |
| 2 | *Brahmaea hearseyi* (White, 1862) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 3 | *Brahmaea wallichii* (Gray, 1831) | + | + | – | Dar et al. (2012) |
| **1c. Eupterotidae Swinhoe, 1892** | | | | | |
| 4 | *Apona caschmirensis* (Kollar, 1844) | + | – | + | Dar (2014) and Kirti et al. (2012–2014) |
| 5 | *Eupterote undata* (Blanchard, [1844]) | + | – | + | Dar (2014) and Kirti et al. (2012–2014) |
| **1d. Saturniidae Boisduval, 1837** | | | | | |
| 6 | *Actias selene* (Hübner, 1807) | + | + | + | Khan et al. (2009) |
| 7 | *Antheraea pernyi* (Guerin-Meneville, 1855) | + | + | + | Khan et al. (2009) |
| 8 | *Caligula simla* (Westwood, 1847) | + | – | – | Khan et al. (2015) |
| 9 | *Neoris stoliczkana* (Felder, 1874) | + | + | + | Khan et al. (2015) |
| 10 | *Salassa lola* (Westwood, 1847) | + | – | – | Khan et al. (2015) |
| 11 | *Samia canningi* (Hutton, 1860) | + | – | – | Khan et al. (2009) |
| 12 | *Saturnia pyretorum* (Westwood, 1847) | + | + | – | Khan et al. (2009) |
| **1e. Sphingidae Latreille, 1802** | | | | | |
| 13 | *Acherontia styx* (Westwood, 1847) | + | – | – | Khan et al. (2015) |
| 14 | *Acosmeryx castanea* (Rothschild & Jordan, 1903) | + | + | – | Khan et al. (2015) |
| 15 | *Acosmeryx naga* (Moore, [1858]) | + | + | – | Khan et al. (2015) |
| 16 | *Ambulyx ochracea* (Butler, 1885) | + | + | – | Khan et al. (2015) |
| 17 | *Ambulyx lahora* (Butler, 1875) | + | + | – | Khan et al. (2015) |
| 18 | *Ambulyx placida* (Moore, 1888) | + | + | – | Khan et al. (2015) |
| 19 | *Ambulyx sericeipennis okurai* (Okano, 1959) | + | + | – | Khan et al. (2015) |
| 20 | *Cechenena lineosa* (Walker, 1856) | + | + | + | Khan et al. (2015) |
| 21 | *Cechenena mirabilis* (Butler, 1875) | + | + | + | Khan et al. (2015) |
| 22 | *Cephonodes hylas* (Linnaeus, [1771]) | + | + | – | Khan et al. (2015) |
| 23 | *Clanidopsis exusta* (Butler, 1875) | + | + | – | Khan et al. (2015) |
| 24 | *Clanis deucalion* (Walker, 1856) | + | + | – | Khan et al. (2015) |
| 25 | *Dahira rubiginosa* (Moore, 1888) | + | + | + | Khan et al. (2015) |
| 26 | *Daphnis nerii* (Linnaeus, 1758) | + | + | + | Khan et al. (2015) |
| 27 | *Deilephila elpenor* (Linnaeus, 1758) | + | + | + | Khan et al. (2015) |
| 28 | *Hippotion celerio* (Linnaeus, 1758) | + | + | + | Khan et al. (2015) |
| 29 | *Hippotion rosetta* (Swinhoe, 1892) | + | + | + | Khan et al. (2015) |
| 30 | *Hyles gallii* (Rottemburg, 1775) | + | + | + | Khan et al. (2015) |
| 31 | *Hyles hippophaes bienerti* (Staudinger, 1874) | + | + | + | Khan et al. (2015) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 32 | *Hyles nervosa* (Rothschild & Jordan, 1903) | – | – | + | Smetacek and Kitching (2012) |
| 33 | *Hyles nicaea nicaea* (de Prunner, 1798) | – | – | + | Smetacek and Kitching (2012) |
| 34 | *Langia zenzeroides formosana* (Clark, 1936) | + | + | + | Khan et al. (2015) |
| 35 | *Macroglossum belis* (Linnaeus, 1758) | + | + | + | Khan et al. (2015) |
| 36 | *Macroglossum bombylans* (Boisduval, [1875]) | + | + | + | Khan et al. (2015) |
| 37 | *Macroglossum gyrans* (Walker, 1856) | + | + | + | Khan et al. (2015) |
| 38 | *Macroglossum heliophila* (Boisduval, 1875) | + | + | + | Khan et al. (2015) |
| 39 | *Macroglossum pyrrhosticta* (Butler, 1875) | + | + | + | Khan et al. (2015) |
| 40 | *Marumba cristata* (Butler, 1875) | + | + | + | Khan et al. (2015) |
| 41 | *Marumba juvencus* (Rothschild & Jordan, 1912) | + | – | – | Khan et al. (2015) |
| 42 | *Meganoton rubescens* (Butler, 1876) | + | + | – | Khan et al. (2015) |
| 43 | *Nephele hespera* (Fabricius, 1775) | + | + | + | Khan et al. (2015) |
| 44 | *Neogurelca himachala himachala* (Butler, [1876]) | + | + | + | Khan et al. (2015) |
| 45 | *Neogurelca masuriensis* (Butler, 1875) | + | + | + | Khan et al. (2015) |
| 46 | *Smerinthus kindermannii* (Lederer, 1857) | + | + | + | Khan et al. (2015) |
| 47 | *Theretra alecto* (Linnaeus, 1758) | + | + | + | Khan et al. (2015) |
| 48 | *Theretra nessus* (Drury, 1773) | + | + | + | Khan et al. (2015) |
| 49 | *Theretra oldenlandiae* (Fabricius, 1775) | + | + | + | Khan et al. (2015) |
| 50 | *Xylophanes libya* (Druce, 1878) | + | + | + | Khan et al. (2015) |
| **2. Cossoidea** **2a. Cossidae Leach, 1815** | | | | | |
| 51 | *Catopta cashmirensis* (Moore, 1879) | – | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 52 | *Zeuzera multistrigata* (Moore, 1881) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| **2b. Sesiidae Boisduval, 1828** | | | | | |
| 53 | *Melittia indica* (Butler, 1874) | – | + | – | Khan et al. (2015) |
| **3. Drepanoidea** **3a. Drepanidae Meyrick, 1895** | | | | | |
| 54 | *Deroca hyaline* (Walker, 1855) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 55 | *Habrosyne scripta* (Gosse, 1840) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| **4. Noctuoidea** **4a. Erebidae Leach, 1815** | | | | | |
| 56 | *Acantholipes trajectus* (Walker, 1865) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 57 | *Achaea janata* (Linnaeus, 1758) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 58 | *Aglaomorpha plagiata* (Walker, 1855) | + | + | – | Kirti and Singh (2015, 2016) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 59 | *Agylla prasena* (Moore, 1859) | + | – | – | Hampson (1891–1920) |
| 60 | *Aloa lactinea* (Cramer, 1777) | + | + | + | Kirti and Singh (2015, 2016) |
| 61 | *Alphaea impleta* (Walker, [1865]) | + | + | – | Kirti and Singh (2015, 2016) |
| 62 | *Amata hubneri* (Boisduval, 1828) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 63 | *Amata humeralis* (Butler, 1876) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 64 | *Amata leucosoma* (Butler, 1876) | + | + | – | Hampson (1891–1920) |
| 65 | *Amata syntomoides* (Butler, 1876) | + | – | – | Hampson (1891–1920) |
| 66 | *Amerila astreus* (Drury, 1773) | + | – | – | Kirti and Singh (2015, 2016) |
| 67 | *Amerila omissa* (Rothschild, 1910) | + | – | – | Kirti and Singh (2015, 2016) |
| 68 | *Andala unifascia* (Walker, 1855) | + | – | + | Hampson (1891–1920) |
| 69 | *Anomis mesogona* (Walker, 1857) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 70 | *Anomis sabulifera* (Guenée, 1852) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 71 | *Arcte coerula* (Guenée, 1852) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 72 | *Arcte taprobana* (Moore, 1885) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 73 | *Arctia caja* (Linnaeus, 1758) | + | – | – | Kirti and Singh (2015, 2016) |
| 74 | *Arctia intercalaris* (Eversmann, 1843) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 75 | *Arctia orientalis* (Moore, 1878) | + | – | – | Hampson (1891–1920) |
| 76 | *Arctia thibetica* (Felder, 1874) | + | – | – | Hampson (1891–1920) |
| 77 | *Areas galactina* (Hoeven, 1840) | + | + | – | Kirti and Singh (2015, 2016) |
| 78 | *Areas imperialis* (Kollar, [1844]) | + | – | – | Kirti and Singh (2015, 2016) |
| 79 | *Argina astrea* (Drury, 1773) | + | – | – | Kirti and Singh (2015, 2016) |
| 80 | *Aroa cinnamomea* (Moore, 1879) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 81 | *Artena dotata* (Fabricius, 1794) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 82 | *Asota ficus* (Fabricius, 1775) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 83 | *Asota producta* (Butler, 1875) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 84 | *Asura dharma* (Moore, 1879) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 85 | *Asura infumata* (Felder, 1874) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 86 | *Barsine linga* (Moore, 1859) | + | – | – | Kirti and Singh (2015, 2016) |
| 87 | *Bastilla analis* (Guenée, 1852) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 88 | *Bastilla arctotaenia* (Guenée, 1852) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 89 | *Bastilla crameri* (Moore, 1885) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 90 | *Batracharta irrorata* (Hampson, 1894) | – | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 91 | *Brunia antica* (Walker, 1854) | + | + | – | Kirti and Singh (2015, 2016) |
| 92 | *Callindra similis* (Moore, 1879) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 93 | *Callindra equitalis* (Kollar, [1844]) | + | + | + | Kirti and Singh (2015, 2016) |
| 94 | *Callindra principalis* (Kollar, [1844]) | + | + | – | Kirti and Singh (2015, 2016) |
| 95 | *Calyptra minuticornis* (Guenée, 1852) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 96 | *Capissa alba* (Kirti, Singh & Joshi, 2014) | + | – | – | Kirti and Singh (2015, 2016) |
| 97 | *Capissa vagesa* (Moore, [1860]) | + | – | – | Kirti and Singh (2015, 2016) |
| 98 | *Carcinopyga lichenigera* (Felder, 1874) | + | – | + | Dar (2014, 2017) |
| 99 | *Catocala afghana* (Swinhoe, 1885) | – | – | + | Dar (2014) and Kirti et al. (2012–2014) |
| 100 | *Catocala amnonfreidbergi* (Kravchenko, Speidel, Wit, Moser, Seplyarsky, Saldaitis, Junila & Müller, 2008) | – | – | + | Dar (2014) and Kirti et al. (2012–2014) |
| 101 | *Catocala patala* (Felder & Rogenhofer, 1874) | – | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 102 | *Catocala prolifica* (Walker, 1857) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 103 | *Chrysorabdia bivitta* (Walker, 1856) | + | – | – | Kirti and Singh (2015, 2016) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 104 | *Chrysorabdia vilemani* (Hampson, 1911) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 105 | *Churinga rufifrons* (Moore, 1878) | + | – | – | Kirti and Singh (2015, 2016) |
| 106 | *Cladarctia quadriramosa* (Kollar, [1844]) | + | – | – | Kirti and Singh (2015, 2016) |
| 107 | *Creatonotos gangis* (Linnaeus, 1763) | + | + | + | Kirti and Singh (2015, 2016) |
| 108 | *Creatonotos transiens* (Walker, 1855) | + | + | + | Kirti and Singh (2015, 2016) |
| 109 | *Cyana adita* (Moore, 1859) | + | – | – | Kirti and Singh (2015, 2016) |
| 110 | *Cyana bellissima* (Moore, 1878) | + | – | – | Kirti and Singh (2015, 2016) |
| 111 | *Cyana candida* (Felder, 1874) | + | + | – | Kirti and Singh (2015, 2016) |
| 112 | *Cyana detrita* (Walker, 1854) | + | + | – | Kirti and Singh (2015, 2016) |
| 113 | *Cyana dohertyi* (Elwes, 1890) | + | + | – | Kirti and Singh (2015, 2016) |
| 114 | *Cyana dudgeoni* (Hampson, 1895) | + | – | – | Kirti and Singh (2015, 2016) |
| 115 | *Cyana gazella* (Moore, 1872) | + | – | – | Kirti and Singh (2015, 2016) |
| 116 | *Cyana gelida* (Walker, 1854) | + | – | – | Kirti and Singh (2015, 2016) |
| 117 | *Cyana guttifera* (Walker, 1856) | + | – | – | Kirti and Singh (2015, 2016) |
| 118 | *Cyana intercomma* (Černy & Pinratana, 2009) | + | – | – | Kirti and Singh (2015, 2016) |
| 119 | *Cyana obliquilineata* (Hampson, 1900) | + | – | – | Kirti and Singh (2015, 2016) |
| 120 | *Cyana peregrina* (Walker, 1854) | + | – | – | Kirti and Singh (2015, 2016) |
| 121 | *Cyana perornata* (Walker, 1854) | + | – | – | Kirti and Singh (2015, 2016) |
| 122 | *Cyana quadrinotata* (Walker, 1869) | + | + | – | Kirti and Singh (2015, 2016) |
| 123 | *Cyana rejecta* (Walker, 1854) | + | + | – | Kirti and Singh (2015, 2016) |
| 124 | *Cyana signa* (Walker, 1854) | + | + | – | Kirti and Singh (2015, 2016) |
| 125 | *Dichromia trigonalis* (Guenée, 1854) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 126 | *Digama hearseyana* (Moore, 1859) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 127 | *Dolgoma reticulata* (Moore, 1865) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 128 | *Drasteria nephelostola* (Hampson, 1926) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 129 | *Dysgonia latifascia* (Warren, 1888) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 130 | *Eilema auriflua* (Moore, 1878) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 131 | *Eilema calamaria* (Moore, 1878) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 132 | *Epicepsis dominicensis* (Rothschild, 1911) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 133 | *Erebus glaucopis* (Walker, 1858) | + | + | – | Dar (2014) |
| 134 | *Eressa confinis* (Walker, 1854) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 135 | *Euplagia quadripunctaria* (Poda, 1761) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 136 | *Euproctis albodentata* (Moore, 1879) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 137 | *Euproctis similis* (Füssli, 1775) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 138 | *Euproctis xanthorrhaea* (Kollar, 1848) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 139 | *Ghoria collitoides* (Buttler, 1885) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 140 | *Ghoria postfusca* (Hampson, 1894) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 141 | *Gonerda perornata* (Moore, 1879) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 142 | *Grammodes geometrica* (Fabricius, 1775) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 143 | *Grammodes stolida* (Fabricius, 1775) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 144 | *Hypersypnoides submarginata* (Walker, 1865) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 145 | *Hypocala deflorata* (Fabricius, 1794) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 146 | *Hypocala rostrata* (Fabricius, 1794) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 147 | *Hypocala subsatura* (Guenée, 1852) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 148 | *Kailasha gulmargensis* (Singh, Kirti & Singh, 2015) | + | – | – | Kirti and Singh (2015, 2016) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 149 | *Katha conformis* (Walker, 1854) | + | – | – | Kirti and Singh (2015, 2016) |
| 150 | *Lemyra bimaculata* (Moore, 1879) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 151 | *Lemyra multivittata* (Moore, 1865) | + | – | – | Kirti and Singh (2015, 2016) |
| 152 | *Leucoma salicis* (Linnaeus, 1758) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 153 | *Lyclene calamaria* (Moore, 1888) | + | – | – | Kirti and Singh (2015, 2016) |
| 154 | *Lyclene congerens* (Felder, 1874) | + | – | – | Kirti and Singh (2015, 2016) |
| 155 | *Lyclene dasara* (Moore, 1859) | + | – | – | Kirti and Singh (2015, 2016) |
| 156 | *Lyclene dharma* (Moore, 1879) | + | – | – | Kirti and Singh (2015, 2016) |
| 157 | *Lyclene spilosomoides* (Moore, 1878) | + | – | – | Kirti and Singh (2015, 2016) |
| 158 | *Lyclene undulosa* (Walker, 1854) | + | – | – | Kirti and Singh (2015, 2016) |
| 159 | *Lygephila craccae* (Denis & Schiffermüller, 1775) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 160 | *Lygephila lusoria* (Linnaeus, 1758) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 161 | *Lygniodes schoenbergi* (Pagenstecher,1890) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 162 | *Lymantria obfuscata* (Walker, 1865) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 163 | *Lymantria singapura* (Swinhoe, 1906) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 164 | *Macotasa nubecula* (Moore, 1879) | + | – | + | Kirti and Singh (2015, 2016) |
| 165 | *Macrobrochis albifascia* (Fang, 1982) | + | – | – | Kirti and Singh (2015, 2016) |
| 166 | *Macrobrochis pallens* (Hampson, 1894) | + | – | – | Kirti and Singh (2015, 2016) |
| 167 | *Macrobrochis prasena* (Moore, 1859) | + | – | – | Kirti and Singh (2015, 2016) |
| 168 | *Mangina argus* (Kollar, [1847]) | + | – | – | Kirti and Singh (2015, 2016) |
| 169 | *Mangina syringa* (Cramer, 1775) | + | – | – | Kirti and Singh (2015, 2016) |
| 170 | *Melapia electaria* (Bremer, 1864) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 171 | *Miltochrista striata* (Bremer & Grey, 1852) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 172 | *Mocis discios* (Kollar, 1844) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 173 | *Mocis frugalis* (Fabricius, 1775) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 174 | *Nannoarctia obliquifascia* (Hampson, 1894) | + | – | – | Kirti and Singh (2015, 2016) |
| 175 | *Nepita conferta* (Walker, 1854) | + | – | – | Kirti and Singh (2015, 2016) |
| 176 | *Nyctemera adversata* (Schaller, 1788) | + | – | – | Kirti and Singh (2015, 2016) |
| 177 | *Oeonistis entella* (Cramer, 1779) | + | – | – | Kirti and Singh (2015, 2016) |
| 178 | *Olepa ricini* (Fabricius, 1775) | + | – | – | Kirti and Singh (2015, 2016) |
| 179 | *Ophiusa tirhaca* (Cramer, 1777) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 180 | *Ophiusa trapezium* (Guenée, 1852) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 181 | *Oraesia rectistria* (Guenée, 1852) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 182 | *Paramsacta moorei* (Butler, 1875) | + | – | – | Kirti and Singh (2015, 2016) |
| 183 | *Pericallia transversa* (Moore, 1879) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 184 | *Plecoptera recta* (Pagenstecher, 1886) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 185 | *Plecoptera reflexa* (Guenée, 1852) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 186 | *Polydesma boarmoides* (Guenée, 1852) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 187 | *Pseudophragmatobia parvula* (Felder, 1874) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 188 | *Simplicia caeneusalis* (Walker, [1859]) | + | + | - | Dar (2014) and Kirti et al. (2012–2014) |
| 189 | *Spilarctia comma* (Walker, 1856) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 190 | *Spilarctia leopardina* (Kollar, [1844]) | + | – | – | Kirti and Singh (2015, 2016) |
| 191 | *Spilarctia obliqua* (Walker, 1855) | + | – | – | Kirti and Singh (2015, 2016) |
| 192 | *Spilosoma erythrozona* (Kollar, [1844]) | + | – | – | Kirti and Singh (2015, 2016) |

(continued)

Table 31.1 (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 193 | *Spirama retorta* (Clerck, 1764) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 194 | *Stigmatophora palmata* (Moore, 1878) | + | – | – | Kirti and Singh (2015, 2016) |
| 195 | *Syntomoides imaon* (Cramer, [1779]) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 196 | *Tatargina pannosa* (Moore, 1879) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 197 | *Thyas honesta* (Hübner, 1824) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 198 | *Thyas juno* (Dalman, 1823) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 199 | *Trachea niveiplaga* (Walker, 1857 | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 200 | *Trachea stoliczkae* (Felder & Rogenhofer,1874) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 201 | *Trichoplusia orichalcea* (Fabricius, 1775) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 202 | *Trichoplusia daubei* (Boisduval, 1840) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 203 | *Tricoplusia lectula* (Walker, 1858) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 204 | *Trigonodes hyppasia* (Cramer, 1779) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 205 | *Utetheisa varians* (Walker, 1854) | + | – | – | Kirti and Singh (2015, 2016) |
| 206 | *Vamuna virilis* (Rothschild, 1913) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 207 | *Vamuna maculata* (Moore, 1878) | + | – | – | Kirti and Singh (2015, 2016) |
| **4b. Euteliidae Grote, 1882** | | | | | |
| 208 | *Lophotyna albosignata* (Moore, 1881) | + | – | + | Dar (2014) and Kirti et al. (2012–2014) |
| 209 | *Penicillaria jocosatrix* (Guenée, 1852) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 210 | *Penicillaria nugatrix* (Guenée, 1852) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 211 | *Pericyma umbrina* (Guenée, 1852) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| **4c. Noctuidae Latreille, 1809** | | | | | |
| 212 | *Acronicta major* (Bremer, 1861) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 213 | *Acronicta pruinosa* (Guenée, 1852) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 214 | *Acronicta rumicis* (Linnaeus, 1758) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 215 | *Actinotia intermediata* (Bremer, 1861) | + | + | – | Hampson (1891–1920) |
| 216 | *Adisura atkinsoni* (Moore, 1881) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 217 | *Aedia acronyctoides* (Guenée, 1852) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 218 | *Aedia leucomelas* (Linnaeus, 1758) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 219 | *Agrotis cinerea* (Denis & Schiffermüller, 1775) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 220 | *Agrotis ipsilon* (Hufnagel, 1766) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 221 | *Agrotis segetum* (Denis & Schiffermüller, 1775) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 222 | *Agrotis spinifera* (Hübner, 1808) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 223 | *Aletia decisissima* (Walker, 1865) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 224 | *Aletia l-album* (Linnaeus, 1767) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 225 | *Aletia vitellina* (Hübner, 1808) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 226 | *Amphipyra herrichschaefferi* (Hacker & Peks, 1998) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 227 | *Amphipyra monolitha* (Guenée, 1852 | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 228 | *Amphipyra pyramidea* (Linnaeus, 1758) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 229 | *Anarta stigmosa* (Christoph, 1887) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 230 | *Anarta trifolii* (Hufnagel, 1766) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 231 | *Apsarasa radians* (Westwood, 1848) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 232 | *Athetis bipuncta* (Snellen, [1886]) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 233 | *Athetis lineosa* (Moore, 1881) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 234 | *Auchmis inextricata* (Moore, 1881) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 235 | *Autographa gamma* (Linnaeus, 1758) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 236 | *Autographa nigrisigna* (Walker, 1858) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 237 | *Calyptra bicolor* (Moore, 1883) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 238 | *Chrysodeixis eriosoma* (Doubleday, 1843) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 239 | *Chrysodeixis furihatai* (Okano, 1963) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 240 | *Condica conducta* (Walker, [1857]) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 241 | *Conservula indica* (Moore, 1867) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 242 | *Cornutiplusia circumflexa* (Linnaeus, 1767) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 243 | *Cosmia affinis* (Linnaeus, 1767) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 244 | *Cryphia literata* (Moore, 1881) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 245 | *Cryphia modesta* (Moore, 1881) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 246 | *Ctenoplusia albostriata* (Bremer & Grey, 1853) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 247 | *Ctenoplusia limbirena* (Guenée, 1852) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 248 | *Ctenoplusia placida* (Moore, [1884]) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 249 | *Cucullia biornata* (Fischer de Waldheim, 1840) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 250 | *Cucullia convexipennis* (Grote & Robinson, 1868) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 251 | *Cucullia nigrifascia* (Hampson, 1894) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 252 | *Cucullia splendida* (Stoll, 1782) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 253 | *Deltote obliqua* (Moore, 1882) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 254 | *Diarsia erubescens* (Butler, 1880) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 255 | *Diarsia hoenei* (Boursin, 1954) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 256 | *Dichagyris flammatra* (Denis & Schiffermüller, 1775) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 257 | *Erythroplusia pyropia* (Butler, 1879) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 258 | *Euplexia lucipara* (Linnaeus, 1758) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 259 | *Euplexia semifascia* (Walker, 1865) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 260 | *Eupsilia transversa* (Hufnagel, 1766) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 261 | *Euxoa auxiliaris* (Grote, 1873) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 262 | *Euxoa basigramma* (Staudinger, 1870) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 263 | *Euxoa conspicua* (Hübner, 1824) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 264 | *Euxoa nigricans* (Linnaeus, 1761) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 265 | *Euxoa temera* (Hübner, 1808) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 266 | *Euxoa terrealis* (Grote, 1883) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 267 | *Hecatera dysodea* (Denis & Schiffermüller, 1775) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 268 | *Helicoverpa armigera* (Hübner, [1808]) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 269 | *Helicoverpa zea* (Boddie, 1850) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 270 | *Heliocheilus translucens* (Felder & Rogenhofer, 1874) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 271 | *Heliothis cruentata* (Moore, 1881) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 272 | *Heliothis decorata* (Moore, 1881) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 273 | *Heliothis ononis* (Denis & Schiffermüller, 1775) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 274 | *Heliothis peltigera* (Denis & Schiffermüller, 1775) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 275 | *Heliothis scutosa* (Schiffermüller, 1776) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 276 | *Hermonassa consignata* (Walker, 1865) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 277 | *Hermonassa lunata* (Moore, 1882 | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 278 | *Lacanobia oleracea* (Linnaeus, 1758) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 279 | *Leucania comma* (Linnaeus, 1761) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 280 | *Leucania loreyi* (Duponchel, 1827) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 281 | *Leucania palaestinae* (Staudinger, 1897) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 282 | *Leucania venalba* (Moore, 1867) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 283 | *Lophoptera illucida* (Walker, 1865) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 284 | *Lophoptera squammigera* (Guenée, 1852) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 285 | *Macdunnoughia confusa* (Stephens, 1850) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 286 | *Melapia electaria* (Bremer, 1864) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 287 | *Magusa orbifera* (Walker, 1857) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 288 | *Mythimna conigera angulifera* (Moore, 1881) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 289 | *Mythimna irrorata* (Moore, 1881) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 290 | *Mythimna nainica* (Moore, 1881) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 291 | *Mythimna reversa* (Moore, 1884) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 292 | *Mythimna separata* (Walker, 1865) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 293 | *Mythimna unipuncta* (Haworth, 1809) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 294 | *Mythimna v-album* (Hampson, 1891) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 295 | *Noctua orbona* (Hufnagel, 1766) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 296 | *Ochropleura nivisparsa* (Butler, 1889) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 297 | *Ochropleura plecta* (Linnaeus, 1761) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 298 | *Ochropleura trianglaris* (Moore, 1867) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 299 | *Odontestra submarginalis* (Walker, 1869) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 300 | *Odontodes aleuca* (Guenée, 1852) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 301 | *Oraesia emarginata* (Fabricius, 1794) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 302 | *Orthosia incerta* (Hufnagel, 1766) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 303 | *Pandesma quenavadi* (Guenée, 1852) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 304 | *Peridroma saucia* (Hübner, 1808) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 305 | *Plusia argyrosigna* (Moore, 1882) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 306 | *Polia scotochlora* (Kollar, 1844) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 307 | *Pyrrhia umbra* (Hufnagel, 1766) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 308 | *Scriptoplusia nigriluna* (Walker, [1858]) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 309 | *Sesamia inferens* (Walker, 1856) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 310 | *Spodoptera littoralis* (Boisduval, 1833) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 311 | *Spodoptera mauritia* (Boisduval, 1833) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 312 | *Trachea aurigera* (Walker, 1858) | + | − | − | Dar (2014) and Kirti et al. (2012–2014) |
| 313 | *Triphaenopsis indica* (Moore, 1881) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 314 | *Triphaenopsis pulcherrima* (Moore, 1867) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 315 | *Xestia ashworthi* (Doubleday, 1855) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 316 | *Xestia c-nigrum* (Linnaeus, 1758) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 317 | *Xestia renalis* (Moore, 1881) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 318 | *Xestia semiherbida* (Walker, 1857) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 319 | *Xestia tiangulum* (Hufnagel, 1766) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 320 | *Zonoplusia ochreata* (Walker, 1865) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| **4d. Nolidae Hampson, 1894** | | | | | |
| 321 | *Beara dichromella* (Walker, 1866) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 322 | *Bomolocha crassalis* (Fabricius, 1787) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 323 | *Callopistria aethiops* (Butler, 1878) | + | + | − | Hampson (1891–1920) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 324 | *Callopistria indica* (Butler, 1891) | + | + | − | Hampson (1891–1920) |
| 325 | *Callopistria maillardi* (Guenée, 1862) | + | + | − | Hampson (1891–1920) |
| 326 | *Callopistria placodoides* (Guenée, 1852) | + | + | − | Hampson (1891–1920) |
| 327 | *Callopistria repleta* (Walker, 1858) | + | + | − | Hampson (1891–1920) |
| 328 | *Callopistria rivularis* (Walker, [1858]) | + | + | − | Hampson (1891–1920) |
| 329 | *Callyna siderea* (Guenée, 1852) | + | + | − | Hampson (1891–1920) |
| 330 | *Carea angulata* (Fabricius, 1793) | + | + | − | Hampson (1891–1920) |
| 331 | *Garella musculana* (Erschov, 1874) | − | + | + | Hampson (1891–1920) |
| 332 | *Garella nilotica* (Rogenhofer, 1881) | − | + | + | Hampson (1891–1920) |
| 333 | *Nycteola asiatica* (Krulikovsky, 1904) | − | + | − | Hampson (1891–1920) |
| **4e. Notodontidae Stephens, 1829** | | | | | |
| 334 | *Cerura himalayana* (Moore, 1888) | + | + | + | Hampson (1891–1920) |
| 335 | *Cerura liturata* (Walker, 1855) | + | + | + | Hampson (1891–1920) |
| 336 | *Cerura vinula* (Linnaeus, 1758) | + | + | + | Hampson (1891–1920) |
| 337 | *Furcula occidentalis* (Lintner, 1878) | + | + | + | Hampson (1891–1920) |
| 338 | *Syntypistis cyanea* (Leech, 1889) | + | + | + | Hampson (1891–1920) |
| **5. Geometroidea**<br>**5a. Geometridae Leach, 1815** | | | | | |
| 339 | *Abraxas tenellula* (Inoue, 1984) | − | − | + | Dar (2014) |
| 340 | *Agathia succedanea* (Warren, 1897) | + | − | − | Dar (2014) and Kirti et al. (2012–2014) |
| 341 | *Alcis trikotaria* (Felder & Rogenhofer, 1875) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 342 | *Arichanna picaria* (Wileman, 1910) | + | − | − | Dar (2014) and Kirti et al. (2012–2014) |
| 343 | *Biston betularia* (Linnaeus, 1758) | + | + | − | Dar (2014) and Kirti et al. (2012–2014) |
| 344 | *Biston inouei* (Holloway, 1994) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 345 | *Chiasmia nora* (Walker, 1861) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 346 | *Chlorissa anadema* (Prout, 1930) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 347 | *Chlorissa pretiosaria* (Staudinger, 1877) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 348 | *Chorodna moorei* (Thierry-Mieg, 1899) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 349 | *Cidaria kashmirica* (Moore, 1888) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 350 | *Colostygia albigirata* (Kollar, 1844) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 351 | *Euphyia subangulata* (Kollar, 1844) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 352 | *Lomographa distans* (Warren 1894) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 353 | *Menophra jugorum* (Felder, 1874) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 354 | *Menophra subplagiata* (Walker, 1860) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 355 | *Odontopera angularia* (Moore, 1868) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 356 | *Odontopera bilinearia* (Swinhoe, 1890) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 357 | *Ourapteryx podaliriata* (Guenée, 1858) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 358 | *Ourapteryx yerburii* (Butler, 1886) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 359 | *Peratophyga hyalinata* (Kollar, [1844]) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 360 | *Photoscotosia insularis* (Bastelberger, 1909) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 361 | *Pingasa pseudoterpnaria* (Guenée, 1858) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 362 | *Pseudomiza cruentaria* (Moore, 1867) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 363 | *Rhodostrophia cinerascens* (Moore, 1888) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 364 | *Scopula kashmirensis* (Moore, 1888) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 365 | *Tanaoctenia haliaria* (Walker, 1861) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 366 | *Tanaorhinus reciprocata* (Walker,1861) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 367 | *Zamarada baliata* (Felder & Rogenhofer, 1875) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| **6. Immoidea**<br>**6a. Immidae Heppner, 1977** | | | | | |
| 368 | *Imma flaviceps* (Felder & Rogenhofer, 1874) | – | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| **7. Lasiocampoidea**<br>**7a. Lasiocampidae Harris, 1841** | | | | | |
| 369 | *Trabala garuda* (Roepke, 1951) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 370 | *Trabala hantu* (Roepke, 1951) | + | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| **8. Thyridoidea**<br>**8a. Thyrididae Herrich-Schäffer, 1845** | | | | | |
| 371 | *Telchines vialis* (Moore, 1883) | + | + | + | Hampson (1891–1920) |
| **9. Tortricoidea**<br>**9a. Tortricidae Latreille, 1803** | | | | | |
| 372 | *Acleris birdi* (Ganai & Khan, 2015) | – | + | + | Ahmad (2015, 2018) |
| 373 | *Acleris comariana* (Lienig & Zeller, 1846) | – | + | + | Ahmad (2015, 2018) |
| 374 | *Acleris minuta* (Robinson, 1869) | – | – | + | Ahmad (2015, 2018) |
| 375 | *Acleris orphnocycla* (Meyrick, 1937) | – | + | + | Ahmad (2015) |
| 376 | *Aethes afghan* (Razowski, 1983) | – | – | + | Ahmad (2015, 2018) |
| 377 | *Aethes conomochla* (Meyrick, 1933) | – | + | + | Ahmad (2015, 2018) |
| 378 | *Ahtes pardaliana* (Kennel, 1899) | – | – | + | Ahmad (2015, 2018) |
| 379 | *Archips cantinus* (Razowski, 2006) | – | + | + | Ahmad (2015) |
| 380 | *Archips naltarica* (Razowski, 2006) | + | + | + | Ahmad (2015) |
| 381 | *Archips philippa* (Meyrick, 1918) | – | + | + | Ahmad (2015, 2018) |
| 382 | *Archips termias* (Meyrick, 1918) | – | + | + | Ahmad (2015, 2018) |
| 383 | *Argyroploce mixanthes* (Meyrick, 1932) | – | + | + | Ahmad (2015, 2018) |
| 384 | *Celypha constructa* (Meyrick, 1922) | + | + | + | Ahmad (2015) |
| 385 | *Choristoneura colyma* (Razowski, 2006) | + | + | – | Ahmad (2015) |
| 386 | *Choristoneura griseicoma* (Meyrick, 1924) | – | – | + | Ahmad (2015, 2018) |
| 387 | *Choristoneura leptograpta* (Meyrick, 1924) | – | – | + | Ahmad (2015, 2018) |
| 388 | *Choristoneura neurophaea* (Meyrick, 1932) | – | + | + | Ahmad (2015, 2018) |
| 389 | *Choristoneura propensa* (Razowski, 1992) | – | + | + | Ahmad (2015, 2018) |
| 390 | *Choristoneura pseudofumiferana* (Ganai & Khan, 2015) | – | + | + | Ahmad (2015, 2018) |
| 391 | *Clepsis kupwari* (Ganai & Khan, 2015) | – | + | – | Ahmad (2015, 2018) |
| 392 | *Clepsis rurinana* (Linnaeus, 1758) | + | + | + | Ahmad (2015) |
| 393 | *Clepsis translucida* (Meyrick, 1908) | + | + | + | Ahmad (2015) |
| 394 | *Cnephasia hunzorum* (Diakonoff, 1971) | + | + | – | Ahmad (2015) |
| 395 | *Cnephasia sedana* (Constant, 1884) | – | + | + | Ahmad (2015, 2018) |
| 396 | *Cochylimorpha halophilana* (Christoph, 1872) | – | – | + | Ahmad (2015, 2018) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 397 | *Cochylimorpha jaculana* (Snellen, 1883) | – | + | – | Ahmad (2015, 2018) |
| 398 | *Cochylimorpha scoptes* (Razowski 1984) | – | – | + | Ahmad (2015, 2018) |
| 399 | *Cochylis indica* (Razowski 1868) | – | + | – | Ahmad (2015, 2018) |
| 400 | *Crocidosema plebejana* (Zeller, 1847) | + | + | + | Ahmad (2015) |
| 401 | *Cydia pomonella* (Linnaeus, 1758) | – | – | + | Ahmad (2015) |
| 402 | *Dicellitis nigritula* (Meyrick, 1908) | – | – | + | Ahmad (2015, 2018) |
| 403 | *Dichrorampha euterpes* (Diakonoff, 1971) | – | + | + | Ahmad (2015, 2018) |
| 404 | *Endothenia banausopis* (Meyrick, 1938) | – | – | + | Ahmad (2015, 2018) |
| 405 | *Epelebodina concolorata* (Razowski, 2006) | – | – | + | Ahmad (2015, 2018) |
| 406 | *Epiblema lasiovalva* (Razowski, 2006) | – | – | + | Ahmad (2015, 2018) |
| 407 | *Epiblema lochmoda* (Razowski, 2006) | – | + | – | Ahmad (2015, 2018) |
| 408 | *Epinotia thapsiana* (Zeller, 1847) | – | – | + | Ahmad (2015, 2018) |
| 409 | *Eppihus hippeus* (Razowski, 2006) | – | – | + | Ahmad (2015, 2018) |
| 410 | *Eucosma conterminana* (Guenée, 1845) | + | + | + | Ahmad (2015) |
| 411 | *Eucosma gundai* (Ganai & Khan, 2015) | – | + | – | Ahmad (2015, 2018) |
| 412 | *Eucosma tetraplana* (Moschler, 1866) | + | + | + | Ahmad (2015) |
| 413 | *Eupoecilia dynodesma* (Diakonoff, 1971) | – | – | + | Ahmad (2015, 2018) |
| 414 | *Gibberifera obscura* (Diakonoff, 1964) | + | + | + | Ahmad (2015) |
| 415 | *Grapholita melicrossis* (Meyrick, 1932) | – | + | – | Ahmad (2015, 2018) |
| 416 | *Grapholita molesta* (Busck, 1964) | + | + | – | Ahmad (2015) |
| 417 | *Gypsonoma sociana* (Haworth, [1811]) | – | + | – | Ahmad (2015, 2018) |
| 418 | *Homona coffearia* (Nietner, 1861) | + | + | – | Ahmad (2015) |
| 419 | *Homona nakaoi* (Yasuda, 1969) | + | + | – | Ahmad (2015) |
| 420 | *Lepteucosma charassuncus* (Razowski, 2006) | + | + | – | Ahmad (2015) |
| 421 | *Lepteucosma lutescens* (Razowski, 1967) | – | – | + | Ahmad (2015, 2018) |
| 422 | *Lepteucosma oxychrysa* (Diakonoff, 1971) | – | + | – | Ahmad (2015, 2018) |
| 423 | *Lepteucosma srinagara* (Razowski, 2006) | + | + | – | Ahmad (2015) |
| 424 | *Lobesia clarisecta* (Meyrick,1932) | – | + | + | Ahmad (2015, 2018) |
| 425 | *Lumaria lotsunica* (Razowski, 2006) | – | + | – | Ahmad (2015, 2018) |
| 426 | *Matsumuraeses capax* (Razowski & Yasuda, 1975) | + | + | + | Ahmad (2015) |
| 427 | *Matsumuraeses ochreocervina* (Walsingham, 1900) | – | + | – | Ahmad (2015, 2018) |
| 428 | *Matsumuraeses phaseoli* (Matsumura, 1900) | + | + | + | Ahmad (2015) |
| 429 | *Meridemis subbathymorpha* (Razowski, 2006) | – | + | – | Ahmad (2015, 2018) |
| 430 | *Neocalyptis chlansignum* (Razowski, 2006) | – | – | + | Ahmad (2015) |
| 431 | *Neocalyptis ladakhana* (Razowski, 2006) | – | – | + | Ahmad (2015) |
| 432 | *Neocalyptis nuristana* (Razowski, 1967) | – | – | + | Ahmad (2015, 2018) |
| 433 | *Pandemis thomasi* (Razowski, 2006) | + | + | + | Ahmad (2015) |
| 434 | *Pelochrista frustata* (Razowski, 2006) | – | – | + | Ahmad (2015, 2018) |
| 435 | *Pelochrista pollinaria* (Diakonoff, 1971) | – | – | + | Ahmad (2015, 2018) |
| 436 | *Pelochrista teleopa* (Razowski, 2006) | + | + | + | Ahmad (2015) |
| 437 | *Phalonidia contractana* (Zeller, 1847) | – | + | – | Ahmad (2015, 2018) |
| 438 | *Phaneta pylonitis* (Meyrick, 1932) | – | + | – | Ahmad (2015, 2018) |

(continued)

**Table 31.1** (continued)

| S. No. | Scientific name of species | J | K | L | Literature source |
|---|---|---|---|---|---|
| 439 | *Pyrsarcha hypsicrates* (Meyrick, 1932) | – | + | – | Ahmad (2015, 2018) |
| 440 | *Rhopobota naevana* (Hübner, 1817) | + | + | – | Ahmad (2015) |
| 441 | *Rhopobota pseudonaevana* (Ganai & Khan, 2015) | – | + | – | Ahmad (2015, 2018) |
| 442 | *Tortrix caryocryptis* (Meyrick, 1932) | – | + | – | Ahmad (2015, 2018) |
| 443 | *Tortrix noctivola* (Meyrick, 1932) | – | – | + | Ahmad (2015, 2018) |
| 444 | *Spilonota ocellana* (Denis & Schiffermüller, 1775) | + | + | + | Ahmad (2015) |
| 445 | *Ulodemis trigrapha* (Meyrick, 1907) | – | + | – | Ahmad (2015, 2018) |
| **10. Yponomeutoidea**<br>**10a. Yponomeutidae Stephens, 1829** | | | | | |
| 446 | *Yponomeuta rorrellus* (Hübner, 1796) | – | – | + | Dar et al. (2017) |
| **11. Pyraloidea**<br>**11a. Crambidae Latreille, 1810** | | | | | |
| 447 | *Calamotropha unicolorellus* (Zeller, 1863) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 448 | *Diaphania indica* (Saunders, 1851) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 449 | *Leucinodes orbonalis* (Guenée, 1854) | + | + | + | Khan et al. (2015) |
| 450 | *Maruca vitrata* (Fabricius, 1787) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 451 | *Ostrinia kasmirica* (Moore, 1888) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| 452 | *Pyrausta silhetalis* (Guenée, 1854) | – | + | – | Dar (2014) and Kirti et al. (2012–2014) |
| 453 | *Spoladea recurvalis* (Fabricius, 1775) | + | + | + | Dar (2014) and Kirti et al. (2012–2014) |
| **11b. Pyralidae Latreille, 1809** | | | | | |
| 454 | *Emmalocera fuscostrigella* (Ragonot, 1888) | + | + | + | Hampson (1891–1920) |
| 455 | *Emmalocera umbricostella* (Ragonot, 1888) | + | + | + | Hampson (1891–1920) |
| 456 | *Etiella zinckenella* (Treitschke, 1832) | + | + | + | Hampson (1891–1920) |
| **12. Zygaenoidea**<br>**12a. Limacodidae Duponchel, 1845** | | | | | |
| 457 | *Parasa pastoralis* (Butler, 1885) | + | – | – | Dar (2014) and Kirti et al. (2012–2014) |
| 458 | *Boradia carneola* (Moore, 1879) | + | + | + | Hampson (1891–1920) |
| **12b. Zygaenidae Latreille, 1809** | | | | | |
| 459 | *Chrysartona stipata* (Walker, 1854) | + | + | – | Hampson (1891–1920) |
| 460 | *Epizygaenella caschmirensis* (Kollar, 1844) | – | + | – | Hampson (1891–1920) |
| 461 | *Trypanophora semihyalina* (Kollar, 1844) | + | – | – | Hampson (1891–1920) |

+ = presence, – = absence

**Table 31.2** Superfamily-wise species richness in moth fauna of the Jammu and Kashmir State

| S. No. | Superfamily | Families with respective species number | Total no. of species in a superfamily |
|---|---|---|---|
| 1 | Bombycoidea | 5 families [Bombycidae (1); Brahmaeidae (2); Eupterotidae (2); Saturniidae (7); Sphingidae (38)] | 50 |
| 2 | Cossoidea | 2 families [Cossidae (2); Sesiidae (1)] | 3 |
| 3 | Drepanoidea | 1 family [Drepanidae (2)] | 2 |
| 4 | Noctuoidea | 5 families [Erebidae (152); Euteliidae (4); Noctuidae (109); Nolidae (13); Notodontidae (5)] | 283 |
| 5 | Geometroidea | 1 family [Geometridae (29)] | 29 |
| 6 | Immoidea | 1 family [Immidae (1)] | 1 |
| 7 | Lasiocampoidea | 1 family [Lasiocampidae (2)] | 2 |
| 8 | Thyridoidea | 1 family [Thyrididae (1)] | 1 |
| 9 | Tortricoidea | 1 family [Tortricidae (74)] | 74 |
| 10 | Yponomeutoidea | 1 family [Yponomeutidae (1)] | 1 |
| 11 | Pyraloidea | 2 families [Crambidae (7); Pyralidae (3)] | 10 |
| 12 | Zygaenoidea | 2 families [Limacodidae (2); Zygaenidae (3)] | 5 |
| | | **23 families** | **461 species** |

diverse family followed by Noctuidae (109 species), Tortricidae (74), Sphingidae (38), Geometridae (29), Nolidae (13), and others. The most diverse genera include *Cyana* (16 species), *Mythimna* (7), *Callopistria* (6), *Choristoneura* (6), *Euxoa* (6), *Lyclene* (6), *Heliothis* (5), *Macroglossum* (5), *Xestia* (5), *Acleris* (4), *Agrotis* (4), *Amata* (4), *Ambulyx* (4), *Archips* (4), *Arctia* (4), *Catocala* (4), *Cucullia* (4), *Hyles* (4), *Lepteucosma* (4), *Leucania* (4), and others. Based on our current understanding of regional moth fauna, Jammu division is the most speciose region (392 species) followed by Kashmir (332) and Ladakh (136). Some of the species peculiar to the region of Ladakh include *Neocalyptis chlansignum*, *Neocalyptis ladakhana*, *Cydia pomonella*, and *Yponomeuta rorrellus* with the latter two famous for their economic losses inflicted on apple, apricot, and *Salix* plantations. Some of the other major pests among the regional fauna include *Agrotis ipsilon, Anomis sabulifera, Dichagyris flammatra, Grapholita molesta, Helicoverpa armigera, Mythimna separata, Rhopobota naevana, Sesamia inferens, Spodoptera exigua,* and others responsible for causing considerable damage to other major crops (Plates 31.1 and 31.2).

Speidel, Wit, Moser, Seplyarsky, Saldaitis, Junila & Müller, 2008; **7** *Spirama retorta* (Clerck, 1764); **8** *Acronicta rumicis* (Linnaeus, 1758); **9** *Asota ficus* (Fabricius, 1775); **10** *Autographa gamma* (Linnaeus, 1758); **11** *Bastilla crameri* (Moore, 1885); **12** *Anarta stigmosa* (Christoph, 1887); **13** *Macdunnoughia confusa* (Stephens, 1850); **14** *Lophoptera squammigera* Guenée, 1852; **15** *Callopistria aethiops* Butler, 1878; **16** *Ophiusa tirhaca* (Cramer, 1777); **17** *Mythimna unipuncta* (Haworth, 1809); **18** *Xestia semiherbida* (Walker, 1857); **19** *Noctua orbona* Hafnagel, 1766; **20** *Orthosia incerta* (Hufnagel, 1766); **21** *Cnephasia hunzorum* Diakonoff, 1971; **22** *Yponomeuta rorrellus* (Hübner, 1796)

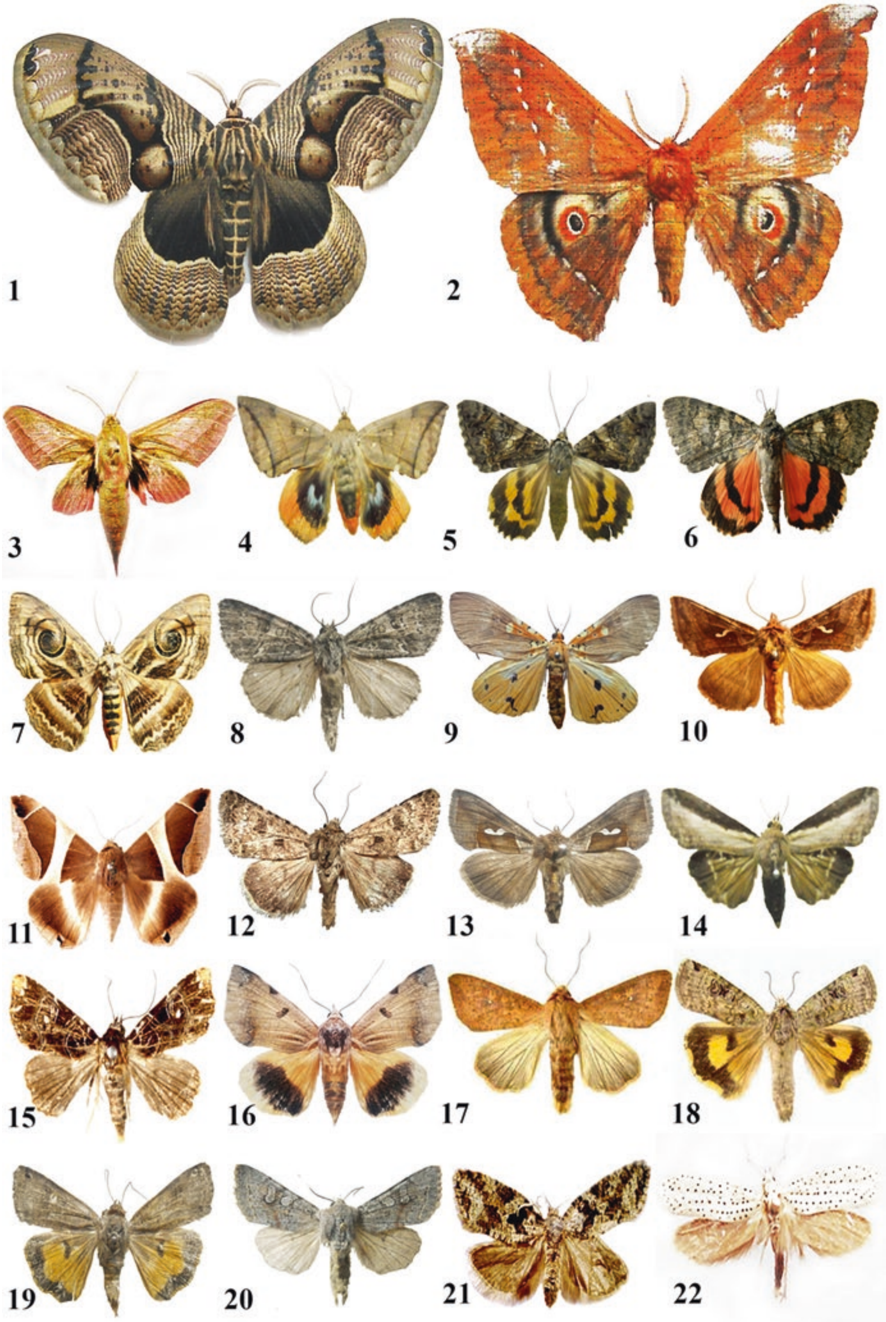


**Plate 31.1 1–22** Habitus dorsal view of some regional moths: **1** *Brahmaea wallichii* (Gray, 1831); **2** *Salassa lola* (Westwood, 1847); **3** *Deilephila elpenor* (Linnaeus, 1758); **4** *Thyas juno* (Dalman, 1823); **5** *Catocala patala* Felder & Rogenhofer, 1874; **6** *Catocala amnonfreidbergi* Kravchenko,


**Plate 31.2 23–30** Larval damage of some regional moths: **23** Codling moth (*Cydia pomonella*) on apple; **24** Cut worm (*Agrotis ipsilon*) on tomato; **25** Pod borer (*Helicoverpa armigera*) on pea pod; **26** Walnut fruit borer (*Garella nilotica*) on walnuts; **27** Brinjal borer (*Leucinodes orbonalis*) on brinjal **28** Blackheaded fireworm (*Rhopobota naevana*) on apple; **29** Oriental fruit moth (*Grapholita molesta*) on cherry; **30** *Yponomeuta rorrellus* on *Salix*

## 31.4 Concluding Remarks

Most of the collections lying in different national museums like Forest Research Institute (FRI), Dehradun; Indian Agricultural Research Institute (IARI), New Delhi; and Zoological Survey of India (ZSI), Kolkata, are still carrying old nomenclature. Moreover, the state of knowledge of the Indian insect fauna and their accessibility is poor. Collections contain less than 50% of the known species found in India. This deficiency has negatively impacted research, popularization, and conservation efforts. As Lepidoptera is one of the keystone species groups, steps to improve their studies in India are strongly recommended. Future studies should be encouraged, along with other important aspects like ecotaxonomy, molecular taxonomy, and morphological systematics. It can be concluded here that the outcome of the present research work will provide a motivational impel to the future workers from the region.

**Acknowledgments** The corresponding author would like to thank Department of Science and Technology (DST), Govt. of India, New Delhi, for financial assistance under N-PDF Fellowship program: File No: PDF/2015/000866.

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# Chapter 32
# Bark Beetle Fauna (Coleoptera: Curculionidae) of Jammu and Kashmir State

**Abdul A. Buhroo, Abdul Lateef Khanday, and Mustahson F. Fazili**

**Abstract** The chapter deals with bark beetle fauna (Coleoptera: Curculionidae: Scolytinae) of Jammu and Kashmir State, primarily based on literature records and examination of recently collected material. Taxonomic diagnosis, distribution and host plant aspects of 12 species of bark beetles belonging to 5 genera and 4 tribes, which occur in different localities of the State, are treated. As the bark beetles are considered among the most damaging pests in forest ecosystems, the present study will form a baseline data in undertaking advanced systematic studies and devising management strategies in this Himalayan region.

**Keywords** Bark beetles · Coleoptera: Curculionidae: Scolytinae · Diversity · Diagnosis · Jammu and Kashmir State

## 32.1 Introduction

Bark beetles (Coleoptera: Curculionidae: Scolytinae) constitute a diverse group of insects (Knížek and Beaver 2007). More than 6000 species of bark beetles have been described throughout the world (Bright and Skidmore 2002). One fourth of these (1430 species) have been recorded from Central and North America (Wood 1982), while 308 species have been listed from the Central and Western Palearctic region (Pfeffer 1995). From India, 270 species of bark beetles grouped under 53 genera have so far been recorded (Maiti and Saha 2009).

The bark beetles are known to damage coniferous and broad-leaved trees in the temperate forests of the Northern Hemisphere. In the Himalayas, these beetles attack mainly living trees or infest freshly fallen logs in the pure or mixed conifer forests (Schmutzenhofer 1988; Tshering and Chhetri 2000). In the Jammu and

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_32

Kashmir (J&K) State, some studies on the biology and population dynamics of *Scolytus nitidus* and *S. kashmirensis* infesting apple and elm trees, respectively, have been carried out (Buhroo et al. 2004; Buhroo and Lakatos 2007; Buhroo and Ramamurthy 2008; Khanday and Buhroo 2015). The trees infested by the bark beetles may be recognized at a distance by fading foliage of the tree, initially a light green and then changing to a light straw colour in a few weeks and eventually to yellowish-brown. Close examination may show a fine reddish-brown boring dust in bark cervices and at the base of the tree. In addition to their ecological roles, some bark beetles compete with humans for valued plants and plant products, and so are significant forest and agricultural pests. These species cause substantial socioeconomic losses and at times necessitate management strategies (Raffa et al. 2015).

The present chapter is intended to provide a baseline data for future studies of the bark beetle fauna, particularly in relation to growing importance of scolytines as economically important pests. It provides a summary of taxonomic diagnosis, distribution and host plants for each species currently known from the State.

## 32.2 Materials and Methods

Bark beetle specimens were collected from Jammu and Kashmir during the years 2010–2016 and usually collected under bark of trees and woody plants, from branches, by light traps and also by rearing infested woody parts of plants for the possible emergence of the beetles. Specimens were dehydrated through a series of rinses in 80%, 90%, 95% and absolute ethanol before critical point drying. Samples were then mounted on stubs and the extraneous debris removed from the exoskeleton under 60X magnification with fine forceps. The samples were then sputter coated at 15–20 nm before image capture commenced. S-3000H Scanning Electron Microscope (HITACHI, Japan) was used to take photographs.

We have followed the nomenclature as provided in Wood and Bright (1992) as well as recent taxonomic changes (Maiti and Saha 2009; Lobl and Smetana 2011). The species diagnosis, distribution and host plant data are based on Buhroo and Lakatos (2007), Maiti and Saha (2009) and Khanday and Buhroo (2015).

## 32.3 Results and Discussion

### *32.3.1 Scolytine Fauna of Jammu and Kashmir*

The scrutiny of the scientific literature (Schedl 1957; Bhat and Buhroo 2009; Maiti and Saha 2009) and examination of the collected material revealed the occurrence of 12 species of bark beetles belonging to 5 genera and 4 tribes from the State.

Tribe **Polygraphini**

Genus ***Polygraphus*** Erichson, 1836

Synonomy: *Lepisomus* Kirby, 1837: 193; *Nipponopolygraphus* Nobuchi, 1981: 12; *Ozophagus* Eggers, 1920: 234; *Pseudopolygraphus* Seitner, 1911: 105; *Spongotarsus* Hagedorn, 1908: 372.

**1. *Polygraphus major* Stebbing, 1903**

**Diagnosis** (Plate 32.1a)

Body oblong or sub-cylindrical. Head and prothorax black and shining. Elytra chestnut-brown or black, covered with greyish pubescence having taxonomic importance. Prothorax possesses a fine median shining longitudinal carina, variable in thickness and a narrow transverse channel in the anterior fourth. Elytra

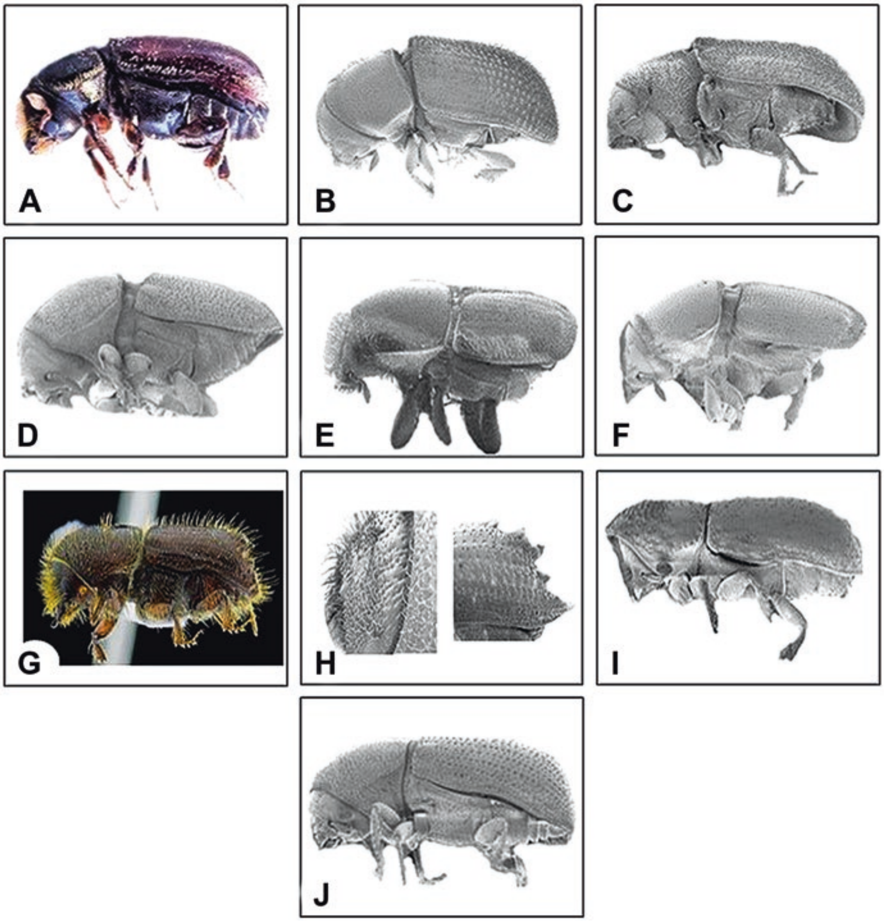


**Plate 32.1** (**a**) *Polygraphus major*, (**b**) *Polygraphus pini,* (**c**) *Polygraphus longifolia,* (**d**) *Scolytus major,* (**e**) *Scolytus nitidus,* (**f**) *Scolytus kashmirensis,* (**g**) *Ips stebbingi,* (**h**) *Ips longifolia,* (**i**) *Pityogenes scitus,* (**j**) *Dryocoetes indicus*

twice as long as prothorax and two thirds as wide as long, scarcely dilated towards apex. Abdomen black usually shining and punctate; the punctures densest on the apical segment; posterior fragments of abdomen fringed with yellow hairs. Length of adult 2.64–3.96 mm

**Distribution in India**: Jammu & Kashmir, Himachal Pradesh, Uttarakhand.

**Elsewhere in world:** Bhutan, Nepal, Xizang (Tibet) in China.

**Host plants**: *Pinus wallichiana, P. gerardiana*, *Picea smithiana*, *Cedrus deodara*

**2. *Polygraphus pini* Stebbing, 1914**

Synonymy: *P*. *minor* Stebbing, 1903: 239.

**Diagnosis** (Plate 32.1b)

Body oblong or sub-cylindrical, black in colour and usually shining. Elytra with a greyish pubescence. Antenna yellow-brown, club bright yellow. Prothorax depressed anteriorly; the transverse channel in the anterior fourth broader, deeper and markedly prominent both medianly and laterally; the disk more strongly convex in posterior three-fourths than in *P. major*; punctures on the prothorax finer and more regularly distributed on surface. Elytra shining and black in colour, twice as long as prothorax, slightly dilated at apex. Abdominal segments black, shining and punctate, with a sparse pubescence scattered uniformly over them. Body length of adult 1.98–2.97 mm.

**Distribution in India:** Jammu & Kashmir, Himachal Pradesh, Punjab and Uttarakhand.

**Host plants:** *Abies pindrow*, *Cedrus deodara, Picea smithiana*, *Pinus wallichiana*

**3. *Polygraphus longifolia* Stebbing, 1903**

Synonymy: *P. himalayensis* Stebbing, 1908: 8.

**Diagnosis** (Plate 32.1c)

Body oblong, head black, antennae and legs yellow; the legs except the tarsi with a slightly chestnut tinge. Head with a circular brush of sparse and short hairs on front; vertex almost smooth with a very fine shining short median longitudinal line posteriorly meeting prothorax (sometimes absent); it has very few scattered punctures with small tubercles, placed transversely. Prothorax about a fourth as broad as long with a transverse channel in the anterior fourth, very much less prominent than in the *P. pini* and scarcely reaching down on sides. Elytra not quite twice as long as prothorax, slightly dilated towards apex; elytral striae rugose, the rugosities disappearing in the apical fourth; they are prominent basally, where the elytra are clothed with a fine whitish–yellow pubescence interspersed with a few long stiff yellow hairs, the rest having a fine sparse pubescence. Abdominal segments with sparse pubescence, not confined to the posterior margin. Length of body 2.58–2.60 mm.

**Distribution in India:** Jammu & Kashmir, Himachal Pradesh and Uttarakhand.

**Host plants:** *Pinus roxburghii*

Tribe **Scolytini**

Genus ***Scolytus*** Geoffroy, 1762

Synonomy: *Archaeoscolytus* Butovitsch, 1929: 21; *Confusoscolytus* Tsai & Hwang, 1962: 3; *Coptogaster* Illiger, 1804: 108; *Eccoptogaster* Gyllenhal, 1813: 346; *Ekkoptogaster* Herbst, 1794: 124; *Pinetoscolytus* Butovitsch, 1929: 22; *Pygmaeoscolytus* Butovitsch, 1929: 21; *Ruguloscolytus* Butovitsch, 1929: 20; *Scolytochelus* Reitter, 1913: 23; *Spinuloscolytus* Butovitsch, 1929: 21; *Tubuloscolytus* Butovitsch, 1929: 21.

**4. *Scolytus major* Stebbing, 1903**

Synonymy: *S. deodara* Stebbing, 1903: 220; *S. minor* Stebbing, 1903: 207.

**Diagnosis** (Plate 32.1d)

Body black and shining, elytra dark red brown or black. Frons plano-convex roughened with minute tubercules, scattered hairs and with a distinct tubercule at the centre; epistomal margin feebly concave with a tuft of hairs at the middle directing forward. Eyes very much elongated with a wide shallow emargination anteriorly. Prothorax constricted and impressed on anterior lateral margin, being very smooth and shining except for a rather thickly punctate and slightly rugose area behind anterior margin; this punctured area stretching down diagonally on either side and intercepted medianly by a narrow longitudinal smooth space; a prolongation from the smooth area on disk, the whole of the area finely pitted, the punctures rather scattered and more abundant laterally; a few longish scattered hairs laterally in anterior portion. Elytra impressed medianly at base and slightly narrowed behind, the outer margins of apical fourth finely serrate, apices separately rounded, striate and punctate. Abdomen with anterior margin of first segment prominent and produced forwards and thickened, second segment of abdomen concave, third and fourth with a small lateral tubercle on posterior margin, fifth segment flat; apical edge incurved medially. Legs brown to blackish. Antennae and tarsi rufous brown. Length of adult 3.30–3.96 mm.

**Distribution in India:** Jammu & Kashmir, Himachal Pradesh, Punjab, Uttarakhand.

**Host plants:** *Cedrus deodara*

**5. *Scolytus nitidus* Schedl, 1936**

**Diagnosis** (Plate 32.1e)

Body cylindrical in shape, with shining black pronotum and dark red-brown elytra. The pronotum thinly punctured and the elytra dotted in rows. The interstices finely punctured. The thorax nearly as long as abdomen. The abdomen has declivity towards apex. On the central underside of the second abdominal sternite, a minute tubercle. The antennae, legs and abdomen rust brown, the head and thorax black. The male has a dense brush of yellowish setae on its head with flat frons. The female has slightly convex and thinly haired frons. The length of the beetle 3.96–4.10 mm.

**Distribution in India:** Jammu & Kashmir, Himachal Pradesh

**Hosts plants:** *Juglans regia*, *Prunus armeniaca, Malus domestica, Cotoneaster microphylla, Betula utilis*

**6. *Scolytus kashmirensis* Schedl, 1957**

**Diagnosis** (Plate 32.1f)

Body cylindrical, with shining black pronotum and dark red-brown elytra. Pronotum thinly punctured and the elytra dotted in rows. Interstices finely punctured. Thorax nearly as long as abdomen. The anterior margins of the elytra form a straight, transverse line and unarmed by crenulations or teeth. Scutellum very large, triangular and depressed. The sternites of the abdomen ascend steeply to meet the elytra. Posterior margin of the second abdominal sternite modified. In females it carries two sharp denticles set one fifth of sternite width apart from sternite lateral margin and in males two strong conical denticles set at the posterior sternite margin at one fourth of sternite width apart from its lateral margin. Central portion of second sternite thickened in females and in males this portion of sternite forms a triangular elevation projecting backwards and overhanging the third sternite. Besides, males have a button-like tubercle in the middle of the anterior third of second sternite; in females this tubercle is larger and laterally compressed. Length of the beetle 3.30–3.96 mm.

**Distribution in India:** Jammu & Kashmir

**Host plants:** *Ulmus wallichiana*, *U. villosa*

Tribe **Ipini**

Genus ***Ips*** De Geer, 1775

Synonomy: *Bonips* Cognato, 2001: 779; *Cumatotomicus* Ferrari, 1867; *Cyrtotomicus* Ferrari, 1867:4; *Emarips* Cognato, 2001: 77; *Granips* Cognato, 2001: 780.

**7. *Ips stebbingi* Strohmeyer, 1908**

Synonymy: *I. blandfordi* Stebbing, 1909; *I. ribbentropi* Stebbing, 1909.

**Diagnosis** (Plate 32.1g)

Adult beetle oblong, shining and black. Antennae and legs piceous brown. Head smooth, shining on vertex, which has few scattered fine punctures on it; front flat and roughly punctuate, two tubercles placed transversely on the face. Prothorax rounded in front, slightly wider behind than in front; it is one-fifth less wide than long, strongly granulate and punctate in anterior two thirds, posterior third smooth and shining with a very few scattered and fine punctures, or the punctures very fine but very numerous; it is rather densely set with long, stiff, yellow hairs anteriorly and laterally. Elytra slightly longer than thorax, striate and punctate, the punctures rather shallow, the interspaces broad and shining, the striae near the suture most prominent and finer towards the declivity. Elytra truncate posteriorly, the declivous portion concave and dull, sometimes slightly shining and finely punctate towards bottom; the sides furnished with four teeth, of which upper one (1) is very small and set with distance from 2; 2 is close to 3 and is larger than 1; 3 is largest with a swollen head to it. 4 is prominent and sharp and smaller than 3; and set farther from 3 than 3 is from 2 on one side and a less distant from lower margin. Elytra laterally and edges of declivity fringed with long, yellow spiny hairs. Undersurface black, slightly shining and punctate with a scattered longish pubescence. Length of adult 4.62–5.94 mm.

**Distribution in India:** Jammu & Kashmir, Himachal Pradesh (Kulu valley), Punjab, Uttarakhand.

**Elsewhere in world:** Bhutan, China (Tibet), Nepal, Pakistan.

**Host plants:** *Pinus wallichiana*, *Abies pindrow*, *Picea smithiana*

**8. *Ips longifolia* (Stebbing), 1909**

**Diagnosis** (Plate 32.1h)

*Ips longifolia* is smaller than *I. stebbingi*. Body very dark or ferruginous brown, with longish rufous brown hairs scattered irregularly over thorax and elytra. Head smooth, moderately shining and finely punctate; it has three or more tubercles on each side of the face. Anterior half of prothorax strongly rugose and punctate, basal half smooth; shining medially and punctate laterally; sides clothed with stiff yellow hairs. Elytra smooth, shining, striate and punctate, punctures large and evenly arranged in parallel rows; lateral margin of declivity armed with four teeth—1 is small, sharp and prominent and set at a distance from 2; 2 and 3 are placed close together on bulging prominence of the margin of nearly equal size, 3 has its apex enlarged into spade-like club with a constriction at its base; 4 is smaller than 2 and 3, and set midway between 3 and the lower margin. Elytra clothed with stout spiny yellow hairs. Undersurface smooth, shining, punctate, fairly thickly clothed with long yellow hairs, on the metathorax medially. Length of the adult 3.96–5.28 mm.

**Distribution in India:** Jammu & Kashmir (Ramban), Himachal Pradesh, Punjab, Uttarakhand.

**Host plants:** *Pinus roxburghii*

Genus ***Pityogenes*** Bedel, 1888

Synonomy: *Eggersia* Lebedev, 1926: 12; *Pityoceragenes* Balachowsky, 1947:44.

**9. *Pityogenes scitus* Blandford, 1893**

Synonymy: *P. coniferae* Stebbing, 1909.

**Diagnosis** (Plate 32.1i)

Body sub-elongate, shining, sub-glabrous, piceous and black. Antennae and legs ferruginous. The forehead in female has three strong foveae with central space raised, smooth and dull. Prothorax narrowed anteriorly; the punctures on the posterior half close, well marked and rugose. Elytra testaceous and yellow; sometimes with a distinct dark lateral border; the apical depression three toothed. In the male forehead convex and punctated. Elytra testaceous; the apical depression more vertical and teeth situated farther back and closer to each other, and the anterior pair point directly backward instead of obliquely upwards with their bases longer. Length of adult 1.32–1.65 mm.

**Distribution in India:** Jammu & Kashmir, Himachal Pradesh, Punjab, Uttarakhand, Assam.

**Elsewhere in world:** China (Yunnan), Nepal, Pakistan.

**Host plants:** *Pinus wallichiana*, *P. gerardiana*, *P. roxburghii*

**10.** ***Pityogenes spessivtsevi*** **Lebedev, 1926**

**Diagnosis**

Head globose, weakly outbulge laterally. Head dorsum reticulately granulate with microhairs, most dense towards epistome; frons flat, somewhat shiny at the middle with scattered minute granules and small hairs; vertex more densely granulate and with microhairs. Eyes entire, feebly emarginate on anterior margins. Pronotum as long as broad, anterior margin with distinct carina provided with few distinct asperities especially at the middle; lateral sides feebly outcurved gradually narrowing into a rounded anterior margin; summit distinct, placed almost at the middle, anterior declivous portion with six to seven crescent rings, each with a row of asperities, asperities gradually becoming larger towards anterior margin; portion below provided with fine granules and punctures, a glabrous and shining median ridge running from the summit to posterior margin, either sides of which with one bulging spot, posterior margin subround, devoid of any ridge. Scutellum tongue-shaped, glabrus, pying slightly below the elytral level. Elytra 1.6 times as long as broad and one and a half times longer than pronotum, discal surface shining, somewhat glabrus with minute punctures and hairs, hairs more prominent towards lateral and posterior margins; basal margin substraight and devoid of carina; sutural line depressed; striae marked with fine shallow punctures, more prominent in the declivity; interstriae much wider than striae and flat with scattered fine punctures with some hairs specially on lateral sides. Declivity commences on posterior third; each declivital margin with three seteferous prominent tubercles, first tubercle at the level of second interstria, smallest in size, almost straight; second one biggest, hooked inward, placed at the level of third and fourth interstriae; third one medium in size and placed at the postero-lateral margin of elytra; posterior margin thickly chitinised; declivital face somewhat smooth, sutural line prominent and sutural stria demarked with indistinct minute punctures.

**Distribution in India:** Jammu and Kashmir, Uttarakhand.

**Elsewhere in world:** China (Xinjiang) and Russia.

**Host plants:** *Picea schrenkiana*, *P. smithiana*, *Pinus wallichiana*, *P. gerardiana*, *P. roxburghii*

Tribe **Dryocoetini**

Genus ***Dryocoetes*** Eichhoff, 1864

Synonymy: *Anodius* Motschulsky, 186; *Dryocoetinus* Balachowsky, 1949.

**11.** ***Dryocoetes indicus*** **Stebbing, 1914**

**Diagnosis** (Plate 32.1j)

Body oblong, light to dark red or red-brown with a rather long sparse pubescence. Head punctate with a bright yellow brush of pubescence on the front. Prothorax slightly more than one fourth the total length of insect. Disk convex behind, sides uniformly curved from base to apex; surface scaly to rugose, the scales are large and prominent on convex portion of disk, they are less well defined and wider apart on anterior parts and replaced by rugose punctures on depressed area posteriorly; pubescence rather long and scattered. Scutellum large, heart shaped, smooth, shining, dark, and brown to black. Elytra broader apically than prothorax, apex rather sharply declivous and rounded; disk shining and strongly punctate, large and shallow punctures placed in rows, each having small puncture at its bottom; the interspaces are smaller, and set with a row of very fine punctures, declivity shining, the sutural striae most strongly impressed in upper part, the punctures smaller and becoming very fine and scattered apically; pubescence long, spiny and denser on declivity. Undersurface dark brown having punctures. Legs red brown and pubescent. Funiculus and club of antenna yellow. Length of adult 3.30–4.29 mm.

**Distribution in India:** Jammu & Kashmir, Himachal Pradesh, Uttarakhand.
**Elsewhere in world:** Nepal
**Host plants:** *Pinus wallichiana, Abies pindrow, Picea smithiana*

**12.** ***Dryocoetes himalayensis*** **Strohmeyer, 1908**
**Diagnosis**

Body cylindrical and shiny. Head, pronotum and elytra pale brown throughout, slightly darker towards elytral declivity. Head globose, shiny, frons with minute punctures and scattered hairs; frons plano-concave specially transversely; epistomal margin with minute fringe of hairs. Frons rugose punctuate, dense towards epistomal margin. Eye entire and elongate with shallow emargination on antennal base. Pronotum slightly longer than broad; sides subparallel on basal half, then gradually narrowing anteriorly, anterior margin broadly rounded, apical half finely and closely aspirate and extending laterally up to base; rest of the basal half finely densely punctured except basal longitudinal narrow strip of hairs distinct anteriorly and postero-laterally. Elytra 1.6 times as long as broad, 1.5 times as long as pronotum; sides straight, three-fourth posterior portion converging to form almost rounded with weak and sharp carina, bearing some minute granules and some erect hairs; basal margin substraight without forming distinct carina; elytral disc shiny; striae distinct marked with fairly large, shallow punctures running almost to the elytral end; punctures devoid of any distinct hairs; interstriae shiny, with few scattered hairs, almost one and a half times broader than striae; striae 1–4 running up to posterior margin; interstriae 1–3 also prominent up to the tip; interstriae 4 terminated at the commencement of declivity. Declivity commencing on posterior fourth; declivital face stiff and with distinct hairs; striae 1 and 3 depressed within declivity; striae punctures more prominent; declivital margin not so demarcated but somewhat marked by slightly swollen interstriae 1–3. Body length 3.20–2.25 mm.

**Distribution in India:** Jammu & Kashmir and Uttarakhand.
**Host plants:** *Juglans regia*

## 32.4 Concluding Remarks

The bark beetles (Coleoptera: Curculionidae: Scolytinae) use the phloem-cambium in the inner bark of their host trees as food and substrate for rearing their young ones. Their act of boring into live trees makes tree tissues susceptible to fungal infestation which often leads to the death of host trees. The present systematic study will form a baseline data towards documentation of scolytine fauna of this Himalayan region which will help in devising management strategies for controlling these pests. Elsewhere in the world, these beetles being considered as serious forest pests have led to considerable research on their biology, ecology, systematics and management. However, in Jammu and Kashmir little research efforts have been made and therefore more needs to be done particularly in studying this group of bark beetles in diverse forest ecosystems of the State. Thorough surveys and in-depth systematic studies most likely will lead to discovery of new species in this Himalayan region

**Acknowledgement** We would like to acknowledge Science and Engineering Research Board (SERB), Govt. of India, New Delhi for providing financial assistance under their project number EMR/2015/000888.

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# Chapter 33
# Diversity of Fishes in Jammu and Kashmir State

**F. A. Bhat, A. R. Yousuf, and M. H. Balkhi**

**Abstract** The present chapter reports 120 species of fishes from various aquatic habitats in the Jammu and Kashmir State. Among these, 105 species occur in the Jammu region, 23 in the Kashmir Valley, while 15 species inhabit the Ladakh region. The variations in altitude and topography have led to different sequence of succession of the water bodies in different areas of the State, which has ultimately resulted in the colonization of these waters by different types of fishes. Across the State, eight species of fishes were found to be common in all the three regions, while nine species were common between the Jammu and Kashmir regions; Jammu and Ladakh and Kashmir and Ladakh each shared single species. Out of 23 species collected from the Jhelum river system in the Kashmir Valley, 18 species belong to order Cypriniformes (with 14 species from family Cyprinidae, 1 from Cobitidae, and 3 species from Balitoridae), 2 species to order Siluriformes (family Sisoridae), 2 to order Salmoniformes (family Salmonidae), while 1 species belongs to order Cyprinodontiformes (family Poeciliidae). High species diversity in the Jammu region is due to presence of warm water fishes, while low fish diversity and density in Ladakh may be due to high altitude and harsh climatic conditions of low temperature, frozen rivers during winter, and high turbidity during summer.

**Keywords** Diversity · Fishes · Jammu · Kashmir and Ladakh · *Schizothoracines* · Endemic and exotic fishes

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_33

## 33.1 Introduction

The Jammu and Kashmir (J&K) State is bestowed with plenty of aquatic ecosystems which harbor economically important bioresources, including fishery resources. The State has three biotic regions, viz. temperate Kashmir, subtropical Jammu and cold arid Ladakh, differing in altitude, catchment and watershed. In the Kashmir Valley, the Jhelum river with its numerous feeder streams, lakes and wetlands forms an important fishery resource, while in Jammu and Ladakh regions the role is played by the Chenab and the Indus river systems, respectively.

The present fish production in the State is 20,390 tons which includes 302 tons of trout (J&K Fisheries Dept., 2016–2017). Fish is preferred over meat due to its health benefits in view of the presence of omega 3 fatty acids that help in checking the cholesterol level and protecting the heart. In order to meet the demand from growing population of the State, considerable quantities of fish are also imported from the neighboring States. However, if the huge fishery resources are properly managed, the production of fish in J&K can be increased many folds to meet the requirement of the people.

The Jhelum is the main drainage water body of Kashmir and flows from south to north-west up to Wular, from where it takes southwesterly direction. The total length of the river from the Verinag up to Uri is about 239 km; it is divisible into three distinct zones—the torrential zone from its origin up to Khanabal, slow-flowing zone from Khanabal to Baramulla, and fast-flowing zone from Baramulla up to Uri. The flow, as well as human habitation along catchment of the river, has greatly affected the distribution and abundance of fishes in the system (Yousuf 1996; Bhat et al. 2010). Besides, Kashmir is also rich in lakes (Dal, Anchar, Manasbal, Khushalsar, Wular, etc.), wetlands (Hokersar, Shalabug, Mirgund and Hygam, etc.) and high-altitude lakes (Gangabal, Kishansar, Gadsar, Tarsar, Marsar, Sheshnag, Kounsernag, Nilnag, Alipathar, etc.). The variety of streams, lakes and other aquatic ecosystems support a diverse fish fauna. These aquatic resources used to meet the requirement of fishes and other aquatic resources for the local people satisfactorily. However, over the years changes have taken place in the species composition, distribution and availability of fishes in this region. Exotics, especially common carps, present in the natural water bodies have outnumbered the indigenous fish fauna in certain water bodies due to their prolific breeding and feeding behavior. Many indigenous species, known to contribute substantially to the capture fishery in the past, have either completely disappeared from certain water bodies or have been pushed to isolated areas; their number and size have also decreased significantly during the past. There has been a gradual decline in the distribution and abundance of different indigenous species, mainly due to change in ecology of the aquatic systems as a result of human interference in and around the water bodies.

The cold arid desert of Ladakh is characterized by dry land of rugged mountains and open plains having scanty vegetation, with sparse human population. The region is mainly drained by the River Indus and its tributaries like Zanskar, Nubra and Suru, etc. The important high-altitude lakes of the area are Pangong Tso, Tso Moriri, Tso Khar, etc. Due to the high altitude, the fish fauna of Ladakh mostly comprises high-altitude fishes, most of them being snow trouts and loaches. The unique feature of the Indus is that during summer the river is mostly turbid, while during winter its surface layer remains frozen. This type of habitat has limited the fish biodiversity of the region.

The climate of the Jammu region varies with altitude; most of the Chenab Valley areas like Kishtwar, Doda, Baderwah, Batote and areas of Ramban and Banihal have temperate climate, whereas the rest of the areas are mostly sub-tropical. The region is traversed by a number of rivers which include Chenab, Tawi, Ravi, etc. Snow in most of the upper reaches and monsoon rain in the plains is the major source of water in Jammu rivers.

## 33.2 Materials and Methods

The present communication is based on the fish surveys conducted by the authors in various water bodies of the Jammu and Kashmir State during 2004–2016. The fishes from the lotic water bodies were collected with the help of an Electrofisher (Plate 33.1a–b). In case of slow-flowing stream segments and lacustrine habitats, Cast Net was also employed (Plate 33.1c–d). In case of electrofishing, river stretches of 100 m were used, while in case of cast net fishing, effort was calculated as fish caught (g) per man hour. Immediately after collection, the fishes were preserved on spot in 10% formalin and brought to the laboratory for detailed study. Identification of the fishes was done with the help of keys provided by Day (1877), Talwar and Jhingran (1992) and Kullander et al. (1999).

## 33.3 Results and Discussion

### *33.3.1 Kashmir Valley*

#### 33.3.1.1 Taxonomic Diversity

Since the first report on the fishes of Kashmir by Heckel in 1838, a number of people have reported on the Ichthyofauna of the Valley (Day 1876; Silas 1960; Das and Subla 1964; Das 1965; Yousuf 1996; Kullander et al. 1999; Enderlin and Yousuf 1999; Balkhi 2007). The number of fishes reported by these workers varies from 18 to 42. This variation in number of fish species seems to have been due to their synonymy or ambiguity in identification. During the present study, a total of 23 species of fishes were collected from the Jhelum river system in Kashmir Valley (Table 33.1; Plate 33.2). Out of total, 18 species belonged to order Cypriniformes (with 14 species from family Cyprinidae, 1 Cobitidae, and 3 Balitoridae), 2 species to order

**Plate 33.1** Electro-fishing: (**a**) in a tributary of river Jhelum, Kashmir; (**b**) in Indus river, Ladakh. Fishing by cast net: (**c**) in main river Jhelum; (**d**) in slow-flowing zone of Lidder stream. (**e**) Lifting of boulders and sand from a river bed; (**f**) stone crusher located in the Kishanganag river bed at Gurez, Kashmir. (**g**) Power Project Uri-I, Dam on river Jhelum; (**h**) Wangat barrage on Wangat nallah in Sind valley, Kashmir. (**i**) Solid waste on bank of river Jhelum; (**j**) human activities along banks of river Jhelum in Kashmir


**Plate 33.1** (continued)



**Plate 33.1** (continued)


**Plate 33.1** (continued)


**Plate 33.1** (continued)

**Table 33.1** List of fish species reported from the Kashmir Valley in the present study

| | |
|---|---|
| **Order Cypriniformes (Family Cyprinidae)** | |
| 1. | *Schizothorax niger* Heckel |
| 2. | *S. esocinus* Heckel |
| 3. | *S. labiatus* McClelland |
| 4. | *S. curvifrons* Heckel |
| 5. | *S. plagiostomus* Heckel |
| 6. | *Cyprinus carpio* var. *communis* Linnaeus and *C. c.* var. *specularis* Linnaeus |
| 7. | *Carassius carassius* Linnaeus |
| 8. | *Puntius conchonius* Hamilton |
| 9. | *Bangana diplostoma* Heckel |
| 10. | *Crossocheilus diplochilus* Heckel |
| 11. | *Diptychus maculatus* Steindachner |
| 12. | *Tor putitora* Hamilton |
| 13. | *Hypophthalmichthys molitrix* Valenciennes[a] |
| 14. | *Ctenopharyngodon idella* Valenciennes[a] |
| **Family Cobitidae** (Subfamily Botinae) | |
| 15. | *Botia birdi* Chaudhari |
| **Family Balitoridae** (Subfamily Nemacheilinae) | |
| 16. | *Schistura punjabensis* Hora |
| 17. | *Triplophysa marmorata* Heckel |
| 18. | *T. kashmirensis* Hora |
| **Order Siluriformes (Family Sisoridae)** | |
| 19. | *Glyptosternon reticulatum* McClelland |
| 20. | *Glyptothorax kashmirensis* Hora |
| **Order Salmoniformes (Family Salmonidae)** | |
| 21. | *Salmo trutta fario* Linnaeus |
| 22. | *Oncorhynchus mykiss* Walbaum[a] |
| **Order Cyprinodontiformes (Family Poeciliidae)** | |
| 23. | *Gambusia holbrooki* Girard |

[a]Restricted to the Fish Farms only

Siluriformes (family Sisoridae), 2 to order Salmoniformes (family Salmonidae), and 1 to order Cyprinodontiformes (family Poeciliidae).

The reporting of lesser number of fish species in the recent studies is mainly attributable to the synonymization of several species by Kullander et al. (1999). For example, *S. sinuatus* and *S. nasus* have been treated as synonyms of *S. plagiostomous*, while S. *planifrons* has been treated as synonym of *S. niger. S. longipinnis*, *S. hugeli* and *S. micropogon* have been treated as synonyms of *S. curvifrons. Exostoma stoliczkae* has been treated as synonym of *Glyptosternon reticulatum.* Further, *Tylognathus valenciennesii* has been renamed as *Bangana diplostoma*. Heckel (1838) reported two cobitid species, but later workers recorded only one.

Similarly the earlier workers have reported seven balitorid species in the Valley, but during the present survey only three species could be collected. Similarly, of the four sisorids recorded by earlier workers, only two species were recorded during the present survey. Kullander et al. (1999) reported *Glyptothorax pectinopterus* from the Jhelum; however, during the present study, this species could not be collected. *Tor putitora*, which was reported in abundance in the Jhelum downstream of the Wular Lake before the 1950s, disappeared from the river completely after the construction of Mangla Dam in Pakistan (Yousuf 1996). However, during the present survey, a single specimen of this fish was collected from the main Jhelum River at Dachhi (Uri) during 2009. A systematic review of past literature clearly indicates that the use of synonyms has been the main reason for reporting higher number of fish species by the earlier workers (Table 33.2).

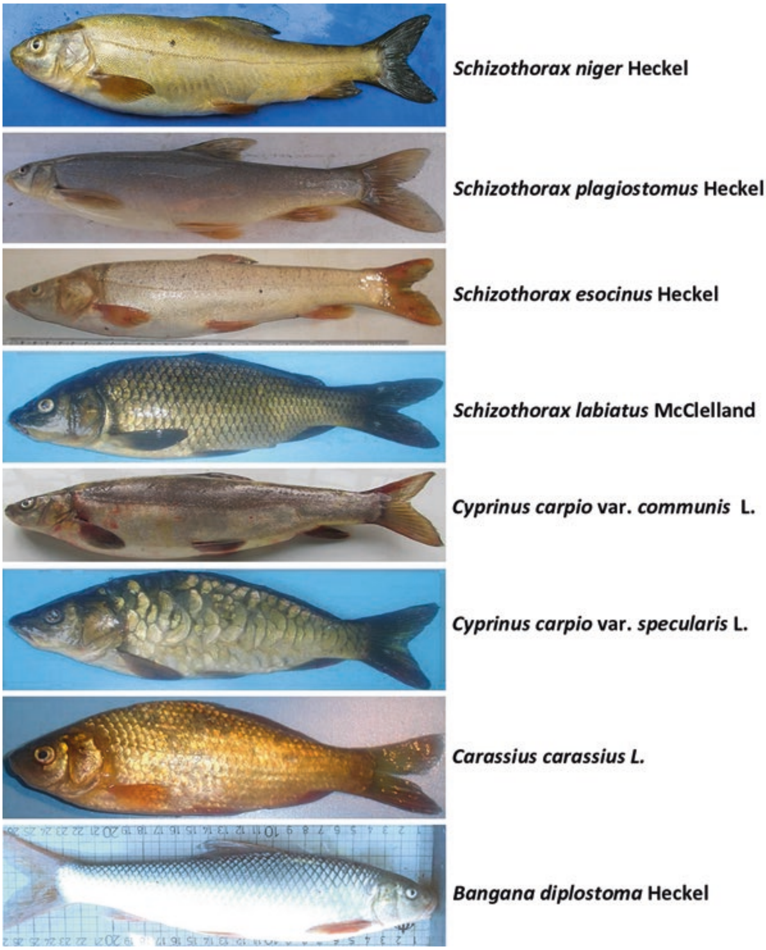


**Plate 33.2** Fishes of Kashmir Valley, J&K State


**Plate 33.2** (continued)

#### 33.3.1.2 Fish Status, Distribution and Catch Composition

The present study revealed that *Schizothorax plagiostomus* was widely distributed in the Jhelum and its tributaries, lotic as well lentic, comprising the whole 40% of the fish catch in the torrential zone, 24% in the slow-flowing zone, and 45% in the fast-flowing zone of the river. The species is an active swimmer (Yousuf 1996; Bhat 2003) and is well established in the torrential streams of the Valley such as the Wangat, Bringi and Lidder rivers. In the slow-flowing areas of the Jhelum (in the Municipal limits of Srinagar city), its contribution to the fish catch was very low (2.94%), while in the lacustrine habitats (Dal Lake), the fish was totally absent. *S. labiatus* and *S. esocinus* were present both in the main river and its tributaries,

**Table 33.2** List of fishes reported from the Kashmir Valley by different workers since 1838

| S. no. | Fish species | Heckel (1838) | Day (1876) | Silas (1960) | Das & Subla (1964) | Das (1965) | Yousuf (1996) | Kullander et al. (1999) | Present study |
|---|---|---|---|---|---|---|---|---|---|
| 1. | *Schizothorax (= Oreinus) plagiostomus* Heckel* | + | + | + | + | + | + | + | + |
| 2. | *Schizothorax (=Oreinus) sinuatus* Heckel | + | + | – | – | + | + | a | a |
| 3. | *S. nasus* Heckel | + | + | + | + | + | + | a | a |
| 4. | *S. niger* Heckel* | + | + | + | + | + | + | + | + |
| 5. | *S. planifrons* Heckel | + | + | + | + | + | + | b | – |
| 6. | *S. curvifrons* Heckel* | + | + | + | + | + | + | + | + |
| 7. | *S. longipinnis* Heckel | + | + | + | + | + | + | c | c |
| 8. | *S. hugelii* Heckel | + | + | + | + | + | + | c | c |
| 9. | *S. micropogon* Heckel | + | + | + | + | + | + | c | c |
| 10. | *S. esocinus* Heckel* | + | + | + | + | + | + | + | + |
| 11. | *S. progastus* McClelland | – | + | + | + | + | + | – | – |
| 12. | *S. punctatus* Day | – | + | – | + | + | + | – | – |
| 13. | *S. labiatus* McClelland* | – | – | | – | – | | + | + |
| 14. | *Ptychobarbus conirostris* Steindachner | – | + | + | + | + | + | – | – |
| 15. | *Diptychus maculatus* Steindachner* | – | + | + | + | + | + | – | + |
| 16. | *Schizopygopsis stoliczkae* Steindachner | – | + | – | + | + | + | – | – |
| 17. | *Labeo dero (L. barbus) diplostomus* Cuvier | + | + | + | + | + | + | – | – |
| 18. | *L. dyocheilus* Cuvier | – | + | + | + | + | + | – | – |
| 19. | *Bangana diplostoma* Heckel* | – | – | – | – | – | – | + | + |
| 20. | *Tylognathus valenciennesii* Heckel | + | – | – | – | – | – | d | d |
| 21. | *Tor putitora* Hamilton* | – | – | + | + | + | – | + | + |
| 22. | *Gara gotyla* Steindachner | – | – | – | + | + | + | – | – |
| 23. | *Crossocheilus diplochilus* Heckel* | + | – | + | + | + | + | + | + |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 24. | *Gambusia holbrooki* Girard∗ | – | – | + | + | + | + | + | + |
| 25. | *Botia birdi* Chaudhari∗ | – | – | + | + | + | + | + | + |
| 26. | *Triplophysa kashmirensis(=Nemacheilus kashmirensis)* Hora∗ | – | – | + | + | + | + | + | + |
| 27. | *T. marmorata (= Nemacheilus marmoratus = Cobitis marmorata)* Heckel∗ | + | + | + | + | + | + | + | + |
| 28. | *Nemacheilus gracilus* Day | – | + | + | + | + | + | – | – |
| 29. | *Nemacheilus (=Cobitis) vittatus* Heckel | + | – | + | + | + | + | e | e |
| 30. | *N. rupicola* McClelland | – | – | + | + | + | + | – | – |
| 31. | *N. yasinensis* Alcock | – | – | + | + | + | + | – | – |
| 32. | *N. stoliczkae* Steindachner | – | + | – | + | + | + | – | – |
| 33. | *N. ladacensis* Gunther | – | + | – | – | – | – | – | – |
| 34. | *Schistura punjabensis* Hora∗ | – | – | – | – | – | – | + | + |
| 35. | *Silurus lamghur* (=*Ompok bimaculatus*) Heckel | + | – | + | – | – | – | – | – |
| 36. | *Glyptosternon (=Glyptosternum) reticulatum* McClelland∗ | – | – | + | + | + | + | + | + |
| 37. | *Exostoma stoliczkae* Steindachner | – | + | – | + | + | + | f | f |
| 38. | *Glyptothorax kashmirensis* Hora∗ | – | – | + | + | + | + | + | + |
| 39. | *Glyptothorax pectinopterus* McClelland | – | – | – | – | – | – | + | – |
| 40. | *Cyprinus carpio* Var. *communis* Linnaeus∗ | – | – | – | + | + | + | + | + |
| 41. | *Cyprinus carpio* Var. *specularis* Linnaeus∗ | – | – | – | + | + | – | + | + |
| 42. | *Carassius carassius* Linnaeus∗ | – | – | – | – | – | + | + | + |
| 43. | *Puntius* (*Barbus*) *conchonius* Hamilton∗ | – | – | – | + | – | + | + | + |
| 44. | *Salmo trutta fario* Linnaeus∗ | – | – | + | + | + | + | + | + |
| 45. | *Oncorhynchus mykiss* (=*Salmo gairdneri*) Walbaum∗ | – | – | – | + | + | + | – | + |

(continued)

**Table 33.2** (continued)

| S. no. | Fish species | Heckel (1838) | Day (1876) | Silas (1960) | Das & Subla (1964) | Das (1965) | Yousuf (1996) | Kullander et al. (1999) | Present study |
|---|---|---|---|---|---|---|---|---|---|
| 46. | *Hypophthalmichthys moltrix* Valenciennes* | – | – | – | – | – | – | – | + |
| 47. | *Ctenopharyngodon idella* Valenciennes* | – | – | – | – | – | – | – | + |
| | **Total species** | **16** | **22** | **28** | **36** | **35** | **37** | **21** | **23** |

*= Fishes recorded during the present study.

a. *S. sinuatus* and *S. nasus* have been treated as synonyms of *S. plagiostomus*

b. *S. planifrons* has been treated as junior synonym of *S. niger*

c. *S. longipinnis*, *S. hugeli* and *S. micropogon* have been treated as junior synonyms of *S. curvifrons*

d. *T. valenciennesii* has been renamed as *B. diplostoma*

e. *N. vittatus* (= *Cobitis vittatus*) has been synonymized with *T. marmorata (=Nemacheilus marmoratus = Cobitis marmorata)*

f. *Exostoma stoliczkae* has been treated as synonym of *G. reticulatum* being present in good numbers in lower reaches of most of the tributaries. These fishes are known to migrate to the middle and upper reaches of the tributaries of the Jhelum River for breeding and feeding during warmer months. *S. niger* is a lacustrine fish (Yousuf 1996; Yousuf et al. 2006) and was recorded in the flat land lakes of the Valley, like Dal, Anchar, Manasbal and Wular lakes. The species was also found in the Jhelum in the stretches lying close to the areas where lake water joined it. *S. curvifrons*, regarded by some authors (Silas 1960) as the riverine variant of *S. niger*, was also recorded from the Dal Lake as well as from the Jhelum river. *Cyprinus carpio communis* and *C. c. specularis*, which were introduced in the State in the mid-twentieth century, were recorded only from the Dal, Manasbal, Anchar, Wular and other flatland lakes as well as from the slow-flowing zone of the Jhleum (in Srinagar Municipal and Sopore area) and its tributaries like Pohru (at Doabgah site) and Sind (at Ganderbal site), where they contributed significantly to the commercial fish catch. *Carassius carassius* was recorded from Dal and Anchar Lake and Zero Bridge (Srinagar) area in River Jhelum. This fish prefers standing waters and can with stand and thrive well in hard waters with high temperatures.

From the Dal Lake, a total of 10 species of fishes were collected, including *C. carpio* (var. *C. c. communis* and *C. c. specularis*), *Schizothorax niger*, *S. esocinus*, *S. curvifrons*, *S. labiatus*, *Carassius carassius*, *Crosocheilus diplocheilus*, *Puntius conchonius*, *Gambusia holbrooki*, and *Botia birdi*. Among Schizothoracids *S. plagiostomus* was absent from the Dal. The highest contribution to the total catch by number in the lake was due to *C c. specularis* (32%) followed by *P. conchonius* (22%) and *C c. communis* (19%), while the contribution by weight was dominated by *C. c. specularis* (48%) and *C. c. communis* (16%) and *S. niger* (14%). *Botia birdi* has almost completely been extirpated from the water body like *S. plagiostomus* and *Nemacheilus* (including *Triplophysa*) species. *C. diplochilus* was recorded from Zones I and II in the Jhelum river system. It was also recorded from Dal and other flatland lakes of the Valley. The contribution of common carps in the Dal Lake was about 65% and that of schizothoracines was 17%. Shafi et al. (2005) have also reported a similar trend (68% by common carps and 15% by Schizothoracines) in the lake.

*Bangana diplostoma* was recorded in the Jhelum throughout its course in Kashmir, with higher numbers in the slow-flowing areas. *Triplophysa* species were restricted mainly to the tributaries of Jhelum; these were also encountered at the Khanabal site in the main Jhelum and seemed to prefer clear waters. These fish are small and cylindrical in shape and hide themselves under the rocks and boulders in the torrential and fast-flowing areas. *Salmo trutta fario* was recorded from most of the clear and soft waters of tributaries such as Sandran, Lidder, Wangat, and Buniyar. The fish is carnivorous and mostly feeds on the benthic organisms. *Schistura punjabensis* was recorded from the Nambla stream and Dachhi area of Jhelum in Uri. *Glyptosternon reticulatum* was found in most of the clear, torrential, and fast-flowing streams of the Valley. This species co-occurred with *S. t. fario* although both of them are carnivorous (Bhat 2003; Yousuf et al. 2006). The trout is an active swimmer and prefers the current, whereas *G. reticulatum* is adapted to a benthic life in the rapids, with a dorso-ventrally flattened body.

The Shannon Diversity Index in respect of fish community was high in Dal Lake as well as in the Srinagar stretch of the Jhelum, which seems to be attributed to the conducive environment available in both these habitats for both the exotics (*C. c. communis*, *C. c. specularis*, *C. carassius*) and indigenous (*Schizothorax* spp.) carps. The low diversity index in case of most of the crystal clear streams can be attributed to the specialized biotope that is conducive only for a few species like S. *t. fario*, *G. reticulatum*, *Triplophysa* spp. and *S. plagiostomus*. The dominance of exotic species of fishes in the slow-flowing zone of the Jhelum river system is a clear indication of the changing ecological conditions in the system.

#### 33.3.1.3 Fishing Effort

In case of the Jhelum, Sunder and Subla (1984) reported a fishing effort of 261 g – 829 g/man-hour, while Yousuf et al. (2006) reported it to be 173 g – 360 g/man-hour. During the present study the fishing effort varied from 210 g during November to 793 g/man-hour during May at Anantnag (Batengoo) and Sopore respectively. In case of Dal Lake, CIFRI (1977) reported the fish catch per man-hour in the range of 156–978 g at Saida Kadal and 117–797 g in Hazratbal basins, while Sunder et al. (1978) reported the mean catch per man-hour as 369 g. The fishing effort varies with season and is dependent upon several factors including time of the day as well as behavior of the fish, whether migratory or resident. Shafi et al. (2005) reported the overall mean effort as 382 g/man-hour in this lake. They reported the fishing effort from 122 gm per man-hour (Hazratbal basin) in December to 1015 gm man-hour (Nishat basin) in October. During the present study, the mean fishing effort from the Dal Lake was recorded as 398 g/man-hour. As the fishing effort is an index of the abundance of the fish population/stocks, it is, therefore, clear that over the years, the fish populations, rather their density, have decreased from the aquatic habitats of Kashmir Valley.

### *33.3.2 Ladakh Region*

#### 33.3.2.1 Taxonomic Diversity

No extensive work has been done on the fisheries of Ladakh in the past except for a few reports (Hora 1936; Mukerji 1936; Hutchinson 1939). Recently Sivakumar (2008) reported on the fish distribution in Ladakh waters and listed 32 species (Table 33.3). During the present study fish were collected from the Indus and its main tributaries in the region, namely the Shyok, Zanaskar, Bazgo and Puga streams, and also from the tributaries of Lake Tso Moriri (Kurzuk Pho and Gyoma streams) and Lake Pangong Tso (Chushul stream). A total of 15 species of fishes (Table 33.3; Plate 33.3), belonging to Cypriniformes (families Cyprinidae and Balitoridae), Siluriformes (family Sisoridae) and Salmoniformes (family Salmonidae) were recorded.

**Table 33.3** List of fish species reported from the Ladakh region in the present study

| | |
|---|---|
| **Order Cypriniformes (Family Cyprinidae)** | |
| 1. | *Schizothorax plagiostomus* Heckel |
| 2. | *S. labiatus* McClelland |
| 3. | *S. progastus* McClelland |
| 4. | *S. esocinus* Heckel |
| 5. | *S. curvifrons* Heckel |
| 6. | *Ptychobarbus conorostris* Steindachner |
| 7. | *Diptychus maculatus* Steindachner |
| 8. | *Schizopygopsis stoliczkae* Steindachner |
| 9. | *Cyprinus carpio* [var. *C. c. communis* & *C. c. specularis*[a]] Linnaeus |
| **Family Balitoridae (Subfamily Nemacheilinae)** | |
| 10. | *Triplophysa stoliczkae* Steindachner |
| 11. | *T. kashmirensis* Hora |
| 12. | *T. gracilis* Day |
| **Order Siluriformes (Family Sisoridae)** | |
| 13. | *Glyptosternon reticulatum* McClelland |
| **Order Salmoniformes (Family Salmonidae)** | |
| 14. | *Salmo trutta fario* Linnaeus |
| 15. | *Oncorhynchus mykiss* Walbaum[a] |

[a]Restricted to State owned farms only

Snow trout formed more than 60% of fishes collected in these water bodies. No commercial fishing is done in Ladakh waters. Majority of the people living in the Leh and Kargil districts do not eat fish, as they think it to be sacred. However, there is considerable demand for fish, from the local population as well as security forces, and as a result, a number of fish farms have come up in the region.

A comparison in the number of fish species reported from Ladakh in the past literature with that in the present study is presented in Table 33.4. From this, it appears that the list provided by Sivakumar (2008) is much exaggerated, mainly because of the inclusion of several synonyms as well as exotic species being reared in the confined waters of fish farms, also including three unidentified species based only on minor variations. Further, *Amblyceps mangois* Hamilton, listed by him, is a cat fish of the Himalayan foothills (Talwar and Jhingran 1992), and its occurrence in the Ladakh waters seems rather doubtful. It may be concluded that the number of fish species inhabiting the Ladakh waters could be in the range of 20–25.

#### 33.3.2.2 Fish Distribution and Catch Composition

During the present study, the maximum number of species on a study site at a particular time was seven, which was recorded in the Bazgo stream. It was the only water body, wherefrom the team was able to collect *S. t. fario* along with *S. plagiostomus*, *S. progastus*, *S. esocinus*, *S. labiatus*, *T. stoliczkae*, and *Glyptosternon reticu-*


**Plate 33.3** Fishes of Ladakh region, J&K State

*latum*. The least number of two species (*Triplophysa stoliczkae*, *T. gracilis*) of fishes was collected from the inlet streams of Tso Moriri. In Chushul stream, an important tributary of Lake Pangong Tso in the Indian Territory, three species—*Schizopygopsis stoliczkae*, *T. stoliczkae*, and *T. gracilis*—were collected.The specimens of *S. stoliczkae* were >50 cm in length and weighed about 1200 gm. In the main Indus River, the maximum number of five species at one time was recorded at Alchi. The maximum number of specimens was recorded in Chushul stream, followed by Bazgoo stream. The maximum biomass of fishes, about 6000 g, was also recorded from the Chushul stream, followed by Bazgo stream (ca. 3500 g). In the main Indus, the maximum biomass of fishes (ca. 2500 g) was recorded from Alchi. The least catch by weight was recorded from the Tso Moriri Lake (ca. 100 g).

In the Ladakh region, altitude was one of the important factors responsible for the distribution and occurrence of fishes. Although all the fishes recorded from Ladakh are the high-altitude fishes, their distribution varied from each other. While *S. plagiostomus*, *S. progastus*, and *Ptychobarbus conorostris* were recorded throughout the course of the Indus river system, *S. stoliczkae* occurred

**Table 33.4** Fish species previously reported from the Ladakh region by different workers

| S. no. | Fish species | Fishes collected by Hutchinson [Reported by Hora (1936) & Mukerji (1936)] | Sivakumar (2008) | Present study |
|---|---|---|---|---|
| **Order: Cypriniformes; Family: Cyprinidae** | | | | |
| 1. | *Catla catla* Hamilton | – | +@ | – |
| 2. | *Cyprinus carpio.* Linnaeus | – | – | + |
| 3. | *C. communis* (Linnaeus) | – | ± | – |
| 4. | *C. specularis* (Lacepede) | – | ± | – |
| 5. | *Diptychus maculatus* Steindachner | – | + | + |
| 6. | *Diptychus* sp. with two yellow bands® | – | + | – |
| 7. | *Diptychus* sp. with one yellow band® | – | + | – |
| 8. | *Labeo calbasu* Hamilton | – | +@ | – |
| 9. | *Oreinus sinuatus* Gray | +** | + | – |
| 10. | *Ptychobarbus conorostris* Steindachner | +** | + | + |
| 11. | *Schizopygopsis* sp. (banded) ® | – | + | – |
| 12. | *S. stoliczkae* Steindachner | +** | + | + |
| 13. | *S. esocinus* Heckel | +** | – | + |
| 14. | *S. labiatus* × *Oreinus sinuatus* | +** | – | – |
| 15. | *S. labiatus* McClelland | +** | + | + |
| 16. | *S. curvifrons* Heckel | – | – | + |
| 17. | *S. plagiostomus* Heckel | – | – | + |
| 18. | *S. progastus* McClelland | – | – | + |
| 19. | *S. richardsonii* Gray | – | + | – |
| 20. | *Gymnocypris biswasi* Talwar | – | + | – |
| **Family: Balitoridae** | | | | |
| 21. | *Triplophysa stoliczkae* Steindachner | – | – | + |
| 22. | *T, kashmirensis* Hora | – | – | + |
| 23. | *T. gracilis* Day | – | + | + |
| 24. | *T. choprai* Hora | – | + | – |
| 25. | *T. griffithi* Günther | – | + | – |
| 26. | *T. ladacensis* Günther | – | + | – |
| 27. | *T. microps* Steindachner | – | + | – |
| 28. | *T. tenuicauda* Steindachner | – | + | – |
| 29. | *Nemacheilus arafi* Mirza & Banarescu | – | + | – |
| 30. | *N. botia* Hamilton | – | + | – |

(continued)

**Table 33.4** (continued)

| S. no. | Fish species | Fishes collected by Hutchinson [Reported by Hora (1936) & Mukerji (1936)] | Sivakumar (2008) | Present study |
|---|---|---|---|---|
| 31. | *N. deTerrai* Hora[a] | +* | – | – |
| 32. | *N. fascimaculatus* Mirza & Nalbant | – | + | – |
| 33. | *N. gracilis* Day | +* | + | – |
| 34. | *N. hutchinsoni* Hora | +* | + | – |
| 35. | *N. montanus* McClelland | – | + | – |
| 36. | *N. rupecola* McClelland | – | + | – |
| 37. | *N. punguri* Hora[a] | +* | – | – |
| 38. | *N. microps* Steindachner | +* | + | – |
| 39. | *N. stolliczkae* Steindachner | +* | + | – |
| 40. | *N. tenuicauda* Steindachner | +* | + | – |
| **Order: Salmoniformes; Family: Salmonidae** | | | | |
| 41. | *Salmo trutta fario* Linnaeus | – | – | + |
| 42. | *Oncorhynchus mykiss* Walbaum | – | +@ | + |
| **Order: Siluriformes; Family: Sisoridae** | | | | |
| 43. | *Glyptosternon reticulatum* McClelland | +** | – | + |
| 44. | *Amblyceps mangois* Hamilton | – | +<br>–+ | – |
| | Total | 15 | 32 | 15 |

*= Identified & reported by Hora (1936), **=Identified & reported by Mukerji (1936)
@= Reported only from Fish Farms, #= Reported as two species by Sivakumar, ®=Unidentified fishes reported by Sivakumar, [a]= junior synonym of *Triplophysa stewarti* Hora

only in the Changthang area. *D. maculatus*, *S. t. fario*, *S. esocinus*, *S. curvifrons*, *S. labiatus*, *T. kashmirensis*, and *G. reticulatum* were recorded in the lower stretch of the Indus river in the region (above and below Leh town). The presence of fishes like *S. stoliczkae*, *T. stoliczkae*, and *T. gracilis* in the tributaries endorheic Tso Moriri, Tso Khar, and Pangong Tso is an indication that these fishes were the most high-altitude fishes of the region, occurring in water bodies with altitude as high as 4500 m. Further the presence of these fishes in the tributaries of the land-locked lakes is an indication that these water bodies must have been connected in the past.

## 33.3.3 Jammu Region

### 33.3.3.1 Taxonomic Diversity

In spite of the varied ecological and geographical features of Jammu province, its ichthyofauna was not adequately investigated until Das and Nath (1965, 1966) reported 20 species of fishes from the Chenab drainage system. Subsequently, many workers have reported fish diversity from different areas of the region (Das and Nath 1971; Malhotra et al. 1975; Malhotra and Dutta 1976; Dutta and Malhotra 1984; Jyoti et al. 2006; Balkhi 2007). In a State-wide fishery survey under outreach activity program (ICAR) during 2002, the Faculty of Fisheries, SKUAST-K, also worked on the fish diversity of the Jammu region. The consolidated list of fish species as reported under this outreach program is presented in Table 33.5 and Plate 33.4.

**Table 33.5** List of fish species reported from the Jammu region in the present study

| **Order:Cypriniformes (Family: Cyprinidae)** | |
|---|---|
| 1. | *Aspidoparia morar* Hamilton[a] |
| 2. | *Amblyopharyngodon gadigarhi* Singh, Dutta & Malhotra |
| 3. | *A. mola* Hamilton |
| 4. | *Barilius bendelisis* Hamilton[a] |
| 5. | *B. vagra* Hamilton[a] |
| 6. | *B. barila* Hamilton[a] |
| 7. | *Bangana diplostoma* Heckel[a] |
| 8. | *Catla catla* Hamilton[a, b] |
| 9. | *Cirrhinus mirgala* Hamilton |
| 10. | *Cirrhinus reba* Hamilton[a] |
| 11. | *Chela cachius* Hamilton[a] |
| 12. | *Chela atpar* Hamilton |
| 13. | *Chela laubuca* Hamilton |
| 14. | *Crossochilus latius diplochilus* Hamilton[a] |
| 15. | *Ctenopharyngodon idella* Valenciennes[b] |
| 16. | *Cyprinus carpio* Linnaeus (*v*ar. *C. c. communis* & C. c. *specularis*)[a, b] |
| 17. | *Danio devario* Hamilton[a] |
| 18. | *Danio rerio* Hamilton |
| 19. | *Esomus danrius* Hamilton[a] |
| 20. | *Garra gotyla* Gray[a] |
| 21. | *G. lamta* Hamilton[a] |
| 22. | *G. variabilis* Heckel |
| 23. | *Hypophthalmichthys molitrix* Valenciennes[b] |
| 24. | *Labeo rohita* Hamilton[a] |
| 25. | *L. dyocheilus* McClelland |
| 26. | *Labeo dero* Cuv & Val[a] |
| 27. | *L. bata* Day |
| 28. | *L. calbasu* Hamilton |
| 29. | *L. gonius* Hamilton[a] |

(continued)

**Table 33.5** (continued)

| | |
|---|---|
| 30. | *L. pangusia* Hamilton |
| 31. | *Osteobrama cotio* Hamilton[a] |
| 32. | *Oxygaster bacaila* Hamilton |
| 33. | *Puntius conchonius* Hamilton[a] |
| 34. | *P. ticto* Hamilton[a] |
| 35. | *P. sarana* Hamilton[a] |
| 36. | *P. morar* Hamilton[a] |
| 37. | *P. sophore* Hamilton |
| 38. | *P. chola* Hamilton |
| 39. | *P. chrysopterus* McClleland |
| 40. | *Rasbora rasbora* Hamilton |
| 41. | *Salmostoma baciala* Hamilton |
| 42. | *S. punjabensis* Day |
| 43. | *Schizothorax plagiostomus* Heckel[a] |
| 44. | *S. esocinus* Heckel[a] |
| 45. | *S. curvifrons* Heckel |
| 46. | *S. labiatus* McClelland[a] |
| 47. | *S. progastus* McClelland |
| 48. | *S.* (=*Oreinus*) *richardsonii* Gray and Hard[a] |
| 49. | *Tor putitora* Hamilton[a] |
| 50. | *T. tor* Hamilton |
| 51. | *T. Khudree* Skyes |
| **Family: Balitoridae** | |
| 52. | *Acanthocohitis botia* Hamilton |
| 53. | *Triplophysa kashmirensis* Hora[a] |
| 54. | *T. yasiensis* Alock |
| 55. | *Triplophysa* spp.[a] |
| 56. | *Nemacheilus* spp.[a] |
| 57. | *Nemacheilus botia* Hamilton |
| 58. | *N. parshadi* Hora |
| **Family: Cobitidae** | |
| 59. | *Botia dayi* Hamilton[a] |
| 60. | *Lepidocephalus guntia* Hamilton[a] |
| **Order: Siluriformes (Family: Sisoridae)** | |
| 61. | *Amblyceps mangois* Hamilton |
| 62. | *Bagarius bagarius* Hamilton |
| 63. | *Gagata cenia* Hamilton |
| 64. | *Glyptothorax pectinopterus* McClelland[a] |
| 65. | *G. kashmirensis* Hora |
| 66. | *G. stoliczkae* Steindachner |
| 67. | *G. botium* Hamilton & Bloch |
| 68. | *G. punjabensis* Mirza & Kashmiri |
| 69. | *G. cavia* Hamilton & Bloch |
| 70. | *G. Garhwali* Tilak |
| 71. | *G. telechitta* Hamilton |
| 72. | *G. reticulatum* McClelland |
| 73. | *Gagatia cenia* Hamilton[a] |

(continued)

**Table 33.5** (continued)

| | |
|---|---|
| **Family: Bagridae** | |
| 74. | *Aorichthys seenghali* Sykes |
| 75. | *Lepidocephalus guntia* Hamilton[a] |
| 76. | *Mystus bleekeri* Day[a] |
| 77. | *M. cavasius* Hamilton[a] |
| 78. | *M. seenghala* Sykes |
| 79. | *M. vittatus* Bloch |
| 80. | *Rita rita* Hamilton & Bloch |
| **Family: Siluridae** | |
| 81. | *Ompok bimaculatus* Bloch[a] |
| 82. | *Wallgoo attu* Schneider |
| **Family: Heteropneustidae** | |
| 83. | *Heteropneustes fossilis* Bloch |
| **Family: Schilbeidae** | |
| 84. | *Clupisoma garua* Hamilton |
| 85. | *Eutropiichthys vacha* Hamilton |
| 86. | *Pseudeutopius atherinoides* Bloch |
| **Order: Perciformes (Family: Channidae)** | |
| 87. | *Channa punctatus* Bloch[a] |
| 88. | *C.marulius* Hamilton |
| 89. | *C. gachua* Hamilton |
| 90. | *C. orientalis* Bloch |
| 91. | *C. striatus* Bloch |
| **Family: Mastacembelidae** | |
| 92. | *Mastacembelus armatus* Lacepede |
| 93. | *M. pancalus* Hamilton |
| 94. | *Macrognathus aral* Bloch & Schneider[a] |
| 95. | *M. jammunensis* Malhotra & Dutta |
| **Family: Ambassidae** | |
| 96. | *Paraambassis* spp.[a] |
| **Family: Belontiidae** | |
| 97. | *Colisa fasciatus* Schneider |
| 98. | *Trichogaster fasciatus* Bloch |
| **Family: Nandidae** | |
| 99. | *Nandus nandus* Hamilton |
| 100. | *Badis badis* Hamilton |
| **Family: Nandidae** | |
| 101. | *Glossogobius giuris* Hamilton |
| **Order: Cyprinodontiformes (Family: Belonidae)** | |
| 102. | *Xenontodon cancila* Hamilton[a] |
| **Order: Synbranchiformes (Family: Synbranchidae)** | |
| 103. | *Monopterus cuchia* Hamilton[a] |
| **Order: Salmoniformes (Family: Salmonidae)** | |
| 104. | *Salmo trutta fario* Linnaeus[b] |
| 105. | *Oncorhynchus mykiss* Walbaum[b] |

[a]Collected during the present study
[b]Exotic fishes

The presence of fishes belonging to the families Belonidae, Synbranchidae, Belontiidae, Ambassidae, Nandidae, Channidae and Heteropneustidae in different areas of Jammu shows the varied climate as well as the varied quality of water bodies of this region as compared to Kashmir and Ladakh. In Jammu, most of the warm water fishes showed their presence, and the presence of warm water and cold water ecosystems depends mainly on the altitude of the place of occurrence.

### 33.3.4 Threats to Fish Diversity

The fish inhabiting the Jhelum River are under great stress due to increasing load of pollution in the river and its tributaries. The schizothoracine fish are adapted to crystal clear waters, and the increase in load of pollution leads to their expulsion

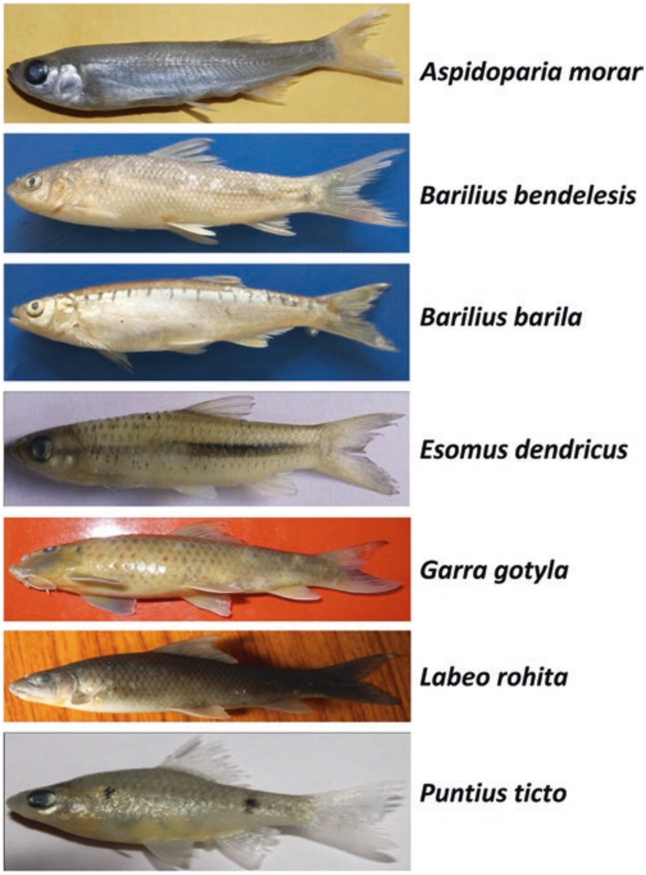


**Plate 33.4** Fishes of Jammu region, J&K State

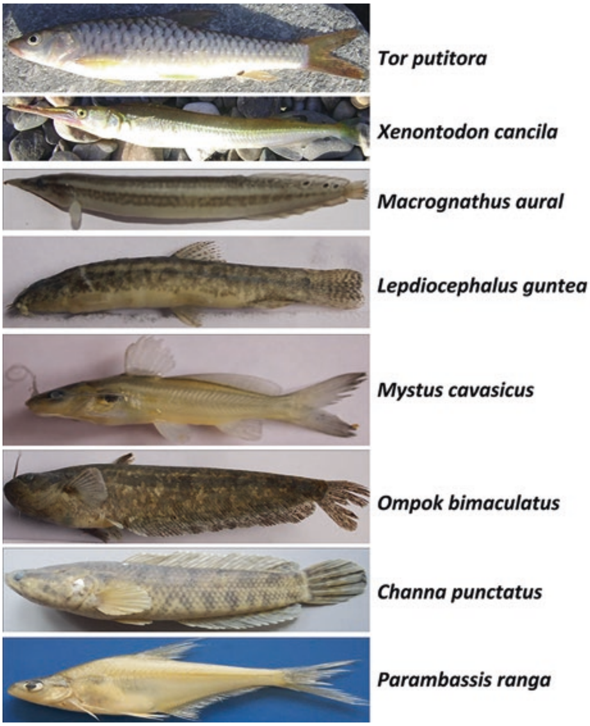


**Plate 33.4** (continued)

from the system. For example, *S. plagiostomus*, which was common in Dal Lake about four decades back, is now totally absent there. Its close relative, *S. esocinus* is still present in the lake but in only small numbers and if the ecological conditions of the lake continued to deteriorate at the same pace, it may also get extirpated from this water body. This phenomenon is not restricted to this water body alone. In other lakes like Anchar and Wular, and for that matter even in the Jhelum, the population of the indigenous fishes, especially the schizothoracines has drastically decreased over the years (Yousuf et al. 2003, 2006).

The introduction of exotic fish species, such as *Cyprinus communis communis*, *Cyprinus communis specularis*, and *Salmo trutta fario*, has greatly affected the local fish population. These exotic species compete for space as well as food with the native species. The introduced common carps being hardy fishes have the ability to withstand the pollution and changing ecological conditions in the waters of the region and thus are able to thrive well in such changing environs. On the other hand, snow trout, being very sensitive, cannot withstand such changing environment, with the result their population has drastically declined. Similarly *S. t. fario*, being carnivorous, has been found to devour on the juveniles of schizothoracines and adults of *Triplophysa* species (Yousuf 1996; Bhat 2003). *Botia birdi*, which was once commonly found in the fisher's catch from the lakes as well as in the Jhelum River, is now rare. *Glyptothorax kashmirensis*, which was also once abundant in the Jhelum River and formed substantial portion of the fish catch (Das and Subla 1964), has shown appreciable decline in its population. Lately *Ctenopharyngodon idella*, an exotic carp, has due to its unplanned release by J & K Directorate of Fisheries into lacustrine habitats of the Valley, started to appear in the fish catches from Dal, Manasbal and Wular lakes, albeit only in small numbers. It is to be seen whether the fish is able to establish natural populations in any of these waters. And if that happens, the fish community structure in Kashmir waters, especially lentic systems, will be greatly influenced.

The dominance of exotic species of fishes in the slow-flowing zone of the Jhelum in Kashmir as well as in the flat land lakes like Dal, Anchar and Wular, etc., is a clear indication of the changing ecological conditions in the system. The unabated extraction of sand and boulders from the river Jhelum and its most tributaries is also a major cause of the decline of fish population (Plate 33.1e–f). This is also true of the Chenab River system in the Jammu region. Many of the fishes of the region spawn in the areas having bottom with sand and boulders, where they rub their belly with bottom and spawn. Deterioration of such bottom environs has drastically affected the recruitment of fishes and has ultimately led to decline in their population.

The construction of dams like Mangla Dam in Mir Pur (Pakistan Administered Kashmir), Uri dams in Uri, Lower Jhelum barrage, Wangat Barrage and Baglihar, etc. has greatly affected the fish migration both upstream and downstream, which has resulted in a change in their distributional pattern (Plate 33.1g–h). The diversion of the waters for the irrigation and for drinking in majority of the tributaries in the water bodies of J&K to meet the needs of local human populations is also an important factor of concern. This diversion/damming in some rivers/streams has drastically led to the lowered water depth, with the result that fish in such habitats have been badly affected as they do not find the required water depth/eco-flow for their movement and life.

Pollution in the water bodies of Jammu and Kashmir is also a matter of serious concern (Plate 33.1i–j). Untreated effluents, including solid waste, from households, hotels, industries, etc., are directly thrown into the waters, which has led to the environmental deterioration of our water resources. The use of biocides (pesticides, insecticides, herbicides, fungicides, etc.) and other chemicals in the horticulture and agriculture activities has contaminated our water resources. Consequently the aquatic biota, particularly fishes, is getting affected. The fish populations impacted by deteriorated water quality fall easy prey to several diseases, including those due to parasitic infestation and their growth and reproduction capability is affected (Zargar et al. 2011, 2013; Shah et al. 2013a, b; Shahi et al. 2013).

## 33.4 Concluding Remarks

On the basis of the present survey coupled with earlier reports it may be safely concluded that the aquatic habitats of Jammu and Kashmir are inhabited by about 120 species of fishes. Among these 105 species are present in the Jammu region, 23 in Kashmir Valley and 15 species in the Ladakh region. Eight species of fishes are common between all the three ecological zones of the State, nine species common between the Jammu and Kashmir zones, while Jammu and Ladakh and Kashmir and Ladakh share one species each (Fig. 33.1).

In the Kashmir Valley, five valid species of *Schizothorax*, viz. *S. plagiostomus*, *S. niger*, *S. esocinus*, *S. labiatus*, and *S. curvifrons* and one species of *Diptychus* (*D. maculates*) could be easily located, while the other previously reported schizothoracine species, like *P. conirostris*, *S. stoliczki*, and *S. progastus*, are untraceable. This is also true of some species of *Nemacheilus*. However, these species are reported from the Ladakh region. Since many of the early workers didn't provide details about the collection locations of reported species (see, e.g., Silas 1960; Das and Subla 1964; Das 1965), it is most probable that the lists provided are based on clubbing of fishes of Kashmir and Ladakh together.

The high species diversity in the Jammu region is mainly due to the presence of warm water fishes. In the Ladakh region, low species diversity seems to be due to high altitude, coupled with harsh environmental conditions. The low temperature, frozen rivers during winter, and high turbidity during summer seem to be the major factors responsible for low fish species diversity and density in the region. The Indus river system along with its tributaries and brackish and salt water land-locked lakes need to be assessed for the fisheries development.

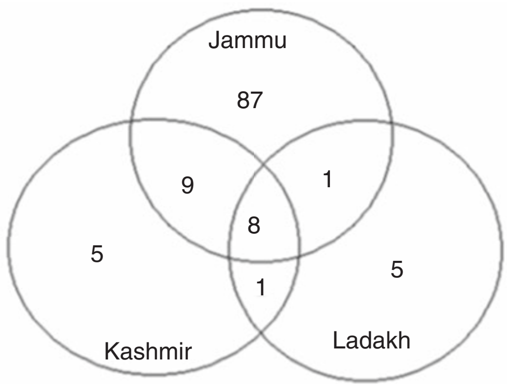


**Fig. 33.1** Fish species occurrence and distribution in three regions Ladakh, Kashmir and Jammu of J&K State

Jammu & Kashmir is the leading State in trout production in India and has a great potential for cold water fisheries. Aquatic resources are available in plenty for the development of the aquaculture of the native as well as exotic species throughout the State. If proper management, conservation and regulations of the aquatic/fishery resources of the State are taken, it is expected that the fish production from the natural resources can be increased many fold. Propagation/culture of indigenous and fast growing fishes will also help in conservation and production of fishes in the State.

**Acknowledgments** The authors are grateful to the funding agencies, viz. Swedish International Development Agency (SIDA), National Hydropower Corporation, New Delhi, G B Pant Institute of Himalayan Ecology & Development, Almora, ICAR, New Delhi, WAPCOS, New Delhi and Lakes & Waterways Development Authority, J & K Govt., Srinagar for facilitating the field collections in different aquatic ecosystems. The help extended by Director Research, SKUAST (K) and Director, CORD, University of Kashmir is duly acknowledged. Field collections were possible only with the active cooperation of the Directorate of Fisheries, J & K Govt., especially its field staff. Thanks are also due to Dr. Arshid Jehangir, Dr. Aftab Ahmad and Dr. Dilgeer Mahdi for their help in field collections.

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# Chapter 34
# Annotated List of Amphibians and Reptiles of Jammu and Kashmir State

**D. N. Sahi and Sakshi Koul**

**Abstract** In this chapter 17 species of amphibians and 63 species of reptiles are documented from the territories of the Jammu and Kashmir State. The amphibian species belong to ten genera under four families in the order Anura. Among the families, Ranidae is the largest (with eight species in six genera), followed by Bufonidae (with six species in a single genus), Microhylidae (with two species in two genera), and Pelobatidae (with a single species). Most of the amphibian species are reported from the Zanskar range in the Greater Himalayan zone. The reptilian species are grouped into 44 genera under 14 families and 3 orders (Chelonia, Lacertilia, and Ophidia). Chelonia contain 7 species belonging to 5 genera in 2 families, Lacertilia contain 24 species belonging to 15 genera in 6 families, whereas Ophidia contain 32 species belonging to 24 genera in 6 six families. Colubridae (Ophidia) is the largest family with 20 species in 13 genera, followed by Agamidae (Lacertilia) with 7 species in 4 genera and Gekkonidae (Lacertilia) with 7 species in 3 genera. The family Scincidae (Lacertilia) has five species in four genera, whereas Eublepharidae (Lacertilia) and Pythonidae (Ophidia) are represented by a single species each. Most of the reptiles are reported to occur along the Shivalik Himalayan zone.

**Keywords** Faunal diversity · Annotated list · Amphibia · Reptilia · Jammu and Kashmir State

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_34

## 34.1 Introduction

Biodiversity inventories or checklists serve as repositories of baseline information on species occurrences, biogeography and their conservation status (Chandra & Gajbe 2005). Such information is also fundamental to assess changes in species composition and distribution in the face of perturbations that may be anthropogenic or natural (Abraham et al. 2011).

The Jammu and Kashmir (J&K) State is fortunate enough that the nature has blessed it with the high mountains, lush green forests, rivers, salubrious cold climate, rich fauna and flora. Although fauna of this State has received the attention of many zoologists since very early times, complete inventory of species richness in various groups of animals occurring in the region is still unavailable. This is also true for its rich and varied herpetofauna. Despite notable works of Boulenger (1890), Das et al. (1964), Duda and Sahi (1977, 1978), Dubois (1978), Sahi (1979), Sahi and Duda (1978, 1983, 1985, 1986), Duda et al. (1993), Sahi and Duda (1996), Sahi and Verma (1996), Sahi et al. (1996), Verma and Sahi (1998), and Verma et al. (1999), the diversity of the amphibians and reptiles of J&K State is inadequately documented. This prompted the authors to consolidate in this chapter all the information so far available on species diversity of amphibians and reptiles of the State.

## 34.2 Materials and Methods

The list presented herein is based on the published literature pertaining to diversity of amphibian and reptilian taxa occurring in the J&K State. This has been enriched with the data and vast experience gained through extensive field surveys and collections made across the study area during last three decades.

## 34.3 Results

### *34.3.1 Taxonomic Diversity in Amphibia*

The J&K serves as a homeland for 17 species of amphibians distributed under 10 genera, 4 families, and falling under single order Anura. Ranidae is the largest family with 6 genera and 8 species, while Bufonidae has single genus with 6 species, Microhylidae has 2 genera with 2 species, and Pelobatidae is represented by a single species (Table 34.1). Most of the amphibian species are distributed in habitats along the Greater or the Inner Himalayan zone which is represented by the Zanskar range.

**Table 34.1** Taxonomic diversity of amphibians of Jammu and Kashmir State

| Order | Family | Name of species | Habitat |
|---|---|---|---|
| **Anura** | **1. Bufonidae** | *Duttaphrynus* (=*Bufo*) *beddomii* | Greater Himalaya |
| | | *Duttaphrynus* (=*Bufo*) *himalayanus* | Shivalik & Lesser Himalaya |
| | | *Duttaphrynus* (=*Bufo*) *latastii* | Greater Himalaya |
| | | *Duttaphrynus* (=*Bufo*) *melanostictus* | Shivalik & Lesser Himalaya |
| | | *Duttaphrynus* (=*Bufo*) *stomaticus* | Shivalik |
| | | *Duttaphrynus* (=*Bufo*) *viridis* | Lesser & Greater Himalaya |
| | **2. Ranidae** | *Euphlyctis cyanophylyctis* | Shivalik & Lesser Himalaya |
| | | *Hoplobatrachus tigerinus* | Shivalik & Lesser Himalaya |
| | | *Fejervarya* (=*Limnocetes*) *limnocharis* | Shivalik |
| | | *Nanorana* (=*Paa*) *liebigii* | Greater Himalaya |
| | | *Nanorana* (=*Paa*) *minica* (Dubois) | Greater Himalaya |
| | | *Chrysopaa* (=*Paa*) *sternosignata* (Murraya) | Lesser Himalaya |
| | | *Nanorana* (=*Paa*) *vicina* (Stoliczka) | Greater Himalaya |
| | | *Sphaerotheca* (=*Tomopterna*) *breviceps* (Schneider) | Shivalik |
| | **3. Pelobatidae** | *Scutiger nyingchiensis* (=*occidentalis*) | Greater Himalaya |
| | **4. Microhylidae** | *Microhyla ornata* | Shivalik & Lesser Himalaya |
| | | *Uperodon systoma* | Shivalik |

### *34.3.2 Taxonomic Diversity in Reptilia*

Reptiles are represented by 63 species, belonging to 44 genera, 14 families, and 3 orders – Chelonia, Lacertilia, and Ophidia. The Chelonia contain 7 species belonging to 5 genera in 2 families, Lacertilia contain 24 species belonging to 15 genera in 6 families, whereas Ophidia contain 32 species belonging to 24 genera in 6 families. Colubridae (order Ophidia) is the largest family with 20 species in 13 genera, followed by Agamidae (order Lacertilia) with 7 species in 4 genera and Gekkonidae (order Lacertilia) with 7 species in 3 genera (Table 34.2). Scincidae (order Lacertilia) have five species in four genera, whereas the families Eublepharidae (order Lacertilia) and Pythonidae (order Ophidia) are represented here by a single species each. Most of the reptilian species are distributed in habitats along the Shivalik Himalayan zone.

**Table 34.2** Taxonomic diversity of reptiles of Jammu and Kashmir State

| Order | Family | Name of species | Habitat |
|---|---|---|---|
| **1. Chelonia** | **1. Emydidae** | *Geoclemys hamiltonii* | Shivalik |
| | | *Pangshura* (=*Kachuga*) *smithii* | Shivalik |
| | | *Pangshura* (=*Kachuga*) *tectum* | Shivalik |
| | **2. Trionychidae** | *Chitra indica* | Shivalik |
| | | *Lissemys punctata* | Shivalik |
| | | *Nilssonia* (=*Trionyx*) *gangetica* | Shivalik |
| | | *Nilssonia* (=*Trionyx*) *hurum* | Shivalik |
| **2. Lacertilia** | **1. Gekkonidae** | *Cyrtodactylus himalayanus* | Lesser Himalaya |
| | | *Cyrtodactylus lawderanus* | Greater Himalaya |
| | | *Cyrtodactylus Stoliczkai* | Greater Himalaya |
| | | *Cyrtopodion montiumsalsorum* | Greater Himalaya |
| | | *Cyrtopodion scabrum* | Shivalik |
| | | *Hemidactylus brooki* | Shivalik |
| | | *Hemidactylus flaviviridis* | Shivalik |
| | **2. Eublepharidae** | *Eublepharis macularius* | Shivalik |
| | **3. Agamidae** | *Laudakia* (=*Agama*) *agrorensis* | Shivalik |
| | | *Laudakia* (=*Agama*) *himalayana* | Greater Himalaya |
| | | *Laudakia* (=*Agama*) *tuberculata* | Greater Himalaya Lesser Himalaya |
| | | *Calotes versicolor* | Shivalik and Lesser Himalaya |
| | | *Sitana ponticeriana* | Shivalik |
| | | *Phrynocephalus theobaldi* | Greater Himalaya |
| | | *Phrynocephalus reticulatus* | Greater Himalaya |
| | **4. Varanidae** | *Varanus benghalensis* | Shivalik |
| | | *Varanus flavescens* | Shivalik |
| | **5. Scincidae** | *Eurylepis* (=*Eumeces*) *taeniolatus* | Shivalik and Lesser Himalaya |
| | | *Eutropis* (=*Mabuya*) *dissimilis* | Shivalik |
| | | *Asymblepharus* (=*Scincella*) *himalayanus* | Lesser and Greater Himalaya |
| | | *Asymblepharus* (=*Scincella*) *ladacensis* | Lesser and Greater Himalaya |
| | | *Ablepharus* (=*Scincella*) *pannonicus* | Shivalik |
| | **6. Lacertidae** | *Acanthodactylus cantoris* | Shivalik |
| | | *Ophisops jerdoni* | Shivalik |
| **3. Ophidia** | **1. Typhlopidae** | *Ramphotyphlops braminus* | Shivalik |
| | | *Typhlops porrectus* | Shivalik |
| | **2. Boidae** | *Gongylophis* (=*Eryx*) *conicus* | Shivalik and Lesser Himalaya |
| | | *Eryx johnii* | Shivalik |
| | **3. Pythonidae** | *Python molurus molurus* | Shivalik |

(continued)

**Table 34.2** (continued)

| Order | Family | Name of species | Habitat |
|---|---|---|---|
| | **4. Colubridae** | *Amphiesma stolatum* | Shivalik and Lesser Himalaya |
| | | *Amphiesma platyceps* | Shivalik and Lesser Himalaya |
| | | *Boiga trigonata* | Shivalik and Lesser Himalaya |
| | | *Boiga multifasciata* | Shivalik and Lesser Himalaya |
| | | *Platyceps* (=*Coluber*) *ventromaculatus* | Shivalik and Lesser Himalaya |
| | | *Platyceps* (=*Coluber*) *rhodorachis* | Lesser Himalaya |
| | | *Dendrelophis tristis* | Shivalik |
| | | *Coelognathus* (=*Elaphe*) *helena* | Shivalik |
| | | *Orthriophis* (=*Elaphe*) *hodgsonii* | Lesser and Greater Himalaya |
| | | *Lycodon aulicus* | Shivalik |
| | | *Lycodon striatus* | Lesser and Greater Himalaya |
| | | *Oligodon arnensis* | Shivalik |
| | | *Psammophis leithii* | Shivalik |
| | | *Psammophis schokari* | Lesser Himalaya |
| | | *Ptyas mucosa* | Shivalik, Lesser and Greater Himalaya |
| | | *Sibynophis sagittarius* | Shivalik |
| | | *Spalerosophis arenarius* | Shivalik and Lesser Himalaya |
| | | *Spalerosophis diadema* | Shivalik and Lesser Himalaya |
| | | *Spalerosophis atriceps* | Shivalik and Lesser Himalaya |
| | | *Xenochrophis piscator* | Shivalik and Lesser Himalaya |
| | **5. Elapidae** | *Bungarus caeruleus* | Shivalik and Lesser Himalaya |
| | | *Naja naja naja* | Shivalik |
| | | *Naja naja oxiana* | Shivalik |
| | **6. Viperidae** | *Gloydius* (=*Agkistrodon*) *himalayanus* | Lesser Himalaya |
| | | *Echis carinatus* | Shivalik |
| | | *Daboia* (=*Vipera*) *russelii* | Shivalik and Lesser Himalaya |
| | | *Macrovipera* (=*Vipera*) *lebetina* | Lesser Himalaya |

## 34.4 Concluding Remarks

Since a large portion of the Jammu and Kashmir State has as yet not been intensively surveyed for its overall faunal diversity, further explorations and field work, together with detailed taxonomic research, are bound to add to and improve the documentation of amphibian and reptilian biodiversity presented in this chapter (Plates 34.1 and 34.2).


**Plate 34.1** Amphibian and Reptilian Diversity of Jammu and Kashmir State


**Plate 34.2** Reptilian Diversity of Jammu and Kashmir State

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# Chapter 35
# Avifaunal Diversity in Jammu and Kashmir State

**Intesar Suhail, Riyaz Ahmad, and Khursheed Ahmad**

**Abstract** This chapter puts together a complete checklist of the birds found within the geographical limits of the Jammu and Kashmir State. Geographically, the State represents heterogeneous landscape with a varied altitudinal range, characterized by enormous diversity in habitats and climatic regimes. The three distinct biotic provinces comprising the State, including the subtropical plains of Jammu, the temperate valley of Kashmir and the Trans-Himalayan cold desert of Ladakh, together represent a species-rich region which is home to 555 species of birds. Overall 20 orders of avian taxa represented by 76 families have been reported from the State; these includes 32 species classified as 'threatened' under various categories in the Red List of the International Union for Conservation of Nature (IUCN). This chapter also tabularizes the distribution (presence or absence) of all the bird species in the Jammu, Kashmir and Ladakh regions and presents their status (Resident/Passage Migrant/Summer Visitor/Winter Visitor) in these regions.

**Keywords** Avifauna · Checklist · Threatened birds · Status · Distribution · Conservation · Jammu and Kashmir State

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_35

## 35.1 Introduction

Jammu and Kashmir (J&K) State is situated at the intersection of two bio-geographic regions of the world, namely the Palearctic and the Oriental regions. Besides harboring some species that are shared with the tropical and subtropical parts of the Indian subcontinent, it is home to some faunal elements, particularly among birds and mammals that are unique to higher altitudes (Rahmani et al. 2012). The State lies in the Western Himalaya Endemic Bird Area (EBA 128) and also represents three Biomes: Biome 5 (Eurasian High Montane-Alpine & Tibetan) ca. 3600 m asl; Biome 7 (Sino-Himalayan Temperate Forest) mainly ca. 1800–3600 m asl; and Biome 8 (Sino-Himalayan Subtropical Forest) between ca. 1000 and 2000 m asl.

The State constitutes a part of the Central Asian and the East Africa-West Asia Flyways of the migratory waterfowl and acts as a transit for a number of migratory populations (passage migrants), on way to or back from their wintering destinations elsewhere in the subcontinent. Birds contribute most to chordate diversity of the State (Hilaluddin 1997) and show the highest amount of endemism in the group. Rahmani et al. (2012) have designated 21 Important Bird Area or IBA (now Important Biodiversity Area) sites and also identified 7 potential IBA sites in the State.

Even as the published literature on birds of the State dates back to the late nineteenth century and includes classic works like *The Valley of Kashmir* (Lawrence 1895) and *Breeding Birds of Kashmir* (Bates and Lowther 1952) or more recently the *Birds & Mammals of Ladakh* (Pfister 2004); a proper documentation of avian diversity of the entire State in the shape of a complete checklist has not been accomplished as yet. This chapter is the first ever attempt to do so. The checklist presented here is aimed at providing updated information about the bird diversity of the J&K State, along with distribution and conservation status of the included taxa, and is expected to act as a reference guide for the ornithologists, birdwatchers and avian researchers.

## 35.2 Materials and Methods

The checklist presented here is based on compilation of data from the scientific literature, published and unpublished; electronic and print, currently available in the form of books, papers, articles, field notes, websites and web pages. Published material mainly referred to includes that of Lawrence (1895), Ali (1949, 1996), Bates and Lowther (1952), Ali and Ripley (1968, 1987), Qadri et al. (1990), Price and Jamdar (1990, 1991), Price (1991), Javed (1992), Ahmadullah (1997), Grimmett et al. (1998), Ahmad (1999), Suhail (2000), Price et al. (2003), Pfister (2004), Naoroji and Schmitt (2007), Rahmani and Islam (2008), Rahmani et al. (2012), Grewal (2016), and Ahmad et al. (2017). Web sources consulted include the following: https://www.iucnredlist.org, http://www.facebook.com/groups/kashmirbirdwatch, and http://www.facebook.com/groups/j&kbirdlife.

Unpublished records mainly include the notes collected by the authors during their own field observations and bird watching trips spanning over a period of more than two decades. All the species that are known to have been reliably recorded from the State up to year 2017 have been included in the checklist.

Depending upon their presence within the limits of the State, the individual species have been grouped into the following four categories: **Resident (R):** Recorded throughout the year, mostly breeding; **Passage Migrant (P):** Recorded for a brief period of the year only; **Summer Visitor (S):** Recorded during summer, mostly breeding; and **Winter Visitor (W):** Recorded during winter.

Species for which the records are either only sparse/isolated or are very old with no recent confirmations have also been enlisted and are suffixed by an asterisk (*****). The individual species have been assigned conservation status as per the Red List of the International Union for Conservation of Nature (IUCN), which includes the following categories: **CR=** Critically Endangered; **EN=** Endangered; **VU=** Vulnerable; **NT=** Near Threatened; **LC=** Least Concern.

Species endemic to the State (Western Himalaya) are denoted as EWH. Region-wise distribution of the individual species, i.e., their presence or absence within the administrative boundaries of Jammu (J), Kashmir (K), and Ladakh (L) regions of the State, has also been recorded.

## 35.3 Results and Discussion

### *35.3.1 Taxonomic Diversity*

A total of 555 species of birds belonging to 20 orders occur in the Jammu and Kashmir State (Table 35.1). This constitutes 40.36% of the total bird species count (1375) for the Indian subcontinent. Out of 105 families occurring in the subcontinent, 76 (72.38%) are represented in this State. Passerines (Order Passeriformes) are the dominant group represented by 40 families with 287 species (57.40% of the total count for the State). All but 9 out of 49 families (81.63%) of Passerines occurring in the subcontinent are represented here.

Among all the families present in the State, Muscicapidae has the highest number of species (42), followed by Accipitridae (39) and Anatidae (26). Of the major families (having at least 20 species), Motacillidae (wagtails and pipits) is the best represented [78.94% of the subcontinent count], followed by Paridae (tits) [66.66%], Accipitridae (hawks, kites, and eagles) [65%], Anatidae (ducks, geese, and swans) [59.09%], and Aludidae (larks) [59.09].

**Table 35.1** Checklist of the birds of Jammu and Kashmir State

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| Family Phasianidae (partridges and pheasants) | | | | | |
| 001 | Chukar Partridge | *Alectoris chukar* | R | J,K,L | LC |
| 002 | Hill Partridge | *Arborophila torqueola* | R | J | LC |
| 003 | Tibetan Partridge | *Perdix hodgsoniae* | R | L | LC |
| 004 | Grey Francolin | *Francolinus pondicerianus* | R | J | LC |
| 005 | Black Francolin | *Francolinus francolinus* | R | J | LC |
| 006 | Snow Partridge | *Lerwa lerwa* | R | L | LC |
| 007 | Common Quail | *Coturnix coturnix* | S | K,L | LC |
| 008 | Jungle Bush-quail | *Perdicula asiatica* | R | J | LC |
| 009 | Red Junglefowl | *Gallus gallus* | R | J | LC |
| 010 | Western Tragopan | *Tragopan melanocephalus* | R | J,K (EWH) | VU |
| 011 | Himalayan Monal | *Lophophorus impejanus* | R | J,K | LC |
| 012 | Cheer Pheasant | *Catreus wallichii* | R | J,K (EWH) | VU |
| 013 | Kalij Pheasant | *Lophura leucomelanos* | R | J,K | LC |
| 014 | Koklass Pheasant | *Pucrasia macrolopha* | R | J,K | LC |
| 015 | Himalayan Snowcock | *Tetraogallus himalayensis* | R | K | LC |
| 016 | Tibetan Snowcock | *Tetraogallus tibetanus* | R | L | LC |
| 017 | Indian Peafowl | *Pavo cristatus* | R | J | LC |
| Anatidae (ducks, geese, and swans) | | | | | |
| 018 | Lesser Whistling-Duck | *Dendrocygna javanica* | S | J | LC |
| 019 | Greater White-fronted Goose∗ | *Anser albifrons* | W | J | LC |
| 020 | Lesser White-fronted Goose∗ | *Anser erythropus* | V/W | K | VU |
| 021 | Bar-headed Goose | *Anser indicus* | S/W | J,L | LC |
| 022 | Greylag Goose | *Anser anser* | P | J,K,L | LC |
| 023 | Whooper Swan∗ | *Cygnus cygnus* | V/W | K | LC |
| 024 | Long-tailed Duck∗ | *Clangula hyemalis* | V/W | K,L | VU |
| 025 | Ruddy Shelduck | *Tadorna ferruginea* | S/P | J,K,L | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 026 | Common Shelduck | *Tadorna tadorna* | P | J,K,L | LC |
| 027 | Common Teal | *Anas crecca* | W/P | J,K,L | LC |
| 028 | Marbled Duck∗ | *Marmaronetta angustirostris* | W | K | VU |
| 029 | Garganey | *Anas querquedula* | P | J,K,L | LC |
| 030 | Baikal Teal∗ | *Anas Formosa* | V/W | K | LC |
| 031 | Gadwall | *Anas strepera* | W/P | J,K,L | LC |
| 032 | Eurasian Wigeon | *Anas penelope* | W/P | J,K,L | LC |
| 033 | Northern Shoveller | *Anas clypeata* | W/P | J,K,L | LC |
| 034 | Northern Pintail | *Anas acuta* | W/P | J,K,L | LC |
| 035 | Indian Spot-billed Duck | *Anas poecilorhyncha* | W | J | LC |
| 036 | Mallard | *Anas platyrhynchos* | S/W | J,K,L | LC |
| 037 | White-headed Duck∗ | *Oxyura leucocephala* | W | K | EN |
| 038 | Tufted Duck | *Aythya fuligula* | W | J,K,L | LC |
| 039 | Ferruginous Duck | *Aythya nyroca* | W | J,K,L | NT |
| 040 | Common Pochard | *Aythya ferina* | P/W | J,K,L | LC |
| 041 | Red-crested Pochard | *Rhodonessa rufina* | P/W | J,K,L | LC |
| 042 | Cotton Pygmy-goose∗ | *Nettapus coromandelianus* | V/W | K | LC |
| 043 | Common Merganser | *Mergellus merganser* | S/P | J,K,L | LC |
| Podicipedidae (grebes) | | | | | |
| 044 | Black-necked Grebe∗ | *Podiceps nigricollis* | V | L | LC |
| 045 | Red-necked Grebe∗ | *Podiceps grisegena* | V | L | LC |
| 046 | Great Crested Grebe | *Podiceps cristatus* | S/P | K,L | LC |
| 047 | Little Grebe | *Tachybaptus ruficollis* | S/W | J,K,L | LC |
| Ardeidea (bitterns, herons and egrets) | | | | | |
| 048 | Little Egret | *Egretta garzetta* | R/P | J,K,L | LC |
| 049 | Great Egret | *Casmerodius albus* | R | J,L | LC |
| 050 | Intermediate Egret | *Ardea intermedia* | R | J | LC |
| 051 | Cattle Egret | *Bubulcus ibis* | R | J,K,L | LC |
| 052 | Grey Heron | *Ardea cinerea* | R/P | J,K,L | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 053 | Purple Heron | *Ardea purpurea* | R | J | LC |
| 054 | Indian Pond-heron | *Ardeola grayii* | R/W | J,K,L | LC |
| 055 | Black-crowned Night-heron | *Nycticorax nycticorax* | R/S | J,K,L | LC |
| 056 | Little Bittern | *Ixobrychus minutus* | S/P | K,L | LC |
| 057 | Black Bittern | *Dupetor flavicollis* | W | J,K,L | LC |
| 058 | Great Bittern | *Botaurus stellaris* | W/V | J,L | LC |
| Ciconidae (storks) | | | | | |
| 059 | Painted Stork | *Mycteria leucocephala* | W | J | NT |
| 060 | Wooly-necked Stork | *Ciconia episcopus* | W | J | LC |
| 061 | Black Stork | *Ciconia nigra* | P | J,K,L | LC |
| 062 | Black-necked Stork | *Ephippiorhynchus asiaticus* | S | L | NT |
| Threskiornithidae (ibises and spoonbills) | | | | | |
| 063 | Glossy Ibis | *Plegadis falcinellus* | P/V | J,L | LC |
| 064 | Black-headed ibis | *Threskiornis melanocephalus* | W | J | NT |
| 065 | Red-naped Ibis | *Pseudibis papillosa* | W | J | LC |
| Phalacrocoracidae (cormorants) | | | | | |
| 066 | Little Cormorant | *Phalacrocorax niger* | R/V | J,L | LC |
| 067 | Indian Cormorant | *Phalacrocorax fuscicollis* | W | J | LC |
| 068 | Great Cormorant | *Phalacrocorax carbo* | P | J,K,L | LC |
| Pandionidae (osprey) | | | | | |
| 069 | Osprey | *Pandion haliaetus* | S/P | K,L | LC |
| Accipitridae (hawks, kites, and eagles) | | | | | |
| 070 | Black-winged Kite | *Elanus caeruleus* | R/V | J,L | LC |
| 071 | Red Kite* | *Milvus milvus* | V | L | NT |
| 072 | Black-eared Kite | *Milvus lineatus* | S/W | J,K,L | LC |
| 073 | Black Kite | *Milvus migrans* | R | J | LC |
| 074 | Besra | *Accipiter virgatus* | R | J,K | LC |
| 075 | Shikra | *Accipter badius* | R/S | J,K | LC |
| 076 | Northern Goshawk | *Accipiter gentilis* | W/P | J,K,L | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 077 | White-eyed Buzzard | *Butastur teesa* | R | J, | LC |
| 078 | Eurasian Sparrowhawk | *Accipiter nisus* | R/P | J,K,L | LC |
| 079 | Common Buzzard | *Buteo buteo* | W | J | LC |
| 080 | Himalayan Buzzard | *Buteo burmanicus* | P | J,K | LC |
| 081 | Long-legged Buzzard | *Buteo rufinus* | R/W/P | J,K,L | LC |
| 082 | Upland Buzzard | *Buteo hemilasius* | W/S | J,K,L | LC |
| 083 | Oriental Honey-buzzard | *Pernis ptilorhyncus* | R/P | J,L | LC |
| 084 | Crested Serpent-eagle | *Spilornis cheela* | R | J | LC |
| 085 | Short-toed Snake-Eagle | *Circaetus gallicus* | R/P | J,L | LC |
| 086 | Booted Eagle | *Hieraaetus pennatus* | W/S/P | J,K,L | LC |
| 087 | Bonelli's Eagle | *Hieraaetus fasciatus* | R | J | LC |
| 088 | Mountain Hawk-eagle | *Spizaetus nipalensis* | R | J,K | LC |
| 089 | Changeable Hawk-Eagle∗ | *Nisaetus limnaeetus* | V | K | LC |
| 090 | Black Eagle | *Ictinaetus malayenis* | R | J | LC |
| 091 | Indian Spotted Eagle | *Aquila hastate* | R | J | LC |
| 092 | Greater Spotted Eagle | *Aquila clanga* | W/P | J,K,L | VU |
| 093 | Tawny Eagle | *Aquila rapax* | V | J,K | LC |
| 094 | Steppe Eagle | *Aquila nipalensis* | W/P | J,L | LC |
| 095 | Eastern Imperial Eagle | *Aquila heliacal* | W/P | J,L | VU |
| 096 | Golden Eagle | *Aquila chrysaetos* | R | J,K,L | LC |
| 097 | Pallas's Fish Eagle | *Haliaeetus leucoryphus* | S/P | K,L | EN |
| 098 | White-rumped Vulture | *Gyps bengalensis* | R | J | CR |
| 099 | Slender-billed Vulture∗ | *Gyps tenuirostris* | R | J | CR |
| 100 | Griffon Vulture∗ | *Gyps fulvus* | R | J,K | LC |
| 101 | Himalayan Vulture | *Gyps himalayensis* | R | J,K,L | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 102 | Egyptian Vulture | *Neophron percnopterus* | R/P | J,K,L | EN |
| 103 | Bearded Vulture | *Gypaetus barbatus* | R | J,K,L | NT |
| 104 | Cinereous Vulture | *Aegypius monachus* | W/P | J,L | NT |
| 105 | Montagu's Harrier | *Circus pygargus* | P | J,K,L | LC |
| 106 | Pallid Harrier | *Circus macrourus* | W/P | J,L | NT |
| 107 | Hen Harrier | *Circus cyaneus* | W/P | J,K,L | LC |
| 108 | Eurasian Marsh Harrier | *Circus aeruginosus* | W/P | J,K,L | LC |
| Falconidae (falcons) | | | | | |
| 109 | Merlin | *Falco columbarius* | W/P | J,L | LC |
| 110 | Lesser Kestrel | *Falco naumanni* | P | J,K | LC |
| 111 | Common Kestrel | *Falco tinnunculus* | W/S | J,K,L | LC |
| 112 | Eurasian Hobby | *Falco subbuteo* | W/S | J,K,L | LC |
| 113 | Peregrine Falcon | *Falco peregrinus* | W/P | J,K,L | LC |
| 114 | Laggar Falcon | *Falco jugger* | R | J | NT |
| 115 | Saker Falcon | *Falco cherrug* | W/P | J,L | EN |
| Rallidae (crakes, rails) | | | | | |
| 116 | Red-legged Crake | *Rallina fasciata* | V | K | LC |
| 117 | Water Rail | *Rallus aquaticus* | S | K | LC |
| 118 | Baillon's Crake | *Porzana pusilla* | W/S | J,K | LC |
| 119 | Spotted Crake | *Porzana porzana* | W/P | J,L | LC |
| 120 | Ruddy-breasted Crake | *Porzana fusca* | R | J,K | LC |
| 121 | Corn Crake | *Crex crex* | P | L | LC |
| 122 | Brown Crake | *Amaurornis akool* | R | J | LC |
| 123 | White-breasted Waterhen | *Amaurornis phoenicurus* | R | J | LC |
| 124 | Grey-headed Swamphen | *Porphyrio popoliocephalus* | R | J,K | LC |
| 125 | Common Moorhen | *Gallinula chloropus* | R/P | J,K,L | LC |
| 126 | Eurasian Coot | *Fulica atra* | R/W/P | J,K,L | LC |
| Gruidae (cranes) | | | | | |
| 127 | Black-necked Crane | *Grus nigricollis* | S | L | VU |
| 128 | Common Crane | *Grus grus* | W | J,K | LC |
| 129 | Demoiselle Crane | *Grus virgo* | P | L | LC |
| 130 | Sarus Crane | *Grus antigone* | W | J | VU |
| 131 | Siberian Crane* | *Grus leucogeranus* | P | L | CR |
| Burhinidae (thicknee) | | | | | |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 132 | Great Thick-knee | *Esacus recurvirostris* | R | J | LC |
| 133 | Eurasian Thick-knee* | *Burhinus oedicnemus* | V | K | LC |
| 134 | Indian Thick-knee | *Burhinus indicus* | W | J | LC |
| Ibidorhynchidae (ibisbill) | | | | | |
| 135 | Ibisbill | *Ibidorhyncha struthersii* | R | K,L | LC |
| Recurvirostridae (stilts and avocets) | | | | | |
| 136 | Black-winged Stilt | *Himantopus himantopus* | W/P | J,K,L | LC |
| 137 | Pied Avocet | *Recurvirostra avosetta* | W | J,L | LC |
| Charadriidae (plovers and lapwings) | | | | | |
| 138 | Red-wattled Lapwing | *Vanellus indicus* | R | J,K | LC |
| 139 | White-tailed Lapwing | *Vanellus leucurus* | W | J | LC |
| 140 | Northern Lapwing | *Vanellus vanellus* | W/P | J,K,L | LC |
| 141 | Grey Plover* | *Pluvialis squatarola* | P | L | LC |
| 142 | Pacific Golden Plover | *Pluvialis fulva* | P | L | LC |
| 143 | Greater Sand Plover | *Charadrius leschenaultii* | W | L | LC |
| 144 | Lesser Sand Plover | *Charadrius mongolus* | P/S | J,L | LC |
| 145 | Common Ringed Plover | *Charadrius hiaticula* | W | L | LC |
| 146 | Little Ringed Plover | *Charadrius dubius* | R/S | J,K,L | LC |
| 147 | Kentish Plover | *Charadrius alexandrinus* | P | L | LC |
| Rostratulidae (painted snipe) | | | | | |
| 148 | Greater Painted Snipe | *Rostratula benghalensis* | R | J,K | LC |
| Jacanidae (Jacanas) | | | | | |
| 149 | Pheasant-tailed Jacana | *Hydrophasianus chirurgus* | S | J,K,L | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| Scolopacidae (snipes, sandpipers, and other waders) | | | | | |
| 150 | Eurasian Curlew | *Numenius arquata* | P | K,L | NT |
| 151 | Whimbrel* | *Numenius phaeopus* | P | L | LC |
| 152 | Black-tailed Godwit* | *Limosa limosa* | P | L | NT |
| 153 | Terek Sandpiper | *Xenus cinereus* | P | L | LC |
| 154 | Common Greenshank | *Tringa nebularia* | W/P | J,K,L | LC |
| 155 | Wood Sandpiper | *Tringa glareola* | P | J,K,L | LC |
| 156 | Green Sandpiper | *Tringa ochropus* | W/P | J,L | LC |
| 157 | Common Sandpiper | *Actitis hypoleucos* | W/S | J,K,L | LC |
| 158 | Marsh Sandpiper* | *Tringa stagnatilis* | P | L | LC |
| 159 | Common Redshank | *Tringa totanus* | W/P/S | J,L | LC |
| 160 | Spotted Redshank | *Tringa erythropus* | W | L | LC |
| 161 | Ruddy Turnstone* | *Arenaria interpres* | P | L | LC |
| 162 | Ruff and Reeve | *Philomachus pugnax* | P | J,K,L | LC |
| 163 | Curlew Sandpiper | *Calidris ferruginea* | P | L | LC |
| 164 | Dunlin* | *Calidris alpina* | P | L | LC |
| 165 | Temminck's Stint | *Calidris temminckii* | W/P | J,L | LC |
| 166 | Little Stint | *Calidris minuta* | P | J,L | LC |
| 167 | Red-necked Phalarope | *Phalaropus lobatus* | P | L | LC |
| 168 | Common Snipe | *Gallinago gallinago* | W/P | J,K,L | LC |
| 169 | Jack Snipe* | *Lymnocryptes minimus* | W | K | LC |
| 170 | Pintail Snipe | *Gallinago stenura* | P | K,L | LC |
| 171 | Solitary Snipe | *Gallinago solitaria* | R/P | K,L | LC |
| 172 | Eurasian Woodcock | *Scolopax rusticola* | S | K | LC |
| Glareolidae (coursers and pratincoles) | | | | | |
| 173 | Collared Pratincole* | *Glareola pratincola* | P | L | LC |
| 174 | Oriental Pratincole | *Glareola maldivarum* | P | J | LC |
| 175 | Small Pratincole | *Glareola laceta* | R | J | LC |
| Laridae (gulls,terns) | | | | | |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 176 | Parasitic Jaeger∗ | *Stercorarius parasiticus* | V | L | LC |
| 177 | Pallas's Gull | *Larus ichthyaetus* | P | L | LC |
| 178 | Brown-headed Gull | *Larus brunnicephalus* | W/S | J,K,L | LC |
| 179 | Black-headed Gull | *Larus ridibundus* | W | K,L | LC |
| 180 | Little Gull∗ | *Larusminutus* | P | L | LC |
| 181 | Little Tern∗ | *Sterna albifrons* | P | L | LC |
| 182 | Common Tern | *Sterna hirundo* | S | L | LC |
| 183 | Gull-billed Tern∗ | *Gelochelidon nilotica* | P | L | LC |
| 184 | River Tern | *Sterna aurantia* | R/S | J,K,L | NT |
| 185 | Whiskered Tern | *Chlidonias hybrida* | S/P | K,L | LC |
| 186 | White-winged Tern∗ | *Chlidonias leucopterus* | P | L | LC |
| Pteroclidae (sandgrouse) | | | | | |
| 187 | Tibetan Sandgrouse | *Syrrhaptes tibetanus* | R | L | LC |
| Columbidae (pigeons and doves) | | | | | |
| 188 | Common Pigeon | *Columba livia* | R | J,K,L | LC |
| 189 | Hill Pigeon | *Columba rupestris* | R | K,L | LC |
| 190 | Yellow-eyed Pigeon∗ | *Columba eversmanni* | W/V | K,L | VU |
| 191 | Snow Pigeon | *Columba leuconota* | R | J,K,L | LC |
| 192 | Common Woodpigeon | *Columba palumbus* | R | J,K | LC |
| 193 | Speckled Woodpigeon | *Columba hodgsonii* | R | K | LC |
| 194 | Oriental Turtle-dove | *Streptopelia orientalis* | R/S | J,K,L | LC |
| 195 | Laughing Dove | *Streptopelia senegalensis* | R/P | J,K,L | LC |
| 196 | Red Collared-dove | *Streptopelia tranquebarica* | S | J | LC |
| 197 | Spotted Dove | *Streptopelia chinensis* | R/S | J,K | LC |
| 198 | Eurasian Collared-dove | *Streptopelia decaocto* | R/S | J,K,L | LC |
| 199 | European Turtle Dove∗ | *Streptopelia turtur* | P | L | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 200 | Yellow-footed Green Pigeon | *Terron phoenicopterus* | R | J | LC |
| 201 | Wedge-tailed Green-pigeon | *Treron sphenura* | R | J | LC |
| Psittacidae (parrots and parakeets) | | | | | |
| 202 | Slaty-headed Parakeet | *Psittacula himalayana* | R | J,K | LC |
| 203 | Plum-headed Parakeet | *Psittacula cyanocephala* | R | J | LC |
| 204 | Red-breasted Parakeet | *Psittacula alexandri* | R | J | LC |
| 205 | Rose-ringed Parakeet | *Psittacula krameri* | R | J,K | LC |
| 206 | Alexandrine Parakeet | *Psittacula eupatria* | R | J,K | LC |
| Cuculidae (cuckoos) | | | | | |
| 207 | Grey-bellied Cuckoo | *Cacomantis passerinus* | S | J | LC |
| 208 | Banded Bay Cuckoo∗ | *Cacomantis sonneratii* | V | J | LC |
| 209 | Drongo-cuckoo | *Surniculus lugubris* | S | J | LC |
| 210 | Jacobin Cuckoo | *Clamator jacobinus* | S | J,K,L | LC |
| 211 | Asian Koel | *Eudynamys scolopacea* | R/S | J,K,L | LC |
| 212 | Indian Cuckoo | *Cuculus micropterus* | S | J | LC |
| 213 | Eurasian Cuckoo | *Cuculus canorus* | S | J,K,L | LC |
| 214 | Himalayan Cuckoo | *Cuculus saturates* | S | J,K | LC |
| 215 | Lesser Cuckoo | *Cuculus poliocephalus* | S | J,K | LC |
| 216 | Large Hawk-Cuckoo | *Hierococcyx sparverioides* | S | J | LC |
| 217 | Common Hawk-cuckoo | *Hierococcyx varius* | R | J | LC |
| 218 | Sirkeer Malkoha | *Phaenicophaeus leschenaultii* | R | J | LC |
| 219 | Greater Coucal | *Centropus sinensis* | R | J | LC |
| Tytonidae (barn owls) | | | | | |
| 220 | Barn Owl | *Tyto alba* | R | K | LC |
| Strigidae (owls) | | | | | |
| 221 | Brown Fish-owl∗ | *Ketupa zeylonensis* | V | J | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 222 | Pallid Scops Owl* | *Otus brucei* | V | L | LC |
| 223 | Indian Scops Owl | *Ottus bakkamoena* | R | J | LC |
| 224 | Eurasian Scops Owl | *Otus scops* | S | J | LC |
| 225 | Eurasian Eagle-owl | *Bubo bubo* | R | K,L | LC |
| 226 | Indian Eagle Owl | *Bubo bengalensis* | R | J | LC |
| 227 | Long-eared Owl | *Asio otus* | W/S | J,K,L | LC |
| 228 | Short-eared Owl | *Asio flammeus* | W/P | J,L | LC |
| 229 | Tawny Owl | *Strix aluco* | R | K | LC |
| 230 | Brown Wood-owl* | *Strix leptogrammica* | V | J | LC |
| 231 | Little Owl | *Athene noctua* | R | L | LC |
| 232 | Spotted Owlet | *Athene brama* | R | J | LC |
| 233 | Collared owlet | *Glaucidium brodiei* | R | K | LC |
| 234 | Asian Barred Owlet | *Glaucidium cuculoides* | R | J,K | LC |
| Caprimulgidae (nightjars) | | | | | |
| 235 | European Nightjar | *Caprimulgus europaeus* | S/P | K,L | LC |
| 236 | Indian Nightjar* | *Caprimulgus asiaticus* | V | J | LC |
| Apodidae (swifts) | | | | | |
| 237 | Little Swift | *Apus affinis* | R | J | LC |
| 238 | Common Swift | *Apus apus* | S | J,K,L | LC |
| 239 | Fork-tailed Swift | *Apus pacificus* | S | K,L | LC |
| 240 | Alpine Swift | *Tachymarptis melba* | S | J,K,L | LC |
| 241 | White-throated Needletail | *Hirundapus caudacutus* | S | J,K | LC |
| Coraciidae (rollers) | | | | | |
| 242 | Eurasian Roller | *Coracias garrulus* | P/S | J,K,L | LC |
| 243 | Indian Roller | *Coracias benghalensis* | R | J | LC |
| Alcedinidae (kingfishers) | | | | | |
| 244 | White-throated Kingfisher | *Halcyon smyrnensis* | R | J,K | LC |
| 245 | Crested Kingfisher | *Megaceryle lugubris* | R | J,K | LC |
| 246 | Pied Kingfisher | *Ceryle rudis* | R | J,K | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 247 | Common Kingfisher | *Alcedo atthis* | R/S | J,K,L | LC |
| Meropidae (bee-eaters) | | | | | |
| 248 | European Bee-eater | *Merops apiaster* | S/P | J,K,L | LC |
| 249 | Blue-cheeked Bee-eater* | *Merops persicus* | P | L | LC |
| 250 | Blue-tailed Bee-eater | *Merops philippinus* | S | J | LC |
| 251 | Green Bee-eater | *Merops orientalis* | R | J | LC |
| Upupidae (hoopoe) | | | | | |
| 252 | Common Hoopoe | *Upupa epops* | R/S | J,K,L | LC |
| Bucerotidae (hornbills) | | | | | |
| 253 | Indian Grey Hornbill | *Ocyceros birostris* | R | J | LC |
| Megalaimidae (barbets) | | | | | |
| 254 | Coppersmith Barbet | *Megalaima haemacephala* | R | J | LC |
| 255 | Great Barbet | *Megalaima virens* | R | J,K | LC |
| 256 | Blue-throated Barbet | *Megalaima asiatica* | R | J | LC |
| 257 | Brown-headed Barbet | *Megalaima zeylanica* | R | J | LC |
| Picidae (woodpeckers) | | | | | |
| 258 | Eurasian Wryneck | *Jynx torquilla* | S/P | J,K,L | LC |
| 259 | Speckled Piculet | *Picumnus innominatus* | R | J,K | LC |
| 260 | Yellow-crowned Woodpecker | *Dendrocopos mahrattensis* | R | J | LC |
| 261 | Brown-fronted Woodpecker | *Dendrocopos auriceps* | R | J,K | LC |
| 262 | Rufous-bellied Woodpecker | *Dendrocopos hyperythrus* | R | J | LC |
| 263 | Grey-capped Pygmy Woodpecker | *Dendrocopos canicapillus* | R | J | LC |
| 264 | Himalayan Woodpecker | *Dendrocopos himalayensis* | R | J,K | LC |
| 265 | Scaly-bellied Woodpecker | *Picus squamatus* | R | J,K,L | LC |
| 266 | Lesser Yellownape | *Picus chlorolophus* | R | J | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 267 | Grey-headed Woodpecker | *Picus canus* | R | J,K | LC |
| 268 | Lesser Goldenback | *Dinopium benghalense* | R | J | LC |
| Tephrodornithidae (woodshrikes) | | | | | |
| 269 | Common Woodshrike | *Tephrodornis pondicerianus* | R | J | LC |
| Aegithinidae (ioras) | | | | | |
| 270 | Common Iora | *Aegithina tiphia* | R | J | LC |
| Campephagidae (cuckooshrikes and minivets) | | | | | |
| 271 | Black-winged Cuckooshrike∗ | *Coracina melaschistos* | V | J | LC |
| 272 | Large Cuckooshrike | *Coracina macei* | R | J | LC |
| 273 | Long-tailed Minivet | *Pericrocotus ethologus* | S | J,K | LC |
| 274 | Scarlet Minivet∗ | *Pericrocotus speciosus* | R | J | LC |
| 275 | Small Minivet | *Pericrocotus cinnamomeus* | R | J | LC |
| 276 | Rosy Minivet∗ | *Pericrocotus roseus* | V | J | LC |
| Laniidae (shrikes) | | | | | |
| 277 | Long-tailed Shrike | *Lanius schach* | R/S | J,K,L | LC |
| 278 | Lesser Grey Shrike∗ | *Lanius minor* | P | L | LC |
| 279 | Southern Grey Shrike∗ | *Lanius meridionalis* | V | L | LC |
| 280 | Grey-backed Shrike∗ | *Lanius tephronotus* | P | J,L | LC |
| 281 | Isabelline Shrike | *Lanius isabellinus* | W/P | J,L | LC |
| 282 | Bay-backed Shrike | *Lanius vittatus* | R | J | LC |
| 283 | Red-backed Shrike∗ | *Lanius collurio* | P | L | LC |
| Oriolidae (orioles) | | | | | |
| 284 | Golden Oriole | *Oriolus oriolus* | S | J,K,L | LC |
| Dicruridae (Drongos) | | | | | |
| 285 | Spangled Drongo∗ | *Dicrurus hottentottus* | V | J | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 286 | Black Drongo | *Dicrurus macrocerus* | R/V | J,K,L | LC |
| 287 | Ashy Drongo | *Dicrurus leucophaus* | S | J,K | LC |
| 288 | Bronzed Drongo∗ | *Dicrurus aeneus* | S | J | LC |
| Rhipiduridae (fantails) | | | | | |
| 289 | White-browed Fantail | *Rhipidura aureola* | R | J | LC |
| 290 | White-throated Fantail | *Rhipidura albicollis* | W | J | LC |
| Monarchidae (monarch flycatchers) | | | | | |
| 291 | Asian paradise flycatcher | *Terpsiphone paradisi* | S | J,K | LC |
| Corvidae (Jays, magpies, and crows) | | | | | |
| 292 | Large-Spotted Nutcracker | *Nucifraga multipunctata* | R | J,K | LC |
| 293 | Groundpecker | *Pseudopodoces humilis* | R | L | LC |
| 294 | Eurasian Jackdaw | *Corvus monedula)* | R/S | K,L | LC |
| 295 | Red-billed Chough | *Pyrrhocorax pyrrhocorax* | R | J,K,L | LC |
| 296 | Alpine Chough | *Pyrrhocorax graculus* | R | K,L | LC |
| 297 | Rook | *Corvus frugilegus* | W | J,K | LC |
| 298 | Carrion Crow | *Corvus corone* | S/R | K,L | LC |
| 299 | House Crow | *Corvus splendens* | R/V | J,K,L | LC |
| 300 | Indian Jungle Crow | *Corvus levaillantii* | R | J | LC |
| 301 | Large-billed Crow | *Corvus macrorhynchos* | R | K,L | LC |
| 302 | Northern Raven | *Corvus corax* | R/W | J,K,L | LC |
| 303 | Punjab Raven | *Corvus subcorax* | R | J | LC |
| 304 | Eurasian Magpie | *Pica pica* | R | L | LC |
| 305 | Eurasian Jay | *Garrulus glandarius* | R | J,K | LC |
| 306 | Black-headed Jay | *Garrulus lanceolatus* | R | J,K | LC |
| 307 | Yellow-billed Blue Magpie | *Urocissa flavirostris* | R | J,K | LC |
| 308 | Rufous Treepie | *Dendrocitta vagabunda* | R | J | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 309 | Grey Treepie | *Dendrocitta formosae* | R | J,K | LC |
| Stenostiridae (fantail, canary flycatcher) | | | | | |
| 310 | Yellow-bellied Fantail | *Rhipidura hypoxantha* | W | J | LC |
| 311 | Grey-headed Canary Flycatcher | *Culicicapa ceylonensis* | S | J,K | LC |
| Paridae (tits) | | | | | |
| 312 | White-crowned Penduline Tit* | *Remiz coronatus* | V | L | LC |
| 313 | Fire-capped Tit | *Cephalopyrus flammiceps* | S | J,K,L | LC |
| 314 | Rufous-vented Tit | *Parus rubidiventris* | R | J,K | LC |
| 315 | Rufous-naped Tit | *Parus rufonuchalis* | R | J,K,L | LC |
| 316 | Coal Tit | *Periparus ater* | R | J,K | LC |
| 317 | Grey-crested Tit | *Lophophanes dichrous* | R | J | LC |
| 318 | Yellow-browed Tit* | *Sylviparus modestus* | V | K,L | LC |
| 319 | Cinereous Tit | *Parus cinerous* | R/S | J,K,L | LC |
| 320 | Green-backed Tit | *Parus monticolus* | R | J,K,L | LC |
| 321 | Black-throated Tit | *Aegithalos concinnus* | R | J,K | LC |
| 322 | White-throated Tit | *Aegithalos niveogularis* | R | J,K | LC |
| 323 | Black-lored Yellow Tit | *Parus xanthogenys* | R | J | LC |
| Aludidae (larks) | | | | | |
| 324 | Bengal Bushlark | *Mirafra assamica* | R | J | LC |
| 325 | Ashy-crowned Sparrow Lark | *Eremopterix grisea* | R | J | LC |
| 326 | Oriental Skylark | *Alauda gulgula* | S | J,K,L | LC |
| 327 | Eurasian Skylark | *Alauda arvensis* | W | J,K | LC |
| 328 | Crested Lark | *Galerida cristata* | R/P | J,L | LC |
| 329 | Bimaculated Lark* | *Melanocorypha bimaculata* | P | L | LC |
| 330 | Tibetan Lark | *Melanocorypha maxima* | S | L | LC |
| 331 | Horned Lark | *Eremophila alpestris* | R | K,L | LC |
| 332 | Desert Lark* | *Ammomanes deserti* | V | J | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 333 | Greater Short-toed Lark | *Calandrella brachydactyla* | P | L | LC |
| 334 | Asian Short-toed Lark* | *Calandrella cheleensis* | V | L | LC |
| 335 | Hume's Short-toed Lark | *Calandrella acutirostris* | S | L | LC |
| 336 | Sand Lark | *Calandrella raytal* | R | J | LC |
| Pycnonotidae (bulbuls) | | | | | |
| 337 | Red-vented Bulbul | *Pycnonotus cafer* | R | J | LC |
| 338 | Himalayan Bulbul | *Pycnonotus leucogenys* | R | J,K | LC |
| 339 | Black Bulbul | *Hypsipetes leucocephalus* | R | J,K | LC |
| 340 | Red-whiskered Bulbul | *Pycnonotus jocosus* | R | J | LC |
| Hirundinidae (swallows and martins) | | | | | |
| 341 | Plain Martin | *Riparia paludicola* | R/P | J,L | LC |
| 342 | Pale Martin | *Riparia diluta* | S | K,L | LC |
| 343 | Sand Martin | *Riparia riparia* | S | L | LC |
| 344 | Eurasian Crag Martin | *Hirundo rupestris* | S | K,L | LC |
| 345 | Asian House Martin | *Delichon dasypus* | S | K,L | LC |
| 346 | Common House Martin | *Delichon urbicum* | S | K,L | LC |
| 347 | Streak-throated Swallow | *Hirundo fluvicola* | R | J | LC |
| 348 | Barn Swallow | *Hirundo rustica* | S/P | J,K,L | LC |
| 349 | Red-rumped Swallow | *Hirundo daurica* | S/P | J,K,L | LC |
| 350 | Wire-tailed Swallow | *Hirundo smithii* | S/P | J,K,L | LC |
| Cisticolidae (prinias and tailorbirds) | | | | | |
| 351 | Ashy Prinia | *Prinia socialis* | R | J | LC |
| 352 | Grey-breasted Prinia | *Prinia hodgsonii* | R | J | LC |
| 353 | Jungle Prinia | *Prinia sylvatica* | R | J | LC |
| 354 | Yellow-bellied Prinia | *Prinia flaviventris* | R | J | LC |
| 355 | Plain Prinia | *Prinia inornata* | R | J | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 356 | Rufous-fronted Prinia | *Prinia buchanani* | R | J | LC |
| 357 | Zitting Cisticola | *Cisticola juncidis* | R | J | LC |
| 358 | Striated Prinia | *Prinia crinigera* | R | J | LC |
| 359 | Graceful Prinia | *Prinia gracilis* | R | J | LC |
| 360 | Common Tailorbird | *Orthotomus sutorius* | R | J | LC |
| Cettiidae (bush warblers) | | | | | |
| 361 | Brownish-flanked Bush Warbler | *Cettia fortipes* | S | J,K | LC |
| 362 | Grey-sided Bush Warbler | *Cettia brunnifrons* | R | K | LC |
| Acrociphalidae (reed warblers) | | | | | |
| 363 | Clamorous Reed Warbler | *Acrocephalus stentoreus* | S | K | LC |
| 364 | Black-browed Reed Warbler∗ | *Acrocephalus bistrigiceps* | V | L | LC |
| 365 | Blyth’s Reed Warbler | *Acrocephalus dumetorum* | P | J,L | LC |
| 366 | Moustached Warbler | *Acrocephalus melanopogon* | W | J | LC |
| 367 | Paddyfield Warbler | *Acrocephalus agricola* | P | L | LC |
| 368 | Blunt-winged Warbler | *Acrocephalus concinens* | S | K | LC |
| 369 | Sedge Warbler∗ | *Acrocephalus schoenobaenus* | V | L | LC |
| 370 | Great Reed Warbler∗ | *Acrocephalus arundinaceus* | V | L | LC |
| 371 | Sykes’s Warbler∗ | *Iduna rama* | P | K,L | LC |
| Locustellidae (locustella, warblers, and grassbirds) | | | | | |
| 372 | Long-billed Bush Warbler | *Bradypterus major* | S | K,L | NT |
| Slyviidae (sylvia warblers) | | | | | |
| 373 | Garden Warbler∗ | *Sylvia borin* | P | L | LC |
| 374 | Common Whitethroat | *Sylvia communis* | P | L | LC |
| 375 | Lesser Whitethroat | *Sylvia curruca* | S | L | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 376 | Hume's Whitethroat | *Sylvia althaea* | S | K,L | LC |
| 377 | Barred Warbler | *Sylvia nisoria* | P | L | LC |
| Phylloscopidae (leaf warblers) | | | | | |
| 378 | Common Chiffchaff | *Phylloscopus collybita* | W/P | J,K,L | LC |
| 379 | Mountain Chiffchaff | *Phylloscopus sindianus* | P/S | K,L | LC |
| 380 | Plain Leaf-warbler∗ | *Phylloscopus neglectus* | V | K,L | LC |
| 381 | Dusky Warbler | *Phylloscopus fuscatus* | P | L | LC |
| 382 | Sulphur-bellied Warbler | *Phylloscopus griseolus* | S | J,K,L | LC |
| 383 | Tickell's Leaf Warbler | *Phylloscopus affinis* | S | J,K,L | LC |
| 384 | Tytler's Leaf Warbler | *Phylloscopus tytleri* | P/S | J,K,L (EWH) | NT |
| 385 | Greenish Warbler | *Phylloscopus trochiloides* | P/S | J,K,L | LC |
| 386 | Large-billed Leaf Warbler | *Phylloscopus magnirostris* | S | K,L | LC |
| 387 | Blyth's Leaf Warbler | *Phylloscopus reguloides* | S | K | LC |
| 388 | Western Crowned Warbler | *Phylloscopus occipitalis* | S/P | K,L | LC |
| 389 | Hume's Warbler | *Phylloscopus humei* | S/P | J,K,L | LC |
| 390 | Brooks's Leaf Warbler∗ | *Phylloscopus subviridis* | W | K | LC |
| 391 | Buff-barred Warbler∗ | *Phylloscopus pulcher* | S | K | LC |
| 392 | Lemon-rumped Warbler | *Phylloscopus chloronotus* | S | J,K | LC |
| 393 | Ashy-throated Warbler∗ | *Phylloscopus maculipennis* | R | J | LC |
| 394 | Grey-hooded Warbler | *Phylloscopus xanthoschistos* | R | J,K | LC |
| 395 | Whistler's Warbler | *Seicercus whistleri* | S | J,K | LC |
| 396 | White-browed Tit Warbler | *Leptopoecile sophiae* | R | L | LC |
| Timalidae (babblers) | | | | | |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 397 | Streaked Laughingthrush | *Garrulax lineatus* | R | J,K | LC |
| 398 | Variegated Laughingthrush | *Garrulax variegatus)* | R | J,K | LC |
| 399 | Yellow-eyed Babbler | *Chrysomma sinense* | R | J | LC |
| 400 | Black-chinned Babbler | *Stachyris pyrrhops* | R | J | LC |
| 401 | Common Babbler | *Turdoides caudatus* | R | J | LC |
| 402 | Striated Babbler | *Turdoides earlei* | R | J | LC |
| 403 | Jungle Babbler | *Turdoides striatus* | R | J | LC |
| 404 | Rusty-cheeked Scimitar-babbler | *Pomatorhinus erythrogenys* | R | J | LC |
| 405 | Red-billed Leiothrix | *Leiothrix lutea* | R | J,K | LC |
| 406 | Rufous Sibia | *Heterophasia capistrata* | R | J,K | LC |
| 407 | Whiskered Yuhina | *Yuhina flavicollis* | R | J | LC |
| 408 | White-browed Shrike-babbler* | *Pteruthius flaviscapis* | V | K | LC |
| 409 | Puff-throated Babbler | *Pellorneum ruficeps* | V | J | LC |
| 410 | Bar-throated Siva | *Siva strigula* | R | J | LC |
| Zosteropidae (white-eyes) | | | | | |
| 411 | Oriental White-eye | *Zosterops palpebrosus* | R | J,K | LC |
| Regulidae (goldcrest) | | | | | |
| 412 | Goldcrest | *Regulus regulus* | R/P | K,L | LC |
| Troglodytidae (wren) | | | | | |
| 413 | Eurasian Wren | *Troglodytes troglodytes* | R | J,K,L | LC |
| Sittidae (nuthatches) | | | | | |
| 414 | Kashmir Nuthatch | *Sitta cashmirensis* | R | K (EWH) | LC |
| 415 | White-cheeked Nuthatch | *Sitta leucopsi* | R | K | LC |
| 416 | Chesnut-bellied Nuthatch | *Sitta cinnmoventris* | R | J | LC |
| Trichodromidae (wallcreeper) | | | | | |
| 417 | Wallcreeper | *Tichodroma muraria* | W/R | J,K,L | LC |
| Certhiidae (treecreepers) | | | | | |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 418 | Bar-tailed Treecreeper | *Certhia himalayana* | W/R | J,K | LC |
| 419 | Hodgson's Treecreeper | *Certhia familiaris hodgsoni* | R | J,K | LC |
| Sturnidae (starlings and mynas) | | | | | |
| 420 | Common Starling | *Sturnus vulgaris* | W/S | J,K,L | LC |
| 421 | Spot-winged Starling∗ | *Saroglossa spilopetra* | V | K | LC |
| 422 | Brahminy Starling | *Sturnia pagodarum* | S | J,K,L | LC |
| 423 | Chestnut-tailed Starling | *Sturnia malabarica* | W | J | LC |
| 424 | Rosy Starling | *Sturnus roseus* | W/P | J,L | LC |
| 425 | Asian Pied Starling | *Gracupica contra* | R | J | LC |
| 426 | Bank Myna | *Acridotheres ginginianus* | R | J | LC |
| 427 | Common Myna | *Acridotheres tristis* | R | J,K | LC |
| 428 | Jungle Myna | *Acridotheres fuscus* | R | J | LC |
| Turdidae (thrushes) | | | | | |
| 429 | Blue Whistling-thrush | *Myiophonus caeruleus* | R | J,K,L | LC |
| 430 | Black-throated Thrush | *Turdus atrogularis* | W | J,K,L | LC |
| 431 | Red-throated Thrush | *Turdus ruficollis* | W | L | LC |
| 432 | Dusky Thrush | *Turdus eunomus* | V | L | LC |
| 433 | Tickell's Thrush | *Turdus unicolor* | S | J,K,L | LC |
| 434 | Mistle Thrush | *Turdus viscivorus* | R | J,K | LC |
| 435 | Tibetan Blackbird∗ | *Turdus maximus* | R/V | K,L | LC |
| 436 | Grey-winged Blackbird | *Turdus boulboul* | R | J,K | LC |
| 437 | Chestnut Thrush | *Turdus rubrocanus* | R | K | LC |
| 438 | Alpine Thrush | *Zoothera mollissima* | R | K | LC |
| 439 | Scaly Thrush | *Zoothera dauma* | S | J,K | LC |
| Muscicapidae (flycatchers) | | | | | |
| 440 | Himalayan Bluetail | *Tarsiger rufilatus* | R | J,K | LC |
| 441 | Indian Blue Robin | *Luscinia brunnea* | S | J,K | LC |
| 442 | Bluethroat | *Luscinia svecica* | W/P | J,K,L | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 443 | White-tailed Rubythroat | *Calliope pectoralis* | P/S | J,K,L | LC |
| 444 | Oriental Magpie-Robin | *Copsychus saularis* | R | J,K | LC |
| 445 | Indian Robin | *Saxicoloides fulicatus* | R | J | LC |
| 446 | White-bellied Redstart | *Hodgsonius phoenicuroides* | R | K | LC |
| 447 | Grandala* | *Grandala coelicolor* | R | K,L | LC |
| 448 | Brown Rock-chat | *Cercomela fusca* | R | J | LC |
| 449 | Little Forktail | *Enicurus scouleri* | R | K,L | LC |
| 450 | Spotted Forktail | *Enicurus maculatus* | R | J,K | LC |
| 451 | Black Redstart | *Phoenicurus ochruros* | P/S | J,K,L | LC |
| 452 | Eversmann's Redstart | *Phoenicurus erythronota* | W | J,K,L | LC |
| 453 | Blue-capped Redstart | *Phoenicurus coeruleocephala* | R/S | J,K,L | LC |
| 454 | Blue-fronted Redstart | *Phoenicurus frontalis* | W/S | J,K,L | LC |
| 455 | Guldenstadt's Redstart | *Phoenicurus erythrogastrus* | W/S | K,L | LC |
| 456 | Common Redstart | *Phoenicurus phoenicurus* | P | L | LC |
| 457 | Plumbeous Water-redstart | *Rhyacornis fuliginosa* | R | J,K | LC |
| 458 | White-capped Redstart | *Chaimarrornis leucocephalus* | R/S | J,K,L | LC |
| 459 | Isabelline Wheatear | *Oenanthe isabellina* | P | L | LC |
| 460 | Desert Wheatear | *Oenanthe deserti* | W/S | J,L | LC |
| 461 | Pied Wheatear | *Oenanthe pleschanka* | S | K,L | LC |
| 462 | Variable Wheatear | *Oenanthe picata* | W/S | J,L | LC |
| 463 | Hume's Wheatear* | *Oenanthe albonigra* | V | L | LC |
| 464 | Pied Bushchat | *Saxicola caprata* | S | J,K | LC |
| 465 | Common Stonechat | *Saxicola torquatus* | S/P | J,K,L | LC |
| 466 | Grey Bushchat | *Saxicola ferreus* | R | J,K | LC |
| 467 | Dark-sided Flycatcher | *Muscicapa sibirica* | S | J,K,L | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 468 | Spotted Flycatcher | *Muscicapa striata* | P | K,L | LC |
| 469 | Asian Brown Flycatcher* | *Muscicapa dauurica* | S/V | J,L | LC |
| 470 | Rusty-tailed Flycatcher | *Muscicapa ruficauda* | S | J,K,L | LC |
| 471 | Ultramarine Flycatcher | *Ficedula superciliaris* | S | J,K | LC |
| 472 | Kashmir Flycatcher | *Ficedula subrubra* | S | K (EWH) | VU |
| 473 | Red-breasted Flycatcher | *Ficedula parva* | W/P | J,L | LC |
| 474 | Rufous-gorgeted Flycatcher | *Ficedula strophiata* | R | J | LC |
| 475 | Taiga Flycatcher | *Ficedula albicilla* | W | J | LC |
| 476 | Slaty-blue Flycatcher | *Ficedula tricolor* | W/S | J,K | LC |
| 477 | Little Pied Flycatcher | *Ficedula westermanni* | S | K | LC |
| 478 | Tickell's Blue Flycatcher | *Cyornis tickelliae* | R | J | LC |
| 479 | Blue-throated Blue Flycatcher | *Cyornis rubeculoides* | S | J,K | LC |
| 480 | Rufous-bellied Niltava | *Niltava sundara* | W | J | LC |
| 481 | Verditer Flycatcher | *Eumyias thalassinus* | S | J,K | LC |
| Cinclidae (dippers) | | | | | |
| 482 | Brown Dipper | *Cinclus pallasii* | R | J,K,L | LC |
| 483 | White-throated Dipper | *Cinclus cinclus* | R | K,L | LC |
| Dicaeidae (flowerpeckers) | | | | | |
| 484 | Thick-billed Flowerpecker | *Dicaeum agile* | R | J | LC |
| 485 | Fire-breasted Flowerpecker | *Dicaeum ignipectus* | R | J | LC |
| Nectariniidae (sunbirds and spiderhunters) | | | | | |
| 486 | Purple Sunbird | *Cinnyris asiaticus* | S | J | LC |
| 487 | Crimson Sunbird | *Aethopyga siparaja* | R | J | LC |
| Passeridae (sparrows and snowfinches) | | | | | |
| 488 | House Sparrow | *Passer domesticus* | R | J,K,L | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 489 | Russet Sparrow | *Passer rutilans* | R | J,K | LC |
| 490 | Spanish Sparrow∗ | *Passer hispaniolensis* | V | K,L | LC |
| 491 | Sindh Sparrow | *Passer pyrrhonotus* | R | J | LC |
| 492 | Rock Sparrow | *Petronia petronia* | V | L | LC |
| 493 | Chestnut-shouldered Petronia | *Gymnoris xanthocollis* | S | J | LC |
| 494 | Tibetan Snowfinch | *Montifringilla adamsi* | R | L | LC |
| 495 | Blanford's Snowfinch | *Pyrgilauda blanfordi* | R | L | LC |
| Ploceidae (weavers) | | | | | |
| 496 | Baya Weaver | *Ploceus philippinus* | R | J | LC |
| 497 | Streaked Weaver | *Ploceus manyar* | R | J | LC |
| 498 | Black-breasted Weaver | *Ploceus benghalensis* | R | J | LC |
| Estrildidae (avadavats and munias) | | | | | |
| 499 | Red Avadavat | *Amandava amandava* | R | J | LC |
| 500 | Indian Silverbill | *Euodice malabarica* | R | J | LC |
| 501 | Scaly-breasted Munia | *Lonchura punctulata* | R | J | LC |
| Prunellidae (accentors) | | | | | |
| 502 | Altai Accentor | *Prunella himalayana* | W | K,L | LC |
| 503 | Alpine Accentor | *Prunella collaris* | R | K,L | LC |
| 504 | Robin Accentor | *Prunella rubeculoides* | R | K,L | LC |
| 505 | Rufous-breasted Accentor | *Prunella strophiata* | R/S | J,K,L | LC |
| 506 | Black-throated Accentor | *Prunella atrogularis* | W/P | J,K,L | LC |
| 507 | Brown Accentor | *Prunella fulvescens* | R | K,L | LC |
| Motacillidae (wagtails and pipits) | | | | | |
| 508 | Forest Wagtail | *Dendronanthus indicus* | P | L | LC |
| 509 | Yellow Wagtail | *Motacilla.flava* | P | K,L | LC |
| 510 | Grey Wagtail | *Motacilla. cinerea* | S | J,K,L | LC |
| 511 | Citrine Wagtail | *Motacilla.citreola* | S | J,K,L | LC |
| 512 | White Wagtail | *Motacilla. alba* | S | J,K,L | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 513 | White-browed Wagtail | *Motacilla. maderaspatensis* | R/V | J,L | LC |
| 514 | Olive-backed Pipit* | *Anthus hodgsoni* | V | L | LC |
| 515 | Tree Pipit | *Anthus trivialis* | P | J,K,L | LC |
| 516 | Red-throated Pipit | *Anthus cervinus* | P | L | LC |
| 517 | Rosy Pipit | *Anthus roseatus* | W/S/P | J,K,L | LC |
| 518 | Water Pipit | *Anthus spinoletta* | P | J,L | LC |
| 519 | Paddyfield Pipit | *Anthus rufulus* | R | J | LC |
| 520 | Tawny Pipit | *Anthus campestris* | W | J | LC |
| 521 | Long-billed Pipit | *Anthus similis* | P/S | J,K | LC |
| 522 | Upland Pipit | *Anthus sylvanus* | R | J | LC |
| Fringillidae (finches) | | | | | |
| 523 | Common chaffinch | *Fringilla coelibs* | W | K | LC |
| 524 | Brambling | *Fringilla montifringilla* | W | K | LC |
| 525 | Plain Mountain-finch | *Leucosticte nemoricola* | W/R | J,K,L | LC |
| 526 | Brandt's Mountain-finch | *Leucosticte brandti* | R | L | LC |
| 527 | Eurasian Linnet | *Carduelis cannabina* | P | L | LC |
| 528 | Twite | *Carduelis flavirostris* | R | L | LC |
| 529 | Yellow-breasted Greenfinch | *Carduelis spinoides* | S | J,K | LC |
| 530 | Red-fronted Serin | *Serinus pusillus* | R | K,L | LC |
| 531 | European Goldfinch | *Carduelis carduelis* | R/S | K,L | LC |
| 532 | Spectacled Finch | *Callacanthis burtoni* | R | K | LC |
| 533 | Mongolian Finch | *Bucanetes mongolicus* | R | L | LC |
| 534 | Common Rosefinch | *Carpodacus erythrinus* | P/S | J,K,L | LC |
| 535 | Pink-browed Rosefinch | *Carpodacus rodochroa* | S | K | LC |
| 536 | Red-mantled Rosefinch | *Carpodacus rhodochlamys* | R/S | K,L | LC |
| 537 | Red-fronted Rosefinch | *Carpodacus puniceus* | R | L | LC |
| 538 | Streaked Rosefinch | *Carpodacus rubicilloides* | R | L | LC |

(continued)

**Table 35.1** (continued)

| S. no. | Common name | Scientific name | Status | Distribution | IUCN status |
|---|---|---|---|---|---|
| 539 | Great Rosefinch | *Carpodacus rubicilla* | R | L | LC |
| 540 | White-browed Rosefinch | *Carpodacus thura* | R/S | K,L | LC |
| 541 | Dark-breasted Rosefinch | *Carpodacus nipalensis* | S | J,K | LC |
| 542 | Orange Bullfinch | *Pyrrhula aurantiaca* | R | K (EWH) | LC |
| 543 | Hawfinch* | *Coccothraustes coccothraustes* | V | K | LC |
| 544 | Black-and-yellow Grosbeak | *Mycerobas icterioides* | R | J,K | LC |
| 545 | White-winged Grosbeak | *Mycerobas carnipes* | R | J,K | LC |
| Emberizidae (buntings) | | | | | |
| 546 | Crested Bunting | *Melophus lathami* | S | J,K | LC |
| 547 | Yellowhammer | *Emberiza cicitrinella* | W | L | LC |
| 548 | Common Reed Bunting | *Emberiza schoeniclus* | W | L | LC |
| 549 | Little Bunting | *Emberiza pusilla* | P | L | LC |
| 550 | White-capped Bunting | *Emberiza stewarti* | P/S | J,K | LC |
| 551 | Chestnut-eared Bunting | *Emberiza fucata* | R | K | LC |
| 552 | Rock Bunting | *Emberiza cia* | R/S | J,K,L | LC |
| 553 | Pine Bunting | *Emberiza leucocephalos* | W | J,K,L | LC |
| 554 | Red-headed Bunting | *Emberiza bruniceps* | P | L | LC |
| 555 | Ortolan Bunting | *Emberiza hortulana* | P | L | LC |

## *35.3.2 Distribution and Status*

**Resident (R)** Species recorded throughout the year. Most of these breed in the area. Populations fluctuate and may get augmented temporarily with migrating individuals from outside. Mainly include pheasants and partridges (Phasianidae), many birds of prey (Accipitridae), parakeets (Psittacidae), woodpeckers (Picidae), and a good number of passerine species like crows and magpies (Corvidae), tits (Paridae), bulbuls (Pycnonotidae), prinias and tailorbirds (Cisticolidae), babblers Timalidae, and some redstarts (Muscicapidae).

**Passage Migrant (P)** Species recorded for a brief period of the year only. These species are on passage to or from their wintering destinations elsewhere and use the area briefly as a transit in autumn (September to November) and/or in spring (February to April). Mainly includes ducks and geese (Anatidae), some harriers and buzzards (Accipitridae), many waders (Scolopacidae), and a few leaf warblers (Phylloscopidae).

**Summer Visitor (S)** Species recorded during summer months (March/April to October/November). Such species mostly breed in the area or include those who overstay their visit (over-summering). Mainly includes cuckoos (Cuculidae), swifts (Apopidae), swallows and martins (Hirundinidae), and many leaf warblers (Phylloscopidae).

**Winter Visitor (W)** Species recorded during winter months (September/October to February/March). Mostly include the waterfowl (Anatidae), falcons (Falconidae), some waders (Scolopacidae), and a few bunting species (Emberizidae).

### *35.3.3 Bird habitats*

Based on the types of vegetation, Jammu is divisible into three natural regions (Sharma and Kachroo 1981):

(a) **Flat semi-arid land,** essentially a continuation of the Punjab plains, characterized by a subtropical climate, influenced by the south-west monsoon. This area supports scrub forests dominated by *Acacia modesta*, *Acacia nilotica* and *sapium sebiferum* with annual and perennial shrubs like *Argemone mexicana*, *Coronopus didymus*, *Cleome viscosa*, and *Cassia occidentalis.* This type of vegetation is home to quails, partridges, thick-knees, larks, weavers, munias, and prinias.
(b) **Lower hills (Jammu Kandi),** with scrub forests at lower elevations and mixed deciduous at higher elevations. The vegetation apart from *Acacia* spp. includes species like *Zizphus mauritiana*, *Flacourtia indica*, *Bauhinia variegata*, *Ougenia ougienensis*, *Grewia optiva*, and *Lannea coromandelica* associated with shrub species like *Capparis sepiara*, *Carrisa opacum*, and *Mimosa rubicaulis.* This area supports a huge number of species including raptors, barbets, woodpeckers, shrikes, babblers, flycatchers, and buntings.
(c) **Temperate uplands,** with subtropical forests in the lower and temperate forests in the upper elevations. The vegetation is characterized by tree species like *Butea monosperma*, *Elaeodendron roxburghii*, *Mitragyna parvifolia*, and *Xylosma longifolium* in lower elevations and *Pinus roxburghii* and *Cedrus deodara* in the higher temperate zone. The area supports species of pheasants, eagles, owls, woodpeckers, tits, warblers, thrushes, and flycatchers.

In addition to this, Jammu region has a small but significant assemblage of wetlands which support species of ducks and geese, storks, cormorants, waders, and cranes.

The temperate Kashmir Himalaya comprises three natural regions, which are as follows:

(a) **Kashmir Valley,** drained by river Jhelum and its tributaries, it has vegetation which is influenced by extensive cultivation of croplands and orchards, mainly in the form of paddy, maize and apple. *Myricaria germanica* and *Polygonum alpinum* are the main natural associations on river beds and banks, respectively. Other species include *Spiraea lindleyana*, *Impatiens brachycentra*, *Chenopodium botrys*, *Euonymus hamiltonianus*, *Lavatera kashmiriana* and species of *Geranium*, *Rosa*, and *Salix.* Important fruit species attracting birds are species of *Rubus* and *Juglans.* This type of vegetation harbors species of parakeets, barbets, corvids, bulbuls, leaf warblers, starlings, thrushes, flycatchers, wagtails, and finches.
(b) **Kashmir Mountains,** encasing the valley these mountains include the Pir Panjal Range and the Inner Himalaya, having temperate vegetation comprising *Pinus wallichiana*, *Cedrus deodara*, *Picea smithiana*, *Taxus wallichiana*, *Abies pindrow*, *Aesculus indica*, *Acer* spp., *Juglans regia*, and *Salix dendiculata.* The herbaceous component in these forests includes *Androsace rotundifolia*, *Campanula colorata*, *Fragaria nubicola*, *Germanium wallichianum*, *Lamium album*, *Trichholepis elongata*, *Sedum ewersii*, and *Aconogonum alpinum*. The birds inhabiting these forests include pheasants, raptors, woodpeckers, minivets, tits, warblers, nuthatches, flycatchers, pipits, and buntings.
(c) **Wetlands,** which here would include lakes, marshes and other water bodies in the valley bed, support an aquatic vegetation dominated by *Ceratophyllum demersum*, *Hydrilla verticillata*, *Mirophyllum spicatum*, *Zanichellia palustris*, *callitriche* spp., *Nymphaea alba*, *Nymphoides peltatum*, and *Trapa natans* (Kaul and Zutshi 1967; Kak 1990). The emergent aquatic species include *Cyperus glomeratus*, *Hippurus vulgaris*, *Myriophyllum verticillatum*, and *Nelumbo nucifera.* Birds found in and around wetland habitats include ducks and geese, grebes, herons, cormorants, waders, gulls, kingfishers, and wagtails.

The cold arid trans-Himalayan region of Ladakh is almost tree-less, with most woody vegetation growing along the moist river margins. Common species include *Berberis ulicina*, *Rosa webbiana*, *Salix* spp., *Caragana pygmaea*, *Acantholimon lycopodioides, Thylacospermum rufifragus*, *Artemesia* spp., *Scorzonera virgata*, *Tranacetum longifolium*, *Capparis spinosa*, *Corydalis adiantifolia*, *Euphorbia tibetica*, *Inula raphanorhiza*, *Malcolmia africana*, and *Peganum harmala.* The birds found in this type of habitats are mainly partridges, raptors, larks, leaf warblers, redstarts, snowfinches, accentors, pipits, finches, and buntings. Besides, the Ladakh region is home to some important high-altitude lakes and marshes which support a variety of bird species including ducks and geese, grebes, waders, cranes, gulls, and terns.

### 35.3.4 Threatened Taxa

Rahmani et al. (2014) have listed 24 bird species from J&K which fall under one of the four categories of threatened taxa under the IUCN Red List. These include 2, 2, 11, and 9 species, respectively, under Critically Endangered (CR), Endangered (EN), Vulnerable (VU), and Near Threatened (NT) categories. A fresh look at the species with updating of their conservation status as per 2017 IUCN assessment, however, has revealed that 32 species of birds are threatened in the State (Table 35.2). Among these, three species are “CR” (white-rumped vulture, *Gyps bengalensis*; slender-billed vulture, *Gyps tenuirostris*; and Siberian crane, *Grus leucogeranus*, which is now believed to be extinct from the subcontinent); four species are “EN” (Egyptian vulture, *Neophron percnopterus*; white-headed duck, *Oxyura leucocephala*; Pallas’s fish eagle, *Haliaeetus leucoryphus*; and saker falcon, *Falco cherrug*); one species (Eurasian roller, *Coracias garrulus*, earlier listed under “NT”) is no longer considered as threatened and has been “upgraded” to the “Least Concern” category); while Pallas’s fish eagle, *Haliaeetus leucoryphus*, which earlier figured under “VU” category is now listed under “EN.” Similarly, six species, namely, laggar falcon (*Falco jugger*), bearded vulture (*Gypaetus barbatus*), river tern (*Sterna aurantia*), painted stork (*Mycteria leucocephala*), red kite (*Milvus milvus*), and pallid harrier (*Circus macrourus*), which previously didn’t figure under any threatened category, have been included in “NT” category (Plates 35.1, 35.2, and 35.3).

### 35.3.5 Restricted Range Species and Endemism

In the Western Himalaya (Endemic Bird Area 128), the main habitats are Temperate Coniferous or Broad-Leaved Forests, Subalpine Forests, and Montane Grasslands (Rahmani et al. 2014). These habitats are known to have 11 restricted range avian species (Stattersfield et al. 1998; Birdlife International 2001), out of which 9 are found in Jammu and Kashmir. These are Western Tragopan (*Tragopan melanocephalus*), Cheer Pheasant (*Catreus wallichii*), Brook’s Leaf Warbler (*Phylloscopus subviridis*), Tytler’s Leaf Warbler (*Phylloscopus tytelri*), Kashmir Flycatcher (*Ficedula subrubra*), Spectacled Finch (*Callacanthis burtoni*), White-throated Tit (*Aegithalos nivergularis*), Orange Bullfinch (*Pyrrhula aurantiaca*), and Kashmir Nuthatch (*Sitta cashmirensis*). Six of these are endemic to the western Himalaya and one—Kashmir Flycatcher—is known to breed only in the Kashmir Valley.

**Table 35.2** List of threatened birds of Jammu and Kashmir State

| S. no. | Common name | Scientific name |
|---|---|---|
| **Critically Endangered (3)** | | |
| 01 | White-rumped Vulture | *Gyps bengalensis* |
| 02 | Slender-billed Vulture | *Gyps tenuirostris* |
| 03 | Siberian Crane | *Grus leucogeranus* |
| **Endangered (4)** | | |
| 04 | Egyptian Vulture | *Neophron percnopterus* |
| 05 | White-headed Duck | *Oxyura leucocephala* |
| 06 | Pallas's Fish Eagle | *Haliaeetus leucoryphus* |
| 07 | Saker Falcon | *Falco cherrug* |
| **Vulnerable (11)** | | |
| 08 | Western Tragopan | *Tragopan melanocephalus* |
| 09 | Cheer Pheasant | *Catreus wallichii* |
| 10 | Lesser White-fronted Goose | *Anser erythropus* |
| 11 | Long-tailed Duck | *Clangula hyemalis* |
| 12 | Marbled Duck | *Marmaronetta angustirostris* |
| 13 | Greater Spotted Eagle | *Aquila clanga* |
| 14 | Eastern Imperial Eagle | *Aquila heliacal* |
| 15 | Black-necked Crane | *Grus nigricollis* |
| 16 | Sarus Crane | *Grus antigone* |
| 17 | Yellow-eyed Pigeon | *Columba eversmanni* |
| 18 | Kashmir Flycatcher | *Ficedula subrubra* |
| **Near Threatened (14)** | | |
| 19 | Ferruginous Duck | *Aythya nyroca* |
| 20 | Painted Stork | *Mycteria leucocephala* |
| 21 | Black-necked Stork | *Ephippiorhynchus asiaticus* |
| 22 | Black-headed ibis | *Threskiornis melanocephalus* |
| 23 | Red Kite* | *Milvus milvus* |
| 24 | Bearded Vulture | *Gypaetus barbatus* |
| 25 | Cinereous Vulture | *Aegypius monachus* |
| 26 | Pallid Harrier | *Circus macrourus* |
| 27 | Laggar Falcon | *Falco jugger* |
| 28 | Eurasian Curlew | *Numenius arquata* |
| 29 | Black-tailed Godwit* | *Limosa limosa* |
| 30 | River Tern | *Sterna aurantia* |
| 31 | Long-billed Bush Warbler | *Bradypterus major* |
| 32 | Tytler's Leaf Warbler | *Phylloscopus tytleri* |


**Plate 35.1** (**a**) Cinerious Tit, (**b**) Black Bulbul, (**c**) Rock Bunting, (**d**) Black-throated Accentor, (**e**) Blue Rock Thrush, (**f**) Brown Accentor, (**g**) Brown-headed Gull, (**h**) Chukar Partridge, (**i**) Chestnut-bellied Rock Thrush, (**j**) Chestnut-eared Bunting, (**k**) Common Merganser, (**l**) Yellow-breasted Greenfinch. (Photo credit: Intesar Suhail)

## 35.4 Concluding Remarks

Jammu and Kashmir State has a rich diversity of birds, comprising 555 species belonging to 76 families in 20 orders. Among these, 32 (5.76 %) species are globally threatened and 9 (1.62%) species are endemic to the Western Himalaya. Jammu region, being the most diverse in terms of habitat types and vegetation, supports the largest number (381, 68.64%) of bird species found in the State, followed by the Kashmir region with 299 (53.87%), and closely by the Ladakh region with 291 (52.43%) species. 139 bird species are found only in the Jammu and not in the other


**Plate 35.2** (**a**) Bearded Vulture, (**b**) Eurasian Sparrowhawk, (**c**) Green Sandpiper, (**d**) Himalayan Woodpecker, (**e**) White-throated Kingfisher, (**f**) Spotted Nutcracker, (**g**) Winter Wren, (**h**) Blue Whistling Thrush, (**i**) Variegated Laughing Thrush, (**j**) Brown Dipper, (**k**) Citrine Wagtail, (**l**) European Goldfinch. (Photo credit: Intesar Suhail)

two regions; 83 species are found in Ladakh and not in the other 2 regions, while 39 species that are found in Kashmir do not occur in other 2 regions of the State. In spite of being home to a rich diversity of avifauna, the State lags far behind in avian research. Apart from a handful of studies on a few species or groups, hardly any noteworthy scientific studies are to be found. Focused scientific research on various bird species, particularly those under threat, is earnestly required to understand their ecology and suggest concrete measures for their conservation.


**Plate 35.3** (**a**) Black-necked Crane, (**b**) Black Stork, (**c**) Ruddy Shelduck, (**d**) Northern Pintail, (**e**) Mallard, (**f**) Himalayan Bluetail, (**g**) Robin Accentor, (**h**) Tibetan Sandgrouse, (**i**) Tibetan Snowcock, (**j**) Tibetan Snowfinch, (**k**) Common Raven, (**l**) Fire-fronted Serin. (Photo credit: Intesar Suhail)

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# Chapter 36
# Wild Mammalian Diversity in Jammu and Kashmir State

**Khursheed Ahmad, Bilal A. Bhat, Riyaz Ahmad, and Intesar Suhail**

**Abstract** This chapter presents an overview of the unique diversity and conservation status of wild mammalian fauna of the Jammu and Kashmir State. The State owing to the diverse habitats, wide altitudinal gradient, and climatic variations, ranging from lowland subtropical Jammu plains, temperate region of Kashmir to high-altitude cold desert of Trans-Himalaya of Ladakh, is home to an impressive faunal diversity, including mammals, many of which are endemic to this Himalayan State. The State possesses 112 species of mammals: including 34 globally threatened with 1 Critically Endangered, 6 Endangered, 12 Vulnerable, and 8 Near Threatened species. Looking ahead, recommendations for better and effective management and conservation of the wild mammalian fauna of the State have been proposed for early implementation.

**Keywords** Mammals · Checklist · Distribution · Management · Conservation · Jammu and Kashmir

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_36

## 36.1 Introduction

India is one of the $17^{th}$ mega-diverse countries of the world. India has ten biogeographical regions recognized based on the landmass and species distribution (Rodgers and Panwar 1988). The northwestern Indian Himalayan State of Jammu and Kashmir (J&K) is located at the junction of the temperate Palaearctic and tropical Oriental biogeographic realms of the world. The State is biogeographically divided into three regions: Jammu, Kashmir and Ladakh, which are ecologically distinct entities with the broad vegetation types ranging between the lowland subtropical broadleaved forests of the Jammu plains, temperate forests of Kashmir to high-altitude cold desert vegetation of Ladakh.

Owing to the enormous diversity of habitat types, great altitudinal span and climatic variations, the State possesses a rich faunal diversity. Many of these mammal species are endemic and relatively confined to various areas of this Himalayan range. The diverse assemblage of wild sheep and goats represented by Blue sheep *Pseudois nayaur*, Urial *Ovis orientalis*, Argali *Ovis ammon*, Ibex *Capra sibirica*, Markhor *Capra falconeri*, Himalayan Tahr *Hemitragus jemlahicus*, Serow *Capricornis thar*, and Goral Nemorhaedus goral, is an indicator of the diversity. Though these species have their distribution range spread to far-off Central Asia and Middle East, yet they display greater adaptive variations in this region than in any other part of the world (Schaller 1977). Furthermore, the Kashmir Red Deer *Cervus hanglu hanglu* and Kashmir Musk Deer *Moschus cupreus* and Ladakh Urial Ovis orientalis are extremely threatened species endemic to this region and require immediate management and conservation attention. A comprehensive checlist dedicated to he State has yet not been compiled.

This chapter is an attempt to provide an updated checklist of mammalian diversity in Jammu and Kashmir along with the current conservation status. The chapter will act as a benchmark information and will guide conservation and management of biodiversity at the regional level. Further, with the current accelerated rate of global biodiversity loss and concordant conservation needs, this updated checklist provides desired scientific information to scientists, policy makers, biodiversity managers, technocrats, research scholars, naturalists and all other relevant stakeholders.

## 36.2 Materials and Methods

The current checklist of wild mammalian diversity of Jammu and Kashmir along with the current status, distribution and threats was compiled from primary and secondary sources. We referred to the available scientific literature and the recently conducted extensive field surveys to compile the checklist and document the threats of the wild mammalian species in the State (Ward 1905, 1922a, b; Das et al. 1964;

Das 1966; Gee 1965; Prater 1971; Schaller 1977; Nath 1985, 1987; Dar et al. 2002; Anonymous 2008; Ahmad et al. 2009, 2015; Bhatnagar et al. 2009; Shah et al. 2011; Ahmad 2014; Menon 2014; IUCN 2017).

## 36.3 Results and Discussion

A total of 112 species of mammals belonging to 22 families and 8 orders occur in the State. Rodentia comprise 25 species, followed by Carnivora (with 24 species), Insectivora (21 species), Artiodactyla (20 species), Lagomorpha and Chiroptera (7 species each), Primates (3 species), and Perisiodactyla and Pholidota (1 species each) (Table 36.1).

The State of Jammu and Kashmir possesses an impressive assemblage of mammalian species, ranging from the widely distributed Spotted Deer to the endemic Kashmir Stag. Unlike most other terrestrial landscapes of the country, the wildlife populations in the Himalaya are not restricted to Protected Areas, but occur across the landscape (Bhatnagar et al. 2006c). However, the population and range of these threatened and restricted range species have drastically reduced due to anthropogenic pressure, unwise development, livestock grazing, habitat fragmentation and degradation, poaching poor law enforcement and lack of awareness (Ahmad et al. 2009; Bhatnagar et al. 2009; Namgail et al. 2007; Ahmad et al. 2010a, b; Ahmad 2014). These biotic interferences are known to have long-term conservation implications for restricted range species (Schaller 1977). Some of the Trans-Himalayan large herbivores are also critically threatened and have undergone local extinctions and range reductions over the past few decades (Fox et al. 1991; Mishra et al. 2002; Bhatnagar et al. 2006b).

The wild herbivores, an important component of faunal diversity, form the major prey for mammalian predators, and are as such indicators of health of the habitat (Mishra 1997; Bagchi and Mishra 2006; Ahmad et al. 2009; Shah et al. 2009; Ahmad et al. 2010a, b). Thus, the decline in the ungulate populations and degradation of the wild habitats are regarded as the major factors in the recent increase in human-wildlife conflict in the State. Such conflict has resulted in the loss of human life and wild animals. These incidents have also created a negative attitude in local people towards wildlife conservation. The major stakeholders, such as policy makers, wildlife managers, research scholars/scientists, students, locals, naturalists, conservationists, and government and non-governmental organizations (NGOs) have to work together towards the long term conservation of this precious component of biodiversity.

**Table 36.1** Updated checklist of wild mammals of Jammu and Kashmir State

| S. No. | Common name | Scientific name | IUCN status | Distribution in three regions of J&K | Indian Wildlife Protection Act 1972 (Schedule) |
|---|---|---|---|---|---|
| Order Primates Family Cercopitecidae | | | | | |
| 01 | Rhesus Macaque | *Macaca mulatta* Zimmermann, 1780 | LC* | J**, K | II |
| 02 | Himalayan Langur | *Semnopithecus schistaceus* Hodgson, 1840 | LC | J, K | II |
| 03 | Kashmir Grey Langur | *Semnopithecus ajax* Pocock, 1928 | EN | J, K | II |
| Order Perrisodactyla Family Equidae | | | | | |
| 04 | Tibetan Wild Ass | *Equus kiang kiang* Moorcroft, 1841 | LC | L | I |
| Order Artiodactyla Family Moschidae | | | | | |
| 05 | Himalayan Musk Deer | *Moschus leucogaster* Hodgson, 1839 | EN | J, K | I |
| 06 | Kashmir Musk Deer | *Moschus cupreus* Grubb, 1982 | EN | K | I |
| Family Cervidae | | | | | |
| 07 | Kashmir Red Deer Or Hangul | *Cervus hanglu hanglu* (Wagner, 1844) | CR | K | I |
| 08 | Spotted Deer | *Axis axis* Erxleben, 1777 | LC | J | III |
| 09 | Barking Deer | *Muntiacus muntjak* Zimmermann, 1780 | LC | J, K | III |
| 10 | Sambar | *Rusa unicolor* Kerr, 1792 | VU | J | III |
| 11 | Hog Deer | *Axis porcinus* Zimmermann, 1780 | LC | J | III |
| Family Bovidae | | | | | |
| 12 | Wild Yak | *Bos mutus* Przewalski, 1883 | VU | L | I |
| 13 | Blue Bull or Nilgai | *Boselaphus tragocamelus* Pallas, 1766 | LC | J | III |
| 14 | Tibetan Antelope | *Pantholops hodgsonii* Abel, 1826 | NT | L | I |
| 15 | Tibetan Gazelle | *Procapra picticaudata* Hodgson, 1846 | NT | L | I |
| 16 | Asiatic Ibex | *Capra sibirica* Pallas, 1776 | LC | K, L | I |

(continued)

**Table 36.1** (continued)

| S. No. | Common name | Scientific name | IUCN status | Distribution in three regions of J&K | Indian Wildlife Protection Act 1972 (Schedule) |
|---|---|---|---|---|---|
| 17 | Markhor | *Capra falconeri* Wagner, 1839 | NT | J, K | I |
| 18 | Blue Sheep | *Pseudois nayaur* Hodgson, 1833 | LC | L | I |
| 19 | Himalayan Tahr | *Hemitragus jemlahicus* Smith, 1826 | NT | J | I |
| 20 | Urial | *Ovis orientalis* Gmelin, 1774 | VU | L | I |
| 21 | Argali | *Ovis ammon* Linnaeus, 1758 | NT | L | I |
| 22 | Himalayan Grey Goral | *Nemorhaedus goral bedfordi* Lydekker, 1905 | NT | J, K | III |
| 23 | Himalayan Serow | *Capricornis thar* Hodgson, 1831 | NT | K | I |
| Family Suidae | | | | | |
| 24 | Indian Wild Pig | *Sus scrofa* Linnaeus, 1758 | LC | J, K | III |
| Order Carnivora Family Felidae | | | | | |
| 25 | Common Leopard | *Panthera pardus* Linnaeus, 1758 | VU | J, K | I |
| 26 | Snow Leopard | *Panthera uncia* Schreber, 1775 | VU | J, K, L | I |
| 27 | Eurasian Lynx | *Lynx lynx* Linnaeus, 1758 | LC | L | I |
| 28 | Pallas's Cat | *Octolobus manul* Pallas, 1776 | NT | L | I |
| 29 | Leopard Cat | *Prionailurus bengalensis trevelyani* Kerr, 1792 | LC | J, K | I |
| 30 | Rusty Spotted Cat | *Prionailurus rubiginosus* Geoffroy Saint-Hilaire, 1831 | VU | J | I |
| 31 | Jungle Cat | *Felis chaus affinis* Schreber, 1777 | LC | J, K | II |
| Family Viverridae | | | | | |
| 32 | Himalayan Palm Civet | *Paguma larvata* (Smith, 1827 | LC | J, K | II |
| 33 | Small Indian Civet | *Viverricula indica* Geoffroy Saint-Hilaire, 1803 | LC | J, K | II |

(continued)

**Table 36.1** (continued)

| S. No. | Common name | Scientific name | IUCN status | Distribution in three regions of J&K | Indian Wildlife Protection Act 1972 (Schedule) |
|---|---|---|---|---|---|
| 34 | Common Palm Civet | *Paradoxurus hemaphroditus* Pallas, 1777 | LC | J | II |
| Family Herpestidae | | | | | |
| 35 | The Small Indian Mongoose | *Herpestes auropunctatus* Illiger, 1811 | LC | J | IV |
| 36 | Grey or Common Mongoose | *Herpestes edwardsii* Geoffroy Saint-Hilaire, 1818 | LC | J, K | II |
| Family Canidae | | | | | |
| 37 | Grey Wolf | *Canis lupus chanco* C.I.Chanco Grey, 1863 | LC | J, K, L | I |
| 38 | Golden Jackal | *Canis aureus* Linnaeus, 1758 | LC | J, K | II |
| 39 | Wild Dog | *Cuon alpinus* Pallas, 1811 | EN | L | II |
| 40 | Tibetan Sand Fox | *Vulpes ferrilata* Hodgson, 1842 | LC | L | I |
| 41 | Red Fox | *Vulpes vulpes* Linnaeus, 1758 | LC | J, K, L | II |
| Family Ursidae | | | | | |
| 42 | Asiatic Black Bear | *Ursus thibsetanus* Cuvier, 1823 | VU | J, K | I |
| 43 | Himalayan Brown Bear | *Ursus arctos* Linnaeus, 1758 | LC | J, K, L | II |
| Family Mustelidae | | | | | |
| 44 | Yellow-throated Marten | *Martes flavigula* Bodaert, 1785 | LC | J, K | II |
| 45 | Stone or Beach Marten | *Martes foina intermedia* Erxleeben, 1777 | LC | J, K | I |
| 46 | Eurasian Otter | *Lutra lutra* Linnaeus, 1758 | NT | J, K | I |
| 47 | Mountain Weasel | *Mustela altaica* Pallas, 1811 | NT | J, K, L | II |
| 48 | Himalayan Stoat | *Mustela ermine* Linnaeus, 1758 | LC | J, K, L | II |
| 49 | Siberian Weasel | *Mustela sibirica* Pallas, 1773 | LC | J, K, L | II |
| Order Lagomorpha Family Leporidae | | | | | |
| 50 | Indian Hare | *Lepus nigricollis* F. Cuvier, 1823 | LC | J | IV |

(continued)

**Table 36.1** (continued)

| S. No. | Common name | Scientific name | IUCN status | Distribution in three regions of J&K | Indian Wildlife Protection Act 1972 (Schedule) |
|---|---|---|---|---|---|
| 51 | Desert Hare | *Lepus tibetanus* Waterhouse, 1841 | LC | J, K | Not listed |
| 52 | Woolly Hare | *Lepus oiostolus* Hodgson, 1840 | LC | K,L | Not listed |
| Family Ochotonidae | | | | | |
| 53 | Royle's Pika | *Ochotona roylei* Ogliby, 1839 | LC | J, K | IV |
| 54 | Large Eared Pika | *Ochotona macrotis* Gunther, 1875 | LC | K, L | Not listed |
| 55 | Plateau Pika | *Ochotona curzoniae* Hodgson, 1858 | LC | L | Not listed |
| 56 | Ladakh Pika | *Ochotona ladacensis* Gunther, 1875 | LC | L | Not listed |
| 57 | Nubra Pika | *Ochotona nubrica* Thomas, 1922 | LC | L | Not listed |
| Order Rodentia Family Histicidae | | | | | |
| 58 | Indian Crested Porcupine | *Hystrix indica* Kerr, 1792 | LC | J, K | IV |
| Family Sciuridae | | | | | |
| 59 | Long-Tailed Marmot | *Marmota caudate* Geoffroy, 1844 | LC | K, L | II |
| 60 | Himalayan Marmot | *Marmota himalayana* Hodgson, 1840 | LC | J, K, L | II |
| 61 | Red Giant Flying Squirrel | *Petaurista petaurista Albiventer* Pallas, 1766 | LC | J, K | II |
| 62 | Woolly Flying Squirrel | *Eupetaurus cinereus* Thomas, 1888 | EN | K | II |
| 63 | Kashmir Flying Squirrel | *Eoglaucomys fimbriatus fimbriatus* Grey, 1837 | LC<br>LC | J, K<br>K | Not listed |
| 64 | Five-Striped Palm Squirrel | *Funambulus pennantii* Wroughton, 1905 | LC | J | IV |
| Family Muridae | | | | | |
| 65 | Scully's Mountain Vole | *Alticola blanfordi* Scully, 1880 | DD | J, K | |
| 66 | Silvery Mountain Vole | *Alticola argentatus* Severtzov, 1879 | LC | K, L | Not listed |

(continued)

**Table 36.1** (continued)

| S. No. | Common name | Scientific name | IUCN status | Distribution in three regions of J&K | Indian Wildlife Protection Act 1972 (Schedule) |
|---|---|---|---|---|---|
| 67 | Stoliczka's Mountain Vole | *Alticola stoliczkanus* Blanford, 1875 | LC | L | Not listed |
| 68 | Thomas's Short-Tailed Vole | *Alticola stracheyi* Thomas, 1880 | DD | J, K | Not listed |
| 69 | Sub-alpine Kashmir Vole | *Hyperacrius fertilis* True, 1894 | NT | J, K | Not listed |
| 70 | Muree or Coniferous Kashmir Vole | *Hyperacrius wynnei* Blanford, 1881 | LC | K | Not listed |
| 71 | Kashmir Mountain Vole | *Alticola montosa* True, 1894 | VU | K | Not listed |
| 72 | Blyth's Mountain Vole | *Microtus leucurus* Blyth*, 1863* | LC | J, K, L | Not listed |
| 73 | Tibetan or Ladakh Dwarf Hamster | *Cricetulus alticola* Thomas, 1917 | LC | L | Not listed |
| 74 | Grey Hamster | *Cricetulus migratorius* Pallas*, 1773* | LC | K, L | Not listed |
| 75 | Indian Gerbil | *Tatera indica* Hardwicke*, 1807* | LC | J | Not listed |
| 76 | Himalayan Rat | *Rattus pyctoris* Hodgson, 1845 | LC | J | V |
| 72 | Lesser Bandicoot Rat | *Bandicota bengalensis wardii* Gray and Hardwicke, 1833 | LC | J, K | V |
| 77 | House Mouse | *Mus musculus* Linnaeus, 1758 | LC | J, K, L | V |
| 78 | Indian Long-Tailed Tree Mouse | *Vandleuria oleracea* Bennett, 1832 | LC | J | V |
| 79 | Miller's Wood Mouse or Kashmir Field Mouse | *Apodemus rusiges* Miller, 1913 | LC | J, K | V |
| 80 | Kashmir Birch Mouse | *Sicista concolor leathemi* Buchner, 1892 | LC | K | Not listed |
| 81 | White-Bellied Rat | *Niviventer niviventer* Hodgson, 1836 | LC | J, K | V |
| 82 | House Rat or Black Rat | *Rattus rattus* Linnaeus, 1758 | LC | J, K, L | V |

(continued)

**Table 36.1** (continued)

| S. No. | Common name | Scientific name | IUCN status | Distribution in three regions of J&K | Indian Wildlife Protection Act 1972 (Schedule) |
|---|---|---|---|---|---|
| Order Insectivora Family Soricidae | | | | | |
| 83 | Pale Grey Shrew | *Crocidura perigrisea* Miller, 1913 | DD | J, K | Not listed |
| 84 | Eurasian Pygmy Shrew | *Sorex minutes* Linnaeus, 1766 | LC | J, K | Not listed |
| 85 | Flat Headed Kashmir Shrew | *Sorex planiceps* Miller, 1911 | LC | J, K | Not listed |
| 86 | Gueldenstaedt's White-Toothed Shrew | *Crocidura suaveolens* (gueldenstaedti) Pallas, 1811 | LC | J, K | Not listed |
| 87 | Kashmir White-Toothed Shrew or Dusky Shrew | *Crocidura pullata* Miller, 1911 | DD | J, K, L | Not listed |
| 88 | Tibetan Shrew | *Sorex thibetanus* Kastschenko, 1905 | DD | L | Not listed |
| 89 | Horsfield's Shrew | *Crocidura horsfieldi* Tomes, 1856 | DD | J, K, L | Not listed |
| 90 | House Shrew or Grey Musk Shrew | *Suncus murinus* Linnaeus, 1766 | LC | J, K, L | Not listed |
| Order Pholidota Family Manidae | | | | | |
| 91 | Indian Pangolin | *Manis crassicaudata* Gray, 1827 | NT | J | I |
| Order Chiroptera Family Megadermatidae | | | | | |
| 92 | Greater False Vampire | *Megaderma lyra* E. Geoffroy Saint-Hilaire, 1810 | LC | J, K | Not listed |
| Family Rhinolophidae | | | | | |
| 93 | Greater Horseshoe Bat | *Rhinolophus ferrumequinum proximus* Schreber, 1774 | LC | J, K | Not listed |
| 94 | Lesser Horseshoe Bat | *Rhinolophus hipposideros* Bechstein, 1800 | LC | J, K | Not listed |
| Family Pteropodidae | | | | | |
| 95 | Indian Flying Fox | *Pteropus giganteus leucocephalus* Brunnich, 1782 | LC | J | V |
| Family Vespertilionidae | | | | | |
| 96 | Common Noctule | *Nyctalus noctula* Schreber, 1774 | LC | J, K | Not listed |

(continued)

**Table 36.1** (continued)

| S. No. | Common name | Scientific name | IUCN status | Distribution in three regions of J&K | Indian Wildlife Protection Act 1972 (Schedule) |
|---|---|---|---|---|---|
| 97 | Grey Long-Eared Bat | *Plecotus austriacus* Fischer, 1829 | LC | J, K, L | Not listed |
| 98 | Leisler's Bat | *Nyctalus leisleri* Kuhl, 1817 | LC | J, K | Not listed |
| 99 | Kashmir Cave Bat | *Myotis longipes* Dobson, 1873 | DD | J, K | Not listed |
| 100 | Nepalese Whiskered Bat | *Myotis muricola caliginosus* Gray, 1846 | LC | J, K | Not listed |
| 101 | Brown Long-Eared Bat | *Plecotus auritus* Linnaeus, 1758 | LC | J, K | Not listed |
| 102 | Scully's Tube-Nosed Bat | *Murina tubinaris* Scully, 1881 | LC | J, K | Not listed |
| 103 | Hutton's Tube-nosed Bat | *Murina huttoni huttoni* Peters, 1872 | LC | J, K | Not listed |
| 104 | Bottae's Serotine | *Eptesicus bottae* Peters, 1869 | LC | J, K | Not listed |
| 105 | Bobrinskii's Serotine | *Eptesicus gobiensis* Bobrinskii, 1926 | LC | J, K | Not listed |
| 106 | Hemprich's Long-Eared Bat | *Otonycteris hemprichii* Peters, 1859 | LC | J, K | Not listed |
| 107 | Common Serotine | *Eptesicus serotinus* Schreber, 1774 | LC | J, K | Not listed |
| 108 | Parti-Coloured Bat | *Vespertilio murinus* Linnaeus, 1758 | LC | J, K | Not listed |
| 109 | Mount Popa Pipistrelle | *Pipistrellus pipistrellus paterculus* Thomas, 1915 | LC | J, K | Not listed |
| 110 | Eastern Barbastelle | *Barbastella leucomelas* Cretzschmar, 1826 | LC | J, K | Not listed |
| 111 | Common Pipistrelle | *Pipistrellus pipistrellus Aladdin* Schreber, 1774 | LC | - | Not listed |
| 112 | Hardwicke's Forest Bat | *Kerivoula hardwickii* Horsfield, 1824 | LC | - | Not listed |

**CR* = Critically Endangered; *EN* = Endangered; *VU* = Vulnerable; *NT* = Near Threatened; *LC* = Least Concern; *DD* = Data Deficient. ***J* = Jammu; *K* = Kashmir; *L* = Ladakh

### *36.3.1 Flagship Mammals of Jammu and Kashmir State*

- Kashmir Red Deer

The Kashmir Red Deer or Hangul *(Cervus hangul hanglu)*, the State animal of Jammu and Kashmir has recently been reassessed as one of the three subspecies of a separate species, Tarim Red Deer (*Cervus hanglu*), and listed as Critically Endangered (Brook et al. 2017; IUCN 2017). Hangul, once distributed widely in the mountains of the Kashmir region of Northwest Himalaya in an arc of 40 mile (64 km) wide, extending from Keran in Kishanganga catchments and Dorus in the Lolab valley in Bandipora to Kishtwar National Park, although small populations, also occurred in Chamba district of Himachal Pradesh (Ahmad et al. 2009; Qureshi et al. 2009; Ahmad et al. 2013; Kaul et al. 2018). At present, the only viable population of Hangul is confined to Dachigam National Park with some relic Hangul populations also occurring in the adjoining areas of Brein/Nishat and Shikargah Conservation Reserves and Overa-Aru Wildlife Sanctuary, besides Surfrao/Akhal and Kangan blocks of the Sind Forest Division in Kashmir valley (Kurt 1978; Ahmad 2006; Ahmad et al. 2009; Qureshi et al. 2009; Ahmad et al. 2015). Estimates over the past years of the Hangul population in Dachigam National Park and adjoining areas show wide fluctuations, with a drastic decline from the 1980s from 2000 in 1947 (Gee 1965) to 140–170 in 1970 (Holloway 1971) and 175 in 1992 to 110–130 in 2015 (Ahmad et al. 2015). Poaching, habitat fragmentation and habitat degradation and livestock pressure, disease transmission from livestock and other anthropogenic pressures are the cause for its continued decline (Nashiruddullah et al. 2007; Ahmad et al. 2009, 2015; Shah et al. 2011; Kaul et al. 2018).

- Kashmir Musk Deer

Musk Deer (*Moschus* sp.) is a primitive deer-like ruminant belonging to the family Moschidae. It inhabits the forested and alpine scrub habitats of mountains in Asia (Sathyakumar et al. 2013). Recently, Groves and Grubb (2011) reclassified Musk Deer into seven species. Kashmir Musk Deer (*Moschus cupreus*) was given the status of a species. It is endemic to the Kashmir region of the Jammu and Kashmir State (Timmins and Duckworth 2015; Sathyakumar et al. 2013) and is Endangered (Timmins and Duckworth 2015). It occurs along the northern bank of Jhelum River, and little is known of the species' current status and distribution in Kashmir mountains. Poaching, habitat degradation, livestock grazing and anthropogenic pressure are the major threats to its survival.

- Kashmir Markhor

The markhor *Capra falconeri* is a goat (Family Bovidae) of the Hindukush-Himalaya (Schaller 1977), occurring from Kashmir (Fox and Johnsingh 1997) in the southeast to Afghanistan in the west (Habibi 1997) and Tajikistan in the north (Wienberg et al. 1997). Its population is estimated to have been about 3000 in the late 1990s, mostly in small groups (Hess et al. 1997). In India, Markhor is found only in Jammu and Kashmir. The State is one of the important areas for Markhor globally and the primary area for the “Pir Panjal Markhor” (*Capra falconeri cashmiriensis*) (Ranjitsinh et al. 2005; Bhatnagar et al. 2009). The historic distribution of Markhor in the State was continuous along the Pirpanjal range from Banihal pass in the south, through Tattakuti and Khara Gali (Poonch), Hirpora (Shopian), Gulmarg (Nilkanth area), and Boniyar (Burrard 1925, Stockley 1936). Across the Jhelum, it occurred from Kazinag to Shamsbari (Burrard 1925, Stockley 1936). However, recent studies have reported reduction in its distribution range, with Kazinag and Hirpora possessing the only viable populations (Ranjitsinh et al. 2005; Bhatnagar et al. 2009) with Tattakuti, Noorpur Gali and Khara Gali inhabiting small populations. The total population of markhor in Jammu and Kashmir has been estimated to be about 300–350 (Ranjitsinh et al. 2005; Bhatnagar et al. 2009).

- Ladakh Urial

The Ladakh Urial (*Ovis vignei vignei*), a wild sheep, is endemic to Jammu and Kashmir. Its distribution is restricted to the Indus and Shayok valleys in Ladakh (Chundawat and Qureshi 1999). Urial is ‘Vulnerable’ (IUCN 2017) and is on decline. The population was estimated to be about 2000 individuals (Namgail et al. 2009) and indicated an increment from 1500 individuals as was reported two decades earlier (Fox et al. 1991). But a recent study puts the number below 800 individuals (Ghoshal et al. 2018), which is perhaps the lowest so far. Competition with livestock, hunting by security agencies and locals and depredation by free ranging dogs have been the major threats (Raghavan and Bhatnagar 2006).

- Tibetan Argali

Tibetan argali (*Ovis ammon hodgsoni*), locally known as Nayan, is the rarest among the wild sheep. It is distributed across the Tibetan Plateau and adjacent mountains. In India, the main population of around 300–360 survives in the Ladakh region of J&K, with a smaller population in Sikkim (Namgail et al. 2009). It is one among the two Argali subspecies categorized as endangered by the IUCN. The preference for open areas, generally closer to human settlements, has made it an easy hunt for nomadic herders, army personnel, and some government officers who hunted the species for meat, besides trophy hunting by hunters (Namgail 2004). Competition from Pashmina goats seems to be current threat, hindering the recovery of Argali in Ladakh (Namgail et al. 2007).

- Snow Leopard

Snow leopard, a native wild cat, is one of the most elusive and rare wild animal species found in the high mountains of Central and South Asia (Schaller et al. 1988; Hussain 2003; McCarthy and Chapron 2003). It is a keystone species and an indicator of healthy high mountain ecosystem. Snow Leopard is the apex predator of the Himalayan ecosystem. It is found in 12 countries including India, and its global population ranges from 3921 to 6290 individuals. The State of Jammu and Kashmir, with a potential habitat of 77,800 km$^2$, is the largest continuous habitat for the Snow Leopard in India, occupying ca 60% of its national distribution range (Anon. 2008). Thus, the State has a crucial role in the conservation of this charismatic species and the associated prey and the fragile high altitude ecosystem.

- Tibetan Antelope

Tibetan antelope (*Pantholops hodgsonii*) or 'Chiru' is confined to the Tibetan Plateau. Its geographical range extends to about 1600 km across the Tibetan Plateau, with an eastern limit near Ngoring Hu (Tibet Autonomous Region) and a western limit in Ladakh (India). In India, it is found only in eastern Ladakh (Fox et al. 1991; Sarkar et al. 2008; Ahmad et al. 2017).

Chiru is a keystone species and world's hardiest mountain ungulates that can survive in temperatures as low as –40$^{o}$ C. Most of their distribution range falls above 4,000 m, and in Depsang Plains in northern Ladakh, they can be found as high as 5500 m (Sarkar et al. 2008; Ahmad et al. 2017). The presence of fine under fleece, known as 'Shahtoosh', enables it to sustain in extreme cold temperature and at very high altitudes. The Shahtoosh is banned as chiru are killed for Shahtoosh, from which fine woolen yarn is produced which commands a high price in the market (Mookerjee et al. 2006).

- Tibetan Gazelle

The Tibetan Gazelle (*Procapra picticaudata*), a species endemic to the Tibetan Plateau, is restricted to the Changthang area of Ladakh in Jammu & Kashmir. In the Ladakh region, its range had declined from ca. 20,000 km$^2$ in the early 1900s to ca. 1000 km$^2$ in the late 1980s. The recent range-wise surveys carried out during 1999–2003 for assessment of the Gazelle's conservation status in Ladakh indicate that the present population of Tibetan Gazelle in Ladakh is ca. 50, restricted to a range of about 100 km$^2$. The survey recommends that this species needs immediate participatory conservation management, as well as a reassessment of its IUCN Red List Status (Bhatnagar et al. 2006a; Mallon and Bhatnagar 2008).

### *36.3.2 Economic Importance of Wild Mammals*

The musk of Musk Deer, and Shahtoosh or 'King of Wool' of Tibetan Antelope are heavily prized materials. Shahtoosh was the main raw material for the handicrafts in weaving the finest shawls of the world. However, it involved the killing of animal which resulted in sharp decline in its population. The illegal trade for musk has decimated the population of Musk Deer. The trophy hunting of Markhor in Pakistan has generated millions of rupees, which are utilised for Markhor conservation and the socioeconomic improvement of the local communities.

This consumptive use, however, for economics may not be sustainable, and many stakeholders, especially naturalists and conservationists, think that it is ethically wrong to kill the animals for just economics. Therefore, it was recommended that special conservation breeding programmes on Musk Deer and Tibetan Antelope may be urgently taken up by the State Government in collaboration with the local institutions (Ahmad et al. 2010a, b). These conservation breeding programmes need to focus on exploring all the possibilities of extraction of Shahtoosh and musk through live-combing by using non-invasive techniques. The concomitant extension work involved in the propagation of these two species of high economic value will heighten people's awareness of these sensitive and vexed issues.

The non-consumptive benefits would be perhaps much more than these consumptive ones. Wildlife Tourism is emerging in Asian countries now and one can have much higher economic benefits. Ladakh, an important part of J&K State, has progressed tremendously in this regard. Tourists from across the world come specifically to Ladakh to have a glimpse of Snow Leopard. This has earned millions each year for the region. Similar examples are from the rest of country, where people in large numbers visit the Wildlife Protected Areas to watch the Wildlife.

### 36.3.3 Threats and Conservation

The diverse mammalian assemblage of Jammu and Kashmir is largely threatened due to various reasons. Fifteen species fall under the threatened categories of Critically Endangered, Endangered, and Vulnerable, while 12 species fall under the Near Threatened category; among others, 78 species belong to the Least Concern and 7 species to Data Deficient categories (Fig. 36.1).

The wide distributional range and population of most of the threatened and restricted range species, such as Kashmir Red Deer, Kashmir Musk Deer, Pirpanjal Markhor, Himalayan Serow, Himalayan Tahr, Ladakh Urial, Tibetan Gazelle, Tibetan Argali, and Eurasian Otter, have drastically been reduced due to burgeoning human and livestock populations, resulting in the fragmentation/degradation of

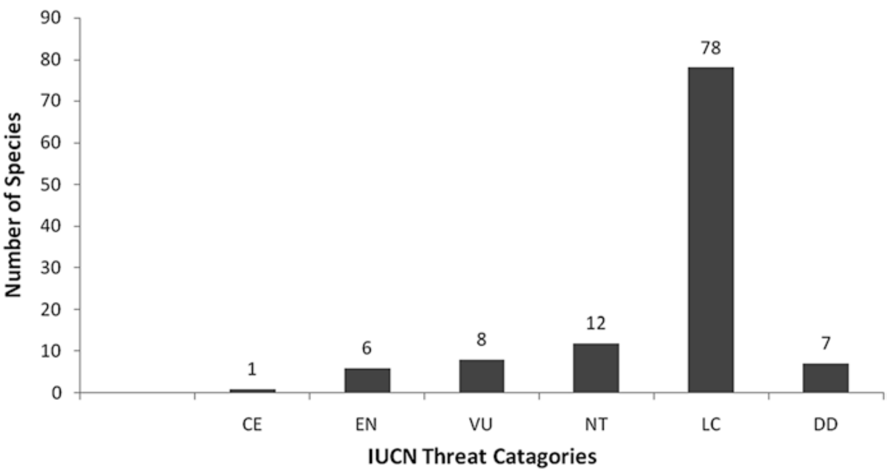


**Fig. 36.1** Number of mammalian species under different IUCN threat categories

natural habitats owing to excessive human interference, livestock grazing, and unwise development (Namgail et al. 2007; Ahmad et al. 2009; Ahmad et al. 2010a, b; Ahmad 2014). The population and distribution range of our State animal—Hangul—has reduced considerably. It was once distributed along a 40 km stretch across the northern bank of Jhelum, and its population was about 5000 individuals (Schaller 1977). Now it is restricted to a small range, and the population has declined sharply to below 200 individuals (Ahmad et al. 2010a, b). Poaching, habitat fragmentation and degradation, livestock grazing, other biotic interference and loose implementation of the Wildlife Act are some of the major factors responsible for this decline (Ahmad et al. 2010a, b).

Markhor in Jammu and Kashmir faces local extinction from its main abode-Pir Panjal due to poaching, livestock grazing, unwise development and habitat fragmentation. The illegal musk trade into China and elsewhere in northeast Asia has increased the demand on Musk Deer population exponentially in the Himalaya as well. There have been a number of reported poaching cases of Musk Deer for its pod in several parts of the State, especially in Gurez, Kupwara, Poonch, and Chenab valley. These wild ungulates are an important component of faunal diversity and also form the major prey for mammalian predators and are as such indicators of health of the habitat and the status of biodiversity (Ahmad et al. 2009, 2010a, b; Shah et al. 2009; Ahmad 2014).

Several Trans-Himalayan wild herbivores and their habitats are threatened and have undergone local extirpations and range reductions over the past few decades (Fox et al. 1991; Mishra et al. 2002; Bhatnagar et al. 2006b). Of the eight wild large herbivore species occurring in the Indian Trans-Himalaya, at least four species number less than 500 surviving individuals (Johnsingh et al. 2006). The reasons are competition from increasing livestock numbers, hunting from locals, nomadic herders and security forces, unwise development, habitat fragmentation and degradation, lack of awareness among major stakeholders and lack of political will.

The major wild carnivores, such as Himalayan Brown Bear, Snow Leopard, Tibetan Wolf, Common Leopard and Himalayan Black Bear have been killed for wildlife trade. They have been persecuted by nomadic herders and locals in retaliation to livestock and crop depredation Further, the Common Leopard and Black Bear are in conflict with humans and are being killed to save the human lives.

Due to decline in the ungulate populations and the habitat degradation in the region, some carnivores, such as Common Leopard and Black Bear, have been staying out of Protected Areas in search of food, and thus come in the contact of humans, creating conflict. As such, human-wildlife conflicts have become more frequent. Nomadic herders take their livestock in PAs also, where carnivorous like Common Leopard, Brown and Black Bear, Snow Leopard and Wolf attack the livestock, and getting killed in retaliation (Ahmad et al. 2011; Bagchi and Mishra 2006). These carnivores have been also preying on livestock in the villages and species like Black Bear and Common Leopard have been reported to even injure or kill people in the fringe villages (Ahmad 2015). Thus, acceptance of wildlife conservation by local people has as such negatively been affected in the region during the recent years. Therefore, it is time to that government and non-governmental organizations, wildlife managers, scientists, and local communities take this issue more seriously and put together a long term and holistic framework to resolve the conflict in the interest of wildlife and human well-being.

Protected areas have been designated in the State to conserve wildlife. However, even these protected areas have not been inviolate to threats, such as heavy livestock presence and unwise development. The manpower with the Wildlife Department is meager to protect these areas. The infrastructure is also weak to facilitate the protection of these priority sites. There is lack of political will and lack of awareness among the major stakeholders to conserve the biodiversity of the State. The wildlife populations in the Himalaya and Trans-Himalaya are not restricted to protected areas, but occur across the landscape and such populations are highly vulnerable (Bhatnagar et al. 2006c; Ahmad et al. 2011). Therefore, the conservation of wild mammals has to be a landscape approach (Plate 36.1).

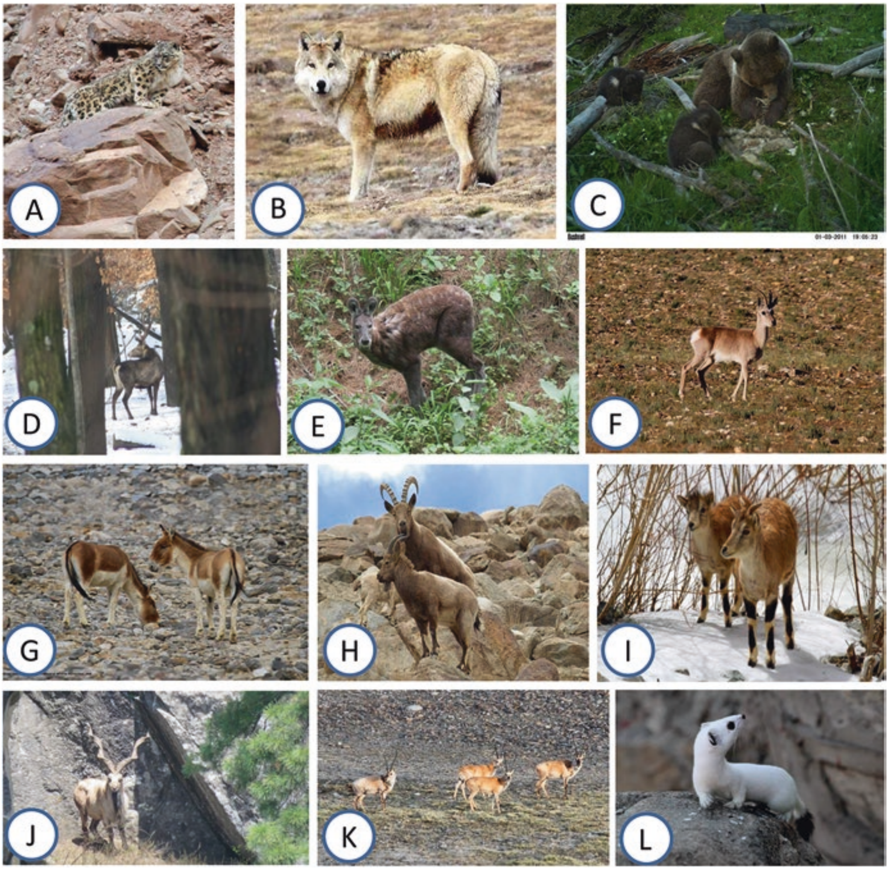


**Plate 36.1** Mammals: (**A**) Snow Leopard (**B**) Tibetan Wolf (**C**) Himalayan Brown Bear (**D**) Kashmir Stag (**E**) Kashmir Musk Deer (**F**) Tibetan Gazelle; (**G**) Wild Ass (**H**). Siberian Ibex (**I**) Himalayan Blue Sheep (**J**) Kashmir Markhor (**K**) Tibetan Antelope (**L**) Himalayan Stoat

The conservation of biodiversity in general, and wild mammalian diversity in particular, should be a collaborative effort of the State Wildlife Protection Department, policy makers and politicians, the education institutes and students, the scientific community and naturalists, NGOs, and the local communities. Necessary support of other departments, like Law, Planning and Finance, are imperative, so that this "invaluable treasure" is not lost to the posterity. The rare species of our fauna need careful and constant monitoring on scientific lines. Time has come to implement the Wildlife Act and Biodiversity Act on ground to conserve our nature for future.

## 36.4 Concluding Remarks

Jammu and Kashmir is bestowed with a rich and unique assemblage of wild mammals. Many of these mammals, such as Ladakh Urial and Tibetan Argali, have restricted distribution, and some of them, such as Hangul and Kashmir Musk Deer, are endemic to the State. We have also keystone and flagship species, like Snow Leopard and Pirpanjal Markhor in J&K. The distribution of many of these species has been recently updated, and exploratory surveys are still needed to update the status and distribution of species like Kashmir Musk Deer, Himalayan Tahr, and Himalayan Serow. Except for a few, the rest of the species are least studied. Information on population dynamics and basic ecology of most of these mammals is still lacking. We also lack the knowledge about the major threats to many of these mammals. In order to understand the impact of management interventions, the monitoring of threatened species is crucial. The understanding of basic ecology and assessment of serious threats would be required to conserve a species.

The status of many of the wild mammals in J&K is threatened, and populations are small, fragmented, and on decline. Poaching, livestock grazing, habitat fragmentation and degradation, unwise development, poor law enforcement, lack of awareness, and lack of political will are some of the major issues biodiversity conservation is facing. Therefore, in order to save our natural heritage, we have to take a holistic approach by involving local communities, government and nongovernment organizations, students and teachers, scholars and scientists, naturalists and conservationists, policy makers and politicians, migratory herders and poachers, and law enforcement agencies and violators. Without losing any more time, implementation of conservation measures has to be done to arrest any further loss or endangering of species.

**Acknowledgments** We are highly grateful to Prof. Nazeer Ahmad, Hon'ble Vice-Chancellor SKUAST-Kashmir, Shalimar, for his help and support. Dr. Zaffar Rais Mir, NPDF Fellow, Division of Wildlife Sciences, SKUAST-Kashmir, is thanked for helping in sorting and formatting of the manuscript. We owe thanks to Rashid Y. Naqash, Department of Wildlife Protection, J&K Government, for providing some historical distribution records of some of the mammals.

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# Part VII
# Biodiversity of Jammu and Kashmir State: Threats and Conservation

# Chapter 37
# Threatened Flora of Jammu and Kashmir State

**Maroof Hamid, Anzar A. Khuroo, Rameez Ahmad, Shugufta Rasheed, Akhtar H. Malik, and Ghulam Hassan Dar**

**Abstract** The chapter provides an updated synthesis of threatened flora of Jammu and Kashmir state. Till date, a total of 429 species of seed plants, belonging to 256 genera in 87 families, have been listed under different threat assessment studies in the State. Among the 429 species assessed, there are 24 species which have been recognized as critically endangered, 88 endangered, 75 vulnerable, 3 near threatened, and 32 least concern as per threat assessment categories currently recognized by the IUCN, the remaining species belonging to rare and indeterminate categories used by previous workers. In addition, several species are noticed as rare and need to be categorized for threat, while in case of several other species previously reported from this region but not having been collected in recent times, their probable extinction/misidentification needs to be ascertained. This chapter highlights the knowledge gaps in the threatened flora of this Himalayan State and proposes a globally standardized research framework for assessment of threat status of various species, which can help in implementing targeted conservation strategies based on empirical scientific evidences.

**Keywords** Biodiversity · Threatened flora · IUCN threat categories · Conservation · J&K State

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_37

## 37.1 Introduction

The extent of biodiversity existing on the planet Earth is amazingly enormous and provides immense benefits to human society, which range from direct economic uses to cultural and esthetic values (Monteiro et al. 2018). However, a large proportion of this biodiversity is severely threatened by unsustainable anthropogenic activities. A growing body of scientific evidence indicates that the current species extinction rates are higher than the pre-human background extinction rate (Raup 1991, Dirzo et al. 2014, Ceballos et al. 2015), and extinction risks to species and ecosystem degradation have witnessed an unprecedented acceleration during the twenty-first century (Pimm et al. 2014). It is believed that the current extinction episode, also known as the "sixth extinction wave," may prove to be the most rapid and devastating (Ceballos et al. 2010).

Like other forms of biodiversity, extinction of plants is also worrying as they play a key role in supporting the planet's ecological balance and being also an irreplaceable component of natural habitats. Globally, plants are threatened by a plethora of planetary-scale human-driven pressures (Martins et al. 2017). Habitat loss and fragmentation, owing to land-use conversion for agriculture and allied activities, mining, infrastructure development, and overharvesting of species of economic interest, are the major threats to plants of the world (Martinelli and Moraes 2013). In this regard, assessing the threat status of plants occurring in a particular region has emerged as one of the universal tools to initiate conservation and policy action (Cooke 2013). The listing of threatened species, commonly known as Red List, assesses the global extinction risk of species by assigning threat status to the species concerned. However, quite often, a species' global conservation status is not necessarily the same as the conservation status on a regional scale. Therefore, given the growing concerns on the higher rates of loss of biodiversity, it becomes imperative to immediately assess the current status of biodiversity, both at the regional and global scales. Since the International Union for Conservation of Nature and Natural Resources (IUCN) Red List scheme is not sufficient for formulating actionable conservation strategies at the local and regional scales, there is urgent need for collection and maintenance of authentic scientific data that can be used for the local area- and region-specific conservation prioritization of biodiversity.

In recent times, rich biodiversity of the Himalaya is experiencing grave threats which have led to its listing as one of Global Biodiversity Hotspots (Mittermeier et al. 2004). The Jammu and Kashmir (J&K) state, situated in the northwestern boundary of the Himalaya, harbors a rich and endemic flora (Singh et al. 2002). Over the decades, however, a large number of species have become threatened due to various anthropogenic activities, such as habitat loss or modification, overexploitation of economically important plants, unchecked livestock grazing, and unsustainable development activities (Dar 2008; Dar and Khuroo 2013; Khuroo et al. 2018; Tali et al. 2018). Therefore, it becomes imperative from biodiversity conservation perspective to assess the threat status of the flora of J&K. Previously, some preliminary studies have been carried out on the threatened flora of J&K (Dar and

Naqshi 2001; Dar et al. 2002, 2006a, b, 2008, 2009, 2010; Khuroo et al. 2005; Dar 2008; Tali et al. 2015), and some national and global Red Lists have also included several species from this State (Jain and Sastry 1980, 1983, 1984; Nayar and Sastry 1987–1990; Molur and Walker 1998; Walter and Gillett 1998; Rao et al. 2003; IUCN 2017). However, all these sources of crucial information on threat status of the flora of J&K are scattered. Therefore, this chapter provides an updated synthesis of the threatened seed-plant flora of Jammu and Kashmir state. Furthermore, the chapter highlights the knowledge gaps and proposes a globally standardized research framework for empirical assessment of threat status of biodiversity of the State.

## 37.2 Materials and Methods

### *37.2.1 Study Area*

The J&K State lies between the coordinates 32°17′ to 37°20′ north latitude and 73°25′ to 80°30′ east longitude (Fig. 37.1). Biogeographically, the State falls under Boreal zone with two subzones, viz. Sino-Siberian or the Trans-Himalaya, and

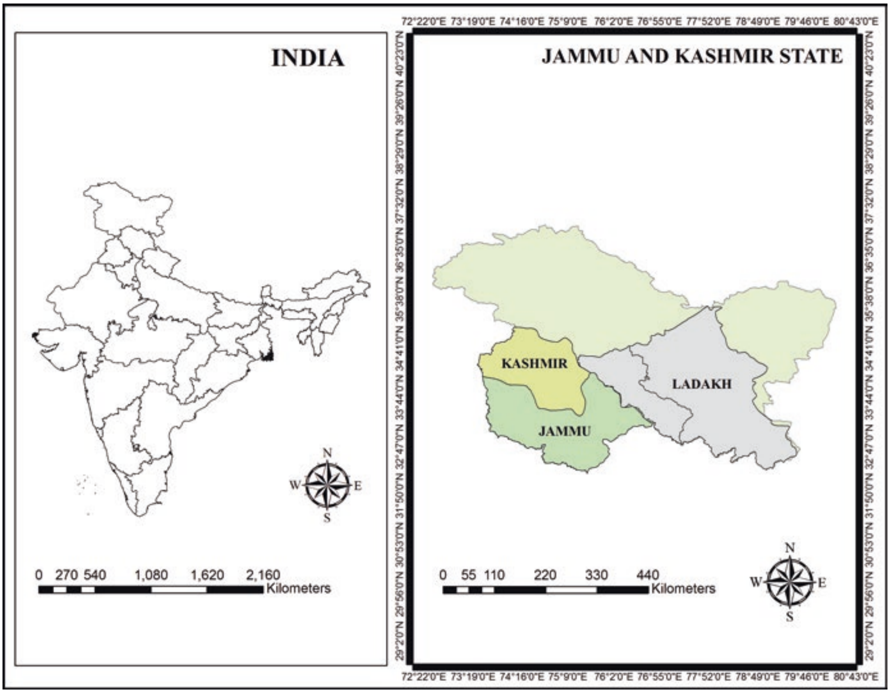


**Fig. 37.1** Location map of Jammu and Kashmir state

Sino-Himalayan or the Northwest Himalaya, and four biomes, viz. Tundra zone, Alpine zone, Temperate zone, and Subtropical zone (Rodgers 1985). It consists of three regions: Jammu, Kashmir, and Ladakh, with diverse climatic conditions. Therefore, biogeographically strategic location of J&K State, coupled with varied phyto-climatic conditions, makes it one of the hyper-biodiversity states of the Himalaya.

### *37.2.2 Data Sources*

The data for this chapter were obtained by undertaking systematic review of the relevant scientific literature (especially Nayar and Sastry 1987, 1988, 1990; Molur and Walker 1998; Walter and Gillett 1998; Dar and Naqshi 2001; Rao et al. 2003 and IUCN 2017). Based on the comparative analysis of these and other previous studies, this chapter has summarized the field observations of the authors, available literature, and plant collections housed in the herbarium of University of Kashmir (KASH). The threatened species mentioned in this chapter have been arranged alphabetically under their respective genera in families as per APG-IV (Chase et al. 2016). Since complete information on the flora of this Himalayan region is still lacking, the study provides an extent of the threatened seed-plant flora in the State and a sound baseline for detailed work in the near future.

## 37.3 Results

A total of 429 species represent the threatened seed-plant flora of Jammu and Kashmir state (Table 37.1). These species belong to 256 genera in 87 families, angiosperms being represented by 428 species in 255 genera and 86 families and gymnosperms by 1 species in 1 genus and 1 family. In all the angiosperm families, Poaceae contains the largest number of threatened taxa, followed by Asteraceae and Brassicaceae; indeed, the largest ten families in this group of plants contribute more than half of the total threatened flora (i.e., 229 species), while the remaining 77 families are represented by 200 species (Fig. 37.2); 40 families are represented by a single species each (Fig. 37.3).

The results reveal that in the threatened seed-plant flora of J&K State, 24 species are critically endangered, 88 endangered, 75 vulnerable, 3 near threatened, and 32 least concern. Also, there are 178 and 190 species that have been previously recognized as rare and indeterminate, respectively (Table 37.2). Out of 24 species categorized as critically endangered, 20 were reported in Molur and Walker (1998) and 4 in the IUCN Red List (2017). Similarly, out of 88 species categorized as endangered, 40 were reported by Dar and Naqshi (2001), 20 by Rao et al. (2003), 16 by Walter and Gillett (1998), 9 by Molur and Walker (1998), 2 in IUCN Red List (2017), and only 1 by Nayar and Sastry (1987–1990). Out of 75 species categorized

**Table 37.1** Comparative list of threatened seed-plant species of J&K State

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 1. | *Abutilon theophrastii* Medik. | Malvaceae | – | – | – | VU | – | – |
| 2. | *Acer acuminatum* Wall. | Aceraceae | – | – | – | I | – | LC |
| 3. | *Acer caesium* Wall. ex Brandis | Aceraceae | VU | – | – | – | VU | LC |
| 4. | *Aconitum balfourii* Stapf | Ranunculaceae | – | – | CR | – | – | – |
| 5. | *Aconitum deinorrhizum* Holmes ex Stapf | Ranunculaceae | VU | – | CR | – | – | – |
| 6. | *Aconitum falconeri* Holmes ex Stapf | Ranunculaceae | – | – | CR | – | – | – |
| 7. | *Aconitum ferox* Wall. | Ranunculaceae | – | – | CR | – | – | – |
| 8. | *Aconitum heterophyllum* Wall. ex Royle | Ranunculaceae | – | EN | CR | EN | – | EN |
| 9. | *Aconitum kashmiricum* Stapf ex Coventry | Ranunculaceae | – | – | – | – | EN | – |
| 10. | *Aconitum moschatum* Stapf | Ranunculaceae | – | – | CR | – | I | – |
| 11. | *Aconitum violaceum* Stapf | Ranunculaceae | – | – | CR | – | – | VU |
| 12. | *Acorus calamus* Linn. | Araceae | – | – | – | EN | – | LC |
| 13. | *Acroglochin persicarioides* (Poir.) Moq. | Chenopodiaceae | – | – | – | R | – | – |
| 14. | *Acroptilon repens* (Linn.) DC. | Asteraceae | – | – | – | VU | – | – |
| 15. | *Adonis chrysocyathus* Hook. f. and Thoms. | Ranunculaceae | – | – | – | VU | – | – |
| 16. | *Adoxa moschatellina* Linn. | Adoxaceae | – | – | – | EN | – | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 17. | *Agrostis filipes* Hook. f. | Poaceae | – | – | – | I | – | – |
| 18. | *Alchemilla cashmiriana* Rothm. | Rosaceae | – | I | – | I | – | – |
| 19. | *Alchemilla trollii* Rothm. | Rosaceae | – | – | – | R | – | – |
| 20. | *Aletris pauciflora* (Klotzsch) Hand. Mazz. | Haemodoraceae | – | – | – | EN | – | – |
| 21. | *Allium auriculatum* Kunth. | Alliaceae | – | – | – | – | EN | – |
| 22. | *Allium loratum* Baker | Alliaceae | – | – | – | – | EN | – |
| 23. | *Allium roylei* Stearn | Alliaceae | – | EN | – | VU | EN | NT |
| 24. | *Allium stracheyi* Baker | Alliaceae | VU | – | – | – | VU | – |
| 25. | *Allium victorialis* Linn. | Alliaceae | – | – | – | R | – | – |
| 26. | *Alnus nitida* Endl. | Betulaceae | – | – | – | VU | – | LC |
| 27. | *Althaea broussonetiifolia* Iljin | Malvaceae | – | – | – | VU | – | – |
| 28. | *Althaea officinalis* Linn. | Malvaceae | – | – | – | I | – | – |
| 29. | *Alysicarpus meeboldii* Schindl. | Fabaceae | – | – | – | – | I | – |
| 30. | *Amphicarpaea anomalus* Bunge. | Fabaceae | – | – | – | – | I | – |
| 31. | *Amphicarpaea edgeworthii* Benth. | Fabaceae | – | – | – | – | I | – |
| 32. | *Anaphalis timmua* D. Don | Asteraceae | – | – | – | R | – | – |
| 33. | *Andropogon munroi* C.B. Clarke | Poaceae | – | – | – | I | – | – |
| 34. | *Androsace aizoon* Duby. | Primulaceae | – | – | – | – | I | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 35. | *Androsace himalaica* (Knuth) Hand.-Maz. | Primulaceae | – | – | – | R | – | – |
| 36. | *Androsace lanuginosa* Wall. | Primulaceae | – | – | – | R | – | – |
| 37. | *Androsace mucronifolia* Watt. | Primulaceae | – | – | – | – | I | – |
| 38. | *Androsace robusta* (Knuth) Hand.-Maz. | Primulaceae | – | – | – | R | – | – |
| 39. | *Androsace russelii* Y. Nasir | Primulaceae | – | – | – | R | – | – |
| 40. | *Anemone polyanthes* D. Don | Ranunculaceae | – | – | – | R | – | – |
| 41. | *Angelica glauca* Edgew. | Apiaceae | – | – | CR | – | – | EN |
| 42. | *Aquilegia nakaoi* Tamura | Ranunculaceae | – | – | – | – | I | – |
| 43. | *Aquilegia nivalis* Falc. ex Jackson | Ranunculaceae | – | EN | – | VU | EN | – |
| 44. | *Arabis stewartiana* Jafri | Brassicaceae | – | – | – | I | I | – |
| 45. | *Arabis tenuirostris* O. Schulz | Brassicaceae | – | – | – | – | I | – |
| 46. | *Aralia cachemirica* Decne. | Araliaceae | – | – | – | R | – | – |
| 47. | *Arcyosperma primulifolium* (T.T.) O.E.S. | Brassicaceae | – | – | – | I | – | – |
| 48. | *Arenaria neelgerrensis* Wight and Arn. | Caryophyllaceae | – | – | – | – | I | – |
| 49. | *Arnebia guttata* Bunge. | Boraginaceae | – | – | – | VU | – | – |
| 50. | *Arnebia benthamii* (Wall. ex G. Don) I.M. Johnston | Boraginaceae | – | EN | CR | EN | EN | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 51. | *Artemisia amygdalina* Decne. | Asteraceae | – | – | – | EN | – | – |
| 52. | *Artemisia dolicocephala* Pampan. | Asteraceae | – | I | – | I | I | – |
| 53. | *Aruncus vulgaris* Rafin. | Rosaceae | – | – | – | R | – | – |
| 54. | *Astragalus anomalus* Bunge | Fabaceae | – | – | – | – | I | – |
| 55. | *Astragalus bakeri* Ali | Fabaceae | – | – | – | – | I | – |
| 56. | *Astragalus heydei* Baker | Fabaceae | – | – | – | R | – | |
| 57. | *Astragalus imitensis* Ali | Fabaceae | – | – | – | I | – | – |
| 58. | *Astragalus kashmirensis* Bunge | Fabaceae | – | – | – | R | – | – |
| 59. | *Astragalus oxyodon* Baker | Fabaceae | – | – | – | R | – | – |
| 60. | *Atropa acuminata* Royle | Solanaceae | – | – | CR | VU | – | – |
| 61. | *Balanophora involucrata* Hook. f. | Balanophoraceae | – | – | – | EN | – | – |
| 62. | *Bassia divaricata* (Kar. and Kir.) O. Ktze. | Chenopodiaceae | – | – | – | I | – | – |
| 63. | *Berberis aristata* DC. | Berberidaceae | – | – | EN | – | – | – |
| 64. | *Berberis calliobotrys* Aitch. ex. Koehne | Berberidaceae | – | – | – | I | – | – |
| 65. | *Berberis chitria* Lindl. | Berberidaceae | – | – | EN | I | – | – |
| 66. | *Berberis glaucocarpa* Stapf | Berberidaceae | – | – | – | I | – | – |
| 67. | *Berberis huegeliana* Schneider | Berberidaceae | I | I | – | I | I | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 68. | *Berberis kasmiriana* Ahrendt. | Berberidaceae | R | R | CR | R | R | – |
| 69. | *Berberis lycium* var. *simlensis* Royle | Berberidaceae | – | – | EN | – | – | – |
| 70. | *Berberis orthobotrys* Bien. ex Aitch. | Berberidaceae | – | – | – | – | I | – |
| 71. | *Berberis petiolaris* Parker, non Wall. | Berberidaceae | – | – | CR | – | – | – |
| 72. | *Berberis pseudumbellata* R. Parker | Berberidaceae | – | – | – | – | I | – |
| 73. | *Berberis royleana* Ahrendt. | Berberidaceae | – | I | – | R | I | – |
| 74. | *Bergenia ciliata* (Haw.) Sternb. | Saxifragaceae | – | – | VU | – | – | – |
| 75. | *Blyxa aubertii* L.C. Rich. | Hydrocharitaceae | – | – | – | EN | – | – |
| 76. | *Brassica tournefortii* Gouan | Brassicaceae | – | – | – | R | – | – |
| 77. | *Braya rosea* (Turcz.) Bunge | Brassicaceae | – | – | – | R | – | – |
| 78. | *Braya tibetica* Hook. f. and Thoms. | Brassicaceae | – | – | – | R | – | – |
| 79. | *Bulbostylis densa* (Wall.) Hand.-Mazz. | Cyperaceae | – | – | – | R | – | LC |
| 80. | *Bunium persicum* (Boiss.) B. Fedt. | Apiaceae | – | – | EN | – | – | – |
| 81. | *Calamagrostis decora* Hook. f. | Poaceae | – | I | – | I | I | – |
| 82. | *Calamagrostis stoliczkai* Hook. f. | Poaceae | – | – | – | I | – | – |
| 83. | *Caldesia grandis* Sams. | Alismataceae | – | – | – | I | – | LC |
| 84. | *Calendula arvensis* Linn. | Asteraceae | – | – | – | R | – | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 85. | *Campanula tenuissima* Dunn | Campanulaceae | – | – | – | R | – | LC |
| 86. | *Campylotropis macrostyla* (D. Don) Schindl. | Fabaceae | – | – | – | I | – | – |
| 87. | *Campylotropis stenocarpa* (Klotzsch.) Schindl. | Fabaceae | – | – | – | I | – | – |
| 88. | *Carduus kumaonensis* (J. Ar.) Kazmi | Asteraceae | – | – | – | R | – | – |
| 89. | *Carex annulata* Kuk. | Cyperaceae | – | – | – | – | I | – |
| 90. | *Carex borii* Nelmes | Cyperaceae | – | – | – | – | I | LC |
| 91. | *Carex lehmanii* Drejer | Cyperaceae | – | – | – | R | – | – |
| 92. | *Carex nigerrima* Nelmes | Cyperaceae | – | – | – | R | – | LC |
| 93. | *Carpinus viminea* Lindl. | Corylaceae | – | – | – | I | – | LC |
| 94. | *Cassiope fastigiata* (Wall.) D. Don | Ericaceae | – | – | – | E | – | – |
| 95. | *Catabrosa aquatica* (L.) P. Beauv. | Poaceae | – | I | – | I | I | LC |
| 96. | *Cedrela serrata* Royle | Meliaceae | – | – | – | R | – | – |
| 97. | *Chamaerhodos sabulosa* Bunge | Rosaceae | – | – | – | R | – | – |
| 98. | *Chelonopsis cashmerica* (Muk.) Hedge | Lamiaceae | – | – | – | EN | – | – |
| 99. | *Chondrilla setulosa* Clarke | Asteraceae | R | – | – | VU | – | – |
| 100. | *Chrorispora tenella* (Pall.) DC. | Brassicaceae | – | – | – | VU | – | – |
| 101. | *Chrozophora obliqua* (Vahl.) Juss. ex Spreng. | Euphorbiaceae | – | – | – | R | – | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 102. | *Chrozophora tinctoria* (Linn.) Juss. | Euphorbiaceae | – | – | – | I | – | LC |
| 103. | *Chrysosplenium trichospermum* Edgew. | Saxifragaceae | – | – | – | I | – | – |
| 104. | *Cicuta virosa* Linn. | Apiaceae | – | – | – | I | – | LC |
| 105. | *Cinnamomum tamala* Nees and Eberm. | Lauraceae | – | – | NT | – | – | – |
| 106. | *Cirsium segetum* Bunge | Asteraceae | – | – | – | R | – | – |
| 107. | *Coriaria nepalensis* Wall. | Coriariaceae | – | – | – | EN | – | – |
| 108. | *Cornus oblonga* Wall. ex Roxb. | Cornaceae | – | – | – | VU | – | – |
| 109. | *Corydalis cashmeriana* Royle | Fumariaceae | – | EN | – | EN | EN | – |
| 110. | *Corydalis crassifolia* Royle | Fumariaceae | – | – | – | R | – | – |
| 111. | *Corydalis hendersonii* Hemsl. | Fumariaceae | – | – | – | R | – | – |
| 112. | *Corydalis sikkimensis* (Prain) Fedde | Fumariaceae | – | – | – | R | – | – |
| 113. | *Cotoneaster brandissi* Klotz. | Rosaceae | – | – | – | R | – | – |
| 114. | *Cotoneaster cashmiriensis* G. Klotz | Rosaceae | – | I | – | I | I | – |
| 115. | *Cotoneaster gilgitensis* G. Klotz | Rosaceae | – | – | – | I | – | – |
| 116. | *Cotoneaster humilis* Dunn. | Rosaceae | – | – | – | I | – | – |
| 117. | *Cotoneaster kaganensis* G. Klotz. | Rosaceae | – | – | – | R | – | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 118. | *Cotoneaster minuta* Klotz. | Rosaceae | – | – | – | I | – | – |
| 119. | *Cotoneaster schulertii* Klotz. | Rosaceae | – | – | – | I | – | – |
| 120. | *Cotula anthemoides* Linn. | Asteraceae | – | – | – | EN | – | – |
| 121. | *Cousinia falconeri* Hook. f. | Asteraceae | – | – | – | – | I | – |
| 122. | *Cousinia mircocarpa* Boiss. | Asteraceae | – | – | – | EN | – | – |
| 123. | *Crataegus clarkei* Hook. f. | Rosaceae | – | – | – | R | – | – |
| 124. | *Cremanthodium arnicoides* (Wall. ex. DC.) R. Good | Asteraceae | – | EN | – | VU | EN | – |
| 125. | *Crupina vulgaris* Cass. | Asteraceae | – | – | – | I | – | – |
| 126. | *Cuscuta lehmanniana* Bunge | Cuscutaceae | – | – | – | I | – | – |
| 127. | *Cymbopogon ramnagarensis* B.K. Gupta | Poaceae | – | – | – | – | I | – |
| 128. | *Cynanchum heydei* Hook. f. | Asclepiadaceae | – | – | – | VU | – | – |
| 129. | *Cyperipedium cordigerum* D. Don | Orchidaceae | R | – | – | VU | – | – |
| 130. | *Dactylorhiza hatagirea* (D. Don) Soo | Orchidaceae | – | – | CR | – | – | – |
| 131. | *Daphne papyracea* Wall. ex Steud. | Thymelaeaceae | – | – | – | R | – | – |
| 132. | *Daphne retusa* Hemsl. | Thymelaeaceae | – | – | – | I | – | – |
| 133. | *Datisca cannabina* Linn. | Datiscaceae | – | – | – | VU | – | – |
| 134. | *Delphinium denudatum* Wall. ex H. and T. | Ranunculaceae | – | – | CR | – | I | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 135. | *Delphinium roylei* Munz. | Ranunculaceae | – | – | – | – | I | – |
| 136. | *Delphinium uncinatum* H. and T. | Ranunculaceae | VU | – | – | – | – | – |
| 137. | *Deutzia amurensis* (Regel) Airy Shaw | Hydrageaceae | – | – | – | – | I | – |
| 138. | *Deyeuxia kashmeriana* Bor | Poaceae | – | – | – | – | I | – |
| 139. | *Dianthus minimus* Javeid | Caryophyllaceae | – | – | – | – | I | – |
| 140. | *Digitaria stewartiana* Bor | Poaceae | – | – | – | R | – | – |
| 141. | *Dilophia salsa* T. Thomson | Brassicaceae | – | – | – | I | – | – |
| 142. | *Dioscorea deltoidea* Wall. ex Kunth | Dioscoreaceae | VU | – | CR | – | – | – |
| 143. | *Draba aubrietioides* Jafri | Brassicaceae | – | – | – | R | – | – |
| 144. | *Draba dasyastra* Gilg and O.E. Schulz | Brassicaceae | – | – | – | – | I | – |
| 145. | *Dubyaea oligocephala* (Sch. Bip.) Stebbins | Asteraceae | – | – | – | R | – | – |
| 146. | *Eleocharis congesta* D. Don | Cyperaceae | – | – | – | R | – | LC |
| 147. | *Elsholtzia densa* Benth. | Lamiaceae | – | – | – | – | I | – |
| 148. | *Elsholtzia strobilifera* Benth. | Lamiaceae | – | – | – | R | – | – |
| 149. | *Elymus jacquemontii* (Hk. f.) T.A. Cope | Poaceae | – | – | – | R | – | – |
| 150. | *Elymus russellii* (Meld.) T.A. Cope | Poaceae | – | – | – | R | – | – |

(continued)

Table 37.1 (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 151. | *Elymus stewartii* (Meld.) T.A. Cope | Poaceae | – | – | – | R | – | – |
| 152. | *Epilobium aitchisonii* Raven | Onagraceae | – | – | – | R | – | – |
| 153. | *Epilobium glaciale* Raven | Onagraceae | – | I | – | I | – | – |
| 154. | *Epilobium leiophyllum* Hausskn. | Onagraceae | – | – | – | R | – | – |
| 155. | *Epilobium pseudobscurum* Hausskn. | Onagraceae | – | – | – | I | – | – |
| 156. | *Epilobium rhynchospermum* Hausskn. | Onagraceae | – | – | – | R | – | – |
| 157. | *Epilobium tetragonum* (non L.) Aitch. | Onagraceae | – | – | – | R | – | – |
| 158. | *Epipogium tuberosum* Duthie | Orchidaceae | – | – | – | VU | – | – |
| 159. | *Eremerus himalaicus* Baker | Liliaceae | R | – | – | – | – | – |
| 160. | *Erigeron angustissimum* Lindl. ex DC. | Asteraceae | – | – | – | R | – | – |
| 161. | *Eriocaulon sieboldianum* Sieb. and Zucc. ex Steud. | Eriocaulaceae | – | – | – | R | – | – |
| 162. | *Eriocycla nuda* Lindley | Apiaceae | – | – | – | R | – | – |
| 163. | *Eriocycla thomsonii* (Clarke) Wolff. | Apiaceae | – | – | – | R | – | – |
| 164. | *Erodium stephanianum* Willd. | Geraniaceae | – | – | – | VU | – | – |
| 165. | *Erophila tenerrima* (O.E.Schulz) Jafri | Brassicaceae | – | I | – | I | I | – |
| 166. | *Erysimum aitchisonii* O.E.S. | Brassicaceae | R | – | – | I | – | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 167. | *Erysimum sisymbrioides* C.A. Mey. | Brassicaceae | – | – | – | I | – | – |
| 168. | *Erysimum thomsonii* Hook. f. and Thoms. | Brassicaceae | – | – | – | R | – | – |
| 169. | *Eupatorium cannabinum* L. | Asteraceae | – | – | – | I | – | – |
| 170. | *Eupatorium reevesii* Wall. ex DC. | Asteraceae | – | – | – | I | – | – |
| 171. | *Euphorbia cognata* (KI. and Garcke) Boiss. | Euphorbiaceae | – | – | – | I | – | – |
| 172. | *Euphorbia jacquemontii* Boiss. | Euphorbiaceae | – | – | – | I | – | – |
| 173. | *Euphorbia micractina* Boiss. | Euphorbiaceae | – | – | – | R | – | – |
| 174. | *Euphrasia jaeschkei* Wettst. | Scrophulariaceae | – | – | – | VU | – | – |
| 175. | *Euphrasia secundiflora* Penn. | Scrophulariaceae | – | – | – | I | – | – |
| 176. | *Euryale ferox* Salisb. | Euryalaceae | – | – | – | EN | – | LC |
| 177. | *Ferula jaeschkeana* Vatke. | Apiaceae | – | – | – | VU | – | – |
| 178. | *Festuca asthenica* Hook. f. | Poaceae | – | – | – | R | – | – |
| 179. | *Festuca debilis* (Stapf) Alexeev. | Poaceae | – | – | – | R | – | – |
| 180. | *Festuca levingei* Stapf | Poaceae | – | EN | – | I | EN | – |
| 181. | *Festuca lucida* Stapf | Poaceae | – | – | – | – | I | – |
| 182. | *Fritillaria imperialis* Linn. | Liliaceae | – | – | – | R | – | – |
| 183. | *Fritillaria roylei* Hook. | Liliaceae | – | – | CR | R | – | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 184. | *Fumaria vaillantii* Loisel. | Fumariaceae | – | – | – | I | – | – |
| 185. | *Gagea gageoides* (Zucc.) Vved. | Liliaceae | – | – | – | R | – | – |
| 186. | *Galium ceratophylloides* Hook. f. | Rubiaceae | – | – | – | R | – | – |
| 187. | *Garhadiolus minutissimus* (Bunge) Kitamura | Asteraceae | – | – | – | R | – | – |
| 188. | *Gastrodia orobanchoides* (Falc.) Benth. | Orchidaceae | – | – | – | I | – | – |
| 189. | *Gaultheria trichophylla* Royle | Ericaceae | – | – | – | VU | – | – |
| 190. | *Gentiana cachmirica* Decne | Gentianaceae | – | – | – | – | EN | – |
| 191. | *Gentiana kurroo* Royle | Gentianaceae | – | – | CR | – | – | CR |
| 192. | *Gentiana thomsonii* Clarke | Gentianaceae | – | – | – | R | – | – |
| 193. | *Gentianella azurea* (Bunge) H. Smith | Gentianaceae | – | – | – | R | – | – |
| 194. | *Geranium rubifolium* Lindl. | Geraniaceae | – | – | – | R | – | – |
| 195. | *Geranium tuberaria* Cambess. | Geraniaceae | – | I | – | VU | I | – |
| 196. | *Goodyera repens* (Linn) R. Br. | Orchidaceae | – | – | – | VU | – | – |
| 197. | *Gypsophila floribunda* (Kar. and Kir) Turez. ex Ledeb. | Caryophyllaceae | – | – | – | I | – | – |
| 198. | *Halenia elliptica* D. Don | Gentianaceae | – | – | – | I | – | – |
| 199. | *Halophyllum gilesii* (Hemsl.) C.C.Townsend | Rutaceae | – | – | – | I | – | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 200. | *Hedinia tibetica* (Thoms) Ostenf. | Brassicaceae | – | – | – | I | – | – |
| 201. | *Hedychium spicatum* Lodd. | Zingiberaceae | – | – | VU | – | – | – |
| 202. | *Hedysarum alpinum* Linn. | Fabaceae | – | – | – | R | – | LC |
| 203. | *Hedysarum astragaloides* Benth. ex Baker | Fabaceae | R | – | – | – | R | – |
| 204. | *Hedysarum cachemirianum* Benth ex Baker | Fabaceae | R | – | – | R | – | – |
| 205. | *Hedysarum microcalyx* Baker | Fabaceae | VU | – | – | R | – | – |
| 206. | *Heracleum cachemiricum* Clarke | Apiaceae | – | – | – | R | – | – |
| 207. | *Heracleum candicans* Wall. ex DC. | Apiaceae | – | – | EN | – | – | – |
| 208. | *Heracleum jacquemontii* C.B. Clarke | Apiaceae | – | – | – | – | I | – |
| 209. | *Herminium pugioniforme* Lindl. ex Hk. f. | Orchidaceae | – | – | – | VU | – | – |
| 210. | *Hyoscyamus niger* Linn. | Solanaceae | – | – | – | R | – | – |
| 211. | *Impatiens meeboldii* Hk. f. | Balsaminaceae | – | I | – | I | I | – |
| 212. | *Impatiens pahalgamensis* Hk. f. | Balsaminaceae | – | I | – | I | I | – |
| 213. | *Indigofera cedrorum* Dunn. | Fabaceae | – | – | – | – | I | – |
| 214. | *Indigofera himalayensis* Ali | Fabaceae | – | – | – | VU | – | – |
| 215. | *Inula acuminata* Royle ex DC. | Asteraceae | – | – | – | R | – | – |
| 216. | *Inula clarkei* (Hk. f.) R.R. Stewart | Asteraceae | – | – | – | R | VU | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 217. | *Inula racemosa* Hk. f. (*I. royleana*) | Asteraceae | VU | VU | – | R | – | – |
| 218. | *Iris decora* Wall. | Iridaceae | – | – | – | VU | – | – |
| 219. | *Iris milesii* Foster | Iridaceae | – | I | – | R | I | – |
| 220. | *Iris reticulata* M. Bieb. | Iridaceae | – | – | – | EN | – | – |
| 221. | *Isatis costata* C.A. Mey. | Brassicaceae | – | – | – | I | – | – |
| 222. | *Isopyrum ludlowii* Tamura and Lauener | Ranunculaceae | – | – | – | – | I | – |
| 223. | *Ixiolirion tataricum* (Pall.) Herbert | Amaryllidaceae | – | – | – | EN | – | – |
| 224. | *Juncus triglumis* Linn. | Juncaceae | – | – | – | VU | – | LC |
| 225. | *Jurinea dolomiaea* Boiss. | Asteraceae | – | – | – | R | – | – |
| 226. | *Kickxia incana* (Wall.) Penn. | Scrophulariaceae | – | – | – | VU | – | – |
| 227. | *Kickxia ramosissima* (Wall.) Janchen | Scrophulariaceae | – | – | – | R | – | – |
| 228. | *Kobresia nitens* Clarke | Cyperaceae | – | – | – | R | – | – |
| 229. | *Kobresia pamiroalaica* Ivanova | Cyperaceae | – | – | – | R | – | – |
| 230. | *Koeleria argentea* Griseb. var. *argentea* | Poaceae | – | – | – | R | – | – |
| 231. | *Lactuca benthamii* C.B. Clarke | Asteraceae | – | EN | – | I | EN | – |
| 232. | *Lactuca undulata* Ledeb. | Asteraceae | E | EN | – | I | EN | – |
| 233. | *Lagotis cashmeriana* (Royle) Rupr. | Scrophulariaceae | – | – | – | R | – | – |
| 234. | *Lagotis globosa* (Kurz) Hook. f. | Scrophulariaceae | – | – | – | I | – | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 235. | *Lathraea squamaria* Linn. | Orobanchaceae | – | – | – | R | – | – |
| 236. | *Lavatera kashmiriana* Camb. | Malvaceae | – | – | EN | – | – | – |
| 237. | *Leersia oryzoides* (L.) Swartz | Poaceae | – | – | – | EN | – | LC |
| 238. | *Lespedeza elegans* Camb. | Fabaceae | – | – | – | R | – | – |
| 239. | *Lespedeza gerardiana* Grah. ex Maxim. | Fabaceae | – | – | – | I | – | – |
| 240. | *Lilium polyphyllum* D. Don | Liliaceae | – | – | – | EN | – | CR |
| 241. | *Lindenbergia indica* (Linn.) Vatke | Scrophulariaceae | – | – | – | I | – | LC |
| 242. | *Lindenbergia macrostachya* (Benth.) Benth. | Scrophulariaceae | – | – | – | VU | – | – |
| 243. | *Linum corymbulosum* Reichenb. | Linaceae | – | – | – | I | – | – |
| 244. | *Linum perenne* Linn. | Linaceae | – | – | – | R | – | – |
| 245. | *Liriope graminifolia* (L.) Baker | Haemodoraceae | – | – | – | I | – | – |
| 246. | *Lloydia himalensis* Royle | Liliaceae | R | – | – | – | R | – |
| 247. | *Lloydia serotina* (Linn.) Reichenb. | Liliaceae | – | – | – | EN | – | – |
| 248. | *Lomatogonium brachyantherum* (Clarke) Fernald | Gentianaceae | – | – | – | R | – | – |
| 249. | *Lonicera coerulea* L. var. *altaica* Sweet ex Dippel | Caprifoliaceae | – | – | – | R | – | – |
| 250. | *Lonicera coerulea* L. var. *glabresence* Rupr. ex Herder | Caprifoliaceae | – | – | – | R | – | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 251. | *Lophochloa clarkenna* (Domin) Bor. | Poaceae | – | – | – | – | I | – |
| 252. | *Lysimachia chenopodioides* Watt. ex Hook. f. | Primulaceae | – | – | – | R | – | – |
| 253. | *Lysimachia lobelioides* Wall. | Primulaceae | – | – | – | R | – | – |
| 254. | *Lythrum hyssopifolia* Linn. | Lythraceae | – | – | – | EN | – | LC |
| 255. | *Malva parviflora* Linn. | Malvaceae | – | – | – | R | – | – |
| 256. | *Meconopsis aculeata* Royle | Papaveraceae | – | EN | – | EN | EN | – |
| 257. | *Meconopsis latifolia* Prain | Papaveraceae | VU | VU | – | EN | VU | – |
| 258. | *Megacarpaea bifida* Benth. | Brassicaceae | – | EN | – | EN | EN | – |
| 259. | *Megacarpaea polyandra* Benth. | Brassicaceae | – | – | – | EN | – | – |
| 260. | *Melica secunda* Regel. | Poaceae | – | – | – | I | – | – |
| 261. | *Menyanthes trifoliata* Linn. | Menyanthaceae | – | – | – | EN | – | LC |
| 262. | *Microsisymbrium flaccidum* O.E.S. | Brassicaceae | – | – | – | I | – | – |
| 263. | *Microsisymbrium minutiflorum* (Hook. f. and Thoms.) O.E.S. | Brassicaceae | – | – | – | I | – | – |
| 264. | *Mimulus strictus* Benth. | Scrophulariaceae | – | – | – | I | – | – |
| 265. | *Moneses uniflora* (Linn.) A. Gray | Pyrolaceae | – | – | – | I | – | – |
| 266. | *Monochoria vaginalis* (L.) Presl. | Pontederiaceae | – | – | – | VU | – | LC |
| 267. | *Monotropa hypopithys* Linn. | Pyrolaceae | – | – | – | EN | – | – |
| 268. | *Mosla dianthera* (Buch. Ham. ex Roxb.) Maxim | Lamiaceae | – | – | – | VU | – | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 269. | *Myrsine semiserrata* Wall. ex Roxb. | Myrsinaceae | – | – | – | R | – | – |
| 270. | *Nardostachys jatamansi* (D. Don) DC. | Caprifoliaceae | VU | – | CR | – | – | CR |
| 271. | *Neottia inayatii* (Du.) Beauverd | Orchidaceae | R | – | – | EN | – | – |
| 272. | *Neottia kashmiriana* (Duthie) P. Beauv. | Orchidaceae | – | I | – | EN | I | – |
| 273. | *Nepeta campestris* Benth. | Lamiaceae | – | I | – | R | I | – |
| 274. | *Nepeta paucifolia* Mukerjee | Lamiaceae | – | I | – | I | I | – |
| 275. | *Odontites himalayica* Penn. | Scrophulariaceae | – | – | – | I | – | – |
| 276. | *Onosma hypoleucum* I. M. Johnston | Boraginaceae | – | – | – | VU | – | – |
| 277. | *Ophiopogon intermedius* D. Don | Haemodoraceae | – | – | – | I | – | – |
| 278. | *Oreocnide frutescens* (Blume.) Miq. | Urticaceae | – | – | – | I | – | – |
| 279. | *Orinus thoroldii* (Stapf) Bor | Poaceae | – | – | – | I | – | – |
| 280. | *Orobanche clarkei* Hook. f. | Orobanchaceae | – | – | – | I | – | – |
| 281. | *Orobanche kashmirica* Clarke ex Hook. f. | Orobanchaceae | – | – | – | EN | – | – |
| 282. | *Orobanche psila* Clarke | Orobanchaceae | – | – | – | VU | – | – |
| 283. | *Osmorhiza aristata* (Thunb.) Makino and Yabe. | Apiaceae | – | – | – | R | – | – |
| 284. | *Oxytropis densa* Benth ex Bunge | Fabaceae | – | – | – | R | – | – |
| 285. | *Paeonia emodi* Wall. ex Hk. f. | Paeoniaceae | – | – | VU | – | – | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 286. | *Papaver himalaicum* Cretz. | Papaveraceae | – | – | – | – | I | – |
| 287. | *Papaver nudicaule* Linn. | Papaveraceae | – | – | – | VU | – | – |
| 288. | *Parietaria judaica* Strand. | Urticaceae | – | – | – | R | – | – |
| 289. | *Parnassia cabulica* Planch. ex Clarke | Parnassiaceae | – | – | – | R | – | – |
| 290. | *Pedicularis mollis* Wall. ex Benth. | Scrophulariaceae | – | – | – | VU | – | – |
| 291. | *Pegaeophyton scapiflorum* (Hook.f. and Thoms.) Marq. and Shaw. | Brassicaceae | – | – | – | I | – | – |
| 292. | *Petrohagia alpina* (Habl.) P. W. Ball and Heywood | Caryophyllaceae | – | – | – | R | – | – |
| 293. | *Phaeonychium albiflorum* (T. And.) Jafri. | Brassicaceae | – | – | – | R | – | – |
| 294. | *Phaeonychium parryoides* (Kurz.) O.E.S. | Brassicaceae | – | – | – | R | – | – |
| 295. | *Phryma leptostachya* Linn. | Phrymaceae | – | – | – | I | – | – |
| 296. | *Picrorhiza kurrooa* Royle ex Benth. | Scrophulariaceae | VU | – | – | EU | – | – |
| 297. | *Pinus gerardiana* Wall. ex Lamb. | Pinnaceae | – | – | – | – | R | NT |
| 298. | *Pleurospermum corydalifolium* Aitch and Hems. | Apiaceae | – | – | – | R | – | – |
| 299. | *Pleurospermum hookeri* C. B. Clarke | Apiaceae | – | – | – | R | – | – |
| 300. | *Poa falconeri* Hook. f. | Poaceae | – | – | – | I | – | – |
| 301. | *Poa koelzii* Bor | Poaceae | – | – | – | R | – | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 302. | *Poa palustris* Linn. | Poaceae | – | – | – | R | – | LC |
| 303. | *Poa sikkimensis* Bor | Poaceae | – | – | – | R | – | – |
| 304. | *Polygala abyssinica* R. Br. ex Fresen. | Polygalaceae | – | – | – | I | – | – |
| 305. | *Polygonatum geminiflorum* Decne | Liliaceae | – | – | – | R | – | – |
| 306. | *Polygonum bellardii* All. | Polygonaceae | – | – | – | I | – | – |
| 307. | *Polygonum bistorta* Linn. | Polygonaceae | – | – | – | I | – | – |
| 308. | *Potentilla clarkei* Hook. f. | Rosaceae | – | – | – | R | – | – |
| 309. | *Potentilla collettiana* Aitch. ex Hemsl. | Rosaceae | – | – | – | R | – | – |
| 310. | *Potentilla kashmirica* Hk. f. | Rosaceae | – | – | – | R | I | – |
| 311. | *Potentilla monanthes* Lindl. ex Helm. | Rosaceae | – | – | – | R | – | – |
| 312. | *Potentilla salesoviana* Steph. | Rosaceae | – | – | – | R | – | – |
| 313. | *Potentilla sericophylla* Parker | Rosaceae | – | – | – | R | – | – |
| 314. | *Potentilla thomsonii* Hand. - Mazz. | Rosaceae | – | – | – | R | – | – |
| 315. | *Poygonatum verticillatum* All. | Polygonaceae | – | – | EN | – | – | – |
| 316. | *Primula clarkei* Watt. | Primulaceae | – | – | – | EN | EN | – |
| 317. | *Primula minutissima* Jacq. ex Duby | Primulaceae | – | – | – | VU | I | – |
| 318. | *Primula obtusifolia* Royle | Primulaceae | – | – | – | I | – | – |

(continued)

Table 37.1 (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 319. | *Primula pulchra* Watt. | Primulaceae | – | – | – | I | – | – |
| 320. | *Primula reidii* Duthie | Primulaceae | – | – | – | R | – | – |
| 321. | *Pseudomertensia drummondii* Kazmi | Boraginaceae | – | – | – | I | – | – |
| 322. | *Pseudomertensia trollii* (Melch.) Stewart and Kazmi | Boraginaceae | – | – | – | R | – | – |
| 323. | *Puccinellia distans* (Wahlb.) Parl. ssp. *Distans* | Poaceae | – | – | – | R | – | LC |
| 324. | *Puccinellia himalaica* Tzvelev | Poaceae | – | – | – | I | – | – |
| 325. | *Puccinellia kashmiriana* Bor | Poaceae | R | R | – | I | R | – |
| 326. | *Puccinellia stapfiana* R.R. Stewart | Poaceae | – | – | – | I | – | – |
| 327. | *Puccinellia thomsonii* (Stapf) R.R. Stewart | Poaceae | – | I | – | I | I | – |
| 328. | *Pulsatilla wallichiana* (Royle) Ulbr | Ranunculaceae | – | I | – | R | I | – |
| 329. | *Pycnoplinthus uniflorus* (Hook. f. and Thoms.) O.E.S. | Brassicaceae | – | – | – | I | – | – |
| 330. | *Pyrola karakoramica* Krisa | Pyrolaceae | – | – | – | VU | – | – |
| 331. | *Pyrola secunda* Linn. | Pyrolaceae | – | – | – | EN | – | – |
| 332. | *Ranunculus diffusus* DC. | Ranunculaceae | – | – | – | R | – | – |
| 333. | *Ranunculus lingua* Linn. | Ranunculaceae | – | – | – | EN | – | LC |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 334. | *Ranunculus lobatus* Jacquem. ex Camb. | Ranunculaceae | – | – | – | R | – | – |
| 335. | *Ranunculus membranaceus* Royle | Ranunculaceae | – | – | – | R | – | – |
| 336. | *Ranunculus natans* C.A. Mey. | Ranunculaceae | – | – | – | R | – | – |
| 337. | *Ranunculus pangiensis* Watt. | Ranunculaceae | – | – | – | R | – | – |
| 338. | *Rheum australe* D. Don | Polygonaceae | – | – | VU | – | – | – |
| 339. | *Rhododendron campanulatum* D. Don | Ericaceae | – | – | – | VU | – | – |
| 340. | *Rhododendron hypenanthum* Balf. | Ericaceae | – | – | – | VU | – | – |
| 341. | *Rhododendron lepidotum* Wall. ex D. Don | Ericaceae | – | – | – | EN | – | – |
| 342. | *Rhus punjabensis* Stewart ex Brandis | Anacardiaceae | – | – | – | I | – | – |
| 343. | *Rosa foetida* Herrm. | Rosaceae | – | – | – | EN | – | – |
| 344. | *Rubia edgeworthii* Hook. f. | Rubiaceae | – | – | – | – | VU | – |
| 345. | *Rubia himalayensis* Klotzsch | Rubiaceae | VU | VU | – | I | VU | – |
| 346. | *Rubia tinctorum* Linn. | Rubiaceae | – | – | – | I | – | – |
| 347. | *Rubus macilentus* Camb. | Rosaceae | – | – | – | I | – | – |
| 348. | *Sabia campanulata* Wall. | Sabiaceae | – | – | – | I | – | – |
| 349. | *Sageretia theezans* (Linn.) Brongn. | Rhamnaceae | – | – | – | I | – | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 350. | *Sagittaria trifolia* Linn. | Alismataceae | – | – | – | R | – | LC |
| 351. | *Saussurea atkinsonii* C.B. Clarke | Asteraceae | – | I | – | I | I | – |
| 352. | *Saussurea bracteata* Decne. | Asteraceae | R | R | – | R | R | – |
| 353. | *Saussurea clarkei* Hk. f. | Asteraceae | R | R | – | I | R | – |
| 354. | *Saussurea costus* (Falc.) Lipsch. | Asteraceae | EN | EN | CR | VU | EN | CR |
| 355. | *Saussurea gossypiphora* D. Don | Asteraceae | – | – | CR | VU | – | – |
| 356. | *Saussurea obvallata* (DC.) Sch. Bip. | Asteraceae | – | – | EN | – | – | – |
| 357. | *Saussurea roylei* (DC.) Sch. Bip. | Asteraceae | – | I | – | I | I | – |
| 358. | *Saussurea simpsoniana* (Field and Garden) Lipsch. | Asteraceae | – | – | EN | EN | – | – |
| 359. | *Saxifraga asarifolia* Sternb. | Saxifragaceae | – | – | – | R | – | – |
| 360. | *Saxifraga jacquemontiana* Decne. | Saxifragaceae | – | EN | – | VU | EN | – |
| 361. | *Saxifraga lilacina* Duthie | Saxifragaceae | – | – | – | VU | – | – |
| 362. | *Saxifraga pulvinaria* H. Smith | Saxifragaceae | – | – | – | R | – | – |
| 363. | *Schizachyrium impressum* (Hackel) A. Camus | Poaceae | – | EN | – | I | EN | – |
| 364. | *Schultzia dissecta* (Clarke) Norman | Apiaceae | – | – | – | I | – | – |
| 365. | *Scirpus mucronatus* L. | Cyperaceae | – | – | – | R | – | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 366. | *Sedum fischeri* Hamet. | Crassulaceae | – | – | – | R | – | – |
| 367. | *Sedum trullipetalum* Hook.f. and Thoms. | Crassulaceae | – | – | – | R | – | – |
| 368. | *Sempervivella alba* (Edgew.) Stapf | Crassulaceae | – | – | – | R | – | – |
| 369. | *Silene kunawurensis* Benth. | Caryophyllaceae | R | – | – | – | R | – |
| 370. | *Smilax vaginata* Decne. | Liliaceae | – | – | – | R | – | – |
| 371. | *Solanum dulcamara* Linn. | Solanaceae | – | – | – | I | – | – |
| 372. | *Sorbus cashmiriana* Hedlund. | Rosaceae | – | – | – | R | – | – |
| 373. | *Sparganium ramosum* Hudson | Sparganiaceae | – | – | – | R | – | LC |
| 374. | *Sparganium simplex* Hudson | Sparganiaceae | – | – | – | R | – | – |
| 375. | *Spodiopogon cotulifer* Hack | Poaceae | – | – | – | I | – | – |
| 376. | *Stachys palustris* Linn. | Lamiaceae | – | – | – | R | – | LC |
| 377. | *Stachys sylvatica* Linn. | Lamiaceae | – | – | – | R | – | – |
| 378. | *Staphylea emodi* Wall. ex Brandis | Staphyleaceae | – | – | – | R | – | – |
| 379. | *Stellaria depressa* Schmid. | Caryophyllaceae | – | – | – | – | I | – |
| 380. | *Stipa breviflora* Griseb | Poaceae | – | – | – | I | – | – |
| 381. | *Stipa chitralensis* Bor | Poaceae | – | – | – | – | I | – |
| 382. | *Stipa mongholica* Turez. ex Trin. | Poaceae | – | – | – | R | – | – |
| 383. | *Stipa purpurea* Griseb. | Poaceae | – | – | – | R | – | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 384. | *Stracheya tibetica* Benth. | Fabaceae | – | – | – | R | – | – |
| 385. | *Strobilanthes wallichii* Nees | Acanthaceae | – | – | – | I | – | – |
| 386. | *Swertia alata* (D. Don) Clarke | Gentianaceae | – | – | – | R | – | – |
| 387. | *Swertia alternifolia* Royle | Gentianaceae | – | – | – | I | – | – |
| 388. | *Swertia chirayita* (Roxb. ex Fleming) Karst. | Gentianaceae | – | – | CR | – | – | – |
| 389. | *Tetracme pamirica* Vass. | Brassicaceae | – | – | – | R | – | – |
| 390. | *Teucrium scordium* Linn. | Lamiaceae | – | – | – | R | – | – |
| 391. | *Thalictrum platycarpum* Hook. f. and Thoms. | Ranunculaceae | – | – | – | R | – | – |
| 392. | *Thalictrum rutaefolium* Hook. f. and Thoms. | Ranunculaceae | – | – | – | R | – | – |
| 393. | *Thalspi andersonii* (Hook. f. and Thoms.) O.E.S. | Brassicaceae | – | – | – | VU | – | – |
| 394. | *Thalspi septigerum* (Bunge) Jafri | Brassicaceae | – | – | – | VU | – | – |
| 395. | *Thermopsis inflata* Cambess. | Fabaceae | – | – | – | – | I | – |
| 396. | *Thesium hookeri* Hendrych | Santalaceae | – | – | – | VU | – | – |
| 397. | *Tovara virginiana* (Linn.) Rafin. | Polygonaceae | – | – | – | I | – | – |
| 398. | *Tribulus terrestris* Linn. | Zygophyllaceae | – | – | – | EN | – | – |
| 399. | *Trisetum micans* (Hook. f.) Bor | Poaceae | – | – | – | – | I | – |
| 400. | *Trollius acaulis* Lindl. | Ranunculaceae | – | EN | – | VU | EN | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 401. | *Turgenia latifolia* (Linn.) Hoffm. | Apiaceae | – | – | – | R | – | – |
| 402. | *Ulmus chumlia* Melville and Heybroek | Ulmaceae | – | – | – | I | – | – |
| 403. | *Ulmus wallichiana* Planch. | Ulmaceae | – | EN | – | EN | EN | VU |
| 404. | *Urtica ardens* Link. | Urticaceae | – | – | – | R | – | – |
| 405. | *Valeriana clarkei* Briq. | Valerianaceae | – | – | – | R | – | – |
| 406. | *Valeriana ficariifolia* Boiss. | Valerianaceae | – | – | – | R | – | – |
| 407. | *Vallisneria spiralis* Linn. | Hydrocharitaceae | – | – | – | EN | – | LC |
| 408. | *Verbascum blattaria* Linn. | Scrophulariaceae | – | – | – | I | – | – |
| 409. | *Veronica cachemirica* Gandoger. | Scrophulariaceae | – | – | – | R | – | – |
| 410. | *Veronica campylopoda* Boiss. | Scrophulariaceae | – | – | – | VU | – | – |
| 411. | *Veronica leucothrix* Penn. | Scrophulariaceae | – | – | – | I | – | – |
| 412. | *Veronica macrostemom* Bunge ex Ledeb. | Scrophulariaceae | – | – | – | I | – | – |
| 413. | *Veronica nana* Penn. | Scrophulariaceae | – | – | – | I | – | – |
| 414. | *Veronica uncinata* Penn. | Scrophulariaceae | – | – | – | I | – | – |
| 415. | *Vicatia coniifolia* DC. | Apiaceae | – | – | – | R | – | – |
| 416. | *Vicatia wolffiana* (Wolff ex Fedde) Norman | Apiaceae | – | – | – | R | – | – |
| 417. | *Vicia benthamiana* Ali | Fabaceae | – | – | – | – | I | – |

(continued)

**Table 37.1** (continued)

| S. no. | Name of the species | Family | Nayar and Sastry (1987–1988) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN Red List (2017) |
|---|---|---|---|---|---|---|---|---|
| 418. | *Viola falconeri* Hook. f. and Thoms. | Violaceae | – | – | – | R | – | – |
| 419. | *Viola fedtschenkoana* W. Becker | Violaceae | – | – | – | I | – | – |
| 420. | *Viola himalayensis* W. Becker | Violaceae | – | – | – | - | I | – |
| 421. | *Viola kunawarensis* Royle | Violaceae | – | I | – | R | I | – |
| 422. | *Vulpia unilateralis* (Linn.) Stace | Poaceae | – | – | – | R | – | – |
| 423. | *Waldheimia vestita* (Hook. and Thoms.) Pamp. | Asteraceae | – | – | – | R | – | – |
| 424. | *Wikstroemia canescens* Meissn. | Thymelaeaceae | – | – | – | VU | – | – |
| 425. | *Wolffia arrhiza* (Linn.) Wimm. | Lemnaceae | – | – | – | R | – | LC |
| 426. | *Wulfeniopsis amherstiana* (Benth.) Hong. | Scrophulariaceae | – | – | – | R | – | – |
| 427. | *Zannichellia palustris* Linn. | Zannichelliaceae | – | – | – | VU | – | LC |
| 428. | *Ziziphus jujuba* Mill. | Rhamnaceae | – | – | – | R | – | LC |
| 429. | *Zozimia tragioides* Boiss. | Apiaceae | – | – | – | I | – | – |

*CR* critically endangered, *EN* endangered, *VU* vulnerable, *R* rare, *I* indeterminate, *NT* near threatened, *LC* least concern, – not listed

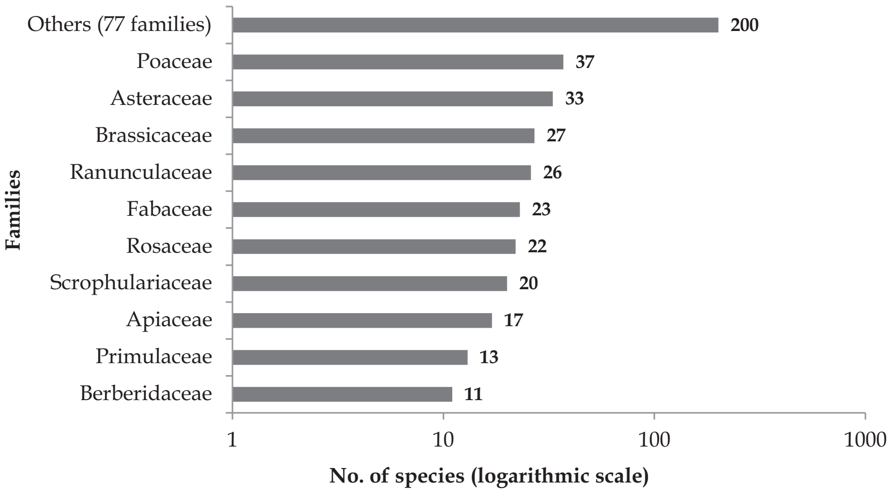


**Fig. 37.2** Numerical distribution of threatened angiosperm species within ten largest families and rest of the families

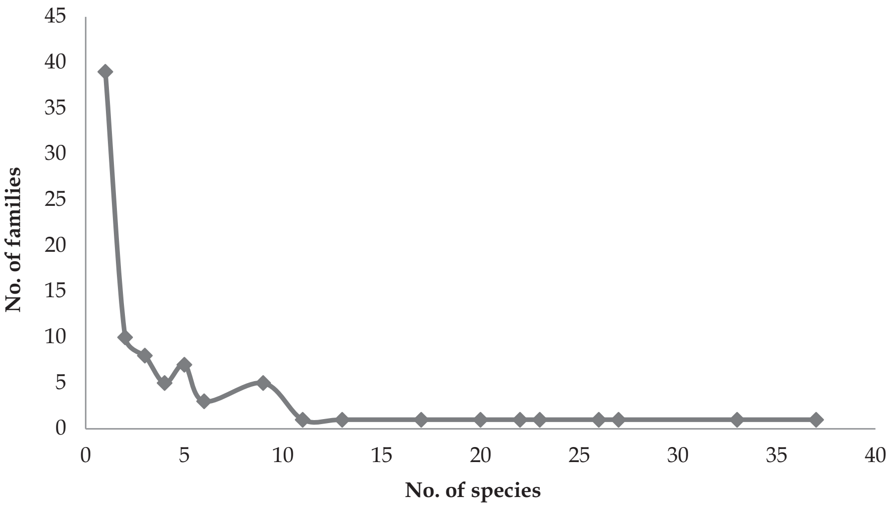


**Fig. 37.3** Numerical distribution of threatened plant species within families

**Table 37.2** Numerical synopsis of the threat status of seed-plant flora of J&K State

| Threat status | Number of plant species | | | | | |
|---|---|---|---|---|---|---|
| | Nayar and Sastry (1987–1990) | Walter and Gillett (1998) | Molur and Walker (1998) | Dar and Naqshi (2001) | Rao et al. (2003) | IUCN (2017) |
| Critically endangered | – | – | 20 | – | – | 4 |
| Endangered | 1 | 16 | 9 | 40 | 20 | 2 |
| Vulnerable | 10 | 3 | 4 | 50 | 6 | 2 |
| Near threatened | – | – | 1 | – | – | 2 |
| Least concern | – | – | – | – | – | 32 |
| Rare | 11 | 4 | – | 155 | 8 | – |
| Indeterminate | 1 | 21 | – | 110 | 58 | – |
| **Total** | **23** | **44** | **34** | **355** | **92** | **42** |

as vulnerable, 50 were reported by Dar and Naqshi (2001), 10 by Nayar and Sastry (1987–1990), 6 by Rao et al. (2003), 4 in Molur and Walker (1998), 3 by Walter and Gillett (1998), and 2 species in IUCN Red List (2017). On comparative analysis of taxa reported in these threatened lists, it is found that Nayar and Sastry (1987–1990) have assessed 23 species belonging to 19 genera in 14 families; Walter and Gillett (1998) assessed 44 species belonging to 34 genera in 21 families; Molur and Walker (1998) assessed 34 species belonging to 22 genera in 18 families; Dar and Naqshi (2001) assessed 355 taxa (345 spp. + 3 subspp. + 7 varieties) belonging to 227 genera in 88 families; Rao et al. (2003) assessed 92 species belonging to 64 genera in 29 families (Table 37.2) (Plate 37.1).

## 37.4 Discussion

Despite the pivotal importance of plants in sustaining life on the planet Earth, plants are increasingly subjected to the threats of habitat loss and land-use change (Newbold et al. 2016), overharvest (Brummitt et al. 2015), and stress associated with climate change (Urban 2015). The pressure that humans exert on natural resources such as plants is at an unprecedented level and may push the planet beyond safe limits (Steffen et al. 2015). Like other resources, plants over the past several decades have been extensively exploited through various anthropogenic pressures like grazing, unabated deforestation, overexploitation of species of economic interest, rapid urbanization, and unsustainable development. The IUCN committee for threatened plants indicates that one in ten species of vascular plants on the Earth is endangered or threatened due to commercial exploitation and international trade.

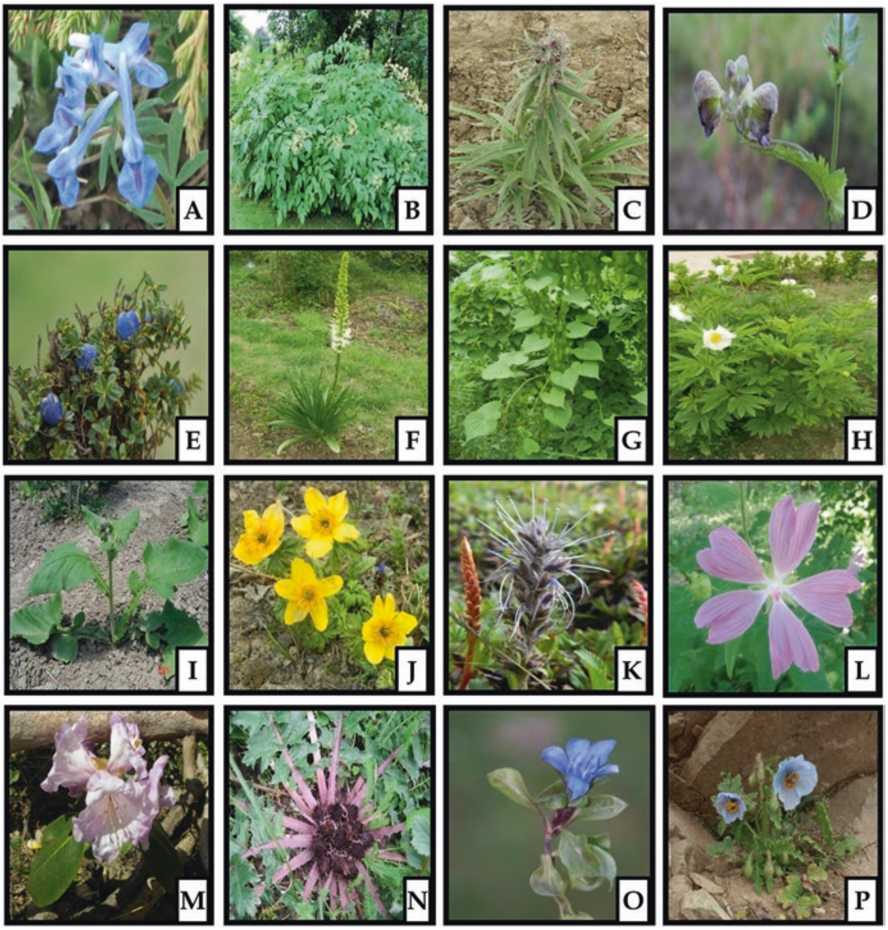


**Plate 37.1** (**a**) *Corydalis cashmeriana*, (**b**) *Aralia cachemirica*, (**c**) *Arnebia benthamii*, (**d**) *Aconitum heterophyllum*, (**e**) *Gaultheria trichophylla*, (**f**) *Eremurus himalaicus*, (**g**) *Dioscorea deltoidea,* (**h**) *Paeonia emodi* , (**i**) *Saussurea costus,* (**j**) *Trollius acaulis,* (**k**) *Picrorhiza kurroa*, (**l**) *Lavatera kashmiriana*, (**m**) *Rhododendron campanulatum*, (**n**) *Dolomiaea macrocephala*, (**o**) *Gentiana cachmerica*, (**p**) *Meconopsis latifolia*

### *37.4.1 Major Threats to Flora of Jammu and Kashmir State*

In J&K State, the habitats of majority of plant species falling under the threatened categories occur within the extensively grazed alpine meadows. The livestock, besides eating the leaves, damage the flowering spikes of these species and thereby restrict their population size and distribution (Dar et al. 2006a, b). For instance, species like *Fritillaria roylei*, *Corydalis cashmeriana*, *Aquilegia nivalis*, and *Lagotis cashmeriana* have been reported to be mostly affected by grazing (Tali et al. 2015).

Dar et al. (2006a) also reported overgrazing as a serious threat to *Lagotis cashmeriana* and *Aquilegia nivalis.*

Overexploitation of species of economic interest is the second major threat. Majority of the plants listed as threatened are overharvested illegally from the wild. The local people collect either whole plants or different parts of these plants, thereby rendering them threatened (Dar and Naqshi 2001). Wani et al. (2006) reported that medicinal plants of Kashmir Himalaya are ruined at an alarming rate as a result of extraction and overexploitation. Dar and Naqshi (2001) also reported that excessive collection of plants from their natural habitats has resulted in virtual extirpation of many taxa. *Aconitum heterophyllum*, *Arnebia benthamii*, *Dioscorea deltoidea*, *Jurinea dolomiaea*, *Picrorhiza kurrooa*, and *Saussurea costus* are some of the target medicinal plants whose overexploitation during the past few decades has led to their endangerment. Similarly, other factors like deforestation, unregulated construction of roads, tourist influx, and landslides have resulted in the decline of these and several other species in natural habitats, bringing them toward the brink of extirpation. *Picrorhiza kurrooa* and *Taxus wallichiana*, among Kashmir Himalayan seed plants, are included in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) [Dar et al. 2002].

### *37.4.2 Knowledge Gaps in Threatened Flora of Jammu and Kashmir State*

Assigning an appropriate threat category to a species is of immense importance for its conservation. This chapter, however, reveals that there have been inconsistencies in assigning threat categories to plants by previous workers. For example, in the absence of adequate information required for the process, Dar and Naqshi (2001) have based their checklist on pre-1994 IUCN threat categories, which recognized extinct, endangered, vulnerable, rare, indeterminate, and insufficiently known categories (see WCMC 1992). The same appears to be true with Nayar and Sastry (1987–1990), Walter and Gillet (1998), and Rao et al. (2003). Thus, *Aconitum heterophyllum*, assigned the category of critically endangered by Molur and Walker (1998), is categorized as endangered by Walter and Gillett (1998) and Dar and Naqshi (2001); *Allium roylei* is categorized as vulnerable by Dar and Naqshi (2001) and as near threatened by IUCN (2017); *Arnebia benthami*, categorized as critically endangered by Molur and Walker (1998), is placed as endangered by Walter and Gillett (1998), Dar and Naqshi (2001), and Rao et al. (2003); *Delphinium denudatum*, categorized as critically endangered by Molur and Walker (1998), is recognized as indeterminate by Rao et al. (2003); and *Fritillaria roylei*, categorized as critically endangered by Molur and Walker (1998), is placed as rare by Dar and Naqshi (2001).

Furthermore, our recent field studies point toward the fact that many plant species among angiosperms (e.g., *Betula utilis*, *Colchicum luteum*, *Corylus jacque-*

*montii*, *Dactylorhiza hatagirea*, *Eremostachys superba*, *Heracleum canescens*, *Impatiens balfourii*, *Lavatera kashmiriana*, *Morus nigra*, *Podophyllum hexandrum*, *Primula inayatii*, *Rheum webbianum*, *Skimmia anquetilia*, *Swertia speciosa*, *Trillium govanianum*, *Valeriana jatamansii*) and gymnosperms (e.g., *Taxus wallichiana*, *Ephedra gerardiana*, and *Juniperus semiglobosa*), whose populations are fast declining due to overexploitation, have been till now left out of the threatened lists and need immediate threat categorization as per IUCN criteria. Similarly, several other species that include *Arabis pangiensis*, *Astragalus maddenianus*, *A. pindreensis*, *Celtis tetrandra*, *Corydalis clarkei*, *C. cyrtocentra*, *C. falconeri*, *Dianthus cachemiricus*, *Eragrostis unioloides*, *Erophila spathulata*, *Festuca simlensis*, *Gentiana ornata*, *G. pedicellata*, *Goldbachia laevigata*, *Herniaria cachemiriana*, *Impatiens bicolor*, *Ixiolirion karateginum*, *Juncus himalensis*, *Lactuca quercina*, *Lindernia pyxidaria*, *Lomatogonium thomsonii*, *Nepeta elliptica*, *N. eriostachys*, *Oxytropis cachemiriana*, *Pedicularis hoffmeisteri*, *Poa kashmiriana*, *Polygala persicariifolia, Salvia virgata*, *Saussurea auriculata*, *S. medusa*, *Sophophora moorcroftiana*, *Thymelaea passerina*, *Tricholepis elongata*, and *Valeriana jaeschkei* have been previously reported from this region and frequently considered rare and threatened; these species, however, have not been collected from the State in recent times, indicating their probable extinction, misidentification or erroneous reports. Such inconsistencies and knowledge gaps in the threatened flora are mostly due to insufficient field data available on the plants of the region, which is the basis for evaluation against different IUCN criteria for threat assessment. To overcome this, there is immediate need to collate/improve the field data of plants required for their accurate threat assessment as per the current versions of IUCN and national/regional threat categories.

### *37.4.3 Future Roadmap*

In light of knowledge gaps and to overcome the methodological shortfalls, it is crucial to adopt globally standardized modern tools for conservation assessment. The IUCN has recently recommended the development of techniques that better reflect threats to species' persistence than those from the predicted range changes. Recently emerging tools, such as the web-based software, e.g., GeoCAT (Bachman et al. 2011), species distribution models (SDMs), statistical packages in R, e.g., ConR (Dauby et al. 2017), rCAT (Moat and Bachman 2017), redlistr (Lee and Murray 2017), red (Cardoso 2017), speciesgeocodeR (Topel et al. 2017), and rredlist (Chamberlain 2017) have been successfully used in the assessment of threat status and prioritize conservation in different parts of the world. These state-of-the-art tools can help in formulating a clear-cut roadmap for red listing of plants in J&K State. These tools can provide a novel guide and facilitate conservation by enabling practitioners to conduct preliminary assessment simultaneously for hundreds of species in an efficient and time-saving manner.

In brief, the following parameters can be the vital components of the operational methodological framework to be followed for threat assessment of the flora in J&K State:

- The species' occurrence data, which form the starting point in the threat assessment, can be obtained from field records (literature and herbarium reconstruction data) and supplemented with data from the Global Biodiversity Information Facility (GBIF) (https:/www.gbif.org/).
- Although species' occurrence data from herbarium collections are valuable for mapping biodiversity patterns in space and time, yet these collections may be associated with sampling biases and taxonomic errors. If such biases and errors are not taken into consideration, it can lead to data quality issues which can influence the quality of the products derived from them. Recently, one innovative R package *Biogeo* (Robertson et al. 2016) has been developed which can detect and correct such errors and thus help in assessing data quality of herbarium collections consisting of occurrence records.
- Species' occurrence records are often biased toward areas that are easily accessible or near cities or other areas of high population density. This spatial sampling bias can be removed by spatial thinning using R package *spThin* (Aiello-Lammens et al. 2015).
- The Criterion B of IUCN Red List Evaluation, which principally uses distribution data, is the most widely used parameter to assess conservation status, particularly of plant species. Criterion B involves two sub-criteria: extent of occurrence (EOO) and area of occupancy (AOO). The EOO is defined as "the area contained within the shortest continuous imaginary boundary that can be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon, excluding cases of vagrancy" (IUCN, 2012b). On the other hand, the AOO is defined as "the area within its 'extent of occurrence' that is occupied by a taxon, excluding cases of vagrancy" (IUCN, 2012b). Using the species' occurrence data by adopting the abovementioned methods, it is possible to calculate AOO and EOO key geographic range parameters and estimate the number of locations as empirical thresholds for designation under different threat categories under Criterion B. Furthermore, it can provide a visualization of the results by generating maps suitable for the full assessment as per the IUCN Red List Criteria at Regional Levels (IUCN 2012a).

## 37.5 Concluding Remarks

This chapter provides an updated synthesis on the threatened flora of J&K State, which will help in identifying the threatened species and prioritize them for conservation. Since such Red Lists help in prioritizing species for conservation and management, they need to be continuously improved and refined by using recently emerging robust empirical tools and authentic field data. Therefore, we call for a well-planned objective approach in assessing the threat status of the flora of J&K State, which can effectively determine the success of plant conservation in this biodiversity-rich Himalayan region.

**Acknowledgments** The authors are thankful to the Head, Department of Botany, University of Kashmir, for providing necessary facilities. The support provided by the research scholars at the Centre for Biodiversity and Taxonomy, University of Kashmir, is highly acknowledged. Anzar A Khuroo acknowledges the financial support received under AICOPTAX scheme of MoEFCC, New Delhi, during the course of present study.

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# Chapter 38
# Threatened Fauna of Jammu and Kashmir State

**Bilal A. Bhat, Riyaz Ahmad, Mustahson F. Fazili, Iqram Ul Haq, and G. A. Bhat**

**Abstract** The empirical assessment of species for assigning threat status guides priority setting in conservation efforts. This chapter has documented 71 threatened and near-threatened faunal species from the Jammu and Kashmir State. These include 33 species of birds, 26 species of mammals, 5 species each of reptiles and fishes and 2 species of amphibians. Among the birds, 3 species are critically endangered (CR), 4 endangered (EN), 11 vulnerable (VU) and 15 near threatened (NT), while among the mammals, one species is CR, 5 are EN, 8 VU and 12 NT. The threatened herpetofauna includes five reptilian (EN = 2; VU = 2; NT, 1) and two amphibian (EN = 1; VU = 1) species. Three fish species are assessed as threatened (CR = 1; EN = 1; VU = 1) and 2 as NT. Overall, the number of CR, EN and VU species is 5, 13 and 23, respectively, whereas the number of NT species is 30. The inclusion of majority of these species in CITES appendices and various schedules of the Wildlife Protection Act of India, 1972 (amended in 2006), points towards their threat status in this Himalayan State. The major threats to fauna of the State include loss, degradation and fragmentation of habitat, poaching, livestock grazing, over-exploitation and human–wildlife conflict. This chapter also highlights the knowledge gaps about threat status of faunal diversity in the State and the appropriate steps required to be initiated in the immediate future.

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_38

**Keywords** Fauna · Red List · Threats to fauna · Conservation · Jammu and Kashmir

## 38.1 Introduction

Although there is a growing awareness of how biodiversity sustains our well-being, we still continue to threaten it. Across the globe, the pace of population decline of species is accelerating to unprecedented levels and is mainly triggered through human-induced threats such as unsustainable use, unwise development, wildlife trade, poaching, habitat loss, habitat degradation and fragmentation, overgrazing, pollution, invasion, encroachment and change in land use (Kurt 1978; Ahmad et al. 2009; Bhat et al. 2010; Shah et al. 2011; Rahmani et al. 2013; Ahmad 2014; Steffen et al. 2015). The current species extinction rates have been greatly accelerated and are between 1000 and 10,000 times higher than the background rate in geological past (May et al. 1995). The IUCN Red List is one of the standard tools to empirically assess the threat status of species at the global level for prioritizing conservation initiatives (Rodrigues et al. 2006; Miller et al. 2007). In this connection, the threatened fauna is a general term that includes all those species which are vulnerable to endangerment in the near future. The Red List has been instrumental in globally guiding research, conservation and monitoring of the species by the governments and conservation organizations (Butchart et al. 2005; Young et al. 2014). However, the lack of sound scientific information can sometimes lead to incorrect categorization of species. Therefore, it becomes imperative to generate the requisite information about a species in order to assign it an appropriate threat status category for catalysing its conservation through scientifically robust methods.

The Jammu and Kashmir (J&K) State is recognized for its rich and endemic faunal diversity (Rahmani et al. 2013), but lack of adequate knowledge about majority of the species may hinder the attempts to achieve conservation goals. Such information has been generated only for a few flagship species such as hangul (*Cervus hanglu hanglu*), markhor (*Capra falconeri*), snow leopard (*Panthera uncia*) and black-necked crane (*Grus nigricollis*) (Bhat 2008; Ahmad et al. 2009; Bhatnagar et al. 2009; Shah et al. 2011; Rahmani et al. 2013). Although the compilation of *Threatened Birds of Jammu and Kashmir* by Rahmani et al. (2013) is a step forward, the available information on most of the faunal groups in the State has not been compiled to present a complete picture of the threatened fauna of the State. It is in this backdrop that the present chapter has consolidated all the available information about the existing threatened fauna of the State.

## 38.2 Materials and Methods

### *38.2.1 Study Area*

The J&K State lies in the extreme north-west of India. It falls between the coordinates 32°17′ to 37°20′ north latitude and 73°25′ to 80°30′ east longitude. The State possesses three distinct biogeographic zones, viz. Trans Himalaya, Northwest Himalaya and Semi-arid Plains (Rodgers and Panwar 1988). The Trans Himalaya is mainly represented by Ladakh in the State, Northwest Himalaya mainly by Kashmir and northern parts of Jammu and the Semi-arid Plains by Jammu. The three regions provide different settings of climate, altitude and precipitation, thus making the State biodiversity-rich.

### *38.2.2 Data Sources*

The updated list of threatened fauna was compiled using published literature, unpublished information, web sources, field notes and expert interviews (Lawrence 1895; Bates and Lowther 1952; Das and Subla 1964; Prater 1971; Sahi and Duda 1985; Ali and Ripley 1987; Jhingran 1991; Yousuf 1996; Dar et al. 2002; Pfister 2004; Balkhi 2007; Bhat et al. 2010; Rahmani et al. 2013; Menon 2014; Chandra et al. 2018; Suhail et al. 2019; Sahi and Koul 2019). The IUCN status and listing of animals in schedules of the Wildlife Protection Act of India, 1972 (amended 2006), and CITES appendices have been retrieved from the web sources (www.iucnredlist.org; www.wiienvis.nic.in; www.cites.org). Information on threats and conservation aspects was gathered from published sources and the authors' own field surveys (Bhat 2008; Ahmad et al. 2009; Bhatnagar et al. 2009; Shah et al. 2011; Ahmad et al. 2017).

## 38.3 Results

This chapter documents a total of 71 threatened and near-threatened faunal species from the State (Table 38.1, Fig. 38.1). These belong to 4 orders and 11 families of mammals, 11 orders and 14 families of birds, 1 order and 2 families of reptiles, 1 order and 2 families of amphibians, and 1 order and 1 family of fishes. Of the total species, birds have the highest number of 33 threatened species followed by mammals with 26 species, reptiles and fishes with 5 species each and amphibians with 2 species. The number of critically endangered, endangered and vulnerable species is 5, 13 and 23, respectively. The number of near-threatened species is 30 (Plate 38.1).

**Table 38.1** Threatened fauna of Jammu and Kashmir state

| S. no. | Common name | Scientific name | Threat status[a] | CITES (appendix) | Indian Wildlife Protection Act, 1972 (Schedule) |
|---|---|---|---|---|---|
| **Mammals** | | | | | |
| **Order: Primates** | | **Family: Cercopithecidae** | | | |
| 01 | Kashmir grey langur | *Semnopithecus ajax* Pocock, 1928 | EN | – | II |
| **Order: Artiodactyla** | | **Family: Moschidae** | | | |
| 02 | Himalayan musk deer | *Moschus leucogaster* Hodgson, 1839 | EN | I | I |
| 03 | Kashmir musk deer | *Moschus cupreus* Grubb, 1982 | EN | I | I |
| | | **Family: Cervidae** | | | |
| 04 | Kashmir red deer or hangul | *Cervus hanglu hanglu* (Wagner, 1844) | CR | I | I |
| 05 | Sambar | *Rusa unicolor* Kerr, 1792 | VU | – | III |
| | | **Family: Bovidae** | | | |
| 06 | Wild yak | *Bos mutus* Przewalski, 1883 | VU | I | I |
| 07 | Tibetan antelope | *Pantholops hodgsonii* Abel, 1826 | NT | I | I |
| 08 | Tibetan gazelle | *Procapra picticaudata* Hodgson, 1846 | NT | – | I |
| 09 | Markhor | *Capra falconeri* Wagner, 1839 | NT | I | I |
| 10 | Himalayan tahr | *Hemitragus jemlahicus* Smith, 1826 | NT | – | I |
| 11 | Urial | *Ovis orientalis* Gmelin, 1774 | VU | – | I |
| 12 | Argali | *Ovis ammon* Linnaeus, 1758 | NT | I | I |
| 13 | Himalayan grey goral | *Nemorhaedus bedfordi* Lydekker, 1905 | NT | – | III |
| 14 | Himalayan serow | *Capricornis thar* Hodgson, 1831 | NT | – | I |
| **Order: Carnivora** | | **Family: Felidae** | | | |
| 15 | Common leopard | *Panthera pardus* Linnaeus, 1758 | VU | I | I |
| 16 | Snow leopard | *Panthera uncia* Schreber, 1775 | VU | I | I |
| 17 | Pallas's cat | *Otocolobus manul* Pallas, 1776 | NT | – | I |
| 18 | Rusty-spotted cat | *Prionailurus rubiginosus* Geoffroy Saint-Hilaire, 1831 | VU | – | I |

(continued)

**Table 38.1** (continued)

| S. no. | Common name | Scientific name | Threat status[a] | CITES (appendix) | Indian Wildlife Protection Act, 1972 (Schedule) |
|---|---|---|---|---|---|
| | | **Family: Canidae** | | | |
| 19 | Wild dog | *Cuon alpinus* Pallas, 1811 | EN | – | II |
| | | **Family: Ursidae** | | | |
| 20 | Asiatic black bear | *Ursus thibetanus* Cuvier, 1823 | VU | – | I |
| | | **Family: Mustelidae** | | | |
| 21 | Eurasian otter | *Lutra lutra* Linnaeus, 1758 | NT | – | I |
| 22 | Mountain weasel | *Mustela altaica* Pallas, 1811 | NT | – | II |
| | | **Family: Sciuridae** | | | |
| 23 | Woolly flying squirrel | *Eupetaurus cinereus* Thomas, 1888 | EN | – | II |
| | | **Family: Muridae** | | | |
| 24 | Sub-alpine Kashmir vole | *Hyperacrius fertilis* (True, 1894 | NT | – | – |
| 25 | Kashmir mountain vole | *Alticola montosa* True, 1894 | VU | – | – |
| **Order: Pholidota** | | **Family: Manidae** | | | |
| 26 | Indian pangolin | *Manis crassicaudata* Gray, 1827 | NT | – | I |
| **Birds** | | | | | |
| **Order: Galliformes** | | **Family: Phasianidae** | | | |
| 01 | Western tragopan | *Tragopan melanocephalus* (Gray, 1829) | VU | I | I |
| 02 | Cheer pheasant | *Catreus wallichii* (Hardwicke, 1827) | VU | I | I |
| **Order: Anseriformes** | | **Family: Anatidae** | | | |
| 03 | Lesser white-fronted goose | *Anser erythropus* (Linnaeus, 1758) | VU | – | IV |
| 04 | Long-tailed duck | *Clangula hyemalis* (Linnaeus, 1758) | VU | – | IV |
| 05 | Marbled duck | *Marmaronetta angustirostris* (Menetries, 1832) | VU | – | IV |
| 06 | White-headed duck | *Oxyura leucocephala* (Scopoli, 1769) | EN | II | IV |
| 07 | Ferruginous duck | *Aythya nyroca* (Guldenstadt, 1770) | NT | – | IV |
| **Order: Ciconiiformes** | | **Family: Ciconiidae** | | | |
| 08 | Painted stork | *Mycteria leucocephala* (Pennant, 1769) | NT | – | IV |
| 09 | Black-necked stork | *Ephippiorhynchus asiaticus* (Latham, 1790) | NT | – | I |

(continued)

**Table 38.1** (continued)

| S. no. | Common name | Scientific name | Threat status[a] | CITES (appendix) | Indian Wildlife Protection Act, 1972 (Schedule) |
|---|---|---|---|---|---|
| **Order: Pelecaniformes** | | **Family: Threskiornithidae** | | | |
| 10 | Black-headed ibis | *Threskiornis melanocephalus* (Latham, 1790) | NT | – | IV |
| **Order: Accipitriformes** | | **Family: Accipitridae** | | | |
| 11 | Red kite | *Milvus milvus* (Linnaeus 1758) | NT | – | I |
| 12 | Greater spotted eagle | *Aquila clanga* Pallas 1811 | VU | – | I |
| 13 | Eastern imperial eagle | *Aquila heliaca* Savigny 1809 | VU | I | I |
| 14 | Pallas's Fish Eagle | *Haliaeetus leucoryphus* (Pallas 1771) | EN | II | IV |
| 15 | White-rumped vulture | *Gyps bengalensis* (Gmelin 1788) | CR | II | I |
| 16 | Slender-billed vulture | *Gyps tenuirostris* Gray 1844 | CR | II | I |
| 17 | Egyptian vulture | *Neophron percnopterus* (Linnaeus 1758) | EN | II | IV |
| 18 | Bearded vulture | *Gypaetus barbatus* (Linnaeus 1758) | NT | II | I |
| 19 | Cinereous vulture | *Aegypius monachus* (Linnaeus 1766) | NT | II | IV |
| 20 | Pallid harrier | *Circus macrourus* (Gmelin 1770) | NT | II | I |
| **Order: Falconiformes** | | **Family: Falconidae** | | | |
| 21 | Laggar falcon | *Falco jugger* Gray 1834 | NT | I | IV |
| 22 | Saker Falcon | *Falco cherrug* Gray 1834 | EN | II | IV |
| **Order: Gruiformes** | | **Family: Gruidae** | | | |
| 23 | Black-necked crane | *Grus nigricollis* Przevalski 1876 | VU | I | I |
| 24 | Sarus crane | *Grus antigone* (Linnaeus 1758) | VU | II | IV |
| 25 | Siberian crane | *Grus leucogeranus* Pallas, 1773 | CR | I | I |
| **Order: Charadriiformes** | | **Family: Scolopacidae** | | | |
| 26 | Eurasian curlew | *Numenius arquata* (Linnaeus 1758) | NT | – | IV |
| 27 | Black-tailed godwit | *Limosa limosa* (Linnaeus 1758) | NT | – | IV |

(continued)

**Table 38.1** (continued)

| S. no. | Common name | Scientific name | Threat status[a] | CITES (appendix) | Indian Wildlife Protection Act, 1972 (Schedule) |
|---|---|---|---|---|---|
| | | **Family: Laridae** | | | |
| 28 | River tern | *Sterna aurantia* Gray, 1831 | NT | – | IV |
| **Order: Columbiformes** | | **Family: Columbidae** | | | |
| 29 | Yellow-eyed pigeon | *Columba eversmanni* Bonaparte 1856 | VU | – | IV |
| **Order: Passeriformes** | | **Family: Locustellidae** | | | |
| 30 | Long-billed bush warbler | *Bradypterus major* (Brooks 1872) | NT | – | IV |
| | | **Family: Sylviidae** | | | |
| 31 | Tytler's leaf warbler | *Phylloscopus tytleri* Brooks 1872 | NT | – | IV |
| | | **Family: Muscicapidae** | | | |
| 32 | Kashmir Flycatcher | *Ficedula subrubra* (Hartert & Steinbacher 1934) | VU | – | IV |
| **Order: Psittaciformes** | | **Family: Psittacidae** | | | |
| 33 | Alexandrine parakeet | *Psittacula eupatria* (Linnaeus, 1766) | NT | – | IV |
| **Reptiles** | | | | | |
| **Order: Testudines** | | **Family: Emydidae** | | | |
| 01 | Spotted pond turtle | *Geoclemys hamiltonii* (Gray, 1831) | EN | – | – |
| 02 | Brown roofed turtle | *Pangshura smithii* (Gray, 1831) | NT | I | – |
| | | **Family: Trionychidae** | | | |
| 03 | Indian narrow-headed softshell turtle | *Chitra indica* (Gray, 1831) | EN | II | – |
| 04 | Indian softshell turtle | *Nilssonia gangetica* Cuvier 1825 | VU | I | I |
| 05 | Indian peacock softshell turtle | *Nilssonia hurum* (Gray 1830) | VU | I | I |
| **Amphibians** | | | | | |
| **Order: Anura** | | **Family: Bufonidae** | | | |
| 01 | Beddome's toad | *Duttaphrynus beddomii* Gunther, 1876 | EN | I | – |
| | | **Family: Ranidae** | | | |
| 02 | Tiny frog/small paa frog | *Nanorana minica* (Dubois, 1975) | VU | – | – |

(continued)

**Table 38.1** (continued)

| S. no. | Common name | Scientific name | Threat status[a] | CITES (appendix) | Indian Wildlife Protection Act, 1972 (Schedule) |
|---|---|---|---|---|---|
| **Fishes** | | | | | |
| **Order: Cypriniformes** | | **Family: Cyprinidae** | | | |
| 01 | Anur | *Glyptothorax kashmirensis* Hora, 1923 | CR | – | – |
| 02 | Common carp | *Cyprinus carpio* Linnaeus, 1758 | VU | – | – |
| 03 | Grass carp | *Hypophthalmichthys molitrix* (Valenciennes, 1844) | NT | – | – |
| 04 | Katli | *Neolissochilus hexagonolepis* (McClelland, 1839) | NT | – | – |
| 05 | Golden mahseer | *Tor putitora* Hamilton, 1822 | EN | – | – |

[a]*Data sources*: mammals (Menon, 2014), birds (Rahmani et al. 2013, Suhail et al. 2019), reptiles and amphibians (Chandra et al. 2018), fishes (Bhat et al. 2010; Chandra et al. 2018). *Threat status*: *CR* critically endangered, *EN* endangered, *VU* vulnerable, *NT* near threatened

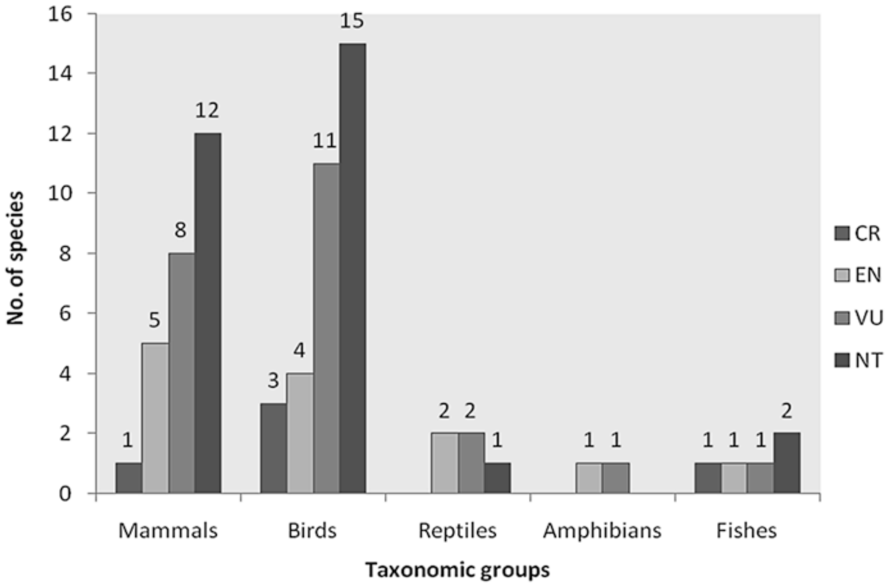


**Fig. 38.1** Number of faunal species under different threat categories in Jammu and Kashmir state

**Plate 38.1** Threatened fauna of Jammu and Kashmir State: (**a**) Kashmir Stag, (**b**) Snow Leopard, (**c**) Kashmir Grey Langur, (**d**) Himalayan Brown Bear, (**e**) Kashmir Markhor, (**f**) Western Tragopan, (**g**) Black Necked Crane, (**h**) Bearded Vulture. (Images: Dhritiman Mukherjee (**a**, **b**), Iqram ul Haq (**c**), Wildlife Trust of India (**d**), Riyaz Ahmad (**e**), John Corder (**f**), Intesar Suhail (**g**, **h**))

## 38.4 Discussion

Biodiversity plays a vital role in maintaining the ecosystem stability and health, yet the status of majority of the species occurring on the planet Earth awaits conservation evaluation (Mace 1993). The accelerating anthropogenic pressure on natural resources has led to degradation, fragmentation and loss of habitat with resultant decline of species (Rahmani et al. 2013). Prior to 1947, there was some focus on conservation of large mammals in the J&K State when Maharaja's regime established game reserves to protect the animals for sport hunting. The only species that continued to receive conservation attention was hangul (Kashmir red deer) with management plan drafted for the then Dachigam Wildlife Sanctuary (Kurt 1978; Rahmani et al. 2013). Wildlife conservation has not been a priority and thus majority of the species and the wildlife areas in the State were ignored for conservation till early 1980s, when most of the protected areas got notified to conserve the biodiversity, particularly the threatened species. However, several major threats still continue to operate and impair the survival of threatened species in these protected areas (Schaller 1969; Kurt 1978; Bhat 2008; Ahmad et al. 2009; Bhatnagar et al. 2009; Shah et al. 2011).

### *38.4.1 Major Threats to Fauna*

The major threats to faunal diversity of the State include habitat loss, habitat degradation and fragmentation, unregulated livestock grazing, poaching, pollution, unsustainable use, over-exploitation, and changing land use patterns. The biotic interference, including unsustainable land use pattern, encroachment and livestock grazing, has resulted in dislocation of many wildlife species (Rahmani et al. 2013). Ungulates in the State are facing competition from increasing livestock numbers, poaching for meat and wildlife trade and habitat shrinkage (Bhatnagar et al. 2009; Namgail 2009; Ahmad 2014). Several species, especially hangul and marcher, are at the risk of extinction whose survival is threatened by habitat loss and fragmentation, poaching, livestock grazing, forest fires and ill-planned developmental activities (Schaller 1969; Kurt 1978; Bhat 2008; Ahmad et al. 2009, 2017; Shah et al. 2011; Ahmad 2014, ). Carnivores are killed in retaliation for killing livestock and humans and are also poached for wildlife trade. Similarly, the management of threatened birds is made difficult by a range of forces, including encroachment, overgrazing by livestock, tourism, firewood collection, forest fires, plantation of marshes, and feral dogs (Rahmani et al. 2013). Pheasants are threatened due to rampant hunting, collection of non-timber forest produce, habitat degradation and changing land use (Ahmad et al. 2017). Climate change, habitat loss, habitat fragmentation and degradation, poaching, introduction of invasive species and disease have affected the survival of reptile species (Chandra et al. 2018). A host of factors like deforestation, habitat destruction, damming of rivers and streams, overfishing, pollution by pesticides, stone quarrying, climate change, draining of water bodies for construction purposes and introduction of exotic carp fishes are impacting amphibian populations of Indian Himalaya (Chandra et al. 2018)**.**

The degradation of wetlands in the State has been due to eutrophication, overfishing, and conversion for agricultural activities (Rahmani et al. 2013) as has been also reported from several other sites across the world (Dudgeon et al. 2006). Waterfowl species face threat from large-scale hunting for sport and meat. Water bodies play an important role in socioeconomic development, but unfortunately these resources have been badly affected by pollution, encroachments, earth filling, illegal constructions and converting water channels into roads, due to which our aquatic fauna is declining and getting disappeared (Yousuf 1996; Balkhi 2007; Bhat et al. 2010). The introduction of exotic species is the second leading cause, after habitat degradation, of species extinction in freshwater systems (Hill et al. 1997). Some investigations have suggested that the introduction of exotic species in the Kashmir waters in an unscientific manner is one of the reasons responsible for the declining of the indigenous *Schizothorax* species (Yousuf 1996; Bhat et al. 2010).

### 38.4.2 Knowledge Gaps

The available scientific literature reveals several hitherto unrecognized issues which are pivotal to the future conservation of faunal diversity in this Himalayan State. Firstly, availability of relevant research data about a species is prerequisite to assign an appropriate threat status category. However, lack of such information at regional level sometimes leads to under-representation and/or wrong categorization of a species at the global level. During the present study, it was observed that detailed ecological information crucial to conservation of any threatened species is still unavailable and, therefore, hampers framing management policy. The adequate taxonomic knowledge of animal groups is desired to address many conservation issues and design conservation plan (Lowry 2001; McNeely 2002). There is dearth of scientific data pertaining to reptiles of the State, and thus the IUCN status of majority of reptile species is still lacking. Little is known about the amphibian species of the State, as most of the areas are still underexplored. Even the baseline information like distributional patterns of majority of species is unknown. Such type of information is crucial in determining the status of species at the regional level and would contribute to the global threat categorization of the species as well. The information will also guide its management and conservations plan at local level.

### 38.4.3 Future Roadmap

The existing knowledge gap seems one of the major issues to be addressed in the near future. The generation of baseline information such as distribution and population assessment on data deficient and lesser studied species should be the primary focus of different research organizations and universities. Such information would be of utmost importance to place a species under an appropriate category and design the relevant management strategies. The threatened species need regular monitoring to track threats and assess the success of management planning. The relevant data collection on endemic and locally conservation priority species to augment the existing data is indispensable for meeting major conservation challenges. The less magnificent species and ignored taxa such as reptiles, amphibians, fishes and invertebrates need detailed taxonomic treatment which is the first and foremost requirement before determining their conservation status.

## 38.5 Concluding Remarks

This chapter paves way for making efforts to compile the available information about the threatened fauna and has highlighted the knowledge gaps which need to be addressed in future. Such efforts may be continued in future not only to update the list but also to highlight the steps to be taken for long-term conservation of the threatened faunal species in the State.

**Acknowledgements** The authors wish to thank, Mr. Jahangir Ahmad, Mr. Hameem Mushtaq, Mr. Umer Hameed, Mr. Rouf Ahmad, Mr. Iyaz Qayoom and Mr. Zakir Hussain, research scholars at the Department of Zoology, University of Kashmir, for assisting in compilation of updated list of threatened fauna of J&K State. Thanks are also due to Dhritiman Mukherjee and Suhail Intesar for providing images.

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# Chapter 39
# Urbanization and Its Impact on Biodiversity in the Kashmir Himalaya

**Zafar A. Reshi, Pervaiz A. Dar, M. Sultan Bhat, Manzoor A. Shah, and Syed Mubashir Andrabi**

**Abstract** Urbanization, a process currently occurring at an alarming rate, is a global phenomenon with many social, economic and ecological consequences. In Kashmir, rural areas are being transformed into urban areas at a moderate rate with urban population increasing from 18.41% in 1951 to 31.6% in 2011. Although the number of urban centres has increased from 1 in 1901 to 46 in 2011, urbanization has been highly uneven with majority of the population concentrated in Srinagar urban centre. Some of the major consequences of urbanization have been the prominent land use/land cover change associated with impacts on biodiversity which include large-scale simplification of biota, species extinction and promotion of invasion by alien species. Research in Kashmir Himalayan region has revealed that urban areas, in comparison to rural areas, are characterized by higher incidence of alien species. In addition, urbanization has resulted in large-scale homogenization of habitats, which is a serious ecological concern. This uneven and unprecedented urbanization is severely damaging the fragile ecosystems of the Kashmir Himalayan region with grave consequences for sustenance of these ecosystems.

**Keywords** Biotic homogenization · Biotic invasion · Species diversity · Urbanization

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_39

## 39.1 Introduction

Urbanization refers to an increase in human habitation linked with increased per capita energy and resource consumption and extensive landscape modification (McDonnell and Picket 1990). In this process, large numbers of people become permanently concentrated in relatively small areas, known as cities. Several criteria are used to define an urban area: administrative criteria or political boundaries (e.g. area within the jurisdiction of a municipality or town committee), a threshold population size (where the minimum for an urban settlement is typically in the range of 2000 people, although this varies globally between 200 and 50,000), population density, economic function (e.g. where a significant majority of the population is not primarily engaged in agriculture or where there is surplus employment) or the presence of urban characteristics (e.g. paved streets, electric lighting, sewerage).

Urban areas, more specifically cities, are known to have a variety of impacts due to conversion of agricultural or forest land for urban uses and infrastructure, reclaiming of wetlands, quarrying and excavation of sand, gravel and building materials in large quantities and, in some regions, deforestation to meet fuel demand. Although large cities are usually dynamic, growing centres for modern production and industry, financial services, internal commerce and foreign trade, education and government, these developmental activities have also resulted in habitat destruction and biodiversity loss.

Globally cities representing a setting in which the effects of human demography on biodiversity, are most evident, are expanding because of increase in urban population, and this increased population size of urban areas is due to both increases in the resident urban population and immigration from rural areas and abroad (Dow 2000; Cincotta et al. 2003). Moreover, the area of most cities is expanding faster than their population, a phenomenon known as urban sprawl (Alberti et al. 2003; Radeloff et al. 2005). This is due in part to shrinking household sizes (Liu et al. 2003) but also to larger parcel sizes in newer suburbs compared to older suburbs or central cities (Heimlich & Anderson 2001).Urban systems can serve as model systems for examining the interaction of social and biophysical patterns and processes (Collins et al. 2000; Redman et al. 2004). It is in this backdrop that the extent of urbanization and its influence on biodiversity were studied in the Kashmir valley which is also witnessing fast urbanization and consequent land-cover/land-use changes.

## 39.2 Materials and Methods

Both primary and secondary data were used to study the impact of urbanization and its impact on biodiversity in the Kashmir valley. Data from the Census of India (1901–2011) were used to analyse the changes in the demographic profile of the urban centres. Land-use and land-cover change statistics were generated from Landsat images of two time periods of 1992 and 2011.

For estimating extent of plant invasion, similar-sized urban and rural plots were sampled using quadrats of appropriate size. Species presence/absence data were used to make comparisons between urban and rural plots, and beta diversity was calculated using Jaccard's index, which computes binary values with the following algorithm:

$$J = \frac{a}{a + b + c}$$

where J ranges from 0 to 1, a is the number of species shared between two sites and b and c are the numbers of species unique to either site.

We calculated three measure of beta diversity (1-Jaccard's index), i.e. $\beta o$ (all species included), $\beta_N$ (only native species included) and $\beta_A$ (only alien species included). Then significance of mean values of $\beta_O$, $\beta_A$ and $\beta_N$ was tested using Howell's resampling programme. The significance of these mean values was tested by one-way ANOVA at 5% (0.05) probability. This one-way ANOVA was done using Howell's resampling programme. Level of invasion was expressed as proportion of aliens:

$$\text{Proportion of aliens} = \frac{\text{Total number of alien species occuring at a site}}{\text{Total number of species}} \times 100$$

## 39.3 Results and Discussion

### *39.3.1 Urbanization Trends*

Currently, rural areas are being transformed into urban areas at an alarming rate throughout the world. Although much of this transformation has taken place in regions like South America (82.8% urban), USA (82.1%) and Europe (72.7%), developing regions, such as China (49.2%), Africa (39.2%) and India (39.2%), are just beginning to undergo this urbanization process. In fact, levels of urbanization are closely correlated with national income – the more developed countries are already mostly urbanized – and in almost every country, urban areas account for a disproportionate share of the gross national product (GNP). Developing countries are likely to witness greater impact of this process as the progress of urbanization in these areas has been found to be highly uneven (World Urbanization Prospects, the 2011 Revision, United Nations 2012).

It has been estimated that the world population living in cities is expected to reach 60% by 2030, which was only 49.2% in 2005 (United Nations Population Fund 2007). Proportion of population in metropolitan cities of India has already increased to 37% in 2001, which was just 19% in 1950. Kashmir valley has also witnessed moderate urban growth with urban population increasing from 18.41% in 1951 to 31.6% in 2011. However, majority (62%) of this urban population is

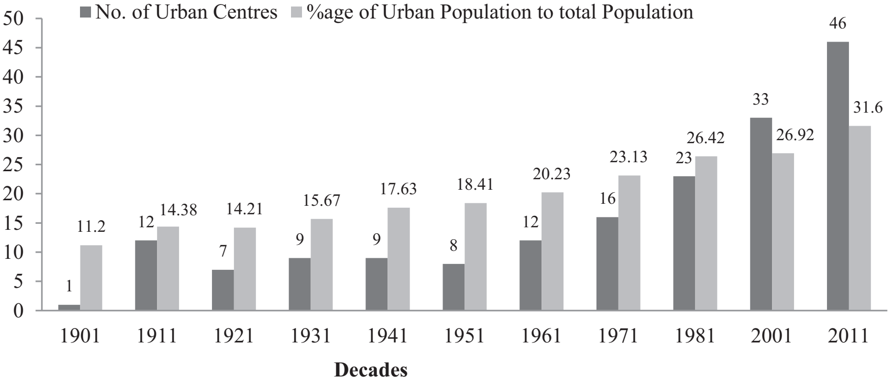


**Fig. 39.1** Increase in number of urban centres in Kashmir division during 1901–2011

**Table 39.1** District-wise distribution of urban centres and population in the Kashmir division 2011

| S. no. | Districts | No. of urban centres | Total population (persons) | Urban population (persons) | | Share of urban population (percentage) |
|---|---|---|---|---|---|---|
| | | | | Absolute | Percent | |
| 1 | Anantnag | 12 | 1,078,692 | 282,887 | 26.22 | 12.99 |
| 2 | Bandipora | 3 | 392,232 | 65,361 | 16.66 | 3.02 |
| 3 | Baramulla | 7 | 1,008,039 | 182,500 | 18.10 | 8.38 |
| 4 | Budgam | 6 | 753,745 | 97,912 | 12.99 | 4.49 |
| 5 | Ganderbal | 1 | 297,446 | 47,039 | 15.80 | 2.16 |
| 6 | Kulgam | 7 | 424,483 | 80,613 | 18.99 | 3.70 |
| 7 | Kupwara | 2 | 870,354 | 104,729 | 12.03 | 4.80 |
| 8 | Pulwama | 5 | 560,440 | 80,462 | 14.35 | 3.69 |
| 9 | Shopian | 1 | 266,215 | 16,360 | 6.14 | 0.75 |
| 10 | Srinagar | 2 | 123,6829 | 1,219,516 | 98.60 | 56.02 |
| | **Kashmir division** | **46** | **6,888,475** | **2,177,379** | **31.67** | **100** |

Source: Compiled from Census of India, 2011

concentrated in Srinagar urban centre alone. In fact, Srinagar is the rapidly growing urban centre amongst all the Himalayan urban centres (Bhat 2008). The number of urban centres in Kashmir division increased from 1 in 1901 to 46 in 2011 (Fig. 39.1). Although this urbanization rate is low, the pattern of urbanization is highly uneven, with its main centre being Srinagar city. Consequently, much of the attention has been paid to the urbanization of Srinagar city (Bhat 2008). District-wise distribution of these 46 urban centres is given in Table 39.1.

This shift towards a dominantly urban world is not simply a demographic phenomenon characterized by an anticipated population movement and change from one locale and profile to another, but it is a multifaceted process permeating many aspects of global development. It is in this backdrop that urban ecology is emerging as an important field of research in which biologists collaborate with anthropologists, sociologists and geographers to understand complex processes in these highly dynamic ecosystems. Apart from its ecological importance, aesthetic or ethical appeal of urban biodiversity is often considered as the most important reason for its study (Szlavecz et al. 2011). Historically, human beings are attracted to nature and its living creatures; E.O. Wilson called this phenomenon 'biophilia' and defined it as our 'innate tendency to affiliate with life and lifelike processes' (Wilson 1984). Being surrounded by plants and animals creates a sense of peace and tranquillity (Coley et al. 1997; Frumkin 2001).

### *39.3.2 Characteristics of Urban Ecosystems*

Urban ecosystems are those in which people live at high densities and where built structures and infrastructure cover much of the land surface (Pickett et al. 2011). All ecosystems are affected by the same broad suite of state factors (Chapin et al. 2002), including (1) the prevailing climate, (2) the substrate, (3) the resident organisms and their residual effects, (4) relief (including elevation, slope, and aspect) and (5) the time over which the first four factors have been acting, which can be summarized as the history of the system. Urban areas are characterized by relatively intense stress levels due to sewage, nutrients, toxic chemicals, heat and biological pathogens associated with increasing human population (Pickett et al. 2001; Freedman 2004). According to Bryson and Ross (1972), three main factors distinguish cities from other environments: (a) physical changes in soil surface, which promote environmental aridity, (b) air turbidity that causes reduction in luminosity due to air pollution and (c) variation in heat production, which makes cities warmer than other environments. During urbanization, large parcels of land are devegetated, paved and dramatically modified in ways that often greatly exceed habitat changes that occur from logging, traditional farming and many other land uses (Marzluff and Ewing 2001). Also, land modifications during urban growth are usually long-term and indeed often intensify with time, because of which there is no opportunity for successional recovery. Much of this urban growth is expected in areas where human–environment interactions are quite common.

Urban growth in Kashmir valley has been associated with significant land-use/land-cover transformation. Table 39.2 gives the percentage change and growth of the various land-use classes in the selected urban centres. Agricultural land, forests, vacant/barren land and water bodies have decreased in all the urban centres, while built-up area and horticulture have shown a positive growth.

The analysis revealed that the agricultural land in the urban centres has decreased by 38% and forest area has reduced by almost 4%, while water bodies and wetlands have decreased by 2%. On the other hand, the total built-up area has registered a positive growth of 112%, plantations and scrublands a positive growth of 3% and horticulture has increased by 59% in the region during the period 1992–2011.

**Table 39.2** Average change in land-use classes for medium-sized urban centres of Kashmir valley

| Land use/cover classes | Area ($km^2$) 1992 | Area ($km^2$) 2011 | Change in area ($km^2$) | Change (%) |
|---|---|---|---|---|
| Agriculture | 31.26 | 19.31 | −11.95 | −38.23 |
| Forests | 1.56 | 1.5 | −0.06 | −3.85 |
| Horticulture | 5.22 | 8.32 | 3.1 | 59.39 |
| Vacant/barren | 5.07 | 3.61 | −1.46 | −28.80 |
| Water bodies and wetlands | 4.24 | 4.17 | −0.07 | −1.65 |
| Plantations and scrubland | 11.7 | 12.09 | 0.39 | 3.33 |
| Built-up area | 8.95 | 18.96 | 10.01 | 111.84 |

Source: Generated from Landsat data (1991 & 2011)

An important phenomenon associated with the urban ecosystems is the 'urban heat island' effect. Heat islands represent the difference between urban and rural temperatures that are directly related to urban land cover and human energy use (Oke 1995). In general, cities have been found to be few degrees warmer than nearby urban areas, e.g. cities in midlatitudes of the USA are typically 1–2 °C warmer than the surroundings in winter and 0.5–1.0 °C warmer in summer (Botkin and Beveridge 1997). The duration and magnitude of the temperature differential between urban and surrounding non-urban areas depend on the spatial heterogeneity of the urban landscape (Arnfield 2003), city size and population density (Oke 1973; Brazel et al. 2000).

Other characteristics of urban areas include greater precipitation because of greater cloudiness and fog (Botkin and Beveridge 1997), reduced wind velocities due to increased surface roughness (Hough 1995), accumulation of carbon dioxide partly due to increased combustion of fossil fuels (Brazel et al. 2000) and depositions in the form of nitrate (as against ammonium in rural areas). In addition, the hydrology in urban areas has been severely modified by rapid urbanization with continuous ecological degradation of streams, referred to as 'urban stream syndrome' (Walsh et al. 2005a). This degradation includes elevated nutrient levels, increased organic and inorganic contaminants, increased hydrologic flashiness and altered biotic assemblages. In particular, streams draining urban areas have been found to differ from streams draining forest, with urban streams having elevated concentrations and loads of nitrogen (Groffman et al. 2004; Wollheim et al. 2005; Bernhardt et al. 2008; Kaushal et al. 2008) and phosphorus (Brett et al. 2005). Other alterations in urban hydrology include magnification of runoff during storm events, erosion, sediment transport, reconfiguration of stream channels and alterations in the timing and amount of nutrient transport (Walsh et al. 2005a, b; Pizzuto et al. 2008; Shields et al. 2008).

Urbanization also causes drastic changes in soil structure and other soil-related features because of anthropogenic disturbance. As such, many soil studies in urban areas have typically focused on highly disturbed and human-constructed soils along streets and in highly developed areas (Craul and Klein 1980; Patterson et al. 1980; Short et al. 1986; Jim 1993, 1998; Pouyat et al. 2007), and urban soils have been viewed as drastically disturbed and of low fertility (Craul 1999). The characteristics of soil, however, can vary greatly across the entire urban complex, including not only highly disturbed but also relatively undisturbed soils that are modified by urban environmental factors (Schleub et al. 1998; Pouyat et al. 2003).

### *39.3.3 Floristic Diversity and Urbanization*

Human activities and the inherent structure of cities have produced similar ecological characteristics in urban areas (such as the prevalence of artificial soils, the 'urban heat island' effect, comparable patterns of disturbance, etc.), even in different biogeographic regions. The response of vegetation and flora to these environmental changes can be traced through the decline of elements of native and natural vegetation and the spread of alien species (Sukopp and Trepl 1987; Kowarik 1990). It has become apparent that different cities, particularly in the inner areas, share a high proportion of spontaneous species. Urban areas, being largely the result of anthropogenic activities, have been found to harbour different floristic elements than surrounding natural areas, with urban areas being dominated by alien invasive species. Anthropogenic activities, such as vehicular movement, industrialisation, etc. often create conditions more suited for alien invasive species.

Further, urban areas, being direct result from human activities, may juxtapose species that have evolved on different continents and under different biophysical conditions (Hobbs et al. 2006). The human-mediated conversion of wild or rural lands to urban lands generally produces reduced diversity of native flora and fauna and elevated numbers of exotic species (Kowarik 1995; Marzluff 2001; McKinney 2002), but there are exceptions to this pattern (Davis 1999; Samu and Szinetár 2000; Niemeleä et al. 2002). In addition, the characteristics of these human constructed communities depend on choices made by organizations, communities of people, households and individuals (Odum 1970; Whitney and Adams 1980; Hope et al. 2003; Martin et al. 2004; Kinzig et al. 2005; Grove et al. 2006).

Several recent studies have attempted to quantify differences in diversity of flora and fauna between urban and rural areas, which, in general, have found that urban areas are more species rich than rural areas (Kowarik 1995; Kühn et al. 2004; Wania et al. 2006). It is well documented from several areas in Central Europe and the USA, and across several spatial scales (from a few hundred $m^2$ to several hundred $km^2$), that urban areas harbour more plant species than surrounding (non-urban) areas. Several hypotheses have been proposed to explain this pattern, and the most popular ones explaining this pattern are (i) introduction of alien plant species, (ii) a sampling artefact, (iii) anthropogenic land-use heterogeneity and (iv) human settlement in biodiversity hotspots. Occasionally, e.g. in Germany, cities have been found to be rich in native plants than rural areas, and this pattern can largely be explained by the richness of different geological substrates (a natural phenomenon) (Kühn et al. 2004). It is also a well-established fact that urbanisation leads to the loss of rare native (and maybe the increase of common native) species, as well as the increase of different neophytic alien species (Kühn et al. 2006).

Recently, many studies have also pointed out the importance of particular urban habitats for biodiversity, including gardens (Thompson et al. 2003; Loram et al. 2008), abandoned, semi-natural habitats (Lenzin et al. 2007; Knapp et al. 2008) and artificial habitats, such as walls or green roofs (Láníková and Lososová 2009; Lososová and Láníková 2010; Lundholm and Richardson 2010) as these habitats have been found to harbour species (not found in wild) which have become extinct in natural habitats. For a deeper understanding of biodiversity within urban habitat mosaics, comparative studies across different urban habitat or land-use types are needed. However, studies comparing the effects of several urban land-use types on species assemblages are scarce, and most are concerned with the biota of a single city (Godefroid and Koedam 2003, 2007; Zerbe et al. 2003; Sudnik-Wójcikowska and Galera 2005; Muratet et al. 2008) or a few cities (Maurer et al. 2000; Horsák et al. 2009).

Surveys by Dar (2011) at 14 urban sites in the Kashmir valley revealed occurrence of 236 species belonging to 158 genera in 44 families. Alien species were represented by 156 (66%) species, leaving only 80 (34%) species as native (Fig. 39.2). Of all the alien species, 59 were invasive, 86 naturalized and 11 species casuals (Table 39.3). Representation of native and alien species in various families varied considerably. The most representative families were Asteraceae (37 spp.), Poaceae (31 spp.), Fabaceae (17 spp.), Brassicaceae (17 spp.) and Lamiaceae (13 spp.). The most representative genera were *Poa* (06 spp.), *Ranunculus* (06 spp.), *Veronica* (06 spp.), *Galium* (05 spp.), *Polygonum* (05), *Artemisia* (04 spp.), *Geranium* (04 spp.) and *Medicago* (04) (Table 39.4)

The invasive species that were found growing around these areas include *Achillea millefolium*, *Aegilops tauschii*, *Amaranthus caudatus*, *Anagallis arvensis*, *Anthemis cotula*, *Arctium lappa*, *Arenaria serpyllifolia*, *Cannabis sativa*, *Capsella bursa-pastoris*, *Carduus edelbergii*, *Centaurea iberica*, *Chenopodium foliolosum*, *Cichorium intybus*, *Cirsium arvense*, *Convolvulus arvensis*, *Conyza canadensis*, *Crepis sancta*, *Cyperus difformis*, *C. rotundus*, *Dactylis glomerata*, *Datura stramonium*, *Daucus carota*, *Epilobium hirsutum*, *Eryngium billardieri*, *Euphorbia helioscopia*, *Galinsoga parviflora*, *Iris ensata*, *Juncus articulatus*, *Leucanthemum vulgare*, *Lithospermum arvense*, *Lolium temulentum*, *Marrubium vulgare*, *Medicago polymorpha*, *Mentha longifolia*, *Oenothera rosea*, *Plantago lanceolata*, *Plantago major*, *Poa annua*, *Polygonum aviculare*, *P. hydropiper*, *Ranunculus arvensis*,

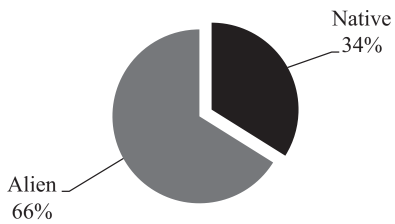


**Fig. 39.2** Percentage of native and alien species at some urban sites in the Kashmir valley

**Table 39.3** Characterization of plant species growing in urban areas in relation to their stage of invasion

| Plant groups | Total number of native species | Total number of alien species | Number of casual species | Number of naturalized species | Number of invasive species |
|---|---|---|---|---|---|
| Dicotyledons | 64 | 131 | 10 | 72 | 48 |
| Monocotyledons | 14 | 25 | 1 | 13 | 11 |
| Pteridophytes | – | – | – | 1 | – |
| **Total** | **80** | **156** | **11** | **86** | **59** |

**Table 39.4** Most representative genera and families at some urban sites in the Kashmir valley

| Most representative genera | | Most representative families | |
|---|---|---|---|
| Genera | Number of species | Families | Number of species |
| *Poa* | 06 | Asteraceae | 37 |
| *Ranunculus* | 06 | Poaceae | 31 |
| *Veronica* | 06 | Fabaceae | 17 |
| *Galium* | 05 | Brassicaceae | 17 |
| *Polygonum* | 05 | Lamiaceae | 13 |

*R. laetus*, *R. muricatus*, *Rubus ulmifolius*, *Setaria viridis*, *Siegesbeckia orientalis*, *Sisymbrium loeselii*, *Sonchus oleraceus*, *Sorghum halepense*, *Stellaria media*, *Taraxacum officinale*, *Trifolium pratense*, *T. repens*, *Urtica dioica*, *Verbascum thapsus*, *Veronica persica*, *Vulpia myuros*, *Xanthium spinosum* and *X. strumarium*.

### *39.3.4 Urbanization and Plant Invasion*

Urbanization acts in many ways on existing biodiversity (Sukopp and Werner 1983; Gilbert 1989;Wittig 1991; Collins et al. 2000; Pickett et al . 2001), e.g. by altering quality of air, water, and soil (Sukopp and Starfinger 1999), temperature regime and rainfall patterns (Landsberg 1981; Oke 1982), habitat fragmentation and disturbance (Kowarik 1995). Although urbanization results in native habitat destruction and is regarded as a major threat to biodiversity (Wilson 1988; Thompson and Jones 1999; Liu et al. 2003; McKinney 2004a), cities are richer in plant species than surrounding areas (Walters 1970; Haeupler 1975; Klotz 1990; Pyšek 1993, 1998; Kowarik 1995; Blair 2001; Dobson et al. 2001; McKinney 2002; Araújo 2003; Hope et al. 2003). It is partly due to the influx of alien species (McKinney 2002, 2004b; Kühn et al. 2004) both from intentional and from unintentional introductions, and partly due to natural factors, as at least in some regions, cities were built up in areas of natural heterogeneity which supports natural biodiversity (Kühn et al. 2004).

Urbanization leads to increase in non-native species richness in two ways: (1) increasing importation of non-native individuals, intentional as well as unintentional and (2) creation of favourable habitat for the establishment of non-native species. Driven by their personal interest, human beings import non-native species for several reasons, ranging from the accidental importation by traffic (trucks, planes and ships) associated with centres of commerce to the intentional importation of species for cultivation, pets and other human uses (Mack and Lonsdale 2001).

Anthropogenic activities in urban areas also create the environmental conditions that allow many of the imported non-native species to become established. Disturbance being a key factor in urban areas, much evidence indicates that disturbance promotes the establishment of non-native species (see D'Antonio and Meyerson 2002 for review). Disturbance alters the natural selection regime, often putting native species at a competitive disadvantage (Byers 2002). However, as Simberloff (1997) has noted, many habitats classified as 'disturbed' could equally be termed 'new' and 'human produced', and it is these features rather than the disturbance per se that often render them vulnerable to invasion. Certainly, many such novel habitats are created by the complex physical alterations of the local environment caused by urbanization.

Shea and Chesson (2002) offer a useful framework for understanding urban disturbance and invasion by focusing on 'niche opportunity'. This defines conditions that promote species invasions in terms of three key variables: resources, natural enemies and the physical environment. An invasion-promoting disturbance, thus, increases the population growth of an invading species by providing resources, reducing the threat of natural enemies and/or altering the physical environment (e.g. temperature) to improve habitability for the invader.

Expanding urbanization often creates niches for synanthropic species, those that are most strongly associated with humans and highly urbanized areas. Examples include the rock dove (*Columba livia*), house mouse (*Mus musculus*) and feral house cats (*Felis catus*), all being very dependent on food resources provided by humans (McKinney 2006). As these so-called 'subsidized species' are imported from outlying areas in large numbers, they are not only able to colonize cities, but they can attain population densities far above those found under natural conditions (Buijs and Van Wijnen 2001). Humans also provide niche opportunities by reducing (and often eliminating) natural enemies, e.g. the elimination of large carnivores (Crooks and Soulé 1999), and geographic expansion of raccoons and other mesopredators (see Byers 2002 for review). Finally, human alteration of the environment can create physical conditions allowing a non-native species to thrive in an area where it would otherwise not survive.

Many studies have quantified the percentage of alien species growing around urban centres. In 54 European cities the average value was 25.2%, ranging from 11% to 48% (Pyšek 1993). The majority of studies dealing with urban flora are limited to inner cities where the representation of aliens is higher (Wittig 2002). The value obtained for the city of Plzeň in 1990s (22.6%) is well within the European average.

Andrabi (2012) reported that urban habitats differ from the corresponding rural habitats in their extent of invasion, species number and other phytosociological attributes. Urban landscapes in the Kashmir valley were found to support higher percentage (64.82) of alien species, compared to rural landscapes (58.77%).

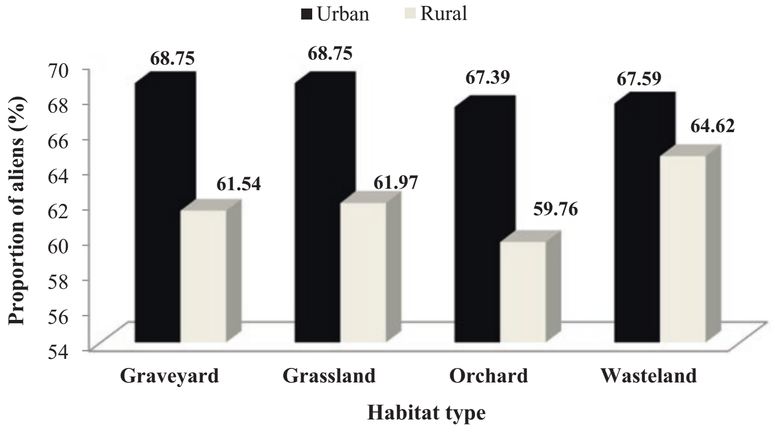


**Fig. 39.3** Level of alien plant invasion in various habitats and landscapes in urban and rural areas of Kashmir valley, expressed as the proportion of the alien to all species

Analysis of level of invasion (Fig. 39.3) revealed that, in general, all urban habitat types in the Kashmir valley were significantly invaded by alien plant species. It varied between 67.39% and 68.75% with a mean value of 68.12%, whereas all rural habitat types were relatively less invaded by alien plant species. The proportion of alien species in rural habitats varied between 59.76% and 64.62%, with a mean value of 61.97%. It clearly indicated that urbanization promotes the invasion of surveyed habitats.

### *39.3.5 Urbanization and Biotic Homogenization*

Biotic homogenization is the increased similarity of biotas over time caused by the replacement of native species with alien species (Rahel 2000). According to McKinney and Lockwood (1999), biotic homogenization occurs when a widespread environmental change promotes the geographic expansion of some species ('winners') and the geographic reduction of others ('losers'). Although many human activities promote biotic homogenization, urbanization is the most homogenizing factor (Blair 2001; Miller & Hobbs 2002; McKinney 2006). The process of urbanization has resulted in expansion of alien plant species and decline of native species, particularly the already rare native species, and has caused a greater similarity between different urban regions, i.e. biotic homogenization (Kühn and Klotz 2006). Dar and Reshi (2015) have shown that roadsides (habitats with greater urban impact) are more homogenous than grasslands and forests in the Kashmir valley. In order to determine which habitats are more homogenized, Dar and Reshi (2015) used three measures of beta diversity, i.e. overall beta diversity ($\beta_O$), beta diversity for natives ($\beta_N$) and beta diversity for aliens ($\beta_A$), to assess the role of alien plant invasions in

**Table 39.5** Mean values of $\beta_O$, $\beta_A$ and $\beta_N$ for beta diversity and one-way ANOVA for testing the significance of mean values (1000 resamples)

| | $\beta_O$ | | | $\beta_A$ | | | $\beta_N$ | | |
|---|---|---|---|---|---|---|---|---|---|
| Habitat | Mean | F-value | p-value | Mean | F-value | p-value | Mean | F-value | p-value |
| Grasslands | 0.742 ± 0.3 | 13.011 | 0.023 | 0.721 ± 0.3 | 11.473 | 0.011 | 0.788 ± 0.4 | 2.683 | 0.071 |
| Forests | 0.749 ± 0.2 | | | 0.742 ± 0.3 | | | 0.806 ± 0.3 | | |
| Roadsides | 0.649 ± 0.3 | | | 0.624 ± 0.3 | | | 0.755 ± 0.3 | | |

biotic homogenization of different ecosystems in the Kashmir valley. The study revealed that the beta diversity for aliens, i.e. $\beta_A$, was lower than the overall beta diversity, i.e. $\beta_O$ (Table 39.5), which indicated that alien species decrease beta diversity and as such increase the similarity.

Urban biotic homogenization is a huge challenge to conservation for at least two fundamentally different but important reasons. One reason is its dominant role in the loss of native species and the consequent homogenization of the world's biota. Another reason is the impact of urbanization on human perceptions of nature. Because so many people live in cities and because so many urban plants and animals are not indigenous to the local urban environment, the human species is becoming increasingly unfamiliar with their native biological environment. Olden et al. (2005) argued that the social repercussions resonating in the wake of biotic homogenization must not be ignored, and there is an urgent need to consider the idea that the increasingly global uniformity in biological life may be linked to the loss of traditional values and quality of life, which could have significant consequences for conservation-oriented advocacy and ecotourism. Thus, the concept of biotic homogenization is important not only for conserving biodiversity but also for maintaining the quality of human life, which may otherwise get degraded if not addressed appropriately.

### *39.3.6 Urbanization: Planning and Development Problems*

Urban pattern in Kashmir region has been found to be spatially and functionally imbalanced as it exhibits high concentration of economic activities and urban population in Srinagar city and virtual stagnation in the other urban centres of the region (Bhat 2008). The city has assumed very high degree of hypertrophy dwarfing in population size, rendering activities of all other urban centres within this region as insignificant. This unplanned and imbalanced urban growth has posed a serious threat to the sensitive geo-ecological set-up of the region which has already degraded the various life-sustaining ecological systems, like wetlands and water bodies, forest areas and green spaces. Keeping in view the unbalanced urban development of the region, Bhat (2008) has suggested two-pronged planning strategy for spatially balanced urban growth and development of the region. The planning strategy constitutes the decentralized growth centre strategy with special focus on integrated development of small- and medium-sized urban centres to make them economically productive and functionally vibrant centres in order to enhance their population retaining capacity. This strategy has to be in consonance with comprehensive land-use planning and policy to be devised for regulating the ecologically and environmentally sustainable urban development process in the region.

## 39.4 Concluding Remarks

Urbanization is one of the most significant global trends of the twenty-first century. Given its expanding impact, urbanization has become a major concern in conservation biology, as it involves one of the most extreme forms of land-use alteration, generally leading to a complete restructuring of vegetation and species composition. Based on the foregoing discussion, it can be safely concluded that the studies so far carried out in the Kashmir Himalaya reveal that urbanization has led to greater establishment and expansion of invasive alien species which are going to affect not only the aboveground biodiversity but its belowground component as well. Urban habitats have already been invaded to a great extent, and in future these are likely to act as repository of alien invasive species which is going to put natural areas at greater risk of invasion.

The unusually high percentage of alien species in urban landscapes is certainly a threat to the overall integrity of the whole region, in general, and to the natural resources of this Himalayan biodiversity hotspot, in particular. It is true that we should not lag behind the world in terms of economic development, but, at the same time, we should take necessary steps to protect our native habitats and endemic species. How to minimize the risk of invasive species proliferation as a result of growing urbanization is a challenge for biodiversity managers!

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# Chapter 40
# Impact of Climate Change on Vegetation Distribution in the Kashmir Himalaya

**Irfan Rashid and Shakil Ahmad Romshoo**

**Abstract** Current vegetation distribution in the Kashmir Himalaya was mapped using remote sensing data supported with extensive ground validation. The vegetation distribution under A1B SRES scenario ending 2085 was projected using IBIS vegetation dynamics model. Climate change projections, from the PRECIS experiment using the HADRM3 model, for the Kashmir region were validated using observed climatic data from two stations. Both the observed and projected climatic data show statistically significant trends across the years. The IBIS model was validated by comparing the model-generated vegetation distribution with the observed vegetation distribution over the Kashmir Himalaya. IBIS-simulated baseline scenario of vegetation (1960–1990) is in good agreement (87.15%) with the observed vegetation distribution, giving credence to the future model projections of vegetation under the changing climate in the region. The projections suggest that grasslands and tropical deciduous forests shall altogether vanish from the region ending this century, whereas the savannah, temperate evergreen broadleaf forest, boreal evergreen forest, and the mixed forest types shall colonize the areas under polar desert/rock/ice. The projections further suggest that a substantial area under permanent snow and ice may vanish by the end of century which shall have severe impact on the streamflows, agriculture productivity, and biodiversity, thus adversely affecting the livelihoods and food security in the region.

**Keywords** Climate change · Kashmir Himalaya · PRECIS RCM · IBIS · Vegetation dynamics

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_40

## 40.1 Introduction

The indicators of climate change are evidential all over the globe (Cox et al. 2000). Evidences suggest warming attributable to human activities (IPCC 2001, 2007; Alley et al. 2003). Many components of the climate system – including temperatures of the atmosphere, land and ocean, the extent of sea ice and mountain glaciers, the sea level, the distribution of precipitation, and the length of seasons are now changing at rates and in patterns that are not natural and are best explained by the increased atmospheric abundance of greenhouse gases and aerosols generated by human activity during the twentieth century (American Geophysical Union 2008).

The potential consequences of the climate change have been established beyond any doubt at the global level (Rosenzweig and Solecki 2001). Climate exhibits a dominant control over the natural distribution of ecosystems. Fossil records (Davis and Botkin 1985; Woodward 1987) and the observed trends (Hughes 2000; Walther et al. 2002) show that changing climate has a profound influence on the vegetation distribution (Suárez et al. 2002; Beniston 2003). It is, therefore, to be expected that the projected climate change (IPCC 2001) will have a significant impact on the vegetation distribution (Peters and Darling 1985; Parmesan and Yohe 2003; Nautiyal et al. 2004). The expected impacts of climate change in mountainous regions will result in the loss of cooler climatic zones at the peaks of the mountains and the shifting of tree line upslope (Beniston 2003; Dullinger 2012; Gottfried et al. 2012). Huntley (1991) advocated that climate change might result in shifts in the distribution of species, biological invasions, and even species extinctions. Adaptation pathways in the face of changing climate include the replacement of the currently dominant species by more thermophilous species (Thuiller et al. 2005; McMahon et al. 2011; Gottfried et al. 2012).

The indicators of climate change are quite loud and clear in the Himalaya (Scherler et al. 2011; Immerzeel et al. 2012; Romshoo and Rashid 2014; Romshoo et al. 2015). Several studies suggest that Himalaya is experiencing temperature increase that is higher than the global mean of about 0.7 °C for the last century (Bhutiyani et al. 2007). In particular, a strong increase in the mean temperature of about 1.7 °C was recorded in the Himalaya, potentially inducing strong impacts on high-altitude ecosystems, especially changes in the vegetation structure and biodiversity of high-altitude environments (Shrestha et al. 1999; Aryal et al. 2014). With vast areas covered by the natural vegetation, there is a large dependence of communities on forest products and services (Roy et al. 2013). It, hence, becomes imperative to assess the likely impacts of climate change on vegetation distribution and composition.

The impact of climate change is seen everywhere in the Himalaya, as it affects key sectors like snow and glaciers, agriculture, biodiversity, and energy. Significant progress in the modelling of vegetation-climate interactions have been witnessed with the development of dynamic global vegetation models (DGVMs), which include mechanistic representations of the physiological, biophysical, and biogeochemical processes (Woodward and Beerling 1997; Cramer et al. 2001). DVGMs endow with the most comprehensive and flexible approach for generating probabilistic projections of changes in vegetation under changing climate scenarios (Bachelet et al. 2000; Lenihan et al. 2003). The application of DVGMs at the regional scale, indeed, has increased the knowledge base pertaining to the climate change impacts on vegetation (Sykes et al. 2001; Pearson and Dawson 2003). DVGMs have demonstrated that the changing climate can affect the distribution of vegetation types, and there could be a potential vegetation dieback (Solomon 1986; King and Neilson 1992; Grime 1997; Solomon et al. 2007). Recent studies in the Himalaya reveal that most of the areas are very likely to experience shift in the vegetation types as a consequence of changing climate (Brandt et al. 2013; Khan et al. 2013).

This chapter maps the current vegetation distribution in the Kashmir Himalaya and projects its evolution under the changing climate. The studies conducted so far across India have certain limitations as far as the validation of vegetation as simulated by DVGMs is concerned. This chapter also aims to map the current vegetation distribution in the region using remotely sensed data, together with extensive field validations, analyse the hydro-meteorological indicators for changing climatic signals over the region, and project the distribution and composition of potential vegetation in the region as simulated by IBIS and its validation.

## 40.2 Materials and Methods

### *40.2.1 Vegetation Mapping and Its Validation*

A medium-resolution vegetation map from NOAA AVHRR, with a spatial resolution of 1 km, was generated for the entire Kashmir Himalaya. The map was reclassified into broader vegetation types. Stratified random sampling approach, involving the sampling of different vegetation types based on their spatial extent, was adopted to validate the vegetation types. Although ground samples should have been ideally chosen in proportion to the spatial extent of the vegetation types, inaccessibility and challenging topography of the region did not allow it to be done. Overall accuracy of the vegetation-type map was calculated using the following formula:

$$\rho = \left(n / N\right) \times 100$$

where $\rho$ is classification accuracy, $n$ is number of points correctly classified on image, and $N$ is number of points checked in the field.

Species composition of vegetation types was determined through fieldwork, following a nested-quadrant approach (Rashid et al. 2013). Published literature was also consulted to know the species composition of vegetation types and look for any possible signal of climate-driven ecosystem change in the region.

### 40.2.2 Observed and Projected Climate Data

Time series meteorological data from 1980 to 2010 for two observation stations, Pahalgam and Gulmarg, were procured from the Indian Meteorological Department (IMD) to look into the signals of changing climate in the study area and to validate the projected temperature and precipitation predictions in the region. The projected climate data from 1960 to 2099 under A1B scenario were extracted from a PRECIS (Predicting Regional Climates for Impact Studies) run simulated over the study area with a spatial resolution of 0.5° × 0.5°. A time series of meteorological projections, ending 2099, from PRECIS under A1B scenario comprising average annual maximum and minimum temperature, and total annual precipitation from 2011 to 2098, was analysed for the region, which centred at $CO_2$ concentrations of 437 and 630 ppm for the years 2025 and 2075, respectively.

Projected temperatures from PRECIS have a spatial resolution of 50 × 50 km, whereas the observed data from IMD are based on local weather stations. IMD temperature data were, thus, up-scaled to 50 × 50 km using GTOPO (1 km resolution) and applying a standard atmospheric lapse rate of −6.5 km$^{-1}$. This was done by computing the elevation difference between a PRECIS grid and IMD observation station. In case of PRECIS (with a 50 × 50 km dimension), average elevation value from 2500 pixels was taken as a representative of the whole grid. Lapse rate was applied to the IMD data taking elevation difference between PRECIS and IMD station into consideration.

### 40.2.3 Trend Analysis of Climate Data

A time series of observed streamflow (1971–2010), meteorological data – temperature and precipitation (1979–2010) – and projected climate data (2010–2099) were used for trend analysis, and the interpretation of the significance of observed trends is based on a non-parametric Mann-Kendall test. The use of non-parametric tests ensures independent use of a series of assumptions about the population values and is well suited for analysing trends in time series data over time (Gilbert 1987). Thus, Mann-Kendall statistical test was used for monotonic and piecewise trend analyses of the time series of hydro-meteorological data. The test does not assume any special form for the distribution function of the data, including missing data (Yue and Pilon 2004). Man-Kendall static is denoted by S and varies between −1 and +1. Rank 1 is assigned to the highest value in the set. The 'n' time series value (X1, X2, X3… Xn) are replaced by their relative ranks (R1, R2, R3…Rn). The test statistic S is given as:

$$S = \sum_{i=1}^{n-1} \left[ \sum_{j=i+1}^{n} \operatorname{sgn}\left(Ri - Rj\right) \right] \tag{40.1}$$

where sgn ($x$) = 1 for $x > 0$, Sgn ($x$) = 0 for $x = 0$, and Sgn ($x$) = −1 for $x < 0$

If the null hypothesis $H_0$ is true, then $S$ is normally distributed, and its positive value is an indicator of an increasing trend.

### *40.2.4 Impact of Changing Climate on Vegetation Distribution*

Impact of climate change on vegetation distribution was assessed on the basis of changes observed in distribution of different forest types using future climate change scenario. For this, the global vegetation dynamics model – IBIS (Integrated Biosphere Simulator) – was used to assess the spatial distribution of current and future climate projected by the high-resolution regional climate model, PRECIS, for A1B scenario. Simulations were generated for two future time-frames: (i) Time-frame of 2021–2050, labelled as '2035' (median of the period) and (ii) Time-frame of 2071–2100, labelled as '2085'. The simulated results of future scenarios were compared with the 'baseline' scenario, which was generated using 1960–1990 observed climate data.

#### 40.2.4.1 Vegetation Dynamics Model

Designed around a hierarchical, modular structure, the dynamic vegetation model IBIS comprises four modules: the land surface module, vegetation phenology module, carbon balance module, and the vegetation dynamics module (Foley et al. 1996; Kucharik et al. 2000). Despite operating at different time steps, these modules are integrated into a single physically consistent model that may be directly incorporated within AGCMs (atmospheric general circulation models). IBIS is currently coupled with two AGCMs, namely, GENESIS-IBIS (Foley et al. 2000) and CCM3-IBIS (Winter et al. 2009). The state description of the model allows trees and grasses experience different light and water regimes, competition for sunlight and soil moisture which determines the geographic distribution of plant functional types, and the relative dominance of trees and grasses, evergreen and deciduous phenologies, broad-leaf and conifer-leaf forms, and C3 and C4 photosynthetic pathways.

#### 40.2.4.2 Input Data

IBIS requires a range of input parameters, including climatic as well as pedologic parameters. The main climatic parameters required are monthly mean cloudiness (%), monthly mean precipitation rate (mm/day), monthly mean relative humidity (%), monthly minimum, maximum, and mean temperature (°C), and wind speed (m/s). The main soil parameter is the texture of soil (i. e. % age of sand, silt, and clay). The model also requires topography information. The available soil and topographic information was re-gridded to a 0.5° × 0.5° resolution and used for the run. The observed climatic variables were obtained from CRU (New et al. 1999), while the soil data were obtained from IGBP (IGBP 2000). For climate change projections, RCM outputs from PRECIS were used (Rupakumar et al. 2006). The climate variables for future scenarios were obtained using the method of anomalies (Bretherton et al. 1992). This involved computing the difference between the projected values for a scenario and the control run of the PRECIS model and adding this difference to the value corresponding to the current climate as obtained from the CRU climatology.

#### 40.2.4.3 Simulating Vegetation Distribution and Composition

The spatial resolution of vegetation simulated with IBIS is 0.5°. For validation, baseline vegetation of the region simulated with IBIS was compared with the vegetation map at 50 × 50 km grid resolution, developed after modifying vegetation map from NOAA AVHRR, ISRO (2010), and Champion and Seth (1968). A digital vegetation-type map of the study area (ISRO 2010) at 1:50,000 scale was used for checking and validation purposes. Since the highest resolution data available for running IBIS had 0.5° resolution, the study area was divided into 0.5° grids, and the vegetation map was reclassified to assess the accuracy of vegetation types and distribution simulated with IBIS. The validation of simulated vegetation was done using kappa coefficient, which is a robust indicator for accuracy assessment, and was calculated using the following formula:

$$k = \frac{N\sum_{i=1}^{r} X_{ii} - \sum_{i=1}^{r}\left(X_{i+}.X_{+i}\right)}{N^2 - \sum_{i=1}^{r}\left(X_{i+}.X_{+i}\right)}$$

where $\boldsymbol{r}$ is number of rows in error matrix
$\boldsymbol{x_{ii}}$ is number of observations in row i and column i (on the major diagonal)
$\boldsymbol{x_{i+}}$ is total of observations in row i (shown as marginal total to right of the matrix)
$\boldsymbol{x_{+i}}$ total of observations in column i (shown as marginal total at bottom of the matrix)
and $N$ is total number of observations included in the matrix

In addition, vegetation distribution for two future time periods, centred at 2035 and 2085, was simulated using IBIS.

## 40.3 Results and Discussion

### *40.3.1 Vegetation Mapping*

The study area showing Jammu and Kashmir state is depicted in Fig. 40.1.

Ten classes of vegetation were delineated in this chapter (Table 40.1; Fig. 40.2). It is evident from the figure that 60% of the area is covered by vegetation, whereas the non-vegetated areas (snow-covered areas, barren lands, water-bodies, and built-up areas) cover ~4 0%. Major vegetation types include shrublands (33.62%), forests (16.69%), grasslands (5.89%), and croplands (3.89%). Vegetation types were checked and validated with extensive ground truthing at 450 samples spread over various geographic and vegetation belts in the study area. However, ground truthing could not be carried out in the Chinese- and Pakistan-administered territories within the study area. The dominant shrubland species observed in the areas with altitude less than 3000 m include *Berberis lycium*, *Viburnum grandiflorum*, *Indigofera heterantha*, *Parrotiopsis jacquemontiana*, *Betula utilis*, while the prevailing vegetation in alpine shrublands includes *Juniperus squamata*, *Rhododendron campanulatum*, and *Rosa webbiana*. Forest species included *Pinus wallichiana*, *Pinus roxburghii*, *Pinus gerardiana*, *Cedrus deodara*, *Abies pindrow*, *Quercus semecarpifolia*, *Q. leucotrichophora*, *Olea cuspidata*, and *Ulmus wallichiana*. Grasslands were dominated by *Cynodon dactylon*, *Stipa sibirica*, *Poa alpina*, and *P. annua* (Rashid et al. 2010; Rashid et al. 2013). It is observed that climate change has resulted in the proliferation of alien invasive species in the region (McCarty 2001; Chen et al. 2003; Williams et al. 2007). Many of these alien species are reported to have invaded forest, grassland, and wetland ecosystems across the Kashmir Himalaya (Zutshi 1975; Khuroo et al. 2007; Masoodi et al. 2013).

Another aspect of this chapter was to compare the land cover types as delineated from AVHRR with land cover map from ISRO, developed in 2010 for part of the Indian-administered Jammu and Kashmir (~1,05,102 km$^2$). For this purpose, land cover classes were generalised into five categories (Petit and Lambin 2002; Buyantuyev and Wu 2007). This is because of the fact that the classification schemes used in AVHRR and ISRO land-cover maps are different, while AVHRR adopts IGBP land-cover nomenclature, and ISRO adopts nomenclature as per Champion and Seth (1968). There is a good agreement as far as cropland and forested area delineation is concerned, but differences occur in spatial extents of grasslands,

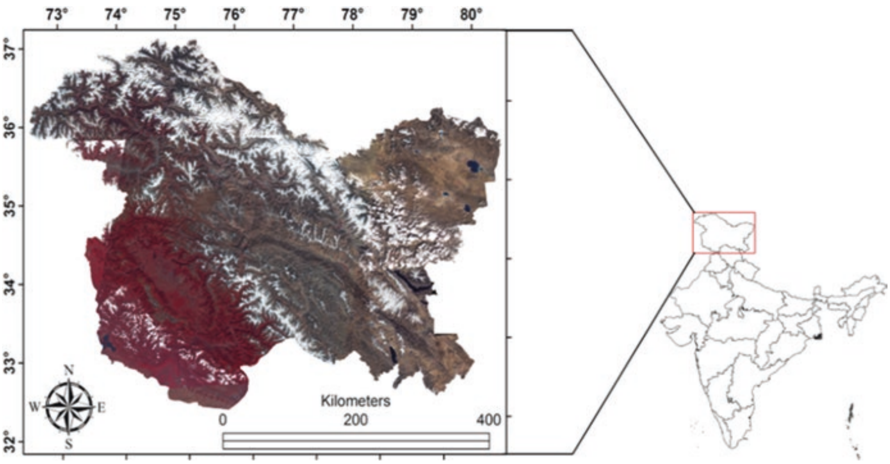


**Fig. 40.1** Study area showing Jammu and Kashmir state

**Table 40.1** Land cover statistics for Jammu and Kashmir state

| Vegetation type | Area (km$^2$) | % age |
|---|---|---|
| Non-vegetated | 88737.45 | 39.93 |
| Closed shrubland | 1208.42 | 0.54 |
| Cropland | 8652.29 | 3.89 |
| Deciduous broadleaf forest | 253.58 | 0.11 |
| Evergreen broadleaf forest | 360.67 | 0.16 |
| Evergreen needleleaf forest | 8394.99 | 3.78 |
| Grassland | 13080.68 | 5.89 |
| Open shrubland | 73478.65 | 33.06 |
| Wooded frassland | 14207.30 | 6.39 |
| Woodland | 13862.25 | 6.24 |
| **Total Area** | **2,22,236.27** | **100.00** |

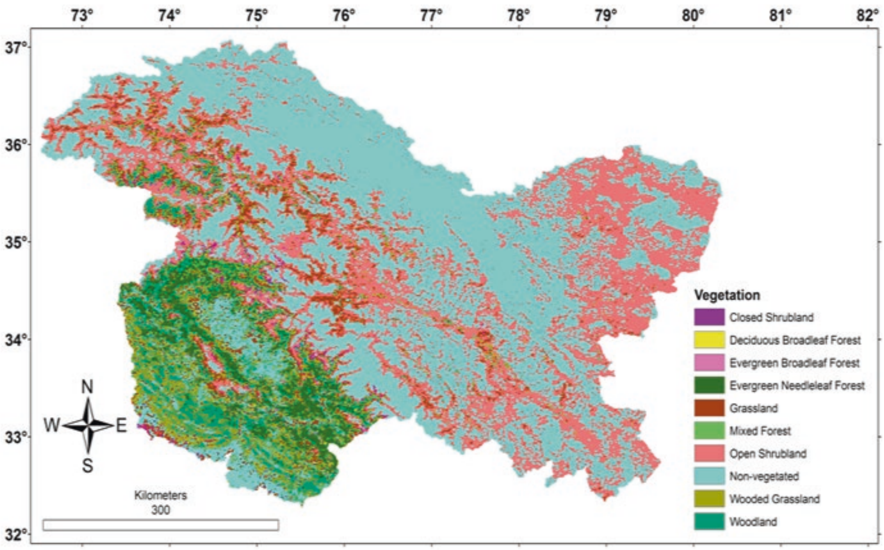


**Fig. 40.2** Major land cover/vegetation types in Jammu and Kashmir state

shrublands, and non-vegetated areas. These variations result partly because of differences in the spatial resolution and mapping scale adopted (Ardizzone et al. 1999; Achard et al. 2001; Shao and Wu 2008). As the spatial resolution of AVHRR is very coarse, grasslands and non-vegetated areas get classified as shrublands.

### 40.3.2 Historical Hydro-meteorological Data

Analysis of the time series of average annual minimum and maximum temperatures at Pahalgam meteorological observation station in the study area from 1980 to 2010 depicts a significant rising trend (99%) over the years with $R^2$ of 0.45 and 0.38, respectively. The mean annual precipitation at Pahalgam shows a slightly decreasing but insignificant trend with a very weak $R^2$ of 0.02 (Fig. 40.3a, b, c). Average annual minimum and maximum temperatures at Gulmarg station from 1980 to 2010 also depict a rising trend over the years with $R^2$ of 0.33 and 0.10, with significance values of 90% and 99%, respectively (Fig. 40.3d, e, f). Statistically insignificant trends were observed in case of observed and projected precipitation patterns over the region (Table 40.2).

As is evident from the analysis, the minimum temperatures are rising faster than maximum temperatures over the region. This may bring about significant habitat alteration in the alpine zone (Hamann and Wang 2006; Telwala et al. 2013; Ernakovich et al. 2014). The rise in temperature, together with decreasing precipitation regimes in the region, can have serious impact on forest distribution

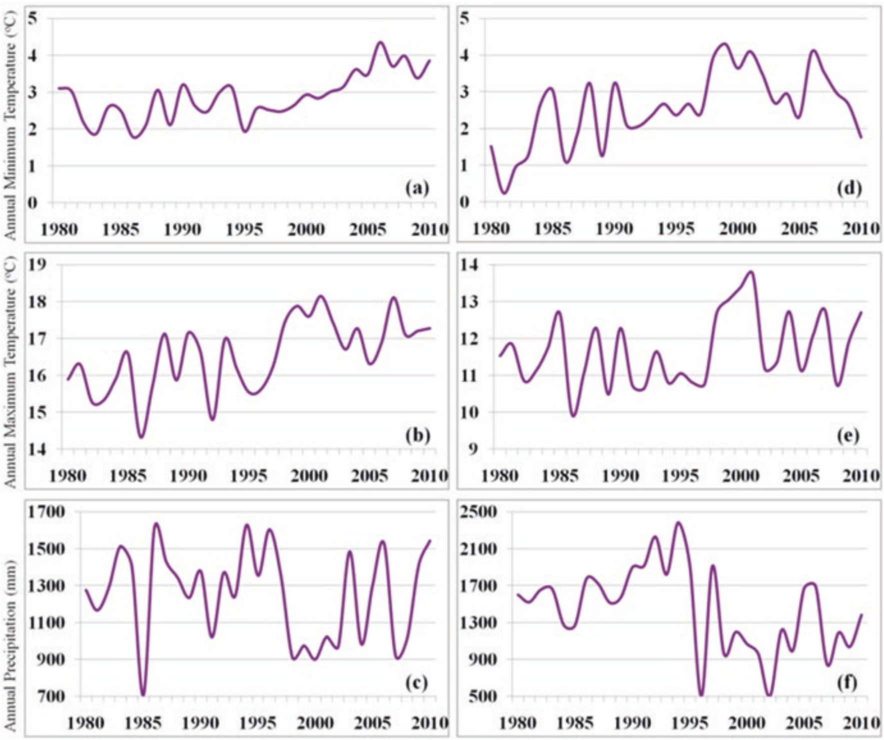


**Fig. 40.3** Observed trends in temperature and precipitation at Pahalgam (**a**, **b**, **c**) and Gulmarg (**d**, **e**, **f**)

**Table 40.2** Mann-Kendall statistics for significance of observed and projected climate data

| Parameter | Test static | Result | |
|---|---|---|---|
| Annual maximum temperature | 3.519 | S (0.01) | Observed climate at Pahalgam |
| Annual minimum temperature | 3.773 | S (0.01) | |
| Annual precipitation | −0.425 | NS | |
| Annual maximum temperature | 1.666 | S (0.1) | Observed climate at Gulmarg |
| Annual minimum temperature | 3.059 | S (0.01) | |
| Annual precipitation | −1.615 | NS | |
| Annual maximum temperature | 9.11 | S (0.01) | Projected climate at Pahalgam |
| Annual minimum temperature | 10.722 | S (0.01) | |
| Annual precipitation | −0.205 | NS | |
| Annual maximum temperature | 9.54 | S (0.01) | Projected climate at Gulmarg |
| Annual minimum temperature | 10.841 | S (0.01) | |
| Annual precipitation | −2.627 | S (0.01) | |

*S* significant, *NS* non-significant

(Joshi et al. 2012; Cong et al. 2013), snow and glacier resources (Murtaza and Romshoo 2017; Romshoo et al. 2015), water availability (Immerzeel et al. 2010; Jeuland et al. 2013; Sharif et al. 2013), and recreation (Dar et al. 2014).

As far as the climate projections for the area are concerned, both average minimum and maximum projected temperatures show an increasing trend at both Pahalgam (with $R^2$ values of 0.90 and 0.77, respectively) (Fig. 40.4a, b) and Gulmarg stations (with $R^2$ values of 0.91 and 0.81, respectively) (Fig. 40.4d, e). Precipitation projections (Fig. 40.4c, f) show a very weak increasing trend with $R^2$ values of 0.04 and 0.005 for Pahalgam and Gulmarg, with significant interannual variations across the time series. The overall average annual maximum and minimum temperatures over Pahalgam are projected to increase, respectively, by 7.23 °C (±1.84 °C) and 4.89 (±1.51) from 2011 to 2098 under the A1B SRES scenario. Likewise, the average annual maximum and minimum temperatures over Gulmarg are projected to increase by 7.68 (±2.01) and 5.88 (±1.51), respectively. Mann-Kendall analysis of time series for observed and projected climate data (Table 40.2) reveals that temperatures are going to rise very significantly (99% significance value). Similar increases are being simulated over other areas in the region. The trend analysis of the average yearly discharge using Man-Kendall tests at Aru (Pahalgam) hydrological station is given in Table 40.2. A significantly decreasing trend (with significance value of 99%) is observed in case of streamflow observations from 1980 to 2010 at this station.

From the analysis of climatic data for the study area, it can, hence, be inferred that there will be a significant increase in the temperatures, decrease in the streamflow, and comparatively insignificant change in the precipitation pattern by the end of this century. Upon comparison of the upscaled IMD data with the PRECIS projected temperatures during the baseline period, it is found that the two datasets agree reasonably well (Fig. 40.5a, b). Thus, the model is considered credible and cogent for simulating future temperatures over the region. Similar findings have

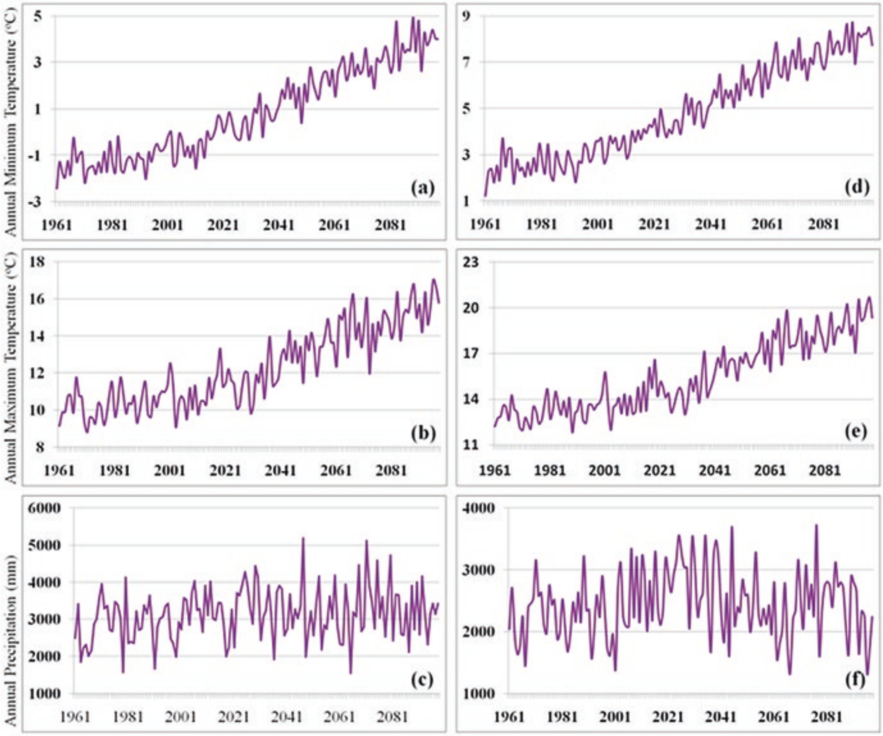


**Fig. 40.4** Projected climate trends at Pahalgam (**a**, **b**, **c**) and Gulmarg (**d**, **e**, **f**)

been reported about the use of PRECIS in Himalaya (Akhtar et al. 2008; Kulkarni et al. 2013) and other parts (Tadross et al. 2005; Xu et al. 2006 Giannakopoulos et al. 2013).

### *40.3.3 Impact of Changing Climate on Vegetation Distribution*

Before going for the impact assessment of climate change on vegetation distribution, it is important to assess the accuracy of the baseline vegetation scenario, simulated by IBIS, with the actual vegetation on ground. For this purpose, an actual vegetation map (Fig. 40.6a) was developed at a resolution of 50 × 50 km by modifying the vegetation maps prepared by NOAA AVHRR, Champion and Seth (1968), and ISRO (2010). Some categories of the vegetation were reclassified as per the IBIS vegetation nomenclature. The baseline map, simulated by IBIS for the region (Fig. 40.6b), was compared with the vegetation map developed at 50 × 50 km. A Kappa coefficient of 87.15% (Table 40.3) indicates that the IBIS simulated the baseline vegetation very well (Yuan et al. 2011; Cunha et al. 2013) and, hence, could be

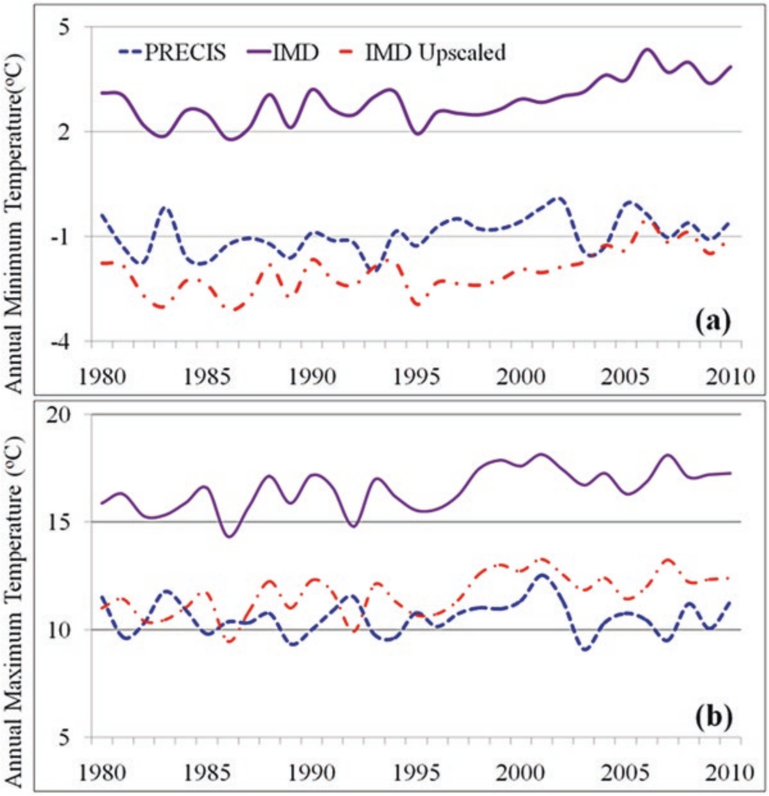


**Fig. 40.5** Validation of PRECIS with IMD upscaled data at Pahalgam. (**a**) Average annual minimum temperature (**b**) Average annual maximum temperature

relied upon for effectively projecting the future vegetation types ending the current century. IBIS simulates temperate evergreen forest and tropical deciduous forest very well during the baseline period as is evident from 100% agreement between the observed and IBIS simulated vegetation. It slightly over-predicts grasslands (only 66.66% correspondence with the vegetation scenario on ground) and tundra (only 72.42% similarity) and slightly under-predicts dense shrublands (by 33.33%), open shrublands (by 14.28%), and polar desert/rock/ice areas (by 13.63%). These dissimilarities in the observed and simulated baseline vegetation distribution and type are insignificant at the spatial resolution of 50 × 50 km.

For the projected vegetation distribution by 2035 (Table 40.4, Fig. 40.6c), most of the area under polar desert/rock/ice is taken over by boreal evergreen forests, and some part of it may be covered by tundra vegetation. Moreover, a substantial part currently under the temperate evergreen forests is colonized by temperate deciduous forests. Areas under open shrublands are taken over by temperate evergreen broad-

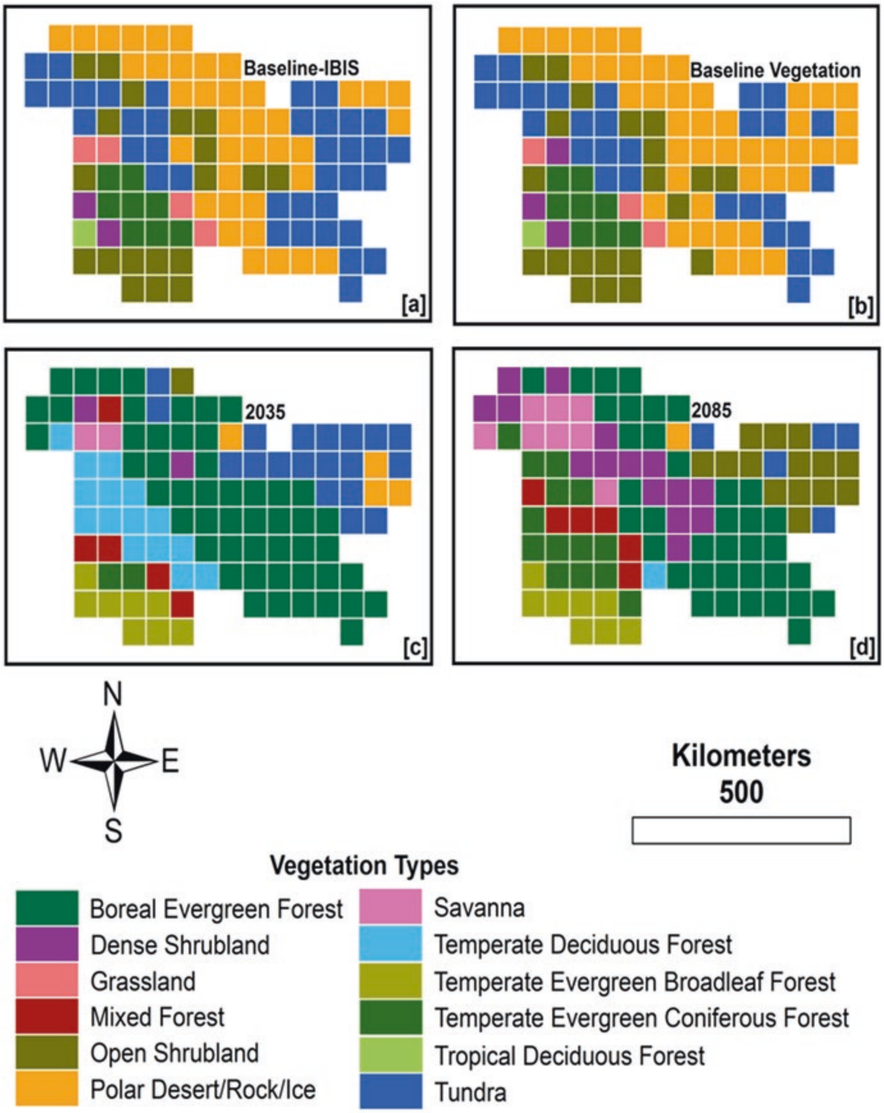


**Fig. 40.6** (**a**) Baseline vegetation simulated with IBIS. (**b**) Actual vegetation after AVHRR, Champion and Seth (1968), ISRO (2010). (**c**) Projected vegetation types by 2035. (**d**) Projected vegetation types by 2085

leaf forests. In addition, mixed forests and savannahs appear due to the increase in the projected temperatures observed over the region.

Vegetation simulated with IBIS for the period towards the end of this century (Table 40.4, Fig. 40.6d) shows expansion of savannahs, reappearance of temperate evergreen coniferous forests, and open shrublands in the Karakoram belt. Dense

**Table 40.3** Matrix showing the comparison of IBIS-simulated baseline vegetation with respect to satellite-derived vegetation

| Vegetation types | | Satellite data DS | GR | OS | PD | TE | TD | TU | Column totals |
|---|---|---|---|---|---|---|---|---|---|
| IBIS baseline | DS | **2** | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| | GR | 1 | **3** | 0 | 0 | 0 | 0 | 0 | 4 |
| | OS | 0 | 0 | **19** | 0 | 0 | 0 | 0 | 19 |
| | PD | 0 | 0 | 2 | **35** | 0 | 0 | 1 | 38 |
| | TE | 0 | 0 | 0 | 0 | **8** | 0 | 0 | 8 |
| | TD | 0 | 0 | 0 | 0 | 0 | **1** | 0 | 1 |
| | TU | 0 | 0 | 0 | 9 | 0 | 0 | **28** | 37 |
| Row totals | | 3 | 3 | 21 | 44 | 8 | 1 | 29 | **109** |

*DS* dense shrubland, *GR* grassland, *OS* open shrubland, *PD* polar desert/rock/ice, *TE* temperate evergreen coniferous forest, *TD* tropical deciduous forest, *TU* tundra
Kappa = (sum of diagonals/total) × 100 = (96/109) × 100 = 88.07

**Table 40.4** Changes in vegetation composition across different scenarios from 1960 to 2099

| Vegetation types | Baseline IBIS projected | Satellite derived | Futuristic scenarios 2035 | 2085 |
|---|---|---|---|---|
| Boreal evergreen forest | 0 | 0 | 51 | 37 |
| Dense shrubland | 2 | 3 | 2 | 15 |
| Grassland | 4 | 3 | 0 | 0 |
| Mixed forest | 0 | 0 | 5 | 6 |
| Open dhrubland | 18 | 21 | 1 | 14 |
| Polar desert/rock/ice | 38 | 44 | 4 | 1 |
| Savannahs | 0 | 0 | 2 | 8 |
| Temperate deciduous forest | 0 | 0 | 15 | 1 |
| Temperate evergreen broadleaf forest | 0 | 0 | 8 | 8 |
| Temperate evergreen coniferous forest | 8 | 8 | 2 | 14 |
| Tropical deciduous forest | 1 | 1 | 0 | 0 |
| Tundra | 37 | 29 | 19 | 5 |

shrublands will overtake boreal evergreen forests in north-western and central part of the region. There remains only one pixel/grid that comes under rock/ice by the end of the century. As such, it is predicted that snow and glacier resources in the region shall recede due to the rising temperatures discerned over here (Bajracharya et al. 2007; Archer et al. 2010; Immerzeel et al. 2010; Romshoo et al. 2015).

## 40.4 Concluding Remarks

This chapter indicates that climate change is evident in the Kashmir Himalaya and affects significantly the naturally occurring vegetation. Northwest Himalaya covers a substantial part of the Himalayan biodiversity hotspot, which signifies the importance of this chapter. A close agreement of the regional climate model projections with the upscaled meteorological data gives credence to the projected vegetation distribution under changing climate, as generated for the region using IBIS. The study demonstrated that the climate change is going to bring about significant changes in the vegetation types and their distribution in the region and might, therefore, adversely affect the products and services available from the forests that currently support a number of livelihoods here. Subalpine and alpine pasture and scrubland vegetation in the upper reaches (>2800 m), which are habitat to many endemic and medicinally important species, are very sensitive to any subtle variation in climate. Hence, in light of the changing climate over the region, these species may get extirpated on altering the fragile ecology of the region. Moreover, the introduction of alien invasive species in terrestrial and aquatic ecosystems in the region can seriously alter the biogeochemical cycling, affecting the biodiversity richness and composition in the Kashmir Himalayan region.

**Acknowledgements** The authors express their gratitude to the National Remote Sensing Centre (NRSC), ISRO, Hyderabad, for financing the development of vegetation map of Kashmir Valley under Biodiversity Characterization project. Also, provision of grant by the Ministry of Earth Sciences, Government of India, for climate change impact studies over Kashmir is thankfully acknowledged. Gratefulness is due to the Centre for Ecological Studies, Indian Institute of Science (IISc), Bangalore, for providing technical assistance in running the IBIS model simulations.

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# Chapter 41
# Biodiversity Conservation in Jammu and Kashmir State: Current Status and Future Challenges

**Anzar A. Khuroo, Gousia Mehraj, Insha Muzafar, Irfan Rashid, and Ghulam Hassan Dar**

**Abstract** A significant proportion of the rich repository of biodiversity in Jammu and Kashmir state is currently experiencing anthropogenic threat at an alarming rate. It is in this backdrop that the present chapter reviews the current status and future prospects of conservation of biodiversity in this state. Historically, the conservation of wildlife and forests in Jammu & Kashmir has an illustrious legacy, tracing back to the erstwhile *Maharaja's* rule. Presently, under in situ conservation approach, about 15.6% of total geographic area of the state has been demarcated under the protected area network; this comprises 5 national parks, 14 wildlife sanctuaries, 37 conservation reserves and 4 Ramsar sites. Over the years, several botanical gardens, zoos and aquaria have been established, which contribute to the ex situ conservation of biodiversity in the state. A set of legislative measures have been promulgated to ensure proper implementation of conservation programmes in the state. Besides, concerted research and comprehensive management plans are in place to conserve the flagship species, such as hangul (*Cervus elaphus hanglu*), markhor (*Capra falconeri*), snow leopard (*Panthera uncia*) and Asian black bear (*Ursus thibetanus*). Notwithstanding all these conservation measures in the recent past, the state has still to surmount daunting challenges of mainstreaming the conservation of biodiversity in public policy-making and integrating it as the dominant discourse in the march of this Himalayan region towards environmental management and sustainable development.

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_41

**Keywords** Biodiversity · Conservation – in situ, ex situ · Jammu and Kashmir State · Protected area network

## 41.1 Introduction

The planet Earth embodies a huge diversity of life forms, represented by a vast variety of plants, animals and microorganisms. Such a diversity of living organisms is commonly referred to as biological diversity or its shorthand form biodiversity. The Article 2 of the Convention on Biological Diversity (CBD) enshrines an all-embracing formal definition of biodiversity, which states that '*biological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems'*. Biodiversity represents the very foundation of human existence. It is an integral part of human daily lives and livelihood and constitutes the resources upon which families, communities, nations and future generations depend for survival and development.

Although essential to humankind with very important values, human actions have caused huge damages to biodiversity, including the disruption of ecosystem processes, habitat destruction, species extinction and the erosion of genetic diversity within species (Gaston and Spicer 2004). Over the geological history of life on Earth, while the general trend has been towards an overall net increase in biodiversity, the late Quaternary has been a period of marked decline due to direct and indirect consequence of anthropogenic activities. Resultantly, the present pace of species loss is unprecedented and irreversible. Recent assessments have revealed that more than one-third of world's known species assessed for threat status are currently threatened with the risk of extinction (UNEP 2002). Globally, concerns have been raised about the contemporary biodiversity crisis, and the primary reason for the concern is being attributed to the realization that biodiversity is being lost even before its size is known. Therefore, in the present era of unprecedented loss of biodiversity all over the world, the conservation of biodiversity assumes an urgent priority.

The conservation of biodiversity essentially aims to maintain the diversity of living organisms, their habitats and the interrelationships between organisms and their environment (Spellerberg and Hardes 1992). Although conservation of biodiversity per se calls for safeguarding it for present and future generations, it is not a new discourse. In recent times, it attracted wide global attention during the *Rio* Summit (1992) that ultimately gave birth to the Convention on Biological Diversity (CBD). It was for the first time that biodiversity was comprehensively addressed in a binding global treaty and conservation of biodiversity was recognized as the common concern of humankind (Glowka et al. 1994). In fact, the Article 1 of the CBD explicitly mentions 'the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits from the use of genetic resources' as the main goals of the Convention. In total, the Convention consists of 42 Articles concerning issues ranging from its objectives, the practical obligations of each signatory, the policies to be followed and the use of terms. All of them are meant to highlight any serious attempt to conserve biodiversity in a broader social and economic context (Gaston and Spicer 2004). The Convention draws attention to the fact that maintenance of biodiversity is connected with many dimensions of human activities, and concerns much more than how to prevent individual species from becoming extinct, or the provision of nature reserves and other protected areas for conservation.

### *41.1.1 Approaches to Conservation of Biodiversity*

There is no denying the fact that more knowledge is required to conserve biodiversity within increasingly reduced space and under intense pressure of human activities. In fact, the most effective and efficient mechanism for conserving biodiversity is to prevent further destruction or degradation of natural habitats and reduce the intensity of threats faced by biodiversity. There are two basic approaches which have been conventionally adopted to conserve biodiversity: in situ (on-site) and ex situ (off-site).

#### 41.1.1.1 In Situ Conservation

The CBD defines in situ conservation as 'the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties'. Article 8 of CBD exclusively deals with in situ conservation of biodiversity. The in situ conservation approaches may include protected area network (e.g. national parks, wildlife sanctuaries, conservation reserves, genetic reserves) and traditional farms for conserving land races (Maxted 2001). Protected areas (PAs) are required to be established as a central plan of a national strategy for conserving biodiversity. There are more than 100,000 protected areas worldwide, comprising about 12% of the Earth's surface (Secretariat of the Convention on Biological Diversity 2008). The main general aim and long-term goal of in situ conservation of target species is to protect, manage and monitor the selected populations in their natural habitats so that the natural evolutionary processes can be maintained, thus allowing new variation to be generated in the gene pool that will allow the species to adapt to changing environmental conditions, such as global warming, changed rainfall patterns, acid rain or habitat loss.

#### 41.1.1.2 Ex Situ Conservation

The CBD defines ex situ conservation as 'the conservation of components of biological diversity outside their natural habitats'. Article 9 of CBD exclusively deals with ex situ conservation of biodiversity. The ex situ conservation measures may include botanical gardens, zoological parks, seed banks, sperm and ova banks, culture collections (e.g. of plant tissues), artificial propagation of plants and captive breeding of animals, etc. The in situ approach of establishing PAs is seldom sufficient in itself for the conservation of biodiversity. Firstly, PAs are not isolated from events beyond their boundaries, and the more degraded conditions become outside, greater the reduction of population viability within the PAs. Secondly, PAs are often vulnerable to threats and accidents emanating from outside, such as resource exploitation and chemical contamination. So in such situations, ex situ conservation is pivotal. Though ex situ conservation strategies are efficient; reproducible and feasible for medium- and long-term storage; easily accessible for characterization, evaluation, and utilization; and need little maintenance, ex situ activities should play only a very secondary role in supplementation of in situ conservation (Gaston and Spicer 2004).

## 41.2 Materials and Methods

This review is primarily based on data from primary as well as secondary sources. The data presented has been compiled by extensive literature survey, online sources and personal observations. The literature surveyed included published research articles, reports and books. Online sources used mostly include data from various official websites and other authentic web links.

## 41.3 Results and Discussion

### *41.3.1 Conservation of Biodiversity in Jammu and Kashmir State*

The CBD, as an international convention, identifies a common problem, sets overall goals and policies and general obligations and organizes technical and financial cooperation. However, the responsibility for achieving its goals rests largely with the countries themselves. Mostly, the diversity and distribution of biodiversity (e.g. flora, fauna) of any place is largely governed by the latitude, longitude, altitude, geology and climate of that region. Specific regions can be classified on the basis of distribution of their distinct flora and fauna and are known as biogeographic zones. Each biogeographic zone has unique habitats, which support diverse biotic communities and ecosystems.

India is one of the world's mega-biodiverse countries. Its immense biodiversity represents about 7% of the world's flora and 6.5% of the fauna (Murti and Chowdhery 2000). Among the 35 biodiversity hotspots of the world, 4 share their boundaries within India and also extend into the neighbouring countries (Zachos and Habel 2011). The Jammu and Kashmir (J&K) state is located in the extreme northwest direction of biodiversity hotspot of the Himalaya. The state comprises three main provinces of Jammu, Kashmir and Ladakh, showing a variety of habitats and climates which in turn harbour unique assemblages of plants and animals. The flora of the state comprises a total of 5056 taxa (4778 species + 278 subspecies/varieties) [Dar and Khuroo this volume-b]. The fauna of the state is equally diverse; about 16% of Indian mammals, reptiles, amphibians and butterflies occur in the state (J&K Environmental Report 2013). Khoshoo (1997) has aptly called it the 'biomass state', as the people of this state are inextricably dependent on the biological resources. The plants of this Himalayan state serve as a storehouse for medicinal and aromatic plants used in pharmaceutical and perfume industries (Dar 2002). Notwithstanding the rich biodiversity that one witnesses in the state, a significant number of species in the region are getting depleted, and their populations are shrinking at an alarming rate because of the anthropogenic activities that cause over-exploitation, habitat loss or fragmentation (Singh et al. 2002). For instance, out of the total 19 species of ungulates reported from this state, 13 have been reported as globally threatened (J&K Environment Report 2013). Thus, the conservation of biodiversity should be the dominant discourse in the state's march towards environmental management and sustainable development.

### *41.3.2 Brief History*

Historically speaking, the protection of wildlife and forests in Jammu and Kashmir state has an illustrious legacy. The erstwhile 'Maharaja' (ruler) of Kashmir is said to have passed an ordinance to curb the export of 'Kuth' (*Saussurea costus*), to save it from extinction (Singh et al. 2002). Some of the sanctuaries were established nearly a century ago, mainly to protect the catchment of important lakes (Singh et al. 2002). The present-day State Wildlife Department has its origin in the Game Preservation Department established way back in 1901 A.D., with an aim to preserve wild animals and birds for royal recreation and sport. The state was among the first few Indian states which took steps to consolidate the law related to Protection and Preservation of the Game Reserves through enactment of the Jammu and Kashmir Game Preservation Act (1942).

There are number of initiatives that have been taken under state plan for the conservation, preservation and development of wildlife. The Jammu and Kashmir Wildlife Protection Act, 1978, was enacted to give fillip to the conservation movement for wild species and habitats in the state. Subsequently, in the year 1982, under the provisions of the Act, a full-fledged Department of Wildlife Protection came into existence, with the mandate of conservation, preservation and promotion of the faunal and floral heritage of the state (http:Z/www.jkwildlife.com/Files/sbwl.asp).

### 41.3.3 In Situ Conservation in Jammu and Kashmir State

#### 41.3.3.1 Protected Area Network (PAN)

Prior to 1978, the main initiatives concerning biodiversity conservation in the state were mainly restricted to wildlife, that too in Kashmir province only. At that time, the number of officially designated wildlife areas (earlier form of protected areas) was mere 16, encompassing an area of 516 km$^2$. To bring more species and communities of other provinces (i.e. Jammu, Ladakh) under the ambit of wildlife conservation, an adequate network of potentially viable wildlife habitats in all the three provinces of the state was identified by the government in 1981. Some of the existing game sanctuaries and reserves were re-designated as national parks, sanctuaries and conservation reserves. At present, the PAN comprises three types of protected areas as shown in Table 41.1, being spread over an area of about 15,806.75 km$^2$, which makes about 15.58% of the total geographic area of the state.

(i) *National Parks*: A national park refers to a natural area of land and/or sea protected and managed to:

 (a) Protect the ecological integrity of one or more ecosystems for present and future generations
 (b) Exclude exploitation or occupation inimical to the purposes of designation of the area
 (c) Provide a foundation for spiritual, scientific, educational and recreational and visitor opportunities, all of which must be environmentally and culturally compatible

Presently occurring national parks in the state, with districts of their occurrence, are shown in Table 41.2.

**Table 41.1** Protected area network (PAN) in the Jammu and Kashmir state

| Protected area type | Number |
|---|---|
| National parks | 5 |
| Wildlife sanctuaries | 14 |
| Conservation reserves | 37 |
| **Total** | **56** |

Source: Department of Wildlife Protection, Government of Jammu and Kashmir

**Table 41.2** List of national parks in Jammu and Kashmir state

| S. no. | Name of the national park | District of occurrence |
|---|---|---|
| 1. | Dachigam National Park | Srinagar/Pulwama |
| 2. | City Forest National Park | Srinagar |
| 3. | Hemis National Park | Leh |
| 4. | Kishtwar National Park | Kishtwar |
| 5. | Kazinag National Park | Baramulla |

Source: Department of Wildlife Protection, Government of Jammu and Kashmir

**Table 41.3** List of wildlife sanctuaries in Jammu and Kashmir state

| S. no. | Name of the wildlife sanctuaries | District of occurrence |
|---|---|---|
| 1. | Gulmarg Wildlife Sanctuary | Baramulla |
| 2. | Limber Wildlife Sanctuary | Baramulla |
| 3. | Lachipora Wildlife Sanctuary | Baramulla |
| 4. | Overa Aru Wildlife Sanctuary | Anantnag |
| 5. | Hirpora Wildlife Sanctuary | Shopian |
| 6. | Rajparian (Daksum) Wildlife Sanctuary | Anantnag |
| 7. | Karakoram Wildlife Sanctuary | Leh |
| 8. | Changthang Wildlife Sanctuary | Leh |
| 9. | Ramnagar Wildlife Sanctuary | Jammu |
| 10. | Jasrota Wildlife Sanctuary | Kathua |
| 11. | Surinsar Mansar Sanctuary | Udhampur/Samba/Jammu |
| 12. | Nandini Wildlife Sanctuary | Jammu |
| 13. | Thajwas (Baltal) Wildlife Sanctuary | Ganderbal |
| 14. | Trikuta Wildlife Sanctuary | Reasi |

Source: Department of Wildlife Protection, Government of Jammu and Kashmir

(ii) *Wildlife Sanctuaries*

A wildlife sanctuary is a space that is set aside exclusively for the use of wild animals, which are protected when they roam or live in that area. It is also referred to as wildlife refuge in some areas. There are a number of reasons to establish a wildlife sanctuary. In many cases, the government creates one for the purpose of protecting endangered species with a limited territorial range. Since it is not always possible to relocate animals or breed them in captivity, protecting their natural habitat can be very important. Some sanctuaries also offer wildlife rehabilitation. Typically, human access to a wildlife sanctuary is restricted. If people are allowed to visit the site, they must be escorted to ensure that they do not disturb the animals or damage the environment. Presently occurring wildlife sanctuaries in the state, with districts of their occurrence, are shown in Table 41.3.

(iii) *Conservation Reserves*

A conservation reserve is an area of land which is specially set aside under law to protect some environmental value inherent in them. The human activities inside the conservation reserves are usually restricted to only those activities which are compatible with conservation of these environmental values. Presently occurring conservation reserves in the state, with districts of their occurrence, are shown in Table 41.4.

#### 41.3.3.2 Conservation of Wetlands

The wetlands are popularly referred to as 'biological supermarkets', for the extensive food chains and rich biodiversity they support (Mitsch and James 2000). Being one of the most productive ecosystems, wetlands are of immense socio-economic, ecological and bio-aesthetic importance to the mankind. The Jammu and Kashmir state is renowned for its wetlands world over, which apart from their enormous ecological, biodiversity and tourism values are directly linked to the livelihood requirements of the local population. A number of wetlands are found in the state; some of them are independent conservation reserves. These wetlands have been under immense pressure on account of silt deposition, human interferences like encroachment, cultivation and habitation, grazing and over-exploitation for fodder, fuel, fishery resources, etc. The conservation of wetlands, therefore, has become essential as many of them are being drained or encroached upon for agricultural expansion and urban enterprise.

The State Wildlife Protection Department is managing the wetlands through state-funded programmes and nationally sponsored schemes on the conservation of wetlands of international importance. Public participation for better management of wetlands is crucial in order to save these precious ecosystems from further degradation. In this regard, the concerned Department has initiated the constitution of Conservation Reserve Management Committees and Eco-Development Committees to ensure public participation in the conservation programme. In consultation with reputed global agencies, the Department is actively engaged in the process of formulation of management plans for these wetlands. In the state, three wetlands – Surinsar-Mansar lakes in Jammu, Wular Lake in Kashmir and Tsomoriri in Ladakh – have been brought under the nationally sponsored Prime Minister's Reconstruction Programme for financial assistance. Comprehensive management action plans for these wetlands have been formulated by the Department. In case of Wular Lake, the Department has formulated the management action plan, and the Forest Department is working as a nodal agency for carrying out the conservation and management practices.

- *Ramsar Sites in Jammu and Kashmir State*

The convention concerning the wetlands of international importance is commonly referred to as Ramsar Convention. The Convention is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The Ramsar Convention is the only global environmental treaty which deals with a particular ecosystem, i.e. wetlands in the world. The treaty was adopted in Iranian city of

**Table 41.4** List of conservation reserves in Jammu and Kashmir state

| S. no. | Name of the conservation reserve | District of occurrence |
|---|---|---|
| 1. | Khiram | Anantnag |
| 2. | Panyar | Pulwama |
| 3. | Khangund | Pulwama |
| 4. | Shikargah | Pulwama |
| 5. | Khrew | Pulwama |
| 6. | Khonmoh | Pulwama |
| 7. | Brain Nishat | Srinagar |
| 8. | Khimber/Dara/Sharazbal | Srinagar |
| 9. | Wangat/Chattergul | Ganderbal |
| 10. | Zaloora, Harwan | Srinagar |
| 11. | Achhabal | Anantnag |
| 12. | Ajas | Bandipora |
| 13. | Naganari | Baramulla |
| 14. | Sudhmahadev | Udhampur |
| 15. | Jawahar Tunnel | Kulgam/Ramban |
| 16. | Thein | Kathua |
| 17. | Bahu | Jammu |
| 18. | Cheshara | Rajouri |
| 19. | Kheri | Rajouri |
| 20. | Sabu | Kargil |
| 21. | BoodhKarbu | Kargil |
| 22. | Kanji | Kargil |
| 23. | Hokesar (Ramsar Site) | Srinagar |
| 24. | Mirgund | Baramulla |
| 25. | Shallabugh | Ganderbal |
| 26. | Hygam | Baramulla |
| 27. | Malgam | Bandipora |
| 28. | Pampur (Chatlam/Manibugh/Kranchoo/ Chandhara) | Pulwama |
| 29. | Gharana | Jammu |
| 30. | Pargwal | Jammu |
| 31. | Kukarian | Jammu |
| 32. | Nanga | Jammu |
| 33. | Sangral-Asa Chak | Jammu |
| 34. | Tsomoriri (Ramsar Site) | Leh |
| 35. | Norrichain (Tsokar Wetland) | Leh |
| 36. | PangongTso | Leh |
| 37. | Hanley Marshes | Leh |

Source: Department of Wildlife Protection, Government of Jammu and Kashmir

**Table 41.5** List of wetlands of international importance in Jammu and Kashmir state under Ramsar Convention

| S. no. | Name of the wetland | Date of declaration | Area (ha) | Location | District of occurrence |
|---|---|---|---|---|---|
| 1. | Surinsar-Mansar lakes | 08-11-200 | 350 | 32°45′N 075°12′E | Udhampur/Samba/ Jammu |
| 2. | Hokersar | 08-11-2005 | 1375 | 34°05′N 074°42′E | Budgam/Srinagar |
| 3. | Wular Lake | 23-03-1990 | 18,900 | 34°16′N 074°33′E | Baramulla/Bandipora |
| 4. | Tsomoriri | 19-08-2002 | 12,000 | 32°54′N 078°18′E | Leh |

Source: Jammu and Kashmir Environment Report, 2013

Ramsar in 1971, and the Convention's member countries cover all geographic regions of the world. The Convention's mission is 'the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world' (http://www.ramsar.org/). In the Jammu and Kashmir state, four wetlands have been declared as the Ramsar sites (Table 41.5) [http://www.ramsar.org/wetland/india.

## *41.3.4 Ex Situ Conservation in Jammu and Kashmir State*

### 41.3.4.1 Botanical Gardens

A botanical garden may be defined as collection of living plants used for research, study and education. These act as a potential ex situ support to the conservation of wild populations and habitats. They can be used to facilitate propagation and micro-propagation of threatened plants. Germplasm sharing within networks of botanical gardens, associations with similar botanical institutions and organizations and maintenance of seed banks can prove to be a great asset to conservation efforts and strategies. Some of important botanical gardens in the state are:

- *Jawaharlal Nehru Memorial Botanical Garden*

This garden was established in 1969 in memory of Pandit Jawaharlal Nehru, the first prime minister of India. The garden is spread over an area of 80 ha and is situated on the Zabarwan mountain slopes near the bank of Dal Lake, along a road that goes to the beautiful Mughal Garden Cheshma Shahi (Royal Spring). The garden is divided into four components – sporting garden, research section garden, botanical garden and centre of plant introduction. The garden also houses a herbal garden, wherein a variety of medicinal plants are grown for the purpose of research and conservation.

- *Kashmir University Botanical Garden*

The Kashmir University Botanical Garden (KUBG) is among the pioneer botanical gardens in the Indian Botanical Garden Network (IBGN). A member of the Global Network of Botanical Gardens, the KUBG is a registered participant in the worldwide implementation of International Agenda in support of plant conservation, environmental awareness and sustainable development. KUBG was established in 1961 in the premises of then Jammu and Kashmir University Campus, near the holy Hazratbal Shrine, some 10 km north of the main Srinagar city. Presently, KUBG is spread over about 10 acres of land, holding a plant collection of about 450 plant species (Dar and Khan 2007). The KUBG plays a significant role in the conservation of plant resources in the Kashmir Himalaya. To maintain their valuable germplasm, a large number of medicinal and other economically useful plants are grown in the medicinal and aromatic plant unit of the garden.

Agro-techniques for several of these and other potential bio-prospective plant species have been developed for their successful mass propagation. Special emphasis is laid on growing ex situ collections of rare, endangered and threatened (RET) plants of the region. A rockery has very recently been set up to showcase the curious alpine rock plants. Many research projects sponsored by various funding agencies have been undertaken in the garden. By virtue of these projects, a large proportion of our precious plant germplasm, collected from near- and far-off and difficult terrains, has been maintained ex situ in KUBG. A high-altitude extension of KUBG is maintained at Gulmarg to facilitate the easy introduction of the medicinal plants (whose conservation protocols are designed) in their natural habitats; the plants are allowed to acclimatize under controlled conditions and then introduced in wild to enable their mass propagation.

- *Jammu University Botanical Garden*

This botanical garden is located in the campus of Jammu University, situated in the Jammu city. The garden, established in 1974, is spread over an area of 8.1 acres. It houses more than 500 species of angiosperms, gymnosperms, pteridophytes, bryophytes and macrofungi. In the garden, certain specific sections of plants are maintained which include succulents, medicinal plants, threatened plants, grasses, etc. Family-wise maintenance of the plants is promoted for easier understanding of evolutionary pattern of the plants. Germplasm collections of a number of economically important plants, such as species of *Allium*, *Crotalaria*, and *Plantago* are being maintained. Some of the endangered plant species, such as *Phlomoides superba*, *Eremurus himalaicus* and *Incarvillea emodi*, are being conserved in this botanical garden. These conservation efforts have led to recovery of *Phlomoides superba* from the point of near extinction (http://www.jammuuniversity.in/index.asp).

- *Baba Ghulam Shah Badshah University Botanical Garden*

This garden is located in the campus of Baba Ghulam Shah Badshah (BGSB) University, situated at the foothills of the Pir Panjal Range in Rajouri, 154 km from

Jammu, the winter capital of Jammu and Kashmir state. The garden has been recognized as the 'Lead Garden' for the phytogeographic region of Northwest Himalaya. The Lead Gardens, as in other parts of the world, function as important resource centres for biodiversity conservation and education vis-à-vis the obligations under the CBD regime.

The botanical garden undertakes research related to biodiversity documentation and conservation. It houses more than 400 plant species, many of which are of medicinal value, and some are rare and threatened. The garden is housed in the Pir Panjal Biodiversity Park, which is spread over an area of ca. 437 acres of land, at an altitude ranging from 1000 to 1337 m and is host to rich flora and fauna. A number of threatened plants, such as *Acorus calamus*, *Asparagus racemosus*, *Buxus wallichiana*, *Eremostachys superba*, *Eremurus persicus*, *Gloriosa superba*, *Habenaria marginata*, *Oenothera speciosa* and *Valeriana jatamansi*, have been introduced into the garden for various types of research studies and are being propagated (Dar and Malik 2017) [http://www.bgsbuniversity.org/].

#### 41.3.4.2 Aquaria

Aquaria are the sites for maintaining aquatic organisms, either freshwater or marine, or a facility in which a collection of aquatic organisms is displayed or studied (WAZA 2005). They can be conservators, educators, scientists and powerful tools for political change if they wish to be. Aquariums were realized as a positive and influential force for conservation of wildlife as early as the beginning of the twentieth century (WAZA 2005). They, therefore, have a choice to forge a new identity and purpose or to be left behind by the conservation movement. There are two major aquariums across the Jammu and Kashmir state:

(i) Aquarium-cum-Awareness Centre, Gagribal, Srinagar: It is situated at Gagribal Srinagar and since the year 1952 is functioning under the control of Fisheries Department.
(ii) Aquarium-cum-Awareness Centre at Bahu Fort: The centre was started during the year 1994–1995 and is located at Bagh-e-Bahu, Jammu, adjacent to the historical Bahu Fort, on the bank of Tawi River (http://jkfisheries.in/).

#### 41.3.4.3 Zoos

In the year 1984, two deer parks at Manda and Mansar of Jammu province were established by the Wildlife Department of the state. The purpose of the deer parks was to restock spotted deer in Jammu, reported to be extinct in Jammu at that time. Later, particularly at Manda (Jammu), it also housed rescued animals brought to the park in injured and sick conditions for treatment and care. Over the years, the Wildlife Department introduced a variety of other herbivores and also raised animal enclosures in the park. Presently, the park is very popular among the local people and tourists, as it hosts variety of animals, such as spotted deer, nilgai, sambhar, barking deer and chinkara, besides ducks, peafowl, black bear and a sizable number of leopards, which are a major source of attraction for the visitors. The population of these animals is being continuously monitored and regulated, and the excess animals are being released in some sanctuaries of the Jammu region. Presently, two sites, one at existing Manda Deer Park and one at Sidhra, are under preliminary evaluation by the consultants for development of zoo, herbivore safari and butterfly park in Bahu Conservation Reserve in Jammu. Similarly, the J&K Wildlife Department had established enclosures at Dachigam National Park in the 1970s and 1980s to protect rescued animals. In the year 2001, a Leopard Rescue Centre was established at the periphery of the park. Under the State Plan funding, the Department established deer parks at Pahalgam and Gulmarg. The deer park at Gulmarg has not come into operation, while animals are being kept at Pahalgam.

During the year 2009, the Central Zoo Authority approved the concept plan for preparation of detailed master plan for long-term development of zoos at Jammu, Srinagar and Ladakh, in pursuance to the directions of the supreme court, with objectives and themes of display. The Department has initiated the process of establishment of zoos at Srinagar as per the guidelines of Central Zoo Authority of India. Two sites for establishment of zoo at Srinagar have been identified and are presently under evaluation by experts, along with the existing site at Pahalgam (http://www.jkwildlife.com/files/pub.asp).

### 41.3.5 Legislative Measures

The Jammu and Kashmir state, owing to its special status under Article 370 of the Constitution of India, has enacted many of its laws, rules and guidelines to ensure conservation of biodiversity in the state (Table 41.6).

**Jammu and Kashmir Wildlife (Protection) Act, 1978**

The Act is broadly based on the Indian Wildlife (Protection) Act, 1972, and became effective on 9 May 1978. The Act is meant to provide protection to wild animals, birds and plants and for matters connected therewith or ancillary or incidental thereto. The Jammu and Kashmir Wildlife Protection Act, 1978, was enacted to give fillip to the conservation movement for wild species and habitats in the state. Subsequently, in the year 1982, under the provisions of the Act, a full-fledged Department of Wildlife Protection came into existence with the mandate of conservation, preservation and promotion of the faunal and floral heritage of the state (http://www.jkwildlife.com/Files/sbwl.asp). As per this department, the important wildlife species included in IUCN Red List and Jammu and Kashmir Wildlife Protection Act are given in Table 41.7.

**Table 41.6** Acts governing the conservation of biodiversity in Jammu and Kashmir state

| Name of the act |
|---|
| Jammu and Kashmir Wildlife (Protection) Act, 1978 |
| The Jammu and Kashmir State Forest Corporation Act, 1978 |
| Air Pollution Act, 1981 |
| Environment Protection Act, 1986 |
| Jammu and Kashmir Forest Act, 1987 |
| Jammu and Kashmir Forest Conservation Act, 1997 |
| The Jammu and Kashmir Willow (Prohibition on Export and Movement ) Act, 2000 |
| The Biological Diversity Act, 2002 |
| Jammu and Kashmir Forest Protection Act, 2009 |
| Kacharai Act, 2011 |

Source: Department of Wildlife Protection, Government of Jammu and Kashmir

**Table 41.7** List of important wildlife species of J&K and their conservation status as per IUCN's Red Data Book/Jammu and Kashmir Wildlife Protection Act, 1978

| S. no. | Name of wildlife species | Region of occurrence | Status as per IUCN's Red Data Book | Status as per Jammu and Kashmir Wildlife Protection Act, 1978 |
|---|---|---|---|---|
| 1. | Snow leopard (*Panthera uncia*) | Ladakh, Kashmir, Jammu | Endangered | Schedule I |
| 2. | Common leopard (*Panthera pardus*) | Jammu, Kashmir, Ladakh | Near threatened | Schedule I/endangered |
| 3. | Black bear (*Ursus thibetanus*) | Kashmir, Jammu | Vulnerable | Schedule II |
| 4. | Brown bear (*Ursus arctos*) | Ladakh, Kashmir, Jammu | Least concern | Schedule I/endangered |
| 5. | Ibex (*Capra ibex*) | Ladakh, Kashmir, Jammu | Least concern | Schedule I/endangered |
| 6. | Himalayan tahr (*Hemitragus jemlahicus*) | Jammu | Near threatened | Schedule I/endangered |
| 7. | Spotted deer (*Axis axis*) | Jammu | Least concern | Schedule III |
| 8. | Barking deer (*Muntiacus muntjak*) | Jammu | Least concern | Schedule III |

(continued)

**Table 41.7** (continued)

| S. no. | Name of wildlife species | Region of occurrence | Status as per IUCN's Red Data Book | Status as per Jammu and Kashmir Wildlife Protection Act, 1978 |
|---|---|---|---|---|
| 9. | Goral (*Naemorhedus goral*) | Jammu | Near threatened | Schedule I |
| 10. | Markhor (*Capra falconeri*) | Kashmir, Jammu | Endangered | Schedule I/critically endangered |
| 11. | Serow (*Capricornis thar*) | Kashmir, Jammu | Near threatened | Schedule I/endangered |
| 12. | Hangul (*Cervus elaphus hanglu*) | Kashmir | Least concern | Schedule I/critically Endangered |
| 13. | Musk deer (*Moschus chrysogaster*) | Jammu, Kashmir, Ladakh | Endangered | Schedule I/endangered |
| 14. | Tibetan antelope (*Pantholops hodgsonii*) | Ladakh | Endangered | Schedule I/critically endangered |
| 15. | Tibetan gazelle (*Procapra picticaudata*) | Ladakh | Near threatened | Schedule I/endangered |
| 16. | Nayan (*Ovis ammon hodgson*i) | Ladakh | – | Schedule I |
| 17. | Wild yak (*Bos grunniens*) | Ladakh | Vulnerable | Schedule I |
| 18. | Pallas's cat (*Otocolobus manul*) | Ladakh | – | Schedule I |
| 19. | Black-necked crane (*Grus nigricollis*) | Ladakh | Vulnerable | Schedule I |
| 20. | Golden eagle (*Aquila chrysaetos*) | Kashmir, Ladakh, Jammu | Least concern | Schedule I/endangered |
| 21. | Western tragopan (*Tragopan melanocephalus*) | Kashmir, Jammu | Vulnerable | Schedule I/endangered |
| 22. | Cheer pheasant (*Catreus wallichii*) | Kashmir, Jammu | Vulnerable | Schedule I/endangered |

Source: Department of Wildlife Protection, Government of Jammu and Kashmir

### 41.3.6 Other Conservation Efforts in J&K State

- *Efforts of the Forest Department*

The J&K state is splendidly gifted with diverse forest resources, which play a fundamental part in sustaining and maintaining fragile ecosystems of the region. Recorded forest area of the state is 20,230 sq. km (http://www.jkforest.com/jkf/index.asp). Forests of Jammu and Kashmir exhibit a remarkable diversity and harbor a variety of plants, animals and microorganisms. Literature indicates that 572 plant species belonging to 109 different families have medicinal value. More than

50% of the plant species used in British pharmacopoeia is reported to grow in Jammu and Kashmir (Jammu and Kashmir State Forest Policy 2011). Forests have a vital role in in situ conservation of biodiversity and maintenance of ecological balance. During the past few decades, the state has witnessed a tremendous decrease in the forest area due to exponential increase in human and livestock populations and spurt in developmental activities. The effects of degradation of forests are already visible in drying up of perennial water sources at many places, accelerated soil erosion, flash floods, silting up of reservoirs, loss of biodiversity and reduced forest productivity. The following are some of the initiatives that State Forest Department has taken to prevent loss of forests.

(i) *People's Participation*

The state is giving high priority for enrolling the participation of village communities in protection and management of forests. All important activities of Forest Department, including execution of major state and central government schemes, are being implemented through a participatory approach centring on Joint Forest Management Committees (JFMCs).

(ii) *Jammu and Kashmir State Forest Policy*, 2011

The Forest Department of Jammu and Kashmir state has taken many steps for the conservation of forests. In fact, the conservation of biodiversity and natural habitats through preservation of natural forests is the basic objective of the J& K State Forest Policy, 2011. The policy recognizes the conservation and development of forests as its principal aim. For effective protection and management of forests, the infrastructure, manpower and organizations are being strengthened. A number of steps have been taken for conservation under the State Forest Policy, which include:

(A) *Wildlife Conservation*

(a) Habitat destruction and disturbances in habitats of wild animals are the foremost reason for reduction in their populations and man–animal conflict. Therefore, forest management outside protected areas has been made an area of focus.
(b) Human activities in core habitat areas of important wildlife species have been restricted to minimize disturbance to wild animals.
(c) Being a repository of the biodiversity and gene pool, the national parks, wildlife sanctuaries and conservation reserves have received utmost attention for their conservation through important management plans and techniques.
(d) Zoological parks and animal rescue centres are planned to be developed as centres of environmental and wildlife education and awareness.
(e) Special attention has been focussed to address the man-animal conflict through a joint mechanism between agencies, such as forest department, revenue department, police, local administration and local institutions, and by creating awareness among general public.

(B) *Biodiversity Conservation*

Apart from in situ conservation of biodiversity in natural forests and habitats, the rich genetic resource base of the state needs to be preserved through the following actions:

(a) Biodiversity of the state requires to be surveyed and documented systematically, and sites having exceptional taxonomic and ecological value need to be conserved. If this process leads to curtailment of traditional and legal rights of the people on usufructs from forestland, appropriate and adequate compensation for the purpose must be provided to local community.
(b) Legal and administrative measures for protection of biodiversity of the state against bio-piracy need to be undertaken. Intellectual property rights of the tribal and local communities should be protected, and domesticated species and varieties of plants and animals be conserved as an integral part of the state's rich genetic diversity.
(c) Modern techniques of ex situ conservation need to be promoted for the preservation of threatened and endangered species.
(d) Adequate regulatory and institutional mechanisms require to be established for protection and conservation of wetlands.

- *State Biodiversity Strategy and Action Plan*

As per the State Biodiversity Strategy and Action Plan (SFRI 2003), the following strategies have been proposed to conserve both wild and domesticated biodiversities in the state.

(a) Complete inventory of plant and animal groups in the state to be prepared.
(b) Identification of more vulnerable taxa, fragile habitats and threatened ecosystems.
(c) Compilation of integrated database and its dissemination.
(d) Economic evaluation of bio-resources in the budgeting and planning process.
(e) Sound management plan needs to be evolved for wild and domesticated biodiversity.
(f) Multiple use of ecosystem needs to be promoted on sustainable basis.
(g) Technologies which are environmentally and biodiversity friendly need to promoted and adopted.
(h) Biodiversity conservation needs to be integrated with all development activities.
(i) Public participation needs to be promoted to conserve biodiversity, with emphasis on women's role on conservation. Village Panchayats and Village Development Committees need to be sensitized for their participation towards biodiversity conservation efforts.
(j) Regulations need to be monitored on a regular basis to foster conservation of bio-resources.
(k) A fair and equitable system of sharing benefits among all the stakeholders needs to be devised.

(l) Mechanism needs to be evolved to collect traditional knowledge and need to be integrated with scientific approach.
(m) Biodiversity issues need to be incorporated in formal and informal education and awareness programmes. Role of print, electronic media, theatres and cultural groups needs to be emphasized in biodiversity conservation.
(n) Training and capacity building of field staff needs to be undertaken for biodiversity conservation.
(o) Religious links with biodiversity need to be revived and strengthened. In situ conservation models of sacred groves and sacred waters need to be replicated.

- *State Biodiversity Board*

The State Government has constituted the State Biodiversity Board as per the Biological Diversity Act, 2002. The constitution of Jammu and Kashmir State Biodiversity Board is an outcome of State Biodiversity Strategy and Action Plan drafted by SFRI in the year 2003 (Vidyarthi 2013). The main mandates of the Board are the following:

(a) Monitor misuse, overuse or illicit smuggling of biodiversity by effective surveillance mechanisms.
(b) Encourage need-based biological research and innovations for economic value-added products.
(c) Issue certificates for legal commercial ventures and make available new technologies and scientific methodologies for ensuring economic benefits to local communities as per provisions of the Biological Diversity Act, 2002.
(d) Documentation of traditional knowledge of ethnic communities in the state. The board imparts the status of Geographical Indications to the local varieties of plants and animals with geographic distinctiveness, e.g. 'Ambri' of Shopian, 'Chilgoza' of Padder, 'Rajmaah' of Bhaderwah, 'Chikdi' of Thannamandi, 'Patrees' of Kashmir, 'Veeri Tethven' of Kajinag, 'Sattar Gaad' of Kashmir and 'Trumba' of Gurez.

- *Conservation of Flagship Species in Jammu and Kashmir State*

(i) *Snow Leopard*

(A) *Project Snow Leopard*

The snow leopard (*Panthera uncia*) is a large cat native to the mountainous ranges of Central and South Asia. It is listed as endangered in the IUCN Red List of Threatened Species (Jackson et al. 2008).The snow leopard is a globally endangered species about which little is known. Merely 7,500 are estimated to be surviving over 2 million km$^2$ in the Himalaya and Central Asian mountains, and all over they are facing tremendous human pressures. India is perhaps home to 10% of the global population in less than 5% of its global range, thus having a substantial proportion of its global population (Project Snow Leopard 2006).

The snow leopard and other endangered wildlife are not restricted to the protected areas only but are spread across almost the entire landscape. The wild populations of these endangered species are facing increasing threats posed due to competition with livestock, degradation, poaching and some species are even facing local extinction. Conservation efforts in the region, therefore, need to be innovative and move beyond the existing approaches to ensure that wildlife is able to persist not only within protected areas but also in the larger landscape. Keeping in view the drastically declining population and habitat threats, Project Snow Leopard was initiated in India in 2006, which strives to ensure conservation in the region, and is based on sound science and participatory planning and implementation of programmes that balances the needs of local people and conservation. The project has proposed important guidelines, built capacity of local people and forest department staff, attempted to strengthen institutions at the village, landscape, state and central levels for project design and implementation and provides funding for implementation conservation actions and subsequent monitoring.

Geographically, the Project Snow Leopard is spread over an area of 1,28,757 km$^2$ in India across five Himalayan states: Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh. The Jammu and Kashmir state occupies the prime position in the list of Indian states under the project. The state occupies 60% of the total project area, covering 77,833 km$^2$. The geographical scope of the project in the state (areas above 3000 m) includes the whole of Ladakh, Zanskar and Karakoram ranges. Further surveys are needed in other parts of the state to examine their potential as possible conservation sites for snow leopard in the near future.

(ii) *Snow Leopard Conservancy India Trust, Ladakh*

The Snow Leopard Conservancy India Trust, started in 2000, is located at Leh, Ladakh. It has been dedicated to promoting innovative community-based stewardship of the endangered snow leopard, its prey and habitat to the benefit of local people and the environment in the Trans-Himalayan regions of Ladakh. It fulfils its objective through the following approaches:

(a) Community Conservation Initiatives and Conflict Mitigation in areas where human-snow leopard conflicts are high, and the local communities suffer heavy losses to subsistence of livestock. The Trust develops alternative income activities like predator proofing, community-based ecotourism, livestock insurance, handicrafts and eco-cafes that benefit local communities and also stops retaliatory killings of snow leopards by local communities.
(b) Environmental education programmes that impart knowledge and appreciation of natural biodiversity and encourage children to become stewards of wildlife in Ladakh.
(c) Research programme, in which the Trust conducts non-invasive camera-trapping monitoring in order to assess the extent to which snow leopard rely upon domestic livestock and number of snow leopards in the area.

(iii) *Hangul*

The hangul (*Cervus elaphus hanglu*) is a critically endangered species of deer listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and is the lone survivor of the red deer group in the Indian sub-continent. Poached for its meat, antlers and skin, the deer's population has shown a decreasing trend from 1940s, as its numbers fell to just 900 in 1989 from around 3000. Furthermore, number stooped to below 200 after insurgency paralysed the state administration as militants and army battled each other deep in the forests, the main abode of this shy animal. Surveys reveal that the largest extant population, about 300 individuals, have been recorded in Dachigam National Park. Owing to its threatened status and declining number, many measures have been taken for the conservation and propagation of hangul. Long-term hangul conservation plan has been implemented with the support of the Union Ministry of Environment, Forest and Climate Change, India. Habitat research study has been initiated, in collaboration with Sher-e-Kashmir University of Agricultural Sciences & Technology, Kashmir, for satellite collaring of hangul in order to understand the movement patterns and the habitat, both in and outside the Dachigam National Park. An important research programme has been launched to study the relic population of hangul outside Dachigam National Park, in collaboration with Wildlife Trust of India (http://www.jkwildlife.com/files/pub.asp).

A long-term Hangul Conservation Action Plan, prepared with technical assistance from the Wildlife Institute of India, Dehradun, has been approved and included in the list of species under the Species Recovery Programme, being funded through the umbrella scheme 'Integrated Development of Wildlife Habitats'. The action plan was initiated in the year 2008–2009.This project will enable conservation of this unique species, along with the rich biodiversity in Dachigam National Park and other habitats of the Hangul. The major hurdle to this action plan is the decline in the population of the species and significant decrease in female and fawn ratio. Such a low population is at a high risk of extinction due to confinement and inbreeding. Reports also indicate that there is high leopard predation of the species, putting this species in critically endangered category.

The focus of the Hangul Conservation Action Plan is the recovery of the declining hangul population from existing endangered status. Under this broad aim, the plan has the following specific objectives:

(a) To improve the recruitment in the adult population
(b) To restore the shrinking habitat range of species

The action plan aims at four major outcomes for the conservation of the species:

- Improved survival rate of the young fawns so as to ensure their recruitment into adult population
- Reduction of disturbance in the summer habitat range of the species so that the animals could use wider range of habitat, particularly during breeding season

- The identification and prioritization of relic habitats based on their ecological status/suitability and connectivity with the existing habitat of Dachigam National Park
- Operational awareness programmes for different stakeholders concerning conservation of this species

Considering the ground position, it is evident that long-term conservation of hangul would require active participation of local communities, landscape-level conservation, capacity building of staff, research, adaptive management of the project, developing grazing grounds, conservation breeding centres, both in situ and ex situ, and management policies along with promotion of conservation and education awareness initiatives, and so on. The operationalization of the Hangul Conservation Action Plan Project in the J&K state will give an opportunity for the conservation of this unique species, along with the rich biodiversity of the inhabiting habitats, and will also address livelihood issues faced by the local people.

**Captive Breeding of Hangul**
Jammu and Kashmir government has taken initiatives to raise Hangul in a captive breeding centre for reversing its population decline. Under the Species Recovery Programme, a Captive Breeding Centre has been established at Shikargah, Tral (in south Kashmir), for the breeding of Hangul. The animal is allowed to breed in captivity and, thereafter, it can be released into the wild (Hussain 2012).

(iv) *Markhor*

Markhor (*Capra falconeri*) is one of the largest and most magnificent members of Caprinae or goat family. Markhor is a globally threatened species with very few remaining populations. It is an endangered species (IUCN Red List 2000) and is included in Schedule I of the Indian Wildlife Protection Act (1972) and Jammu and Kashmir Wildlife Protection Act (1978). Markhor has limited distribution range, confined to moist to semi-arid mountain tracts of Pakistan, India, Afghanistan, Uzbekistan, Turkmenistan and Tajikistan (Ranjitsingh et al. 2005). In India, markhor is restricted to Jammu and Kashmir. In Jammu and Kashmir 'Pir Panjal type' markhor (*Capra falconeri cashmiriensis*) is found (Bhatnagar et al. 2009). Citing local informants, Schaller and Khan (1975) suggested that close to 200 markhors may be surviving in Kashmir, but Roberts (1997) suggested that markhor may have gone extinct in Kashmir. However, based on the field surveys, Sohail and Baba (2002) confirmed that markhor is present in south Kashmir. Markhors are found in three wildlife sanctuaries and one conservation reserve, in all covering 252 $km^2$ – with a range reduction of 33% since 1947. In a recent exhaustive statewide survey of markhor, only two viable populations were confirmed in Kashmir, besides identifying a few more markhor potential areas in the state (Bhatnagar et al. 2009), but, unfortunately, these isolated small populations are also under continued threat. The major threats to the species are competition with livestock and insurgency-related disturbances in the area. The other threats include continued poaching for trophy and meat, increasing fragmentation of the population due to the new fencing that has come up at the Line of Control (LoC) with Pakistan and lack of awareness among locals and officials. Looking at the global status of markhor, the conservation of markhor in Jammu and Kashmir becomes vital, and every single population has a key role (Ranjitsingh et al. 2005).

The J&K state is committed to conserve the endangered species, and to this effect, the State Government agreed to all the recommendations laid down by the National Board for Wildlife while considering the proposal for denotifying the forest land of Hirpora Wildlife Sanctuary for construction of the Mughal Road passing through the Sanctuary. The important recommendations included constituting Kazinag National Park and significant increase in Hirpora Wildlife Sanctuary by addition of more forest area. The Markhor Recovery Plan for Hirpora in southern Kashmir and Kazinag National Park in north Kashmir formulated by the Wildlife Department, Government of Jammu and Kashmir, has been endorsed by the State Government and the Ministry of Environment, Forest and Climate Change. Considering all pros and cons for the survival of Markhor, Supreme Court of India accorded approval to the construction of Mughal Road with conditions, which are being observed by the State Government.

The Markhor Recovery Plan calls for actions like habitat improvement, afforestation, soil and water conservation, development of infrastructure, like offices, guard huts, staff quarters, check posts, measures for mobility and communications, anti-grazing/antipoaching activities, nature trails and inspection paths, publicity and awareness, designing Nature Interpretation Centre, eco-development activities and ecotourism, etc. Regular census and survey of Markhor is also part of the plan. The project has been launched in the state in 2009 (http://www.jkwildlife.com/files/pub.asp).

- *Wildlife Crime Control*

After the amendment of the Jammu and Kashmir Wildlife Protection Act (1978), wildlife crime control has become a very significant activity, particularly as the state falls in the trade route from India to China. The wildlife trade is considered illegal, clandestine and against the provisions of International Treaty obligations and has to be controlled. Government has initiated a number of significant steps in order to curb illegal trade within and at the international borders.

(i) *Control on Trade*

Wildlife hunting, earlier considered as a game and a hobby or an act of wisdom, gradually changed into an organized trade for meeting requirements of various products in domestic and international markets. Prior to 1997, uncontrolled hunting took place at a very large scale to meet the requirements of trade, which resulted in considerable reduction of animal population in wilderness. Jammu and Kashmir Wildlife Protection Act, 1978, did not envisage total ban on the killing of the wild animals; controlled hunting of many was allowed under license. Voice in favour of imposing complete ban was raised by all the sections of the society, nature lovers and eminent environmentalist. As a result, the Act of 1978 was amended on 6 May 2002. Now there is a complete ban on not only killing but also on trade of specified schedule animals, products, articles and trophies made therefrom or derived thereof, i.e. rugs, skin and specimens of such animals wanted in whole or in part, e.g. antler, bone, shell, horn, rhinoceros horn, hair, feather, nail, tooth, tusk, musk, eggs and nests. In order to provide the maximum protection, some of the endangered animal species have been shifted from other Schedules to Schedule I.

(ii) *Ban on Shahtoosh*

The Tibetan antelope (*Pantholops hodgsonii*), locally known as Chiru, endemic to the Tibetan Plateau, is found between Ngoring Hu in China and the Ladakh region in India. Although India does not have native Chiru population, only small herds (200 to 250) migrate to Ladakh in J&K during summer. The habitat of Chiru in Indian territory is Daulat Beg Olde, north of Ladakh in Karakoram range and Chang Chenmo valley (Hot springs) in the northeast of Ladakh (Department of Wildlife Protection, Govt. of J&K 2001–2010). These animals were poached in Tibet, where they were skinned and the wool used to be taken to Srinagar via routes through Ladakh and Nepal.

In J&K, the wool was used for the shahtoosh shawl weaving process, though pashmina, shahmina and jamavar were also popularly woven. Following the ban on shahtoosh trade by Government of India vide Central Wildlife Protection Act, 1972, and its subsequent amendments, the J&K State Government also amended its Jammu and Kashmir Wildlife Protection Act, 1978, in 2002 by bringing the animal in Schedule I of the Act and prohibiting use of shahtoosh wool. A door-to-door survey and census of shahtoosh workers in Jammu and Kashmir, independently carried out by the J&K Wildlife Protection Department and some NGOs like Wildlife Trust of India (WTI) and its partner the International Fund for Animal Welfare (IFAW), in 1997 revealed that about 15,000 workers in Srinagar were directly or indirectly involved in the weaving of shahtoosh shawls at the time of the ban. Most of these workers were aware that the use of shahtoosh wool was illegal outside the state, but they continued with it as it was their only source of livelihood (http://www.jkwildlife.com/files/pub.asp).

(iii) *Poaching*

Measures taken to accord utmost security to the specified scheduled animals include:

(a) Constitution of antipoaching squads
(b) Establishment of control rooms at the divisional office level
(c) Organization of awareness campaign in and outside the protected areas
(d) Regular patrolling carried out by the supervisory
(e) Burning of fur, depicting abolishment of fur trade in Jammu and Kashmir

- *Monitoring and Research*

To develop a better understanding of mechanisms and processes of nature, to use its resources more optimally and in a sustainable manner, as well as to evaluate the conservation status of species and habitats and the impact of conservation activities undertaken, regular monitoring and research need to be done in the protected areas.

At present there is a conspicuous deficiency in the baseline biological data and, thus, a dire need for generation of the information and data via research to properly manage and monitor protected areas. Recognizing this very fact, draft guidelines prepared by the J&K Wildlife Department, on the analogy of those issued by the Ministry of Environment, Forest and Climate Change, Government of India, have been approved by the State Government to facilitate processing and grant of permission for carrying out research in protected areas.

The Department has also initiated Wildlife Health Monitoring Surveys in protected areas of J&K state to identify the current health status of wild animals and to identify key threats to different wildlife species in and around wildlife protected areas. The health status of wild animals in captivity is also being monitored by the Department. Preliminary surveys have been made in Kashmir valley during the year 2010.

- *Peoples' Participation in Wildlife Conservation*

For any conservation plan to succeed, participation of common masses is essential. Understanding this fact, the Wildlife Department of the state organizes many programmes focussed around creating awareness, like making eco-clubs, celebration of wildlife week and world wetland day. Recently, to resolve man-wild animal conflict, conflict resolution squads have been approved to be formed in sensitive villages of the state. These squads are aimed to act as primary response teams in order to control the conflict situation without delay. For making the people, living near or on the fringes of forested and protected areas, aware about the do's and don'ts of handling wild animals in case of a confrontation, awareness and conservation programme with Wildlife SOS and Wildlife Trust of India have been conducted by the Department.

The proposals to constitute Advisory Committees for conservation of each Protected Area have been sent to the government by the Department, as it will also bring the panchayats (local governing bodies of villages) and the civil society, apart from people living in and around the protected areas, into the conservation and protection campaign. The voluntary public participation in the protection of the wild fauna and flora will reduce the dependence on resources of the protected area and will pave way for ultimate success of the conservation programmes being carried out in the state.

- *Conservation Awareness and Education*

Developing a comprehensive understanding and appreciation of biodiversity in the people is prerequisite for building a sound foundation for conservation in both present and future. So, strategies should be formulated carefully and logically to ensure the maximum participation of people in the conservation endeavours and to face the challenges pertaining to it.

In this regard, the Wildlife Protection Department of the state has been making all possible efforts to make people conscious about the importance of wildlife. The Department organizes various activities round the year throughout the state for various target groups. Celebration of wildlife week in the first week of October of every year is an important part of awareness generation. Various activities, like visits to wildlife parks, trekking through the wildlife sanctuaries, audio-visual shows, symposia and debates on wildlife conservation, and painting completions are organized for school children round the year all over the state to generate awareness and zeal for conservation in them, so that they can become the key proponents of biodiversity conservation in future.

## 41.4 Concluding Remarks

Biodiversity loss is a global crisis and, thus, the conservation has to be global in practice. As we conserve the natural world for economic, scientific and spiritual gains and against a backdrop of growing global resource demand and climate change, there is no option left other than conservation. Kareiva et al. (2011), in an essay titled 'Conservation in the Anthropocene', stressed that conservation is failing in its efforts to save both biodiversity and ecosystems, despite setting aside an impressive number of protected areas.

In the recent past, the Jammu and Kashmir state has witnessed about three decades of political turmoil that has had a drastic impact on all spheres of life. Severe impediments to biodiversity research and conservation practices have left large gaps in the achievement and realization of conservation approaches. Hopefully, as the state moves towards a stable political situation, it has to achieve at a steady speed the mainstreaming of biodiversity conservation. Although the in situ and ex situ conservation approaches are being put to practice, people are becoming aware, and biodiversity-related research is achieving recognition, yet much more needs to be done, as outlined hereunder:

- The complete biodiversity of the state needs to be documented, so as to develop suitable protocols for its conservation.
- The conservation approaches adopted so far in the state mainly centred over wild fauna, for many years, and even now some consider wildlife synonym to wild animals. As a result, plant conservation has received little attention and needs to be addressed holistically.
- The Protected Area Network needs to be expanded, and the already notified areas need to be scientifically managed and fully protected.
- We still rely on the conventional methods of conservation. The modern methods, like micropropagation, gene banks, etc. need to be adopted. In vitro-based multiplication of plants holds remarkable potential for the production of high-quality plant-based medicine and, thus, can decrease the pressure on natural populations. The present demand is to put into effect tissue culture-based techniques in implementing multiplication and conservation of threatened species, especially those which are difficult to rejuvenate by conventional methods, and save them from extinction.

- Biodiversity research needs to be viewed as priority area supported by proper funding.
- Our native endemic flora is now facing a tough competition from the invasive alien species (Dar et al. 2002). The pace and impact of the alien invasion qualify it to be a great threat to our biodiversity. Therefore, quarantine measures need to be strengthened and strictly followed to curb the hazard of bioinvasion.
- The developmental approaches need to be sustainable so that they have no negative impact on biodiversity and create no hurdles in its conservation.
- Utilization of bio-resources and conservation of critical habitats need to be reconciled for the sustenance of not only tourism industry but also maintenance of vital ecological functions, like purification of water resources, soil productivity, purification of air, recharge of ground aquifers, availability of pollinators, ecological interactions, climate moderation, perennial flow of water in rivers, and ensuring health, food and water security, as visualized by the fourteenth-century Sufi Saint of Kashmir-Sheikh-Ul-Aalam, popularly known as Nund Rishi, who said, 'Ann poshi teli, yeli van poshi', meaning food is subservient to forest.
- Need-based utilization of forest and wetland bio-products calls for value addition to popular forest products, innovative techniques to reduce timber wastage/use, tapping non-traditional timber trees for timber needs and encouraging cultivation of threatened plants.
- Under in situ conservation programme, Medicinal Plant Conservation Areas (MPCAs) need to be established in all biodiversity-rich sites outside Protected Area Network.
- Under ex situ conservation, botanical gardens, herbal gardens, biodiversity parks, environmental parks, and tree-talk Trails can be established at all district headquarters in different altitudinal zones.
- Public awareness and participation needs to be incorporated as an integral component of biodiversity conservation. The traditional knowledge of local tribes that live in close association with the biodiversity needs to be extracted and properly channelized, and they need to be credited for their contribution. The grassroot involvement is important because 'the lands we call as wild are homes to these people' (Dar et al. 2002).

Above all, we need to rise beyond our selfish needs and realize that every creature has a purpose to exist. Humans are just a part of the broad spectrum of life and will cease to exist if not supported by other life forms. Therefore, a critical balance is to be maintained between our needs and the capacity of the natural world to produce. Anthropocene has to progress within limits, before the time comes when it becomes a reason for human extinction in the same way as it became for the mass extinctions in geological past.

**Acknowledgements** We are thankful to the Head, Department of Botany, University of Kashmir, Srinagar, for providing necessary facilities. The sincere support and help rendered by the research scholars and staff at the Centre for Biodiversity and Taxonomy, University of Kashmir, is gratefully acknowledged.

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# Chapter 42
# Biodiversity Conservation in Jammu and Kashmir State: Legal Framework and Concerns

**Mohammad Ayub Dar**

**Abstract** The Jammu and Kashmir (J&K) State is known for its biological resources. A plethora of State-enacted laws regulate multiple components of these resources. Conservation of biological resources is an indirect or incidental concern in some of these laws, while optimum utilization of resources to generate revenue is the main object hidden between the lines of the statutes. After the Stockholm Conference of June 1972, host of centrally enacted laws for the protection of the environment either has a direct application in the State or has been applied with its concurrence. A comprehensive law for conservation, sustainable use and benefit-sharing of biological resources has been legislated by the Parliament of India in the form of Biological Diversity Act, 2002, which is also applicable to J&K State. Thus, a wide variety of laws, old and new, State and central, operate in the State without a thorough probe to ensure that these laws reconcile with each other and to screen out the laws and policies that are incompatible with or contradictory to conservation goals. Adoption of an integrated approach to biodiversity, integrating biodiversity concerns squarely into existing related statutes and rules, strengthening of Environmental Impact Assessment system and the legal action infrastructure, including locus standi and right to information of citizens and other similar issues, are vital to the efficacy of the laws. In this chapter, an attempt is made to trace out the existing biodiversity laws and their flaws and to suggest a workable alternative to make them achieve the goals of conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of utilization of genetic resources in Jammu and Kashmir State.

**Keywords** Biological diversity · Conservation · Laws and statutes · National Biodiversity Authority · Biodiversity Management Committees · Jammu and Kashmir state

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G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4_42

## 42.1 Introduction

A decade after signing the United Nations Convention on Biological Diversity (CBD) in 1992, the Parliament of India enacted the Biological Diversity Act, 2002 (NBA 2004), which extends to the whole of India, including the Jammu and Kashmir State. The legislation aims to achieve the objectives of sustainable use of biological resources and their conservation and equitable benefit-sharing. It provides a two-tier regulatory mechanism, one at the central level and the other in each of the states to ensure the fulfilment of its objectives highlighted in its preamble.

### *42.1.1 Biological Diversity and Resources: The Legal Definitions*

A comprehensive definition of the term ‘biological diversity’ has been given under section 2 (b) of the Biological Diversity Act as ‘the variability among living organisms from all sources and the ecological complexes of which they are part and includes diversity within species or between species and of ecosystems’ (NBA 2004). Likewise the term ‘biological resources’ under section 2 (c) of the Act means ‘plants, animals and micro-organisms or parts thereof, their genetic material and by-products (excluding value added products) with actual or potential use or value, but does not include human genetic material’. The Act has used some other terms which are vital to the conservation of biological diversity under the law. The term ‘benefit claimers’ means the conservers of biological resources and their by-products, creators and holders of knowledge and information relating to the use of such biological resources, innovations and practices associated with such use and application. ‘Bio-survey and bio-utilization’ means ‘survey or collection of species, subspecies, genes, components and extracts of biological resource for any purpose and includes characterization, inventorization and bioassay’. Of all the terms used, the term ‘commercial utilization’ is of paramount significance under the Act; it means ‘end uses of biological resources for commercial utilization, such as drugs, industrial enzymes, food flavours, fragrance, cosmetics, emulsifiers, oleoresins, colours, extracts and genes used for improving crops and livestock through genetic intervention, but does not include conventional breeding or traditional practices in use in any agriculture, horticulture, poultry, dairy farming, animal husbandry or bee keeping’ (NBA 2004). The Act provides for fair and equitable sharing of benefits arising out of the use of accessed biological resources and their by-products, innovations and practices associated with their use and application and knowledge relating thereto in accordance with mutually agreed terms and conditions between the persons applying for such approval, local bodies concerned and the benefit claimers.

### *42.1.2 National Biodiversity Authority*

With the above basic premise, the Act provides for the establishment of the National Biodiversity Authority (NBA) by the Central Government to advise the said government on matters relating to the conservation of biodiversity, sustainable use of its components and equitable sharing of benefits arising out of the utilization of biological resources (NBA 2004). The Authority is also invested with power to advise the State Governments in the selection of areas of biodiversity importance to be notified as heritage sites and the measures for the management of such heritage sites. The Authority, as representative of the Central Government, is invested with power to take all necessary measures to oppose the grant of intellectual property rights in any country outside India on any biological resource obtained from India or knowledge associated with such biological resource which is derived from India.

In order to prevent biopiracy, the following persons are required to obtain the prior approval of the National Biodiversity Authority before accessing any biological resource occurring in India, or knowledge associated thereto for research, or for commercial utilization or for bio-survey and bio-utilization:

(i) A person who is not a citizen of India
(ii) A citizen of India, who is a non-resident as defined in clause (30) of section 2 of the Income Tax Act, 1961
(iii) A body corporate, association or organization not incorporated or registered in India or incorporated or registered in India under any law for the time being in force which has any non-Indian participation in its share capital or management

Likewise, the Act prohibits, without the approval of the National Biodiversity Authority, the transfer of the results of any research relating to any biological resource occurring in, or obtained from India for monetary consideration, or otherwise to the aforesaid persons. However, transfer does not include publication of research papers or dissemination of knowledge in any seminar or workshop, if such publication is as per the guidelines issued by the Central Government. The scheme of prior approval does not apply to collaborative research projects involving transfer or exchange of biological resources or information relating thereto between institutions, including government-sponsored institutions of India, and such institutions in other countries, provided that the collaborative research projects conform to the policy guidelines issued by the Central Government and are approved by the said government. Again, no person can, without obtaining prior approval of the National Biodiversity Authority, apply for any intellectual property right in or outside India for any invention based on research or information on a biological resource obtained from India. The Act also prohibits transfer of biological resource or knowledge associated thereto by approved persons without the prior permission from the National Biodiversity Authority. All the approvals and permissions granted by the Central Government are subject to equitable benefit-sharing which includes the following:

(a) Grant of joint ownership of intellectual property rights to the National Biodiversity Authority, or where benefit claimers are identified, to such benefit claimers
(b) Transfer of technology
(c) Location of production, research and development units in such areas which will facilitate better living standards to the benefit claimers
(d) Association of Indian scientists, benefit claimers and the local people with research and development in biological resources and bio-survey and bio-utilization
(e) Setting up of venture capital fund for aiding the cause of benefit claimers
(f) Payment of monetary compensation and other nonmonetary benefits to the benefit claimers as the National Biodiversity Authority may deem fit

The amount of money fixed as benefit-sharing is to be deposited in the National Biodiversity Fund but, where biological resource or knowledge was a result of access from specific individual or group of individuals or organizations, the National Biodiversity Authority may direct that the amount shall be paid directly to such individual or group of individuals or organization in accordance with the terms of any agreement and in such manner as it may deem fit. The Authority, however, has been conferred with power to frame guidelines in order to implement the benefit-sharing mechanism in tune with the above lines.

### *42.1.3 Restrictions on Activities Related to Access to Biological Resources*

The National Biodiversity Authority, if it deems necessary and appropriate, shall take the steps to restrict or prohibit the request for access to biological resources for the following reasons (NBA 2004):

(i) The request for access is for any endangered taxa.
(ii) The request for access is for any endemic and rare species.
(iii) The request for access may likely result in adverse effect on the livelihoods of the local people.
(iv) The request for access may result in adverse environmental impact which may be difficult to control and mitigate.
(v) The request for access may cause genetic erosion or affect the ecosystem function.
(vi) Use of resources for purposes contrary to national interest and other related international agreements entered into by India.

### 42.1.4 State Biodiversity Board

Section 22 of the Biological Diversity Act provides for the establishment of a State Biodiversity Board in each of the States by the respective State Governments by notification in the Official Gazette. At the state level, the Board is to advise the State Government, subject to any guidelines issued by the Central Government, on matters related to the conservation of biodiversity, sustainable use of its components and equitable sharing of the benefits arising out of the utilization of biological resources (NBA 2004). The Board is also to regulate by granting of approvals or otherwise requests for commercial utilization or bio-survey and bio-utilization of any biological resource by Indians. The Board is to perform such other functions as may be necessary to carry out the provisions of the Act or as may be prescribed by the State Government.

Citizens of India or corporate bodies, associations or organizations which are registered in India need to give prior intimation to the State Biodiversity Board before obtaining any biological resource for commercial utilization or bio-survey and bio-utilization for commercial utilization. This norm, however, does not apply to the local people and communities of the area, including growers and cultivators of biodiversity, and Vaids and Hakims, who have been practising indigenous medicine. The Board may, on receipt of such intimation and in consultation with the local bodies concerned and after making such enquiries as may be deemed fit, by order, prohibit or restrict any such activity if it is of the opinion that such activity is detrimental or contrary to the objectives of conservation and sustainable use of biodiversity or equitable sharing of benefits arising out of such activity. All such orders of the Board are to be made after giving an opportunity of being heard to the person affected, and all information received by the Board in the format relating to the intimation is to be kept confidential and cannot be disclosed either intentionally or unintentionally to any person not concerned thereto. Like the National Biodiversity Authority, the State Biodiversity Board may, for an efficient discharge of its duties and performance of its functions, constitute committees, and in particular Agro-Biodiversity Committee, for the conservation of agriculture-related species and their wild relatives.

### 42.1.5 Biodiversity Management Committees

Every local body is to constitute a Biodiversity Management Committee (BMC) within its area for the purpose of promoting conservation; sustainable use and documentation of biological diversity, including preservation of habitats; conservation of land races, folk varieties and cultivars, domesticated stocks and breeds of animals and micro-organisms; and chronicling of knowledge relating to biological diversity. A cultivar under the Act means ‘a variety of plant that has originated and persisted under cultivation or was specifically bred for the purpose of cultivation’. Land race means ‘primitive cultivar that was grown by ancient farmers and their successors’. Similarly, folk variety means a ‘cultivated variety of plant that was developed, grown and exchanged informally among farmers’.

A BMC is to consist of a chairperson and not more than six persons, of whom not less than one-third shall be women and not less than 18 % shall be from scheduled castes/scheduled tribes. The local Member of Legislative Assembly/Member of Legislative Council and Member of Parliament can be special invitees to the meetings of committee (Biological Diversity Rules 2004). The mandate of at least 18 % representation to scheduled castes/scheduled tribes in BMCs may be a difficult task in some areas of the Kashmir Valley, where members of such communities do not reside. It may be taken as an intrusion by the locals of an area if members of such communities from other area are nominated by the local body in the BMC. Rule 22 (2) of the Biological Diversity Rules, 2004, will have to address the issue of providing a substitute to the above agreement for areas where people from scheduled castes/scheduled tribes are not residing. The main function of the BMC is to prepare People’s Biodiversity Register in consultation with local people, which shall contain comprehensive information on the availability of local biological resources, the knowledge associated with such resources and their medicinal value or any other use or traditional knowledge associated with them. Besides the People’s Biodiversity Register, the BMC is also to maintain another register which shall contain information about the grant of access to local biological resources and the traditional knowledge, details of the collection fee imposed and of the benefits derived, and the mode of their sharing.

The National Biodiversity Authority and the State Biodiversity Boards are to consult the BMC while taking any decision relating to the use of biological resources and knowledge associated with such resources occurring within the territorial jurisdiction of the Biodiversity Management Committees. The BMC is to maintain the data about the local aids and practitioners using the biological resources. It may levy charges by way of collection fees from any person for accessing or collecting any biological resource for commercial purposes from area falling within its territorial jurisdiction.

## 42.2 Materials and Methods

This chapter adopts a doctrinal type of approach in order to draw conclusions. The material used in this chapter includes various legislations in the form of acts, laws, rules, orders, schedules, etc., and the historical accounts pertaining to biological resources and their sustainable use and conservation, in India, especially the Jammu and Kashmir state, as contained in various books and other published material.

## 42.3 Legal Concerns for Biodiversity in Jammu and Kashmir State: A Bird's-Eye View

### *42.3.1 The Biological Diversity Act Is in Addition to and Not in Derogation of Other Laws Relating to Forests and Wildlife*

The Biological Diversity Act, 2002, specifically provides in section 59 that the legislation is in addition to, and not in derogation of, the provisions in any other law, for the time being in force, relating to forests or wildlife. The Jammu and Kashmir State has shown its unique legal calibre in framing laws on the protection of biodiversity even before the Indian independence, and in the field of medicinal plants, a law had been in vogue from as far back as 1921 AD (in the form of the Kuth Act, 1921). There were no clear-cut provisions in this legislation setting conservation as a priority goal, nor had the legislators made an effort to fill the conservation gap in the legal scheme. The legislation was highly penal in character, providing an armoury of officers with wide powers to store every ounce of wild medicinal wealth in the store banks of the State, where it had been counted so far simply as a minor forest produce and graded only in terms of revenue if fetched each year. The State Forest Act, 1930, a piece of colonial vintage like the Indian Forest Act, 1930, added fuel to the fire by arming the Forest Department with more powers to overexploit all wild resources by sidelining the local people under the garb of protecting trees from thieves. The Wildlife (Protection) Act, 1978, has not changed the position in any way, obviously for the reason that it is heavily loaded with the objective of protecting fauna and ignores the flora (Dar 2001).

The Jammu and Kashmir Game Preservation Act, 1942, provided for preservation and protection of game in the State by inter alia prohibiting export and sale of Small and Big Game. The Act has, however, been repealed to the extent to which matters therein have been dealt under the Wildlife (Protection) Act, 1978. The Jammu and Kashmir State Forest Corporation Act, 1978, provides for better preservation, supervision and development of forests and better exploitation of forest produce within the State. Sustainable grazing in the demarcated forests of the State has been an esteemed concept, and in 1940, on the basis of the recommendations made by the Grazing Committee, the State has ushered an era of sustainable grazing as follows:

> Government recognize that, even in areas thrown open to grazing in any particular year, steps should be taken to ensure that those areas are not over-grazed and are not thereby allowed to deteriorate for providing adequate grazing for the future. (J&K Govt. 1940)

Subsequently, the Jammu and Kashmir Kahcharai Act, 1954, was enacted that deals with the concept of grazing in a holistic manner and provides a scheme of sustainable grazing to avoid overgrazing and maintain adequate grazing for the future. The Act, therefore, can be said to be a unique legislation in as much as it applies the concept of 'intergenerational equity' in respect of livestock of the State

(J&K Govt. 1942). These and some other laws relating to biodiversity in the State need overhauling so that they operate in tandem with the Biological Diversity Act, 2002, and the Biological Diversity Rules, 2004, framed there under.

### *42.3.2 Document and Integrate Customary Laws and Practices Relevant to Biodiversity into Statutory Laws, Providing It a More Substantial Role*

The indigenous people have had a close dependence on their local environment and, in process, they not only have developed a stake in conserving the local biodiversity for their survival but also have gained a detailed empirical and qualitative knowledge base about the biological resources. One of the oldest customary practices still prevalent among the agricultural class is to send their livestock to distant grazing grounds on the high mountains in the summer season under the charge of professional shepherds. Twice or thrice in the season, the villagers used to go themselves, taking salt for their sheep and bringing back various drugs in the form of roots, leaves and seeds, resulting in considerable income to the hill villages. Plant parts thus collected were largely exported and had a readily available market through Panjabi traders. Identifying the indigenous communities who have remained the storehouses of traditional knowledge about the herbal plants, the noted colonial writer W. R. Lawrence gives a century-old account in the following words:

> The *Hakims* have a considerable knowledge of herbs, and their herb-collectors are the shepherds, who spend the summer on the high mountains where most valued plants are found…. Such samples as the *Hakim* does not obtain from the shepherds are brought from the druggists…. Besides the professional *Hakims* there are many "wise women" in the villages who have considerable knowledge of the properties of herbs, and it is remarkable fact that nearly every peasant seems to know something about the medicinal powers of plants (Lawrence 1895; see also Kaul 1997).

The close nexus of the indigenous people with the biological resources of especially the medicinal plant life, from top hills down to lakes, has resulted in the accumulation of knowledge base, which has got disrupted and disturbed because of deprivations from customary rights commenced by the State even from times when there were no hard and fast rules for protection of wildlife in the State. The wiser men had smelt that the State was planning to uproot the rural people from their customary rights and snatch away natural resources so sustainably used by them more than a century before, with the following message in response to such apprehensions:

> 'I have pointed out in Assessment Reports that the land revenue taken from the villages really includes rights enjoyed from time immemorial in the forests which surround the valley. Up to the present the agricultural classes have been allowed timber for their houses and farm implements, and fuel free of charge. I would urge most strongly that no restriction should be placed upon these old rights of user in the forests. If, hereafter, forest conservancy does impair those rights, it will be necessary to reconsider the rates put upon the land by me,

> for I would never have taken so high a revenue had I known that timber and fuel would be charged for by the State. Any drastic measures which would tend to curtail the privileges hitherto enjoyed in the forests may lead to serious difficulties…In a small country like Kashmir the right policy is to encourage cultivation and I believe that if the whole of the village area, which includes all land up to the slopes of the mountains and the borders of the forests, were brought under cultivation, grass, timber, and fuel sufficient for agricultural requirements could be supplied without injury to the State forest'. (Lawrence 1895)

The holders of customary rights and concessions in forest areas of the State were not in a position to raise voices against their curtailments, primarily because of their indigence, ignorance, illiteracy and lack of legal guidance. Though community conservation, control and use of community-based resources came under the purview of customary rights, the affected people did not move the courts to assert these rights even if snatched. There is less conservation and more alienation when one views the relation between the people and the forest and wildlife laws of the State. In order to integrate biodiversity concerns into existing statutes and associated rules, notifications and regulations, wherever necessary, a thorough review of the State Forest Act and the Wildlife (Protection) Act is needed. Besides reviewing the current forest classification system from the conservation and livelihood point of view, a greater role needs to be assigned to forest dwelling men and women in achieving the conservation goals (Lawrence 1895).

It has been argued that in an iniquitous situation of alienation from basic rights to land and resources, benefit-sharing can hardly ever achieve 'fairness and equity' (Anuradha & Kothari 2000). The Government of Jammu and Kashmir has undertaken the task of involving the forest dwelling communities in the regeneration of forest resources on the basis of benefit-sharing arrangements. The Government, in exercise of the powers conferred on it by section 5 and 14 A of the Forest Act, 1930, has framed the J&K (Rehabilitation of Degraded Forests and Village Plantation) Rules, 1992[1]. These Rules provide for formation of Village (Rehabilitation of Degraded Forests) Committees and Village Plantation (Protection and Management) Committee with full participation of the people residing at the edge of degraded forests and other villages. While the members of Village (Rehabilitation of Degraded Forests) Committees are entitled to share harvest up to 50 % in cash or in kind to be utilized for the welfare of villagers, the members of the Village Plantation (Protection and Management) Committee are entitled to share 75 % of the harvest to be utilized for the welfare of the villagers. The committee is to select areas for raising plantation for the benefit of villagers and their cattle and agriculture and for the prevention of denudation and soil erosion. The programme has shown a good success (DFO 2000) but needs to be fully extended to medicinal plant cultivation in at least the areas providing in situ conditions for the development of viable population of medicinal plant species in their natural surroundings. The J&K Forest (Conservation) Act, 1997, also needs to be updated, so that the power conferred under section 2 is not used to achieve any purpose other than conservation of demarcated and other forests.

[1] See SRO 61 OF 1992; see also SRO 17 of 1999 amending the Rules of 1992.

The Advisory Committee envisaged under section 3 of the Act needs to be broad-based, where experts from the field of biodiversity need to be given an effective say in decision-making relating to the use of forest land for non-forest purposes or de-notifying of demarcated forests. There is no justification for allowing exercise of powers under section 2, even by the Government without following the ETA procedures. Similarly, the Environment (Protection) Act, 1986, the Mines and Minerals (Regulation and Development) Act as well as the Patents (Amendment) Act need a fresh review to give life to the logic of conservation as enshrined in the Biological Diversity Act, 2002.

### *42.3.3 Review of the Property Rights and the State Land Laws*

The property laws do not reflect principles of biology, ecology and other natural sciences to anywhere near the extent that property laws reflect principles of philosophy, sociology, economics and other social sciences (Frazier 1998). Green approaches to property law reform seek to address the sometimes apparent disjunction between property rules and common sense by adding consideration of the full range of interests of biological communities and their component parts to the balancing function of property law and by viewing individual interests from a more realistic perspective that recognizes individual resource owners as members of biological communities. If and when we recognize all the interests of the biological communities, while still recognizing interests that promote individual liberty and more traditional community interests, in the balancing function of property law, we will be able to create, interpret and apply property rules that better harmonize enjoyment of our resources today and preservation of resources for our future enjoyment and for the enjoyment of our descendants. Host of the property laws and land laws of the State speaks in terms of private property values, which are devoid of biodiversity conservation values and need a fresh look to inject modern conservation doses in them.

The Transfer of Property Act, 1882, recognizes that things attached to earth constitute immovable property. It also recognizes that 'benefits arising from land' is an interest in the land and, therefore, immovable property. But would benefits arising from land include benefits arising from use of genetic material components in the biological resources found in the land? This question is yet to be answered. Similarly, the Act does not give any significance to 'growing crops and grass' and excludes them from the definition of immovable property in its section 3.

Thus, a valuable resource in the field of biodiversity is pushed into the domain of contract law and is not considered precious as other immovable property, but simply like chattels to be dealt by means of private agreements. The acquisition or requisition of land for different public purposes should be proceeded with only after a thorough and comprehensive environmental impact assessment, so that the biodiversity conservation goals and developmental needs are fully considered objectively. The prominent laws that need a review in the sphere of property and land laws include the Transfer of Property Act, 1882, the State Land Acquisition Act, the Land Revenue Act, Alienation of Land Act, 1938, the Requisitioning and Acquisition of Immovable Property Act, 1968, and the Land Grants Act. Though the State Government has recently undertaken review of some land laws of the State, the purpose of such review is limited to ensure that prime agricultural land is not utilized in an unbridled manner to meet the housing requirements in the State. The purpose of such review needs to be broad based, so as to safeguard unique biodiversity of the State, whether associated with prime agricultural or other land.

### *42.3.4 Review of Agro-Biodiversity-Related Laws*

It has been observed that in Asia the greatest threat to biodiversity is not destruction of plants and animals per se but rather the destruction of their habitat (UN 2001). Modernization of agriculture threatens potentially valuable local crops. Many local varieties are disappearing as farmers plant a single, improved variety. Additionally population growth leads to expansion in human settlements and increasing demand for food, fuel and building materials. Unless significant measures are taken in Jammu and Kashmir also to incorporate environmental concern into agricultural development and land resource management, the situation is likely to worsen. It is equally important to evolve newer policies for the conservation of domesticated biodiversity and the indigenous community practices relating to it. Therefore, the legislations regulating land as a resource and various aspects of agro-biodiversity need a fresh analysis, in tune with the conservation objectives. Some of these enactments are as follows:

(a) Agrarian Reforms Act, 1976
(b) Agricultural Produce Marketing (Regulation) Act, 1997, and the Rules of 2003 framed thereunder
(c) Aid to Agriculturalists and Land Improvement Act, 1936, and Aid to Agriculturalists (Fertilizers Loan) Rules, 1965; Agriculturalist Relief Act, 1926
(d) J&K Utilization of Lands Act, 1953, and the J&K Land Improvement Schemes Act, 1972
(e) The Jammu and Kashmir Prohibition on Conversion of Land and Alienation of Orchards Act, 1975
(f) The Jammu and Kashmir Vegetable Seeds Act, 1952

### 42.3.5 Review of Laws Regulating the Preservation of Specified Trees and Their Derivatives

Some species of trees growing in the State have been the main source of raw material for the specialized industry of Kashmir Art or have otherwise been of vital importance for the economy, prosperity and welfare of a large section of citizens of the State. The Jammu and Kashmir Preservation of Specified Trees Act, 1969, and the Jammu and Kashmir Mulberry Protection Act, 1949 (along with the J&K Mulberry Protection (Amendment) Act, 1987), make provision for the growth, preservation and protection of various species of trees. Similarly, the purpose of the J&K Fruit Nurseries (Licensing) Act, 1987, is to provide for the licensing and regulation of fruit nurseries in private sector in the State. The Act also empowers the State Government to prohibit the import or export, or transport within the State of any fruit plant of unknown pedigree, or such plants as are affected by any infectious or contagious pests or diseases. The objective of these legislations matches the modern concepts of conservation of biological resources; however, the implementation mechanism needs to be updated and, therefore, a review of these laws should aim at consolidation of the laws, industrial and export policy relating to the derived material, flow of information to the public to create awareness about the advantages of conservation and sustainable use of the trees and improvements in the prosecution and penalty mechanism to achieve the conservation goals.

### 42.3.6 Strengthen Implementation of the Laws and Provide Redressal Mechanism at the Grass-Roots Level

The provisions under the Biological Diversity Act, 2002; the Forest Act, 1930; the Wildlife (Protection) Act, 1978; and the centrally enacted laws relating to environmental protection speak about volumes of clashes and conflicts relating to legal action, locus standi and the period of notice to governmental authorities, before citizens can approach the courts to reform the violators of these laws. Uniformity in the above legal areas would ensure equality and fairness, which in turn would strengthen the implementation mechanism. There is a need to integrate the right to information related to biodiversity into all relevant laws, including especially the Biological Diversity Act, 2002. The recently enacted National Green Tribunal Act, 2010, is a welcome legislation that puts an end to the otherwise cumbersome redressal mechanism enshrined in the laws that will stand repealed once the Act is put to implementation. However, keeping in view the range of jurisdiction vested with the Tribunal in respect of various environmental legislations and matters[2], it is submitted that in due course of time need

[2] Sections 14 and 15 confer jurisdiction upon the Green Tribunal to decide all civil cases involving substantial questions relating to environment (including enforcement of legal rights relating to environment) arising out of the implementation of the Acts specified in the Schedule appended to

would arise for a permanent bench of the Green Tribunal to be located in, or in proximity to, the State of Jammu and Kashmir. Besides, minor disputes between the local communities, benefit claimers and the Biodiversity Management Committees are bound to occur, which demand summary type of inexpensive disposal through techniques of ADR like arbitration, mediation and settlement through Lok Adalats, without involving long-drawn procedural intricacies of an adversarial system of justice.

### *42.3.7 Strengthen the Environmental Impact Assessment (EIA)*

Agro-biodiversity, aquatic biodiversity and ecosystem services need to be strongly represented in the central Ministry of Environment, Forest & Climate Change's EIA Notification[3] of September 2006. Extending the procedure to all projects with a likely adverse impact on biodiversity, increasing public participation, involving experts to aid the public in fully understanding the long-term impacts and making the informed and free consent of local affected communities mandatory, penalizing fraudulent practices, ensuring independent funding not linked to project proponents and other such measures are aspects of vital importance to strengthen the EIA. Ignorant and socio-economically weak and underprivileged communities can hardly understand the prospective value of their resources, which the project proponents, too often excessively intoxicated with commercialism, can easily grab from them. It is, therefore, highly desirable to launch programmes of education and awareness and extend support services to the communities in all EIA procedures.

### *42.3.8 Reconcile the State and Central Laws and Policies*

To achieve the goal of biodiversity conservation, it is important to reconcile State and central laws and policies that are incompatible with or contradictory to conservation laws and policies. In order to meet the biodiversity conservation goals at the State level, the State Pollution Control Board (SPCB) needs to adopt its own stan-

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the Act, viz. the Water (Prevention and Control of Pollution) Act, 1974; the Water (Prevention and Control of Pollution) Cess Act,1977; the Forest (Conservation) Act, 1980; the Air (Prevention and Control of Pollution) Act, 1981; the Environment (Protection) Act, 1986; the Public Liability Insurance Act,1991; and the Biological Diversity Act, 2002, including appeals arising from the orders, directions and decisions made under these Acts (see also section 36 and Schedule 111 of the Act amending all the 60 above Acts in respect of appellate powers of different courts). Compensation, relief and restitution matters arising as a result of pollution are also to be settled by the Tribunal. An appeal against the decision of the Tribunal is to lie in the Supreme Court under section 22 of the Act.

[3] Published in the Gazette of India, Extraordinary, Part 11, and section 3, sub-section (ii), Ministry of Environment and Forests, New Delhi, 14 September 2006

dards in respect of air pollution, which have to be stringent than the centrally set standards given under the Environment (Protection) Rules,1986, presently adopted by the SPCB. Again, some of the laws that aim at decentralization and social justice programmes, e.g. the Panchayati Raj Act, 1989, have certain contradictions with the conservation laws, which also need to be reconciled. In fact Panchayati Raj Act, 1989, has more significance from biodiversity and biodiversity-based livelihood point of view, and more powers need to be conferred upon Panchayati Raj Institutions to actively involve them in the implementation of biodiversity legislation.[4] In Ladakh, the Ladakh Autonomous Hill Development Council Act, 1997, provides for the constitution of Autonomous Hill Development Council for the districts of Leh and Kargil. These Councils are to be deemed to be the District Planning and Development Boards for the districts and exercise all the powers vested under the Panchayati Raj Act, 1989, with District Planning and Development Boards. Each Council is vested with powers of allotment, use and occupation of land transferred to it under the Act. Among the other district developmental powers, the Council is to exercise powers for formulating district development programmes; management of un-demarcated forests; use of canal and water courses for the purpose of agriculture, desert development, preservation, protection and improvement of livestock and fisheries; and preservation of the environment and ecology of the area. The powers under the Act have to be exercised subject to the provisions of the Act and other laws for the time being in force in the State and any general or special direction of the Government. Under this controlling provision, there is no doubt that the Council has to exercise its developmental powers in tune with the conservation laws in force in the State, but the developmental policy initiatives under the Act need to be planned in tandem with the conservation principles of the Biological Diversity Act, 2002. 0ne way to achieve it is to give representation to conservation experts by way of nomination in the Councils as well as Inter-District Advisory Council.

### *42.3.9 Lake Biodiversity: The Administrative Jungle and the Mechanism of Protective (Mis) Management*

Besides high mountains, the lakes of the State (especially the Dal Lake) have remained viable ecological resources providing fodder, fish and wildlife, green manure, medicinal plants, timber, firewood, vegetables and other valuable products

[4] *Section 12 of the J&K Panchayati Raj Act, 1989, imposes a duty on Halqa Panchayats to specifically deal with the problems of soil erosion, water management, social forestry, rural industrialization, agriculture, sheep and animal husbandry, sanitation, health and other welfare programmes, besides regulating sale and preservation of fish and vegetables. Under section 13 property, movable and immovable, which has been transferred to the Halqa Panchayat by the Government, any public body or an individual constitute the property of the Halqa Panchayat. Similarly, trees and grass growing on the property belonging to the Halqa Panchayat, fruit and other produce thereof and windfalls thereon are also the property of the Halqa Panchayat.

to the people. Despite the establishment of a separate regulatory body in the name of Lakes and Waterways Development Authority (LAWDA) under the State Development Act, 1970, numerous other State departments and authorities continue to operate with respect to lakes of the State, especially the Dal Lake, in their own spheres, exercising different powers under numerous legislations. These departments and authorities include the following:

(i) Tourism Department
(ii) Forest Department
(iii) Soil Conservation Department
(iv) Wildlife Department
(v) Department of Fisheries
(vi) Department of Environment and Remote Sensing
(vii) Department of Irrigation
(viii) Urban Environmental Engineering Department
(ix) Public Health Engineering Department
(x) Department of Parks and Gardens
(xi) Municipal Corporation, Srinagar
(xii) State Pollution Control Board and, prospectively, the State Biodiversity Board

A wide variety of legislations have a direct or indirect bearing upon the lakes and waterways in the State, though powers thereunder remain scattered in the hands of different authorities and departments other than the LAWDA. The State departments, and the authorities created under the laws, exercise different types of powers, and in respect of the lakes and waterways, these powers are conferred inter alia for the purpose of:

(i) Conservation or prevention and control of pollution or polluting activities, or
(ii) Regulation of trade, tourist and economic activities, or
(iii) Prevention of encroachments and/or regulation of construction activities

### *42.3.10 The Laws for the Conservation/Prevention and Control of Pollution and Polluting Activities*

(i) The Canal and Drainage Act
(ii) The Easements Act
(iii) The Irrigation Act, 1978
(iv) The Jammu and Kashmir Water Supply Act, 1963
(v) The Jammu and Kashmir Non-biodegradable Material (Management, Handling and Disposal) Act, 2007
(vi) The Water (Prevention and Control of Pollution) Act, 1974, and the Environment (Protection) Act, 1986
(vii) Animal Contagious Diseases (Control) Act, 2006 (1949 AD)

(viii) The Cattle Trespass Act, 1920
(ix) The Wildlife (Protection) Act, 1978
(x) The Municipal Act, 2000 (AD) and prospectively
(xi) The Biological Diversity Act, 2002

### 42.3.11 The Laws for the Regulation of Tourist, Trade and Other Economic Activities by Different Departments

(i) The Jammu and Kashmir Registration of Tourist Trade Act, 1978
(ii) The J&K Hotel (Amenities and Services) Tariff Taxation Act, 1980
(iii) The Jammu and Kashmir Professions Trades, Callings and Employments Tax Act, 1981
(iv) Camping and Mooring Sites Act, 2004 (1947 AD)
(v) Ferry Boats Control Act, 1971
(vi) The J&K State Fisheries Act, 1960 (1903 AD)
(vii) The J&K Water-Nuts (Singhara) Rules, 2007 (1950 AD)

### 42.3.12 The Laws for Exercising Control over Constructions and Encroachments

(i) The Land Revenue Act, Samvat 1996 (1939A)
(ii) The J&K Public Premises (Eviction of Unauthorized Occupants) Act, 1988
(iii) The J&K Control of Building Operations Act 1988 as amended by the J&K Control of Building Operations Act 1997
(iv) The Land Acquisition Act, Samvat 1990

### 42.3.13 Lack of Coordination and Need for Integrated Approach in Regulation

A plethora of laws, with multiple enforcement agencies thereunder, create a complicated web of fragmented control. Besides the jungle of administrative bodies, each body is invested with vast number of powers and procedures. There is a possibility of overlapping controls, where a single process or incident could be regulated by more than one body, using different enforcement powers. In many cases, there could be situations of ‘too many cooks spoiling the broth’.

### *42.3.14 Failure to View the Lake Environment as a Whole*

When each department controls separate sector, there can be a reluctance to deal with a problem on a unified basis. Administratively, the existence of multiple bodies with overlapping responsibilities creates tremendous logistical difficulties; misunderstandings creep up, and interdepartmental communication has its own problems, which all lead to inefficient control, ultimately undermining the authority of the law.

This is one of the main reasons why the State High Court has been constrained to assume the responsibilities of looking after the Dal Lake vide its Division Bench order dated 24 March 2009. The need for an integrated and coordinated approach to address the desired physical, biological, ecological and engineering measures, both in the catchment and within the lake basin itself, has been felt by several experts in the past (Kundangar et al. 1997). Dal Lake is simply an instance to project the deplorable condition of the lake resources in the State, and the satellite imagery of other lakes, like Wular, reveals disturbing statistics, more than 70% of the lake having been severely affected by siltation, reducing its water-carrying capacity and, in turn, posing flood threat to the Kashmir Valley (Greater Kashmir, 3 February 2010). It has been observed that as a result of climate change, the impacts of regional climate variation challenges for the State of Jammu and Kashmir would include decreasing volume of glaciers, short-term increase in run-off but overall long-term declining stream and river run-off, reduced spring discharge and reduced lake volume in the Dal, Wular and Manasbal lakes and wetlands. To overcome the new challenges, it has been recommended that the existing policies should be reviewed, with particular attention to the consequences of climate change. Policy and adaptive response should take account of vulnerabilities to environmental change within the natural and social systems of J&K and other hazards to which the region is exposed (Anonymous 2009). In order to reverse environmental degradation, especially in respect of water pollution, closer coordination among government agencies and active community involvement have been suggested as a road plan for action. In tune with the recommendation submitted in respect of lakes and waterways, climate experts have recommended the creation of a dedicated institution in the State mandated to coordinate actions of all organizations, with powers and mandate to address adaptation to and mitigation of climate change.

## 42.4 Concluding Remarks

The Jammu and Kashmir State has the sovereign power to use its natural resources in the way it likes, but the power has to be used to serve the common good. Enough of our biodiversity, especially in the forests and close to boarder areas, continues to be destroyed because of defence activities, this process having never ended since 1947. Additionally, the inappropriate, inflexible, weak and contradictory nature of various laws will continue to weaken the cause of conservation of biodiversity.

Contradictions between environmental laws and policies, on the one hand, and the laws in respect of industrial development, commerce and welfare, on the other, have already raised their ugly heads. Even the environmental laws can be accused of showing less concern for biodiversity. Some of these laws show a centralizing tendency and provide inadequate mechanism for the empowerment of citizens, especially biodiversity-dependent communities, who could otherwise use the existing laws and policies, or challenge them when inimical to biodiversity conservation. Judge-made laws have always played unique role in the legal circles, which also need a thorough analysis at the local level from the biodiversity point of view, so as to maximize their use in achieving conservation, sustainable use and equity.

There is absence of a holistic land-use plan and policy that can specify fragile areas as off-limits to development activities, including mining. There is no law for the protection of wetlands, nor can the State, in the presence of existing private property law regime, exercise control over the diversity of non-living elements, e.g. soil, its uniqueness and fertility, to act as the natural habitat for diverse types or varieties of plants. A thorough review of the existing State laws relating to flora and fauna, and their habitat, has to be undertaken to reap the benefits of conservation of bioresources to the optimum. The conservation objectives demand collaborative decision-making and integrated approach, as against legally sponsored traditional individual and isolated process of implementation of laws.

A consistent effort to identify holders of traditional and existing knowledge relating to biological resources is required to be made, and people are to be made aware about the benefits of conservation of these resources and the need for a consistent hunt to discover their potential use and market. The message of conservation of bioresources, associated traditional knowledge, existing as well as prospective benefits, fair and equitable benefit sharing can reach the stakeholders at the grass root level only when the State takes concrete steps in giving representation to effective persons in the Biodiversity Management Committees. Once they adopt a consistent approach in creating mass awareness by establishing linkages with educational institutions and the mass media at the local level, the Biodiversity Management Committees, in due course, would turn as respectable institutions among the local people.

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# Index





G. H. Dar, A. A. Khuroo (eds.), *Biodiversity of the Himalaya: Jammu and Kashmir State*, Topics in Biodiversity and Conservation 18,
https://doi.org/10.1007/978-981-32-9174-4