Chandrakasan Sivaperuman
Krishnamoorthy Venkataraman *Editors*

Indian Hotspots

Vertebrate Faunal Diversity, Conservation and Management
Volume 2

Springer

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Editors
Chandrakasan Sivaperuman
Andaman & Nicobar Regional Centre
Zoological Survey of India
Port Blair, Andaman & Nicobar Islands
India

Krishnamoorthy Venkataraman
National Centre for Sustainable
Coastal Management
Anna University Campus
Chennai, Tamil Nadu, India

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Foreword

India is one of the seventeen mega-biodiversity countries of the world. Out of the total 35 biodiversity hotspots, India has four, namely, the Eastern Himalaya, the Indo-Burma, the Western Ghats and Sri Lanka, and Sundaland. There are 10 bio-geographical zones in India, these are, the Trans-Himalayan, Himalayan, Desert, Semi-Arid, Western Ghats, Deccan Peninsula, Gangetic plain, Coasts, Northeast, and Islands. The varied edaphic, climatic, and topographic conditions and years of geological stability have resulted in a wide range of ecosystems and habitats such as forests, grasslands, wetlands, deserts, and coastal and marine ecosystems. The location of India is at the confluence of three major bio-geographic realms, namely, the Indo-Malayan, the Eurasian, and the Afro-tropical, enabling it to have an assemblage of diverse elements from all these regions.

The tropical forest ecosystem is one of the most diverse and rich in biological diversity on earth. India has a diverse range of forests from the rainforests of Kerala in the south to the alpine pastures of Ladakh in the north, from the deserts of Rajasthan in the west to the evergreen forests in the Northeast. The forests in India are spread over an area of 6,92,027 km^2, covering 23.39 percent of the geographical area of the country. The tropical rainforests support the greatest diversity of living organisms on Earth. India ranks tenth in the world and fourth in Asia in plant diversity and eleven percent of the world's flora is reported from India.

The present book entitled *Indian Hotspots: Vertebrate Faunal Diversity, Conservation and Management* (Volume: 1 & 2) embodies 39 research chapters of high standard grouped into "Vertebrate Faunal Diversity" and "Conservation & Management." This is a welcome step on the conservation of vertebrate faunal communities in the tropical forest ecosystem especially in the Indian hotspots. I congratulate the editors Dr. C. Sivaperuman and Dr. K. Venkataraman for their earnest efforts to bring this volume with treasure of knowledge to public domain.

Ministry of Environment, Forest & Climate Change — Dr. Amita Prasad
Government of India,
New Delhi, India

29th August, 2017

Preface

The tropical forest ecosystems are one of the most diverse and rich in biological diversity on earth. The tropical rainforests of India are found in the Western Ghats, North-eastern India, and Andaman and Nicobar Islands. The forests in India are spread over an area of 6,92,027 km^2, covering 21.05 percent of the geographical area of the country. The location of India is at the confluence of three major bio-geographic realms, namely, the Indo-Malayan, the Eurasian, and the Afro-tropical, enabling it to have an assemblage of diverse elements from all these regions. The country is exceptionally rich in biodiversity and considered as one of the 17 mega-biodiversity countries in the world. Of the 35 biodiversity hotspots identified in the world, India has four biodiversity hotspots, i.e., the Eastern Himalaya, Indo-Burma, Western Ghats & Sri Lanka, and Sundaland with unique assemblage of plant and animal communities. There are 10 bio-geographical zones in India, these are, the Trans-Himalaya, Himalaya, Desert, Semi-Arid, Western Ghats, Deccan Peninsula, Gangetic plain, Coasts, Northeast, and Islands. The varied edaphic, climatic, and topographic conditions and years of geological stability have resulted in a wide range of ecosystems and habitats such as forests, grasslands, wetlands, deserts, and coastal & marine ecosystems.

India occupies about 2.4% of the world's land area, 4 percent of fresh water, and supports about 8 percent of the world's total species. This region is home to a rich endemic assemblage of plants, birds, reptiles, and amphibians, as well as important populations of Asian elephants, Indian tigers, and the endangered lion-tailed macaque. India ranks tenth in the world and fourth in Asia in plant diversity and tenth in the number of endemic species of higher vertebrates in the world. In terms of species richness, India ranks eighth in mammals, ninth in birds, fifth in reptiles, and fifteenth in amphibians. Eleven percent of the world's flora is reported from India.

This volume is a culmination of detailed studies carried out by reputed researchers working in the field of biodiversity conservation. This book contains a collection of different chapters and concerted effort has been made by the professionals in their respective group. This book is divided into two volumes and covers different faunal communities from the Indian biodiversity hotspots, e.g., biodiversity of Indian hotspots; endemic, endangered, and threatened vertebrates; chiropteran fauna; herpetofaunal diversity; group size composition of gaur, grizzled giant squirrel, Nilgiri tahr, elephant from the Western Ghats; freshwater fishes, birds, and mammals of Andaman and Nicobar Islands; Avifauna of North West Himalaya; bat fauna of Northeast and Western Ghats; and golden langur from Northeast.

This book depicts unique information on vertebrate faunal diversity of Indian hotspots. We sincerely hope that this book will be of great help to the researchers and field scientists in the area of biodiversity conservation not only in India as well as neighboring countries.

Port Blair, Andaman & Nicobar Islands, India — Chandrakasan Sivaperuman
Chennai, Tamil Nadu, India — Krishnamoorthy Venkataraman

Acknowledgments

We express our heartfelt gratitude to all those who helped in different ways to complete this work. Our sincere thanks to the officials of the Ministry of Environment, Forest and Climate Change, Government of India, for their support and encouragement. We thank Dr. Kailash Chandra, Director, Zoological Survey of India for his valuable support and providing facilties during the preparation of this book. We also thank all the authors who have contributed the various chapters for this book.

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About the Editors

Dr. Chandrakasan Sivaperuman is currently a Scientist-D at the Zoological Survey of India, Port Blair. He received his master's degree in wildlife biology from Bharathidasan University, Tamil Nadu, and his doctorate degree in ecology of wetland birds in the Vembanad-Kole Ramsar site from the Kerala Forest Research Institute, Kerala, and Forest Research Institute, Deemed University, Dehra Dun. He has been extensively involved in field surveys in different parts of the country. He has published more than 200 research papers in national and international journals and newsletters. He also authored/edited more than 25 books published by reputed national and international publishers. He has participated in 36th Indian Scientific Expedition to Antarctica during 2016–2017 and carried out studies on the species abundance and distribution of birds and mammals in Antarctica. He has participated and presented research papers at 60 national and international seminars and symposia. He is life member of various scientific societies in India and abroad.

Dr. Krishnamoorthy Venkataraman, former Director Zoological Survey of India, is presently working as a senior Scientific Consultant at the National Centre for Sustainable Coastal Management, Anna University, Chennai.

His research areas include coastal and marine biodiversity assessment; coral reef restoration; integrated management of coastal, marine, and wetland ecosystems; and biodiversity laws and policies. He is an expert on strategy formulation, climate change resilience in management of marine ecosystem, meiofaunal assemblage in Antarctic ecosystem, and training and organizing awareness programs on faunal resources conservation. He has 37 years of research experience in faunal diversity studies and has served at Madurai Kamaraj University, Bombay Natural History Society (BNHS), National Biodiversity Authority, Loss of Ecology Authority, and the Zoological Survey of India (ZSI) in various capacities.

He was the Director of the Zoological Survey of India from 2010 to 2015. At BNHS, he worked with internationally renowned Ornithologist, Dr. Salim Ali, in the management of Keoladeo National Park, Bharatpur, Rajasthan. He has contributed over 458 publications in the field of marine, wetland, terrestrial, and freshwater ecosystems, of which 41 have been published as books. He is a member of the editorial board of leading scientific journals in India and has reviewed several articles for internationally respected journals and various Government of India committees. He has participated in over 500 national and 50 international meetings, chairing sessions and panel discussions and delivering lead talks.

He was the founder member secretary of the National Biodiversity Authority of the Ministry of Environment, Forests and Climate Change, Government of India, and coordinated the implementation of the thematic National Biodiversity Strategy Action Plan, and the action plan for biophysical monitoring of coral reefs in Andaman and Nicobar Islands and Gulf of Mannar Biosphere Reserve. His input and involvement in the enactment and implementation of Biological Diversity Act, 2002 and establishment of State Biodiversity Boards are worth mentioning.

He was instrumental in Great Nicobar Biosphere Reserve (GNBR), Andaman and Nicobar Islands, becoming recognized in the UNESCO-MAB World Network of Biosphere Reserves.

1 Hotspots: An Introduction and Role in Conservation

I. Jaisankar, A. Velmurugan, T. P. Swarnam, and A. K. Singh

Abstract

Biodiversity is integral to the direct benefits that humans receive from nature besides ecosystem services. However, human activities and the negative consequences of climate change are accelerating the loss of biodiversity. There are multiple indications of continuing decline in biodiversity in all three of its components – ecosystems, species and genes. In order to receive continuous ecosystem services and protect the species from extinction, 35 global biodiversity hotspots have been identified for conservation. It is nothing but a biogeographic region with significant levels of biodiversity that is threatened with destruction. The tropical island of Andaman and Nicobar is part of the global biodiversity hotspot having a large number of flora and fauna besides exhibiting great endemism. The recent assessment showed that the plant diversity of these islands comprises 3219 species under 1251 genera belonging to angiosperms, gymnosperms, pteridophytes, bryophytes, lichens and algae. Similarly 1463 species of fishes, 600 species of corals, 120 species of sponges, 290 species of butterflies, 300 species of birds and 36 species of mangroves were recorded. They are imperative for the livelihood of local people, a treasure for humankind; therefore, efforts should be made to strengthen the conservation efforts and preservation of threatened floral and faunal diversity of these islands.

Keywords

Biodiversity · Conservation · Biogeographic region · Bay islands · Ecosystem services

I. Jaisankar (✉) · A. Velmurugan · T. P. Swarnam · A. K. Singh
Central Island Agricultural Research Institute,
Port Blair, Andaman and Nicobar Islands, India

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1.1 Introduction

Concern over the loss of biodiversity and the recognition of its important role in supporting human well-being and ecosystem services has received worldwide attention. This resulted in global consensus on the conservation of biodiversity, the sustainable use of its components and the fair and equitable sharing of benefits arising out of the utilization of genetic resources. In general biodiversity or biodiversity is defined as the variety of the planet's living organisms and their interactions. It encompasses all of life's variation, expressed in genes, individuals, populations, species, communities and ecosystems.

Biodiversity is essentially a dynamic entity as the term defines and has changed throughout the history of life on Earth. The mechanisms responsible for biodiversity change are evolutionary processes of speciation and extinction, along with ecological processes over shorter time periods. This has been altered by anthropogenic activities, particularly modern human actions threatening biodiversity on a worldwide scale, over an extremely short geological time period. Such anthropogenic-centric threats to biodiversity are generally taxonomically specific exploitation, introduced species and genetic or behavioural degradation. These threats of biodiversity not only affect directly, but they can interact resulting in extinction of species and in some cases make them highly vulnerable. These threats combine with the community- and ecosystem-level threats of habitat degradation, fragmentation and destruction, pollution and global climate change leading to disruption and alteration of community and ecosystem structure and function.

There are several organizations involved in systematic assessment of current taxonomic extinction risk, most notably the International Union for the Conservation of Nature and Natural Resources (IUCN). Detailed information is available for well-known groups of organisms, including most vertebrates and flowering plants, and to a much lesser extent for invertebrates, other plants and fungi. Since 1600, at least 1.84% of mammals and 1.20% of bird species have become extinct. Present calculations estimate 25% of mammals and 12% of birds at risk of extinction with a probability of at least 10% over the next 100 years (Myers et al. 2000). In summary, species having small range or population sizes are at risk especially species that have become rare due to human activity.

1.2 Rationale for Conservation

Why should the human community be concerned about the loss of biodiversity? Although it had occurred during the evolutionary process, the rate of loss after industrialization is huge. Owing to biodiversity loss, we human beings lose the ultimate source of our crops and the genes we use to improve agricultural resilience, the inspiration for manufactured products and the basis of the structure and function of the ecosystems that support humans and all life on Earth (McNeely et al. 2009). Above and beyond material welfare and livelihoods, biodiversity also contributes to security, resiliency and freedom of choices and actions (Millennium Ecosystem

Assessment 2005). Conservation and protection of entire ecosystem, therefore, is a common concern and shared responsibility of human beings all over the world. Quantitative measures of biodiversity most often focus on a taxonomic unit, typically the species, although aspects of ecological diversity can also be measured. The most threatened areas of high species diversity on Earth have been labeled biodiversity hotspots and include mostly tropical rainforests, coastal areas and islands. For these reasons, these areas should receive high priority on conservation programmes.

In this context, high biodiversity or presence of number of species alone is an inadequate indication of conservation priority because several areas can share the same species. In contrast, areas with high levels of endemism are irreplaceable, particularly in island ecosystems. We must conserve these places because the unique species they contain cannot be saved elsewhere. In many cases, these areas are facing greater risk of disappearing because of human activities of different nature. As species become threatened and vanish, so too do the broader ecosystems and myriad benefits to human well-being that depend upon biodiversity. Bringing an end to global biodiversity loss requires that limited available resources be guided to those regions that need them most. The biodiversity hotspots do this based on the conservation planning principles of irreplaceability and vulnerability.

1.3 Biodiversity Hotspots

Biodiversity hotspots are a method to identify those regions of the world where attention is needed to address biodiversity loss and to guide investments in conservation. The idea was first developed by Norman Myers in 1988 to identify tropical forest 'hotspots' characterized both by exceptional levels of plant endemism and serious habitat loss, which he then expanded to a more global scope. In general hotspots are the richest and most threatened reservoirs of plant and animal life of the earth. Besides this, biodiversity hotspots have maximum number of endemic species.

Based on these logics and global implication of biodiversity loss, Conservation International adopted Myers' hotspots as its institutional blueprint in 1989, and in 1999, the organization undertook an extensive global review which introduced quantitative thresholds for the designation of biodiversity hotspots. According to Conservation International, to qualify as a hotspot, a region must meet two basic criteria. First it must contain at least 1500 species of vascular plants (> 0.5% of the world's total) as endemics, and secondly, it should have lost at least 70% of its original habitat. Biodiversity hotspot areas held as endemics about 44% of the world's plants and 35% of terrestrial vertebrates in an area that formerly covered only 11.8% of the planet's land surface. The habitat extent of this land area had been reduced by 87.8% of its original extent, such that this wealth of biodiversity was restricted to only 1.4% of Earth's land surface (Mittermeier et al. 1999). Biodiversity hotspots are global in extent; however, it is not rigid as new biodiversity hotspots are periodically added and can be included in the future based on scientific assessments of new regions. Changing circumstances such as sustained habitat loss or the discovery of new species may mean that areas previously not considered biodiversity hotspots could qualify in a future reassessment.

1.4 Global Biodiversity Hotspots

As explained in the previous section, large regions of the world containing exceptional concentrations of plant endemism and experiencing high rates of habitat loss have been identified as biodiversity hotspots and are presented in Table 1.1. Currently, 35 biodiversity hotspots have been identified, most of which occur in tropical forests (Fig. 1.1). They represent just 2.3% of Earth's land surface, but between them, they contain around 50% of the world's endemic plant species and 42% of all terrestrial vertebrates. Overall, hotspots have lost around 86% of their original habitat and also it is observed to be significantly threatened by extinctions induced by climate change.

1.4.1 North and Central America

North and Central America play host to thousands of acres of important habitat. These are new world species known after European expansion.

1.4.2 South America

From Brazil's Cerrado to the Tropical Andes, South America has some of the richest and most diverse life on Earth.

1.4.3 Europe and Central Asia

From the Mediterranean Basin to the Mountains of Central Asia, these four hotspots are unique in their diversity.

1.4.4 Africa

This consists of a total of eight hotspots in the African continent which hold a diversity of plant and animal life, many of which are found nowhere else on Earth.

1.4.5 Asia-Pacific

Composed of large land areas as well as islands dotting the Pacific seas, these 14 hotspots represent important biodiversity. The forests of East Australia are the latest hotspot to have been added after research showed that the area fulfilled all criteria.

Table 1.1 Biodiversity hotspots of the world

Region	Hotspots
North and Central America	California Floristic Province
	Caribbean Islands
	Madrean Pine-Oak Woodlands
	Mesoamerica
South America	Atlantic Forest
	Cerrado
	Chilean Winter Rainfall-Valdivian Forests
	Tumbes-Chocó-Magdalena
	Tropical Andes
Europe and Central Asia	Caucasus
	Irano-Anatolian
	Mediterranean Basin
	Mountains of Central Asia
Africa	Cape Floristic Region
	Coastal Forests of Eastern Africa
	Eastern Afromontane
	Guinean Forests of West Africa
	Horn of Africa
	Madagascar and the Indian Ocean Islands
	Maputaland-Pondoland-Albany
	Succulent Karoo
Asia-Pacific	East Melanesian Islands
	Himalayan ranges
	Indo-Burma
	Japan
	Mountains of Southwest China
	New Caledonia
	New Zealand
	Philippines
	Polynesia-Micronesia
	Southwest Australia
	Forests of Eastern Australia (new)
	Sundaland
	Wallacea
	Western Ghats and Sri Lanka

1.5 Hotspots in India

India is a land of varied flora, fauna and biodiversity besides human race and hence recognized as one of the 17 mega diverse nations of the world. Two of India's great mountain ranges, viz. the Eastern Himalayas and the Western Ghats, have been designated among the world's 18 'hotspots' of biodiversity (Table 1.2). Forests in India are thick and wooded with the flora to back up the fabulous fauna which comprises some 15,000 species of plants. Evergreen forests in the north-east and along

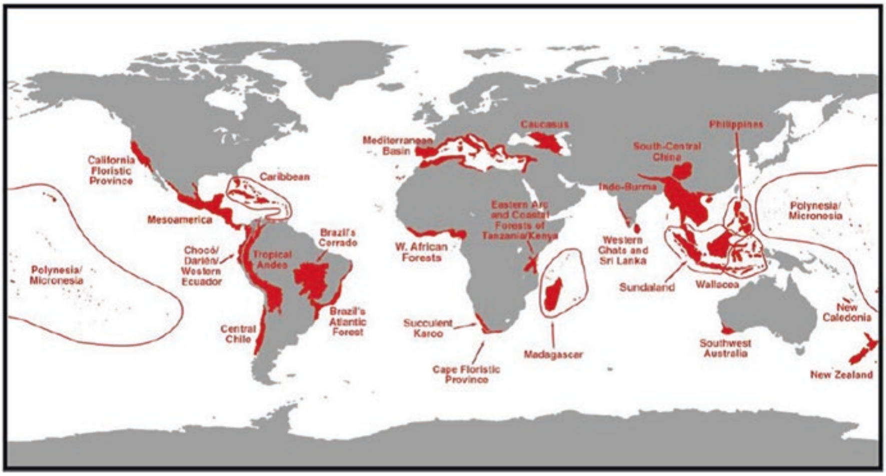

Fig. 1.1 Biodiversity hotspots (Source- www.conservation.org)

Table 1.2 Floral and faunal diversity of India as compared to the global diversity

Group	Number	% of world species
Amphibians	197	4.4
Birds	1224	12.6
Fishes	2546	11.7
Flowering plants	15,000	6.0
Mammals	350	7.6
Reptiles	408	6.2

Data sources: Indira Gandhi Conservation Monitoring Centre (IGCMC), New Delhi and IISc

the Western Ghats, moist and dry deciduous forests of the plains, swampy marshes of Bengal and Madhya Pradesh, pinewoods of the Himalayan foothills and the lagoons and estuaries down south each pave for a different ecosystem, sheltering unique forms of plant and animal life. India is home to several well-known large mammals including the Asian elephant, Bengal tiger, Asiatic lion, leopard and Indian rhinoceros, often ingrained culturally and religiously often being associated with deities. There are four biodiversity hotspots which harbour wide diversity of flora and fauna (Source: www.conservation.org; www.cepf.net). They are as follows:

1.5.1 Himalaya

This is very prominent hotspot and spread across the nations in Asia. It includes the entire Indian Himalayan region, Pakistan, Tibet, Nepal, Bhutan, China and Myanmar. The Eastern Himalayas is the region encompassing Bhutan, north-eastern

India and southern, central and eastern Nepal. The abrupt rise of the Himalayan Mountains from less than 500 m to more than 8000 m results in a diversity of ecosystems that range from alluvial grasslands and subtropical broadleaf forests along the foothills to temperate broadleaf forests in the mid-hills, mixed conifer and conifer forests in the higher hills and alpine meadows above the treeline. The Eastern Himalayan hotspot has nearly 163 globally threatened species (both flora and fauna) including the one-horned rhinoceros [vulnerable] and the wild Asian water buffalo [endangered]. There are an estimated 10,000 species of plants in the Himalayas, of which one-third are endemic and found nowhere else in the world. A few threatened endemic bird species such as the Himalayan quail, cheer pheasant and western tragopan are found here, along with some of Asia's largest and most endangered birds such as the Himalayan vulture and white-bellied heron. Mammals like the golden langur, the Himalayan tahr, the pygmy hog, langurs, Asiatic wild dogs, sloth bears, gaurs, muntjac, sambar, snow leopard, black bear, blue sheep, takin, the Gangetic dolphin, wild water buffalo and swamp deer call the Himalayan ranges their home.

1.5.2 Indo-Burma

The Indo-Burma region lying east of Himalayan hotspot also encompasses several countries of Asia. It includes entire north-eastern India, except Assam and the Andaman group of islands (and Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China). Much of this region has been deteriorating rapidly in the past few decades. This region is home to several primate species such as monkeys, langurs and gibbons with populations numbering only in the hundreds. Many of the species, especially some freshwater turtle species, are endemic. Almost 1300 bird species exist in this region including the threatened white-eared night heron [endangered], the grey-crowned crocias [endangered] and the orange-necked partridge [near threatened]. It is estimated that there are about 13,500 plant species in this hotspot, with over half of them endemic. Ginger, for example, is native to this region.

1.5.3 Sundaland

Sundaland is a region in South East Asia that covers the western part of the Indo-Malayan archipelago. It includes Thailand, Malaysia, Singapore, Brunei and Indonesia. India is represented by the Nicobar Islands. The United Nations declared the islands a world biosphere reserve in 2013. The islands have a rich terrestrial and marine ecosystem that includes mangroves, coral reefs and seagrass beds. The marine biodiversity includes several species such as whales, dolphins, dugongs, turtles, crocodiles, fishes, prawns, lobsters, corals and seashells which exhibit the most spectacular diversity in the world. The primary threat to this biodiversity comes from over-exploitation of marine resources. In addition, the forests on the island also need to be protected.

1.5.4 Western Ghats and Sri Lanka

This includes the entire Western Ghats in India (and Sri Lanka). The Western Ghats, also known as the 'Sahyadri Hills', encompasses the mountain forests in the south-western parts of India and highlands of south-western Sri Lanka. The entire extent of hotspot was originally about 182,500 km^2, but due to tremendous population pressure, now only 12,445 km^2 or 6.8% is in pristine condition. The wide variation of rainfall patterns in the Western Ghats, coupled with the region's complex geography, produces a great variety of vegetation types. These include scrub forests in the lowly ingrained shadow areas and the plains, deciduous and tropical rainforests up to about 1500 m and a unique mosaic of montane forests and rolling grasslands above 1500 m. In Sri Lanka, diversity ranges from dry evergreen forests to *Dipterocarpus* dominated rainforests to tropical montane cloud forests. The important populations include Asian elephant, Nilgiri tahr, Indian tigers, lion-tailed macaque [all endangered], Indian giant squirrel [least concern], etc.

1.6 Biodiversity Hotspot: A Case Example of the Andaman and Nicobar Islands

1.6.1 Physical Setting

The Andaman and Nicobar Islands, India, an archipelago of over 572 islands, islets and rocky outcrops lie as a long and broken chain in the Bay of Bengal between 6′ and 14′ north latitude and 92′ and 94′ east longitude (Fig 1.2). Stretched over an area of more than 700 km north to south with the total geographical area of 8249 km^2, these undulating islands are covered with dense forests and endless variety of indigenous and exotic flora and fauna. The island has elevations of continuous submerged ridges, which extend almost unto Australia. On the eastern side of the ridge lie Sumatra, Java, Bali and other islands of Indonesia. The Andaman group of islands is separated from Nicobar group by the Ten Degree Channel. Ranges of low hills running north–south and enclosing valleys are the characteristic topographic feature of the Andaman Islands, while the Nicobar group is generally flat except Great Nicobar and the Nancowry group, which are hilly. The soil of the Nancowry group is porous coral sand, which quickly absorbs the rainwater, leaving hardly any stagnation. The island receives more than 3100 mm of total annual rainfall, and the relative humidity ranges from 75% to 95% depending on the season. Favourable climate and soils besides very limited human intervention paved the way for the rich and diverse flora and fauna of these islands as it is seen today.

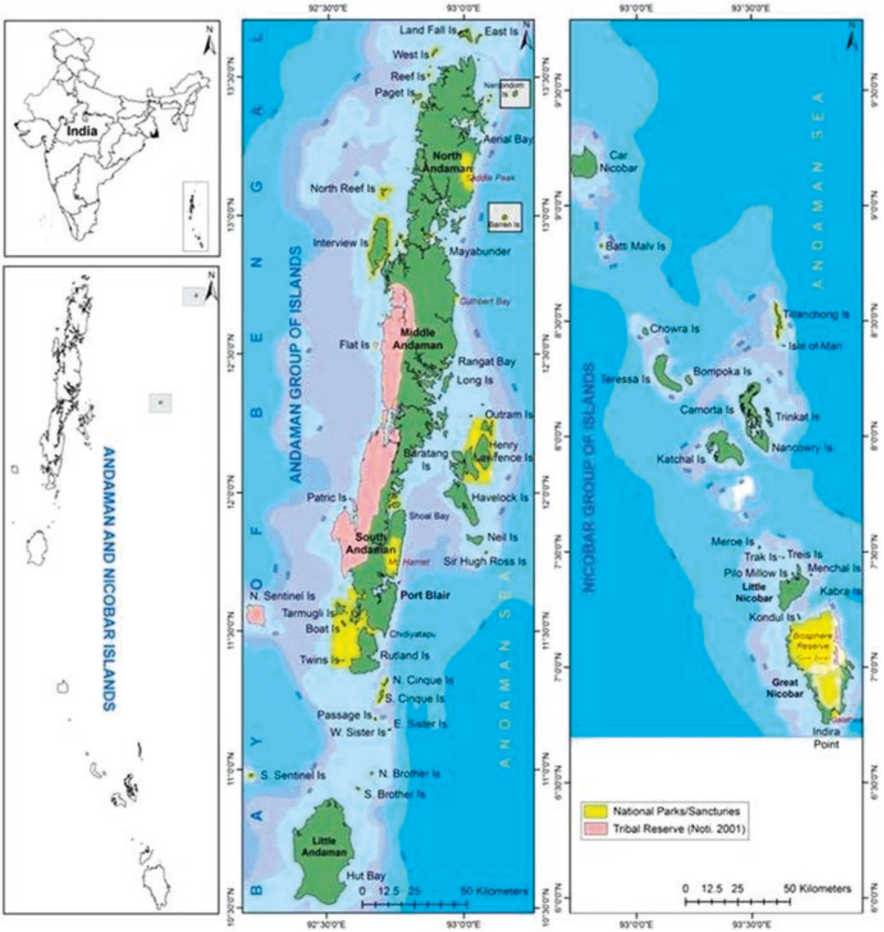

Fig. 1.2 Location of the Andaman and Nicobar Islands

1.6.2 Diversity of Aboriginals

There are six aboriginal groups, viz. the Great Andamanese, Onges, Jarawas, Sentinelese, Nicobarese and Shompens, of which the first four are Negrito hunter-gatherers inhabiting some of the Andaman Islands while the last two are of Mongoloid race and live in the Nicobar Islands. These aboriginal people widely use plants in day-to-day sustenance and some endemic flora for medicinal purposes. The earliest record of flora of this biodiversity-rich island is found in 'Report on the vegetation of the Andaman Islands' (Kurz 1870) in which the various vegetation types, influence of the season upon the vegetation and peculiarities of flora of the Andaman Islands are outlined.

1.6.3 Vegetation Diversity

The flora of Nicobar Islands is closely allied to that of Sumatra and Malaysia as in the case of its geographical relations. Tropical broad-leaved evergreen forests are prominent here. Agricultural activities have pressured these forests to a limited extent. According to Champion and Seth (1968), the vegetation of these islands is broadly classified into (i) beach forests, (ii) mangrove forests, (iii) wet evergreen forests, (iv) semi-evergreen forests, (v) moist deciduous forests and (vi) grasslands (Table 1.3). Pandey and Diwakar (2008) published an integrated check-list for the flora of the Andaman and Nicobar Islands, which reports 2654 plant taxa, including 228 intraspecific taxa under 1083 genera in 237 families belonging to 4 different plant groups, viz. bryophytes, pteridophytes, gymnosperms and angiosperms:

- An updated data on the flora revealed that the island harbours a total of 2662 plant taxa, comprising 2519 species, 33 subspecies, 104 varieties and 6 forma under 1110 genera in 238 families belonging to bryophytes, pteridophytes, gymnosperms and angiosperms (Murugan and Kamble 2012).
- Bryophytes are represented by 58 species and 3 varieties, under 32 genera and 16 families (Lal 2005). Pteridophytes are consisting of 129 species, 1 subspecies and 9 varieties under 62 genera belonging to 38 families (Dixit and Sinha 2001).
- Gymnosperms are represented by 7 species and 2 varieties under 4 genera and 3 families. Besides, the islands also harbour 383 species of lichens under 84 genera and 30 families.
- Angiosperms are the predominant plant group in the Andaman and Nicobar Islands. They are represented by 2314 species, 31 subspecies, 89 varieties and 6 forma under 1011 genera in 181 families, constituting 92% of entire flora of the Andaman and Nicobar Islands.
- Only 3 genera, viz. Nicobariodendron, Pseudodiplospora and Sphyranthera, and about 315 species belonging to 187 genera and 74 families are endemic to the union territory, constituting about 10% of the flora (Singh et al. 2014).
- Algae are represented by 182 species belonging to 84 genera in 32 families.

The details of dominant plant species belonging to different forest types and its distribution are given in Table 1.3. Each forest type has different layers, and in each layer, very specific and well-adapted plant species are found in which most of them are endemic to these islands.

Flora of the Andaman group shows relevant difference from that of the Nicobar region. The *Pterocarpus* and *Dipterocarpus* sp. found as dominant species in the Andaman Islands are not encountered in the Nicobar Islands. *Cyrtandra* and *Stemonurus* belonging to family Icacinaceae, *Spathoglottis* of Orchidaceae and many other endemic species occur only in the Nicobar Islands. Another important aspect of Andaman vegetation reveals that around 11% of the total geographical area of the island is covered with mangroves. The islands contribute nearly 0.25% of the total eco-rich area of the Indian subcontinent. A total of 105 national parks and wildlife sanctuaries cover 18.54% of the total protected area network in the country (Anon 2015). The South Andaman forests have a profuse growth of epiphytic

Table 1.3 Forest types and dominant tree species of the Andaman and Nicobar Islands

Forest type	Distribution	Dominant trees
Andaman giant evergreen forests	Present in small areas near the banks of the larger streams, where soils are deep alluvium	*Dipterocarpus alatus*, *Artocarpus chaplasha L.*, *Artocarpus gomeziana*, *Dipterocarpus gracilis*, *Calophyllum soulattri*, *Sideroxylon longipetiolatum*, *Amoora wallichii*, *Pterocymbium tinctorium*
		In the lower storey can be found *Pometia pirulata*, *Mesua ferrea*, etc. Climbers present are *Dinochloa andamanica*, *Gnetum scandens* and a variety of canes
Andaman tropical evergreen forests	Throughout the Andaman Islands typically as caps to the hills with moist deciduous forests on the slopes. Locality factors: rainfall of over 3000 mm, well distributed and sufficiently retentive deep soil with good internal drainage	*Dipterocarpus grandiflorus*; *D. pilosus*; *Artocarpus chaplasha*; *A. gomeziana*; *Calophyllum soulattri*; *Planchonia andamanica*; *Hopea odorata*; *Endospermum chinense*; *Sideroxylon longipetiolatum*; *Xanthochymus andamanicum*; *Myristica andamanica*; *M. glaucescens*; *Baccaurea sapida*; *Croton argyratus*; *Pterospermum aceroides*; *Anaxagorea luzeniensis*, etc.; *Dinochloa andamanica*; *Calamus palustris*; *Gnetum scandens*; *Ancistrocladus extensus*
Southern hilltop tropical evergreen forests	A more or less inferior addition of the tropical wet evergreen, not more than 10 m high in extreme cases Distribution on the upper slopes and tops of hills and sometimes on steep slopes lower down	*Dipterocarpus costatus*, *Mesua ferrea*, *Canarium manii*, *Harpullia cupanioides*, *Hopea andamanica*, *Cratoxylum formosum*, *Euphorbia trigona* and *Euphorbia epiphylloides. Memecylon caeruleum*, *Cryptocarya ferrarsi* and some small bamboo and Phoenix species
Andaman semi-evergreen forest	The chief characteristic is the immature alluvial soil sufficiently old and raised above flood level to be able to progress to the climatic climax, but with a good subsoil water supply and well-drained soil	**I Storey** *Dipterocarpus alatus*, *D. pilosus*, *Pterygota alata*, *Pterocymbium tinctorium*, *Sterculia campanulata*, *Tenninalia bialata*, *Tenninalia procera*, *Albizia chinensis*, *A. lebbeck*, *Calophyllum soulattri*, *Salmalia insignis*, *Artocarpus lakoocha*, *A. chaplasha*, *Pterocarpus dalbergioides*
		II Storey *Lagerstroemia hypoleuca*, *Dillenia pentagyna*, *Dracontomelum mangiferae. Pometia pinnata*, *Myristica* spp., *Pisorua excelsa*, *Litsea panamonja*, *Xanthophyllum andamanicum*
		II.a Storey Usually no bamboos, *Oxytenanthera* spp.
		III Storey *Saprosma tematum*, *Moosa andamaruca*, *Micromelum pubescens*, *Clerodendrum viscosum*, *Leea indica*, *Clinogyne grandis*

(continued)

Table 1.3 (continued)

Forest type	Distribution	Dominant trees
Andaman moist deciduous forests	The underlying rock is chiefly rather hard coarse-grained sandstone with bands of shale and conglomerate, and the soil, which is often shallow, is a sandy or clayey loam of light yellow colour	**I Storey** *Pterocarpus dalbergioides*, *Terminalia bialata*, *T. manii*, *T. procera*, *Canarium euphyllurn*, *Pterocymbium tinctorium*, *Tetrameles nudiflora*, *Chukrasia tabularis*, *Albizia lebbeck*, *Lagerstroemia hypoleuca*
		II Storey *Lannea coromandelica*, *Adenanthera pavonina*, *Dillenia pentagyna*, *Diospyros marmorata*, *Saccopetalum tinctorium, Sageraea elliptica*, *Cratoxylon formosum*, *Semecarpus kurzii*, *Cinnamomum* spp., *Pterospermum aceroides*
		III Storey *Oxytenanthera nigrociliata*, *Rambusaschizo stachyoides*, *Pleiopermium alaturn*, *Ganthium gracilipes*, *Ixora grandifolia*
		IV Storey
		Byttneria andamanensis
		V Storey *Delima sarmentosa*, *Acacia pennata*, *Entada phaseoloides, Calamus species*
Littoral forests – beach and dune forest	All round the coast wherever a fair width of sandy beach occurs	**I Storey** *Manilkara littoralis*
		II Storey *Pongamia pinnata*, *Morinda citrifolia*, *Erythrina variegata* var. *orientalis*, *Calophyllum inophyllum*, *Terminalia catappa*, *Barringtonia asiatica*, *Cordia subcordata*
		III Storey *Thespesia populnea*, *Hibiscus tiliaceus*, *Pandanus tectorius*
		IV Storey *Ipomoea pes-caprae*, *Crinum asiaticum*, *Vigna retusa*, *Scaevola frutescens*
		V Storey *Mucuna gigantea*, *Colubrina asiatica*, *Caesalpinia bonducella*
Mangrove forest (tidal swamp forest)	Typically a closed evergreen forest of moderate height, composed of trees specially adapted to survive on tidal mud which is permanently wet with saltwater and submerged during every tide. Stilt roots are very typical (notably in *Rhizophora*), so also are leathery entire leaves and vivipary. In the river deltas along the edge of the waterways and sheltered muddy coasts	*Rhizophora amucronata*, *R. candelaria* (outer edge), *Bruguiera conjugata*, *B. parviflora* (just behind), *Avicennia officinalis*, *Ceriops tagal*, *Kandelia candel*, *Xylocarpus moluccensis*, *Sonneratia caseolaris*, *Excoecaria*, etc.

vegetation, mostly ferns and orchids due to favourable climatic and edaphic conditions. The Middle Andaman mostly harbours moist deciduous forests and diverse mangrove patches. North Andaman is characterized by the wet evergreen type, with plenty of woody climbers. In contrast, deciduous forests common in the Andaman Islands show rare occurrence in the Nicobar Islands. The central and southern islands of the Nicobar group have evergreen forest as the dominant vegetation type.

1.6.4 Faunal and Marine Biodiversity

From the Andaman and Nicobar Islands, 1463 species of fishes, 300 species of corals, 120 species of sponges, 215 species of butterflies, 68 species of birds and 34 species of mangroves are documented (Raghunathan 2015) (Table 1.4).

Table 1.4 Faunal and marine biodiversity of the Andaman and Nicobar Islands

SI. No.	Faunal group	World	India	A N Islands	Endemic	% of endemic
1.	Sponges	5100	519	112	5	7.14
2.	Helminthes (marine flatworm)	400	19	19	–	
3.	Corals	700	600	600	–	–
4.	Earthworms	4000	585	21	7	33.33
5.	Leeches	500	59	10	–	–
6.	Polychaetes	8000	428	186	–	–
7.	Arachnids	120	21	14	–	–
8.	Gastrotricha	2500	88	32	6	18.75
9.	Chinorincha	100	10	4	2	50.00
10.	Crustaceans	24,375	2970	607	56	9.22
11.	Spiders and scorpions	35,810	1352	113	28	45.16
12.	Centipedes	3000	100	17	–	–
13.	Millipedes	7500	162	5	–	–
14.	Insects	86,7391	59,353	2274	485	21.5
15.	Molluscs	–	–	–	–	–
	Land	15,000	950	110	75	68.18
	Freshwater	8765	284	51	12	23.52
	Marine	56,235	32,751	1422	2	0.2
	Opisthobranchia	6500	180	180	–	–
16.	Siphonculates	202	38	25	–	–
17.	Echinoderms	6226	765	430	2	0.59
18.	Fishes	21,723	2546	1484	2	0.14
19.	Amphibians	550	219	23	3	16.66
20.	Reptiles	5817	456	104	23	25.55
21.	Aves	9026	1232	284	105	36.97
22.	Mammals	4629	390	62	33	55.00
		11,04,169	1,06,115	8425	6	–

Sivaperuman and Raghunathan (2012)

1.6.5 Birds

The Andaman and Nicobar Islands are one of the Endemic Bird Areas of the world (Stattersfield et al. 1998) due to their high endemism (Rasmussen and Anderton 2012), which could be attributed to their geographical isolation from mainland India (Das 1999; Andrews 2001). A total of 293 species of birds have been reported so far from these islands (Sivaperuman and Raghunathan 2012), of which 158 are identified as wetland-associated birds (Table 1.5).

1.6.6 Butterfly Diversity

These islands have a rich diversity of butterflies. Zoogeographically, the butterfly fauna of the islands can be classified into six major groups, (1) wide-ranging fauna, (2) similar to Myanmar fauna, (3) similar to Malayan fauna, (4) fauna common to the Andamans and Nicobar Islands, (5) endemic to the Andaman Islands and (6) endemic to the Nicobar Islands. Wide-ranging taxa showing affinities with Indian

Table 1.5 Birds of the Andaman and Nicobar Islands

S.No.	Common name	Scientific name	Distribution
1.	Andaman teal	*Anas albogularis*	Andaman Islands
2.	Andaman crake	Rallina canningi	Andaman Islands
3.	Andaman wood pigeon	*Columbo palumboid*es	Andaman Islands
4.	Andaman cuckoo-dove	*Macropygia rufipennis*	Andaman Islands
5.	Andaman barn owl	*Tyto deroepstorffi*	Andaman Islands
6.	Andaman hawk-owl	*Ninox affinis*	Andaman Islands
7.	Hume's hawk-owl	*Ninox obscura*	Andaman Islands
8.	Andaman scops owl	*Otus balli*	Andaman Islands
9.	Andaman nightjar	*Caprimulgus andamanicus*	Andaman Islands
10.	Narcondam hornbill	*Aceros narcondami*	Andaman Islands
11.	Andaman woodpecker	*Dryocopus hodgei*	Andaman Islands
12.	Andaman cuckooshrike	*Coracina dobsoni*	Andaman Islands
13.	Andaman bulbul	*Pycnonotus fuscoflavescens*	Andaman Islands
14.	Andaman shama	*Copsychus albiventris*	Andaman Islands
15.	Andaman flowerpecker	*Dicaeum virescens*	Andaman Islands
16.	Andaman white-headed starling	*Slurnia erythropygia*	Andaman Islands
17.	Andaman treepie	*Dendrocitta bayleii*	Andaman Islands
18.	Nicobar sparrowhawk	*Accipiter butleri*	Nicobar Islands
19.	Great Nicobar serpent eagle	*Spilornis klossi*	Nicobar Islands
20.	Nicobar megapode	*Megapodius nicobariensis*	Nicobar Islands
21.	Nicobar imperial pigeon	*Ducula nicobarica*	Nicobar Islands
22.	Nicobar parakeet	*Psittacula caniceps*	Nicobar Islands
23.	Nicobar scops owl	*Otus alius*	Nicobar Islands
24.	Nicobar bulbul	*Hypsipetes nicobariensis*	Nicobar Islands
25.	Nicobar jungle-flycatcher	*Rhinomyias nicobaricus*	Nicobar Islands

Table 1.6 Endemic subspecies of the Andaman and Nicobar Islands

Family	Subfamily	Andaman	Nicobar
Papilionidae	Papilioninae	12	9
Pieridae	Pierinae	10	11
Lycaenidae	–	58	34
Riodinidae	–	1	–
Nymphalidae	Nymphalinae	34	19
	Danainae	8	17
	Amathusiinae	2	–
	Satyrinae	7	6
Hesperiidae	–	38	13
Total	–	170	109

mainland elements form 10% of the total fauna and are rare in these islands. Half the taxa are endemic to these islands (Table 1.2) and 20% of the species are common to both groups of islands (Khatri 1993). The remaining taxa show similarities with Myanmar and Malayan elements (Table 1.6).

1.6.7 Important Indigenous Livestock Germplasm

Main livestock in these islands are cattle, buffalo, goat, pig, poultry, a few horses and rabbits also. Cattle (28.93% of total livestock) are mainly Desi, crossbred and Trinket cattle (feral); the buffaloes (5.04% of total livestock) are mostly Desi. Goat constitutes 39.74% of total livestock and mostly owned by settlers and Nicobari tribes. The indigenous ones are the Teressa goat and the Barren Island goat. Pig constitutes 23.02% of total livestock and is mostly owned by tribes and settlers. Indigenous ones are mainly the Nicobari pig, Andaman wild pig and Desi pig. Poultry (88.28% of total livestock including poultry) comprises of Nicobari fowl, naked neck, frizzled fowl and barred Desi. Out of 37 islands, 12 islands have no livestock and another 4 islands have a population less than 200 in number. Livestock is almost exclusively comprised of indigenous varieties (Desi), i.e. non-descript, which are about 80% with very few improved varieties (19th Livestock census-2012).

1.7 Endemism

The island biodiversity has huge endemism which is depicted in Fig. 1.3. Out of 8425 species of fauna, 8464 species are endemic and more than 60% of biodiversity have been reported from marine habitat. The main terrestrial mammals are the long-tailed macaque, wild boar, civets and several species of bats, rats and shrews. From the faunistic point of view, the most interesting feature is the absence of large mammals and the presence of a considerable number of endemics among the inland

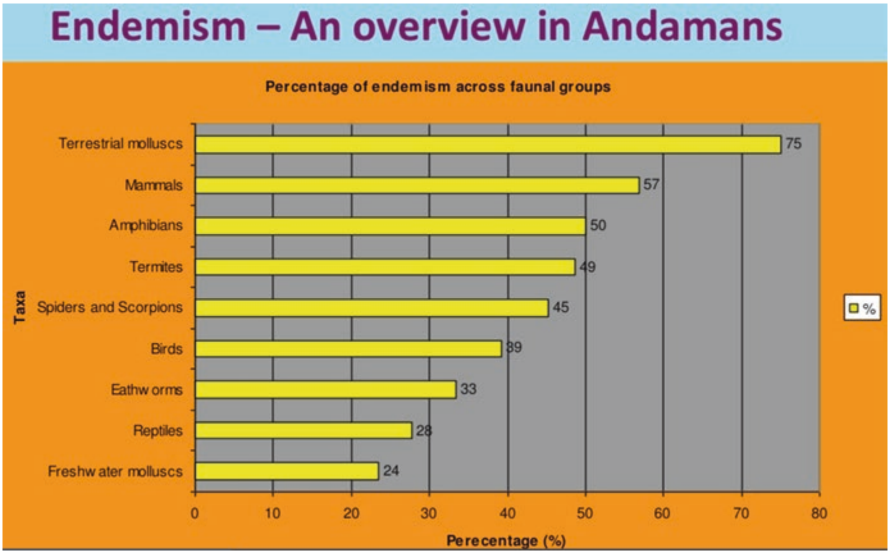

Fig. 1.3 An overview of endemism found in the Andaman Islands

vertebrates (Ellis et al. 2000). *Sphyranthera* sp. belonging to the family Euphorbiaceae and *Pubistylis* sp. belonging to the family Rubiaceae show genetic-level endemism. The Andaman Islands have five mammal species that are strictly endemic to the ecoregion (*Crocidura andamanensis*, *Crocidura jenkinsi*, *Rhinolophus cognatus*, *Rattus stoicus* and *Crocidura hispida*). All five species listed are threatened (categories vulnerable and above) (IUCN 2001).

1.8 The Great Nicobar Biosphere Reserve

Great Nicobar is the largest of the Nicobar Islands in the Indian Union Territory of Andaman and Nicobar Islands which covers an area of 1045 km^2 (Fig. 1.4). It lies about 482 km south of Port Blair and about 145 km north of Sumatra. The island lies in a phytogeographically strategic location, being in the low-latitude region, and experiences tropical climate with mean annual temperature of 22–32 °C, relative humidity of 82% and rainfall of 300–380 cm. The island has several rivers, including the Alexandra, Amrit Kaur, Dogmar and Galathea. Virtually all rivers flow in a southern or south-westerly direction, which is indicative of the general slope of the terrain across the island. The island harbours rich germplasm resources due to which the government of India declared 85% of the island as a biosphere reserve in 1989. In the year 2013, it was included in the list of Man and Biosphere programme of UNESCO to promote sustainable development based on local community effort and sound science.

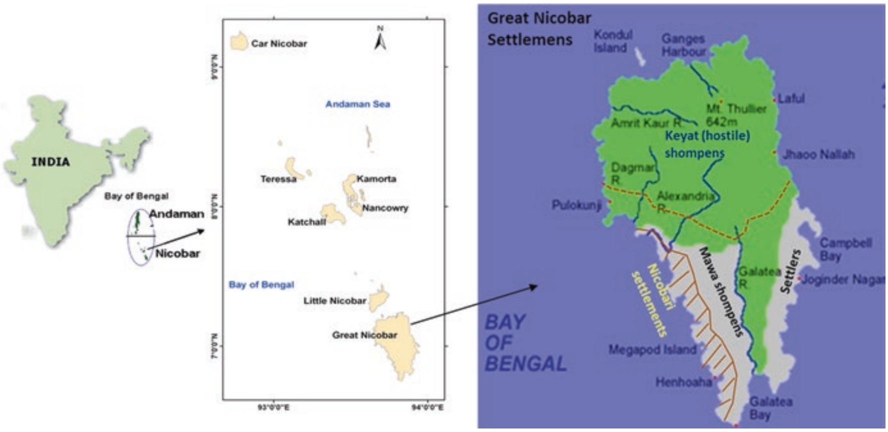

Fig. 1.4 Location of the Great Nicobar biosphere reserve a part of the A&N Hotspot

The Great Nicobar biosphere reserve contains a diverse amount of life that is very important to the biodiversity of the region. Great Nicobar is also home to the natives, the Shompens. These natives were thought to have migrated from the Malaysian regions and occupied the area for over 2000 years. They are divided up into two groups. One group of Shompens inhabits the coastal regions of the island, while the other lives mainly in the interior area of the island. The Shompens survive by hunting and gathering food sources from the forest and often fish in the coastal waters. The Shompens know a lot of information about the island that help them to survive.

The flora on Great Nicobar Island is very diverse. Orchids, which are flowering plants, contribute to the great biodiversity on Great Nicobar. They thrive well on the island because of the tropical climate. The island is known to harbour 27 genera, 32 species and 4 varieties of important orchids. The moist weather produces great habitat for the species to grow and reproduce, which is why there are so many found throughout the biosphere reserve. The island has over 32 species of orchids, four of which are considered rare and endemic. For example, *Eria bractescens* and *Phalaenopsis speciosa* are two orchids that are considered rare and found only in that region (Gupta et al. 2004). The marine life surrounding Great Nicobar also contributes to the diversity of the flora on the biosphere reserve. There are many different species of algae, seagrass and mangroves that inhabit the coastlines. The substrate and water temperature contribute to the growth of these marine flora. Common algae species found off the coast are *Turbinaria* ornata, *Halimeda* and *Cladophora* species (Jagtap 1992). The island does consist of a more diverse amount of flora that includes trees, flowers and plants. The flora on Great Nicobar contributes to a large percent of biodiversity on the island.

The Great Nicobar biosphere reserve is home to different kinds of animals. Most of these animals are native to the island, while others are more common animals. The Nicobar tree shrew is endemic to India. It lives in subtropical or tropical dry forests and is threatened by habitat loss. Great Nicobar is also home to other endemic mammals like the Andaman wild pig and other mammals like the crab-eating macaque, the palm civet, fruit bats, squirrels, rats, blue whales and dugongs. Many birds live on the island as well. The Nicobar megapode, or Nicobar scrub fowl, is a bird found in some of the Nicobar Islands. Another bird endemic to India is the South Nicobar serpent eagle, a bird of prey. They live in subtropical or tropical moist lowland forests. They are becoming rare due to habitat loss. Nicobar parakeets are parrots confined to the Nicobar Islands. They are the largest of the 'true parakeets' at 60 cm. Very little is known about the ecology and conservation status of the Nicobar parakeet. Great Nicobar is also home to other birds like the white-bellied sea eagle, common parakeets, green imperial pigeons, the swiftlet, the myna, the jungle fowl, common parrots, the racket-tailed drongo and the koel. Different species of reptiles and crustaceans live in Great Nicobar as well. Saltwater crocodiles, giant leatherback turtles, Malayan box turtles, reticulated pythons and water monitor lizards are the kinds of reptiles one could find in Great Nicobar. Great Nicobar is also known as home to the giant robber crabs.

1.9 Biodiversity Conservation

In spite of its importance and awareness on biodiversity, the last few decades have witnessed a steady increase in the extinction rate of flora and fauna all over world. Therefore, conservation of biodiversity and its habitats is of utmost importance for the survival of man. Conservation of biodiversity leads to conservation of essential ecological diversity to preserve the continuity of food chains. At the same time, the genetic diversity of plants and animals is preserved. It ensures the sustainable utilization of life support systems on Earth. It provides a vast knowledge of potential use to the scientific community. A reservoir of wild animals and plants is preserved, thus enabling them to be introduced, if need be, in the surrounding areas. Biodiversity provides immediate benefits to the society such as recreation and tourism; besides, it serves as an insurance policy for the future.

1.9.1 Threats to Biodiversity

Biodiversity in India and in the tropical islands, viz. forests, grasslands, wetlands, mountains, deserts and marine ecosystems, is threatened by different anthropogenic activities apart from climate change impact. One of the major causes for the loss of biodiversity has been the depletion of vegetative cover in order to expand agriculture. Since most of the biodiversity-rich forests also contain the maximum mineral wealth and also the best sites for water impoundment, mining and development projects in such areas have often led to destruction of habitats. Poaching and illegal trade of wildlife products too have adversely affected biodiversity. Some of the major threats to biodiversity which are managed under the biodiversity hotspots are:

- Habitat destruction: Huge pressure from the world's rapidly increasing population put pressure on the wild habitat. Therefore, it is important to protect habitat in order to protect biodiversity within it.
- Global climate change: Change in the physical condition affects the biotic elements of ecosystems resulting in consequential biotic change. These are addressed in the biodiversity hotspots.
- Habitat fragmentation: This results from human activity which reduces the ability of habitat to support species.
- Pollution: Introduction of pollutants such as nutrient overloading with nitrate fertilizer as well as more immediately harmful chemicals affects the biodiversity.
- Over-exploitation: This includes the illegal wildlife trade, as well as overfishing, logging of tropical hardwood, etc. These ecosystem-destructive activities are effectively addressed in the hotspots.
- Pest and disease: Reduction in habitat causing high population densities encourages occurrence and spread of diseases.

1.9.2 Conservation in the Andaman and Nicobar Islands

The present-day drastic changes in the environment and habitat due to population explosion and unmanaged developmental activities are so unnatural that the species are not getting full liberty of time and space for their survival and adaptive radiation, therefore resulting in loss of biodiversity, which is a global crisis. It is high time that our natural wealth be preserved from loss. In this context, hotspots are not formally recognized or governed areas. However, the identification of an area as a biodiversity hotspot increases the likelihood of conservation investment. In addition, other designations for biodiversity conservation are likely to be present within these broad areas which may have more formal management structures.

The Andaman and Nicobar Islands have species assemblages not found elsewhere in India, and they are thus very important for conservation. For fulfilling conservation processes 6 national parks and 94 wildlife sanctuaries covering 708 km^2. have already been created in the islands. Of the existing protected area system, 500 km^2. is terrestrial representing 6% of islands combined area of 8327 km^2. These areas help to conserve the food resources of tribes and provide them medicine and habitat. In addition they possess most valuable genetic resources which are highly valued in the changing climate regime. It also provides several ecosystem services, particularly carbon sequestration and climate change mitigation.

1.9.3 The Strategy

The future strategies for the conservation of biodiversity and sustainable development must be adopted as follows:

- Fundamental shift in development planning
- Empower local community to participate in decisions regarding the use of natural resources. This must be based on the twin principles of sustainability and equality
- Proper forest management based on sound environmental principles
- Environment-friendly agricultural strategies
- Strict legal sanctions for preventing loss of biodiversity, habitat protection and control of excessive exploitation of biological resources
- Creation of awareness among islanders of the hazards of biodiversity loss
- Human resource development

The proper adaptation of above-mentioned strategies can not only help in biodiversity conservation but also play a very important role in the development of natural resources on the line of sustainable development.

1.10 Conclusion

The world has been witnessing biodiversity loss at an alarming rate which causes most serious concern. Biodiversity provides unmatched ecosystem services, and its economic value is enormous. It is the most fundamental element of green economic development and sustains humanity. On the other hand, the study of species distribution and its concentration across the globe shows that biodiversity is not evenly distributed on our planet. It is heavily concentrated in certain areas which have exceptionally high concentrations of endemic species. On the other hand, many of these areas are the areas at greatest risk because of biodiversity loss at alarming rates. Threats to terrestrial and aquatic biodiversity are diverse and persistent, and in some cases, it has been increasing. The biodiversity hotspots, for example, are a set of 35 regions of high endemism that collectively has lost more than 85% its original habitat extent. Bringing an end to global biodiversity loss requires that limited available resources be guided to conservation and green economic development in those regions that need it most.

Andaman and Nicobar Islands are hotspot of biodiversity both terrestrial and aquatic, which is a part of global biodiversity hotspots. In an attempt to conserve its formerly rich fauna, the government of India passed the Wildlife Protection Act of 1972, published Schedule I and II of endangered species and imposed a total ban on international trade in several flora and fauna. Great Nicobar biosphere reserve was established so as to conserve biodiversity while promoting environmentally sound development around these areas. It is also utmost essential to respect, preserve and maintain traditional knowledge of the sustainable use of biodiversity with the involvement of indigenous peoples and local communities. Apart from functioning as gene pools, the diverse biota from such hotspot areas can play an important role as indicators of complex environmental changes.

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2 Notes on Snakes of the Genus *Bungarus* (Serpentes: Elapidae) from Northeast India

Abhijit Das

Abstract

In this chapter, taxonomy, natural history and distribution of the snakes of the genus *Bungarus* from Northeast India are described in detail.

Keywords

Distribution · Snake · India · Northeast India

2.1 Introduction

Northeastern India comprises the states of Arunachal Pradesh, Assam, Meghalaya, Nagaland, Manipur, Mizoram, and Tripura. The region extends from 88°–97° E and 22°–29° 30′ N with a geographical area of about 255,083 km^2. The area includes the Himalayan and Indo-Burma biodiversity hotspots (Mittermeier et al. 2004). It can be broadly differentiated into the Eastern Himalayas to the north, the Northeast Hills (Meghalaya) and Mizoram-Manipur-Kachin forest zones to the south, and the Brahmaputra plains, with the Brahmaputra valley forest zone in between (Mani 1974, Olson and Dinerstein 2002). Northeastern India has a relatively complex biogeography due to a combination of factors, including its age, unique plate tectonics, paleoclimatic history, location at the confluence of distinct realms (Afrotropic, Palearctic, and Indo-Malay), wide physiognomic range (e.g., altitude ranging from about 20 m to >6000 m above sea level), and habitat diversity from tropical to alpine (Champion and Seth 1968; Olson and Dinerstein 2002). Distribution data across multiple plant and animal groups indicate that the region's biological affinities are closest to Southeast Asia (Mani 1974).

A. Das (✉)
Wildlife Institute of India, Chandrabani Dehradun, Uttarakhand, India
e-mail: abhijit@wii.gov.in

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The ophidian fauna of northeastern India are still poorly known. This is evident from the fact that many new species and range records were often reported from this region (Slowinski et al. 2001; David et al. 2001, Das and Ahmed 2007). To date, 102 species of snakes were reported in northeastern India, including four species of Krait belonging to genus *Bungarus* (*Bungarus fasciatus, Bungarus niger, Bungarus lividus, and Bungarus bungaroides*) in this region (Ahmed et al. 2009). The information in this chapter is based on original field observations, museum specimens, and data gathered from the literature (Smith 1943, Das 2002, Das et al. 2009).

2.2 Methods

The survey was carried out in the following habitat types: tropical evergreen forests (hill slopes, lowlands), grasslands, caves, grassy swamps and ponds, manmade structures (roads, culverts, huts, and buildings), plantations (teak, tea, beetle-vine, agricultural field, jhum cultivation areas, and mixed type). Road kill and animals caught or killed by local residents are included as opportunistic observations. Snakes were handled using snake hook. Each encountered sighting was photographed.

I collected taxonomic data from museum specimens, college or university collections, or personnel collections of other herpetologists in the region. Data collected and recorded in a field data sheet included locality, date, time, weather condition, habitat, microhabitat, gender of each individual (when possible), reproductive condition of each individual (if it could be determined), co-existing species (if any), and behavioral notes.

Measurements were taken with the help of a digital Mitutoyo dial caliper (to the nearest 0.01 mm) and a meter tape. Dorsal scale rows were counted at one head-length behind the head, at mid-body, and at one head-length anterior to the anal scute. The mid-body scale count was taken as half of the total number of ventral scales. Ventrals were counted according to Dowling (1951). For terminology in hemipenis descriptions, I followed Keogh (1999) and Zaher (1999).

2.2.1 Morphometric Characteristics

Snout to vent length (snout-vent-length): from the tip of the snout till the posterior end of the anal plate and tail length: from the posterior end of anal plate to the tail tip; head length: from the joint of upper and lower jaw to the snout tip; head width: at the joint of the upper and lower jaw; head depth: at angle of jaw; horizontal eye diameter; eye to nostril: from the anterior tip of the eye to the posterior edge of nostril opening; eye to snout: from the anterior side of eye to the tip of the snout; nostril to snout: from the anterior end of nostril to the tip of the snout; median inter-orbital distance: the distance across the eyes at the mid-horizontal line.

The measurements were taken in the manner of maximum height × maximum width for parietal and frontal. For frontal, the height was compared with the distance from the anterior end of the frontal with the tip of snout; in the case of rostral, the width at the base and width at the tip were noted. The number of dorsal scale rows is given at one head length behind the head, at mid-body (i.e. at the level of the ventral plate corresponding to half of the total ventral number), and at one head length before the vent, respectively. The terminal scute was not included in the number of subcaudals.

The geographic coordinates of each survey site and species locality were determined in the field with the help of a Garmin GPS 12 channel receiver. Coordinates were recorded as latitude and longitude in decimal degrees. The geo-coordinates of some old literature records were either collected personally or were derived from a digitized toposheet map of Northeast India (Table 2.1). The locations were then converted into a digital database and imported into the geospatial environment using ERDAS Imaging 8.7 and ArcGIS 8.3.

The following abbreviations were used: pers. obs. for personal observation; pers. comm. for personal communication; BNHS for Bombay Natural History Society Museum; ZSIC for Zoological Survey of India, Calcutta; and USNM for United States National Museum. Personal collections are abbreviated as follows: AD, Abhijit Das; AD/AS, Abhijit Das/Assam; AD/NL, Abhijit Das/Nagaland series. Other abbreviation include the following: NP, national park; WLS, wildlife sanctuary; RF, reserved forest; KNPm Kaziranga National Park; NERIST, North Eastern Regional Institute of Science and Technology, Itanagar; IITG, Indian Institute of Technology, Guwahati.

2.2.2 Family ELAPIDAE Boie 1827

Elapids are defined primarily by the unique presence of two permanently erect canaliculate front fangs, known as the proteroglyphous condition.

2.2.2.1 *Bungarus* Daudin, 1803

Bungarus Daudin 1803a: 434. Official generic name: Nr. 2149 (I.C.Z.N., 1982a. Opinion 1201). Type of genus: *Bungarus annularis* Daudin, 1803 (objective synonym of *Pseudoboa fasciata* Schneider 1801) by subsequent designation (I.C.Z.N., 1982a: 22. Opinion 1201).

Diagnosis The head is not distinct from the neck. The eyes are small. The head has complete scalation. There is no loreal scale. The dorsal scales are smooth and not oblique. The mid-dorsal row is enlarged. The fang is short, the tail is rather small, and the subcaudals are entire (except in *B. bungaroides*).

Table 2.1 Geo-coordinates of localities based on new collections or observations, literature, or database records. Coordinates and elevation are given for specified localities only

Locality name	District or Division/State	Coordinates	Elevation (m)
Amguri	Golaghat Dist./Assam	26° 35′ N; 93°21′ E	55
Aizwal	Aiwawl/Mizoram	23° 43.248′ N; 92 ° 43.979 E	750
Ajarbari,	Orang NP /Darrang/Assam	26° 30.722′ N; 92° 16.624 E	60
Balphakram NP	South Garo Hills Dist./ Meghalaya	25° 30′ N; 90 ° 45′E	224
Borkhola	Cachar/Assam	24° 55.790′ N; 92° 44.910′ E	63
Bihara	Cachar/Assam	24° 57.351 N; 92° 39.192′ E	22
Borjuri village	Golaghat Dist./Assam	26° 37′ N; 93°32′ E	60
Chabua	Dibrugarh Dist./Assam	27° 48′ N; 95° 18′ E	90
Cherrapunjee	East Khasi/Meghalaya	25°16′ N; 91°44′ E	1700
Changlang	Arunachal Pradesh	27° 26 N; 96 ° 55′ E	841
Dejoo	N. Lakhimpur Dist. Assam	27° 17′ N; 94° 03′ E	560
Deepor Beel	Kamrup/Assam	26° 05 26 09 N; 91 ° 36′ 9145′ E	55
Diffolu, knp,	Sonitpur/Assam	26 ° 37.869; 93 ° 13.946	60
Bomdila-Dirang road	West Kameng/Arunachal Pradesh	27 °22′. 738 N; 92 °13.104″ E	1950
Dibrugarh	Dibrugarh Dist./Assam	27° 48´ N; 94° 09′ E	110
Deopahar Dolong	Kaziranga National Park, Assam	26° 34′31.39″ N; 93° 12′ 02.08″ E	74
Dibru Saikhowa NP	Tinsukia/Assam	27° 35′27.5′ N; 95° 10′95 40′ E	105
Doom Dooma	Tinsukia, Assam	27° 33′59.18″ N; 95° 33′ 18.59″ E124	
Doimara	Eaglenest Wildlife Sanctuary, Arunachal Pradesh	26° 58′26.93″ N;92° 24′ 20.74″ E	498
Doloo Tea Estate	Cachar, Assam	24° 55′25.97″ N; 92° 47′ 08.72″ E	36
Guwahati	Kamrup Distr./Assam	26°09′ N; 91°40′ E	58
Joypore Wls	Dibrugarh/Assam	27 ° 20′ N; 95 ° 29′ E	200
IIT, Guwahati	Kamrup, Assam	26 ° 11′34.4091°41′42.23″ E	51
Jiribum	Manipur	24° 48 08 N; 93° 07 20	149
Kokrajhar college	Kokrajhar/Assam	26 ° 24°0.242′ N; 90° 16.744′ E	44
Khonoma	Kohima/Nagaland	25° 37. 93′ N; 94° 01.432′ E	1700
Khellong	Eaglenest wildlife sanctuary, Arunachal Pradesh	26°59°0.39.22″ N;92° 4′39.41″ E	469
Lama camp, Eaglenest	West Kameng/Arunachal Pradesh	27° 09.575″ N 92 ° 27.678″ E	2317
Marua Nullah	Barail WLS, Cachar/Assam	24 °58.342′ N; 92 ° 46. 168′ E	25

(continued)

Table 2.1 (continued)

Locality name	District or Division/State	Coordinates	Elevation (m)
Margherita	Assam	27 ° 17′08.9″ N 95 ° 39′54.3′E	146
Mehao WLS	Lower Dibang Valley/ Arunachal Pradesh	28° 03. 937′ N, 95° 56.506′ E	430
Miao	Changlang Dist./Arunachal Pradesh	27°30′ N; 96°11′ E	181
Mihimukh	Kaziranga NP/Golaghat Dist.	26°37′ N; 93°23′ E	55
Mizoram University	Aizwal/Mizoram	23 ° 44.144′ N 92 ° 40.282′ E	865
Namsang	Tirap/Arunachal Pradesh	27 ° 14 06 N 95 ° 27 37E	151
Nameri NP	Tezpur/Assam	26 ° 55.413 N; 92 ° 51.310E	98
Nengpui Wls	Mizoram	22 ° 29′ N, 92° 48′ E	650
NERIST campus	Itanagar/Arunachal Pradesh	27 ° 04.082 N 93 ° 35.641′ E	120
North Cachar	Haflong, Assam	25°09′48.24″ N 93°00′46.23″ E	660
Borajan-Podumoni WLS	Tinsukia/Assam	27°24′ 51″ N; 95°18′39″ E	120
Sadiya	Tinsukia Dist./Assam	27°50′ N, 95°40′ E	127
Selbelgiri	Garo Hills, Meghalaya	25°22′22.15″ N 90°02′13.49″ E	75
Sibsagar	Sibsagar Dist./Assam	26°98′ N; 94°63′ E	110
Siju Cave	Garo Hills, Meghalaya	25°21′28,52″ N 90°39′42.80″ E	237
Sithikhema	Dimapur, Nagaland	25°47′06.76″ 93°48′11.68”	370
Tezpur	Sonitpur/Assam	26 ° 37.595 92 ° 46.751′	50

2.2.3 Species Account

2.2.3.1 *Bungarus fasciatus* (Schneider 1801)

Pseudoboa fasciata Schneider 1801, *Hist. Amphib., Jena*, 2: 283. (based on Russell's Indian Serpents, vol. I, 1796, p. 3, pl.3). Type locality: Bengal.

Bungarus annularis Daudin 1803, *Hist. Nat. Rept. V*, p. 265, pl.v (based on Russell's plate). Type locality: Mansoor Cottah, Bengal.

Bungarus fasciatus Günther 1858, *Catal. Colubr. Snakes Coll. Brit. Mus., London*: 220.

Description of the Species Based on AD/AS 59, Juvenile, Kaziranga National Park, Assam

This is a fairly large-growing species. The body is triangular in shape. The head and tail are blunt. The vertebral ridge is prominent with distinctly enlarged hexagonal scales. The head length (12.76) is 1.3 times the head width (9.74). The eyes are small, accounting for 21% of the head length. The eye-to-snout distance (5.05) is twice that of the eye diameter (2.66). The nostril is positioned more toward the snout. The eye-to-nostril distance (2.42) is 1.6 times the nostril-to-snout distance (1.50). The parietal (4.98 × 4.31) is slightly higher than broad, with its height almost equal to the eye-to-snout distance. The frontal (4.67 × 3.17) is higher than wide; its height is more than the distance between the anterior end of the frontal to the tip of the snout. The prefrontal (2.43 × 2.49) is slightly wider than high, with its height equal to eye-to-nostril distance. Internasals (1.69 × 2.28) are distinctly wider than high. The rostral (1.97 × 3.90) is much wider than high and visible from above. The supraocular (3.76 × 1.95) is much higher than wide, with its height and width less than frontal. The nasal is divided; the loreal is absent. The first chin (3.04 × 2.09) shield is higher than the second chin (2.76 × 2.11) shield, but the widths of both chin shields are almost the same.

Supralabials 7/7, the third and fourth touch the eye and are sixth is the largest. For infralabials 7/7, the first four touch the anterior chin, with only the fourth touching the posterior chin shield. 1/1 is large preocular, and very small presubocular. Postocular: 2/2; Temporal: 1 + 2, anterior temporal large; Ventral: 227; Subcaudal: 35 (All single); Anal: 1; Dorsal Scale Row 15:15:15; Snout to vent length 430 mm; Tail length 41 mm.

Live Coloration

Eyes are black; the oblique yellow mark from the side of the neck reaches up to the frontal. The upper and lower labials are edged with black; the chin and throat are white. The dorsum has equally spaced, wide, and alternating yellow and black bands. There are 34 of each black and yellow bands on the whole body. The dorsal bands are continuous with ventral bands. The ventral blotches are 3–5 scales wide.

Distributional Localities

ASSAM: Orang National Park; Barkhola, Doloo, Borjuri, Mihimukh, Amguri, Tezpur, Deopahar Dolong, Bihara, Deepar Beel, Indian Institute of Technology Campus Guwahati, Kokrajhar college, Chakrashila wildlife Sanctuary [pers. obs.]; Deoripathar, Goalpara (Mathew 1983); MEGHALAYA: Sijucave, West Garo Hills (Mathew 1995); MIZORAM: Nengpui (Pawar and Birand 2001); ARUNACHAL PRADESH: NERIST campus, Doimara of Eaglenest Wildlife Sanctuary; MANIPUR: Jiribum (Singh 1995) (Fig. 2.1).

Range

India (central, eastern, and northeastern India) and throughout all southeastern Asia, including southern China, Myanmar, Bangladesh, Nepal, Bhutan, Thailand, Cambodia, Laos, Vietnam, and Malaysia, to western Indonesia.

Altitudinal Distribution

During pers. obs., the species was recorded up to an elevation of 600 m. In Eaglenest Wildlife Sanctuary, it was recorded at 450 m (Athreya 2006). Orlov et al. (2000) reported an altitude of 200–1500 m. Historically, the species was reported up to 2300 m in Myanmar.

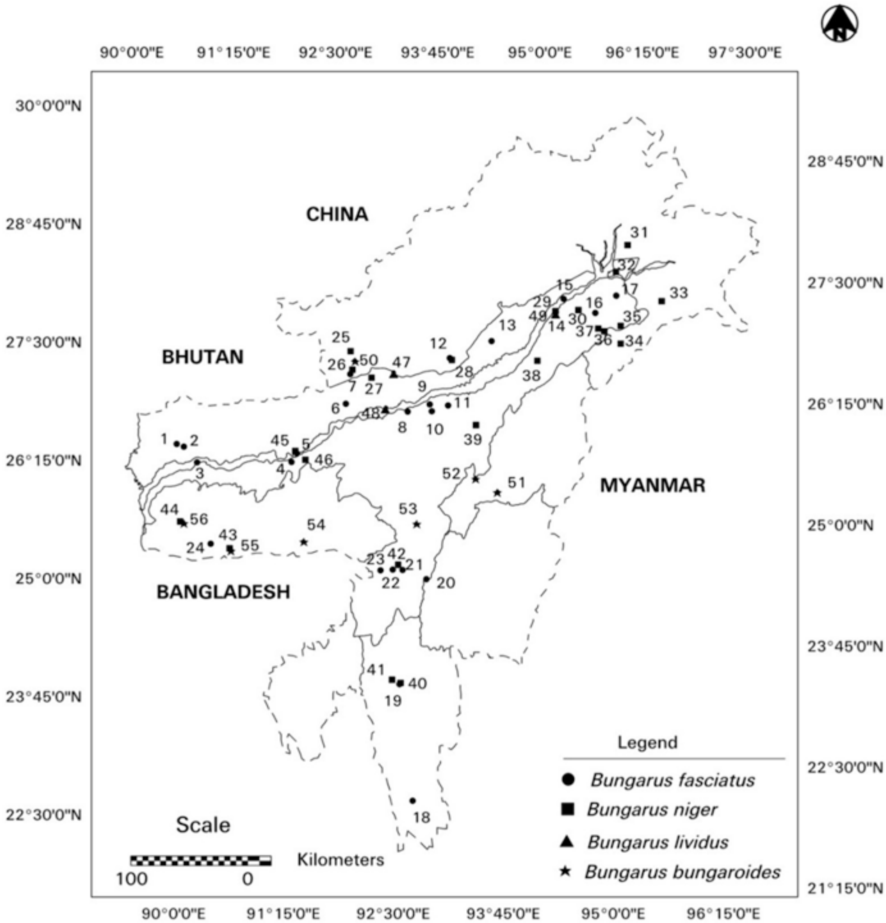

Fig. 2.1 Distributional localities of *Bungarus bungaroides*, *Bungarus fasciatus, Bungarus niger* and *Bungarus lividus* in Northeast India

Natural History Notes

The species has been recorded in roadside waterlogged areas, plantations, paddy fields, tea garden ditches, semi-evergreen forest edges, near termite mounds of alluvial grasslands, and in and around human habitation. Orlov et al. (2000) reported that this species lives in mountainous areas near water in Tam Dao.

Activities are recorded as nocturnal. One individual was photographed while it was feeding on a *Xenochrophis* sp. The species is also known to feed on lizards, rodents, and fish. It lays 4–14 eggs (Cox et al. 1998). When cornered, the snake tries to hide its head under its body coil and throw the body suddenly in any direction.

2.2.3.2 *Bungarus niger* Wall, 1908

Bungarus niger Wall 1908, *J. Bombay nat. Hist. Soc.* 18, p. 715 (Type locality: Tindharia, E. Himalaya).

Description of the Species Based on AD/AS 61 (Adult ♀), Maruacherra, Assam

The head is barely distinct from neck; the eyes are small and the snout is blunt. The scales are smooth without apical pits; the head is slightly distinct from the neck. The head length (19.99) is 1.2 times of its width (16.24). The eye-to-snout distance (7.00) is 2.5 times the diameter of the eye (2.40). The eye-to-nostril distance (3.63) is slightly more than the nostril-to-snout distance (3.18). The parietal (9.71 × 4.86) is twice as high as wide. The frontal (5.55 × 4.81) is higher than wide; its height is equal to the combined length of the Prefrontal and Internasal. The prefrontal (4.37 × 4.63) is slightly wider than high and is extended downward. The internasal (2.99 × 3.13) is wider than long; its height is almost equal to the width of the supraocular. The supraocular (4.12 × 2.75) height is 1.4 times its width; its height is shorter than the frontal and prefrontal height. The rostral (2.50 × 6.20) is 2.4 times wider than its height and is visible from above. The first chin (5.32 × 2.75) is higher than the second chin shield (3.69/2.67), but its width is slightly less than the second chin shield. The internarial (6.46) distance is 2.5 times less than the head width and is almost equal to the rostral width. The middorsal row is distinctly enlarged and slightly wider than long. The tail is short but pointed.

Supralabials: 7/7, the third and fourth touch the eye, the sixth is largest; Infralabial 7/7, four touch the anterior genial, only four touch the posterior genial. Ventral: 225; Subcaudal: 50, all undivided; Anal: 1 Dorsal Scale Row: 15:15:15; Snout to Vent Length 850 mm; Tail length 130 mm.

Live Coloration

Eyes are black. The tongue is pinkish with a lighter tip. The upper and lower labials, chin, and anterior part of the ventrum are whitish. Dorsally, it is shiny black; the interscale skin is whitish. The ventral is cream colored; the edges of the ventrals are powdered with black, which increases further posteriorly from the midventrals.

Variation

Tillack and Grossmann (2001) reported a specimen from Nepal having a small inter-prefrontal scale. This inter-prefrontal scale was found to be absent in observed northeastern specimens.

Locality Records

ASSAM: Guwahati, Barail wildlife sanctuary, Margherita, IIT campus Guwahati, Nameri eco camp, Nambor wildlife sanctuary [pers. obs.], Dibrugarh and Sadiya, Jaipur, Namsang, Sibsagar (Wall 1908, 1910, 1913a, b), USNM 118039 from Margherita, USNM 132111 from Chabua; ARUNACHAL PRADESH: NERIST campus, Mehao wildlife Sanctuary, before Bomdila [pers. obs.], Khellong in Eaglenest Wildlife Sanctuary (Athreya 2006); MEGHALAYA: Selbelgiri and Balpakram, Garo Hills (Mathew 1983, 1995); Miao, Changlang. Itanagar (Whitaker and Captain 2004; http//www.embl-heidelberg.de); MIZORAM: Mizoram University Campus [pers. obs.].

Range

India (Northern West Bengal, Uttarakhand, Northeast India), Bhutan, Nepal, and Bangladesh.

Altitudinal Distribution

During pers. obs., the species was recorded from as low as 18 m in Assam up to 900 m in Arunachal Pradesh. However, most recordings were at elevations below 500 m. In Eaglenest Wildlife Sanctuary, the species was recorded at 700 m (Athreya 2006). In Bhutan, Bauer and Günther (1992) reported it at 200–400 m. The highest altitudinal record comes from the Chin state of Myanmar at 1454 m.

Natural History Notes

Individuals were recorded near rocky riverbeds, abandoned opencast coal mining areas, and human habitation during nighttime hours. Roadkill individuals were recorded on a highway segment passing through semi-evergreen forest as well as through tea gardens.

Individuals have made lashing moves when cornered, with a low hissing sound. No bites were attempted, nor was the species observed hiding its head under the body coil. Tillack and Grossmann (2001) also noted foul-smelling anal excretion when ceased. Wall (1923) recorded *Trachischium tenuiceps* in its diet.

2.2.3.3 *Bungarus lividus* Cantor, 1839

Bungarus lividus Cantor 1839, *Proc. Zool. Soc. London.* p. 32. [Type Locality: Assam].

Composite Description of the Species Based on ZSIC 16133, Dibrugarh and ZSIC 16685, Jalpaiguri

This is a rather small snake. The eyes are small with round pupils. The head length is 4.8 times the eye diameter (1.44). The eye diameter is slightly more than the eye-to-nostril distance (1.33). The eye is positioned more toward the snout. The nostril-to-snout distance (0.94) is less than the eye-to-nostril distance. The parietal (4.16 × 2.26) scale is 1.9 times higher than its width. The frontal (2.28 × 2.24) is marginally higher than wide; the frontal width is almost equal to the parietal width. The prefrontal (1.26 × 1.66) is wider than high. The internasal (0.80 × 1.47) is much smaller than the prefrontal and is 1.8 times wider than its height. The rostral is slightly wider than long, and is slightly wider than the prefrontal width, The mid-dorsal row of scales is slightly enlarged from the dorsal scales. The body scales are smooth.

ZSIC 16685 has 7 Supralabials, the third and fourth touch the eye; Infralabials: 7, the third touches the anterior genial; Temporal: 1 + 2; Postocular: 2; Ventral: 213; Anal: 1; Subcaudal: 41, all undivided. Dorsal Scale Row: 15: 15:15; Snout to vent length: 260 mm; Tail length: 35 mm.

Live Coloration

The eyes are black. The dorsum is black or blackish blue. The upper lip is white. The ventrals are white, edged with grey. The ZSIC specimens are now quite faded (white).

Locality Records

ASSAM: Nameri- Pakke (Pawar and Birand 2001), near Tezpur (Wall 1910).

Range

India (Darjeeling, Tindharia, Jalpaiguri, West Bengal, Northeast India), Nepal, and Bangladesh.

Altitudinal Distribution

The species was recorded at 340 m in the Terai region of Nepal (Schleich and Kästle 2002).

Natural History Notes

The species is mainly ophiophagus. *Ramphotyphlops brahminus* was reported in its stomach. Other prey included unidentified Scolecophidian and member of the genus *Mus*. The longest measurement on record is 3 feet 2 inches in Tezpur.

2.2.3.4 *Bungarus bungaroides* (Cantor 1839)

Elaps bungaroides Cantor 1839, *Proc. Zool. Soc.*, p. 33. [Type Locality: Cherra Pungi (=Cherrapunjee), Khasi Hill. Col sketches in Bodleian Library, No. 4].

Xenurelaps bungaroides Günther 1864. *Rept. Brit. India*, p. 82.

Bungarus bungaroides Boulenger 1890, *Fauna Brit. India*, p. 389.

Description Based on AD/NL 42, Khonoma Village, Nagaland

This is a medium- to large-growing species. The dorsal scales are smooth. The mid-dorsal scales are slightly enlarged anteriorly, but distinctly enlarged posteriorly. The head is short and slightly distinct from the neck; the top of the head is flat. The eyes are small with round pupils; the snout is blunt.

The head length (16.62) is only 1.17 times the head width (14.14) and 6.8 times the diameter of the eye (2.49). The eye diameter is the same as the distance from the eye to the nostril (2.49). The eye-to-snout distance (4.78) is twice the eye diameter. The parietal (7.17 × 4.88) is 1.4 times higher than wide. The frontal (5.67 × 4.59) is higher than wide; its height is equal to the distance between the anterior end of the frontal to the tip of the snout. The prefrontal (3.63 × 3.75) is slightly wider than high. The internasal (2.22 × 2.65) is wider than high. The supraocular (4.09 × 2.66) is 1.5 times higher than wide. The supraocular width is the same as the width of the internasal. The rostrum (2.53 × 4.80) is almost twice as wide as high and is slightly visible from above. The first chin shield (3.19 × 2.86) is wider and higher than the second chin shield (3.04 × 2.70). The internarial distance (5.23) is slightly smaller than the frontal height and is 2.8 times the head width.

Postocular: 2/2, the upper one is larger and reaches the top of the head. Preocular: 1/1, touches the second supralabial; Temporals: 1 + 2; Supralabial: 7/7, 3 and 4 touch the eye, 5 is the largest; Infralabial 7/7, 3 touches the anterior genial, only 4 touches the posterior genial. Dorsal scale rows: 15:15:15; Ventrals: 227; Subcaudals: 46 (all paired); Anal: 1; SVL 700 mm; TL 100 mm.

Additional Specimen Studied: BNHS 2079, *Bungarus bungaroides*, Male, Phubsering, July 1960, J. C Daniel.

Head length: 15.33, Head depth: 7.99, Head width: 11.23, Eye diameter: 2.79, Eye to snout: 5.67, Eye to nostril: 3.01, Parietal: 6.93/4.18, Frontal: 5.06/3.71, height is equal to the snout distance. Prefrontal: 2.71/3.59, Internasal: 2.00/2.47, Rostral: 1.99/3.65, Supraocular: 3.94/2.13, Supralabials: 7/7, the third and fourth touch the eye, the sixth is largest. 2/2 postocular, 1/1 preocular; preocular is connected to the nasal. The nasal is divided. Temporal: 1 + 2/1 + 2; IL: 7/7, the first three touch the anterior chin. The third and fourth touch the second chin shield.

Dorsal Scale Row: 15:15:15, smooth. The middorsal is marginally enlarged. Ventrals: 230, Subcaudals: 49 (tail blunt), A: 1. 55 narrow bands on body and 11 on tail. White bands appear as dorsal scales edged with white. The head has an arrow-shaped indistinct mark. The ventral has alternating black and cream blotches. SVL: 640 mm, TL: 9.3 mm. The hemipenis extends to the 10th caudal plate, with small spines.

Colouration in Preservative: The dorsal body has narrow whitish bands. Anteriorly, the bands are obliquely arranged and are not very distinct; however, posteriorly, the bands are more distinct dorsally. The dorsal bands are 4–6 scales apart. The neck band is distinctly oblique. Each dorsal band gives rise to wide roundish white blotches on the ventrum. These blotches are separated from each other by a wide black space. A narrow bar runs across the prefrontal up to and 2–3 supralabial. Two white bars enter the top of the head from the angle of the jaw and join each other at the mid-frontal. Small white bars are present below the eye.

Locality Records: ASSAM: North Cachar (Wall 1924); ARUNACHAL PRADESH: Eaglenest Wildlife Sanctuary (Ishan Agarwal, *Pers. Comm.*); NAGALAND: Khonoma [pers. obs.], Sitikhima by Ao et al. (2004).

Range: India (Darjeeling, Sikkim, Meghalaya, Nagaland, Assam) and Myanmar.

Altitudinal Distribution: The specimen described was obtained from 1580 m. Boulenger (1896) reported the specimen at an elevation of 2040 m. However, the species was collected from as low as 250 m by Ao et al. (2004).

Natural History Notes: A single individual was found in the footsteps of habitation at around 8 pm in the month of May. Ao et al. (2004) collected the species from subtropical vegetation. This is a poorly known species.

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Herpetofauna of Andaman and Nicobar Islands

3

V. Rangasamy, C. Sivaperuman, G. Gokulakrishnan, and P. Parthipan

Abstract

The herpetofauna of Andaman and Nicobar Island is diverse and has not been much focused. We present a brief history of herpetofaunal exploration and an annotated checklist in this chapter. A total of 102 species of amphibians and reptiles were occurring in terrestrial and marine environments of Andaman and Nicobar Islands. IUCN status and Scheduled species of Indian Wildlife Protection Act 1972 are also provided. Of the recorded species, 2 species were listed in Schedule I, 3 species under Schedule II, and 36 species under Schedule IV of Indian Wildlife Protection Act 1972.

Keywords

Amphibians · Andaman · Distribution · Reptiles · Nicobar

3.1 Introduction

Amphibians and reptiles play an important role in the ecosystem as links in food chains, as bio-monitors in controlling insect pests, and also as excellent ecological indicators owing to their high degree of sensitivity to even a slight change in the environment (Lips 1998; Roy 2002; Daniels 2003). The archipelago has a fauna that shows distinct affinities toward the fauna of Southeast Asia (Smith 1940; Das 1999). Within these islands, the fauna of the Nicobar group of islands is derived from the Sundaic fauna and shows affinities with the Indo-Malayan region (Das 1999). The archipelago comprises 572 islands extending over 800 km. The total geographical area is 8249 km^2, of which very dense forest

V. Rangasamy · C. Sivaperuman (✉) · G. Gokulakrishnan · P. Parthipan
Andaman and Nicobar Regional Centre, Zoological Survey of India,
Port Blair, Andaman and Nicobar Islands, India

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covered 5686 km^2, 685 km^2 moderately dense forest, and 380 km^2 open forest area (ISFR 2015). This archipelago is one of the world's biodiversity hotspots and has diverse fauna and flora. The study of herpetofauna of Andaman and Nicobar Islands has been initiated by Blyth (1846). Later, several studies have been conducted to listing the species. Tytler (1864) described a new species of Giant gecko *Gekko verreauxi* from Andaman. Stoliczka (1873) made the detailed collection of reptiles and reported 13 species of lizards, 10 species of snakes, and 3 species of frogs. Smith (1940) provided the first review of biogeography of the herpetofauna of these islands and listed 60 species of squamate reptiles. Biswas and Sanyal (1965) described a new species of wolf snake *Lycodon tiwarii* from this region. Tiwari and Biswas (1973) described a new species of agamid lizard *Calotes danieli* and a new species of snake *Dendrelaphis humayuni* from Great Nicobar Island. Whitaker (1978) reported 35 species of snakes, 28 species of lizards, and 9 species of amphibians. Pillai (1977) reported two species of microhylid frogs from Andamans including a new species *Microhyla chakrapanii.* Biswas and Sanyal (1977a) reported the skink *Sphenomorphus quadrivittatum* from Great Nicobar. Biswas and Sanyal (1977b) described a new species of tree skink *Dasia nicobarensis* from Car Nicobar. Biswas and Sanyal (1978) described a new species of krait *Bungarus andamanensis* from Andaman. Biswas and Sanyal (1980) reported a collection of 29 species of reptiles from Andaman and Nicobar Islands.

Mansukhani and Sarkar (1980) described *Bufo camortensis* from Camorta in Nicobars. This species was considered a synonym of *Bufo spinipes* Steindachner 1867 that was the very first species of amphibian described from Nicobars (Crombie 1986). As pointed out by Crombie (1986), the characters used by Mansukhani and Sarkar for the recognition of *Bufo camortensis* fall within the range of variation exhibited by *Duttaphrynus melanostictus* Schneider, 1799. Murthy and Chakrapani (1983) rediscovered the blind snake *Typhlops oatesii* Boulenger 1890 that was originally described from Table Island, Cocos Group of north of Andaman. Mehta and Rao (1987) reported *Microhyla heymonsi* Vogt, 1911 from Great Nicobar. Sarkar (1990) in his review listed nine species of amphibians from Nicobars. Pillai (1991) recorded *Fejervarya cancrivora* from the islands. Ratnam (1993) provided information on the natural history of the Andaman day gecko *Phelsuma andamanense.* Tiwari (1992) reported the sunbeam snake *Xenopeltis unicolor* Reinwardt, 1827, from Great Nicobar. Das (1994) listed 17 species of amphibians, 31 species of lizards, and 39 species of snakes from Andaman and Nicobar Islands. Das and Chandra (1994) added two more species of snakes to the fauna, i.e., *Boiga cyanea* from Great Nicobar Island (Dumeril and Bibron 1864) and *Microcephalophis cantoris* Gunther 1864 from Andaman. Das (1995) described a new tree frog *Polypedates insularis* from Great Nicobar Island. The population of cobras from Andaman previously considered as conspecific with *Naja kaouthia* Lesson in Ferussac 1831 was elevated by Wuster et al. (1995) to the level of species as *Naja sagittifera* Wall 1913. Das

(1996a) described a new species of ranid frog *Limnonectes shompenorum* and reported the presence of another frog *Hylarana chalconota* (Schlegel 1837) from Great Nicobar (Das 1996a). Das (1996b) revived *Dibamus nicobaricus* (Fitzinger in Steindachner 1867) from the synonymy of *Dibamus leucrurus* (Bleeker 1860) and considered the former as endemic to Nicobars. Daniels and David (1996) reported eight species of frogs, six species of lizards, and six species of snakes from Great Nicobar. In 1997, Das described a new species of gecko *Cyrtodactylus adleri* from Great Nicobar Island (Das 1997a). Das (1997b) rediscovered the skink *Lipinia macrotympana* (Stoliczka 1873) from the islands of Little Nicobar and Great Nicobar. This species was originally described based on a single specimen collected from South Andaman by Stoliczka (1873). Das (1998) described a new species of frog *Ingerana charlesdarwini* from Mount Harriet in Andamans.

Half a century later, Das (1999) provided an updated biogeography of herpetofauna of these islands with details of introduced species. He has listed 40 species of squamate reptiles and 12 species of amphibians from Andamans and 37 species of reptiles and 11 species of amphibians from Nicobars. Das and Gemel (2000) confirmed the existence of the largely Malayan species *Bronchocela cristatella* from the island of Car Nicobar. Ghodke and Andrews (2001a, b) recorded the snakes *Cantoria violacea* (Girard 1857) from North and Middle Andaman and *Enhydris plumbea* (Boie 1827) from Great Nicobar. Based on collections from 15 islands in the Nicobars, Vijayakumar (2005) recorded 24 species of lizards, 14 species of snakes, and 10 species of amphibians, including several suspected new species. Recently, Vijayakumar and David (2006), Hallermann (2009), Harikrishnan et al. (2010a, b), Harikrishnan et al. (2012), and Harikrishnan and Vasudevan (2013) carried out studies on the reptiles and amphibians of this archipelago and provided checklist of this faunal group. Sivaperuman and Deepak (2013) studied the diversity and distribution of amphibians and reptiles from the Ritchie's Archipelago. Rangasamy et al. (2014) reported the diversity and distribution of 9 species of amphibians and 32 species of reptiles of Andaman and Nicobar group of islands.

3.2 Methods

The field surveys were performed during 2013 through 2017 in South Andaman, Middle Andaman, North Andaman, Little Andaman, Ritchie's Archipelago, Great Nicobar, and Little Nicobar Islands (Fig. 3.1). Search were made opportunistically in small water bodies, on trees, bushes, perennial streams, and seasonal streams and also nocturnal survey also carried out for amphibians and nocturnal reptiles species. The doubtful animals were captured for further examination, and after confirmation of the species, all are released in the same habitat. For preparation of this paper, previously published reports were also consulted.

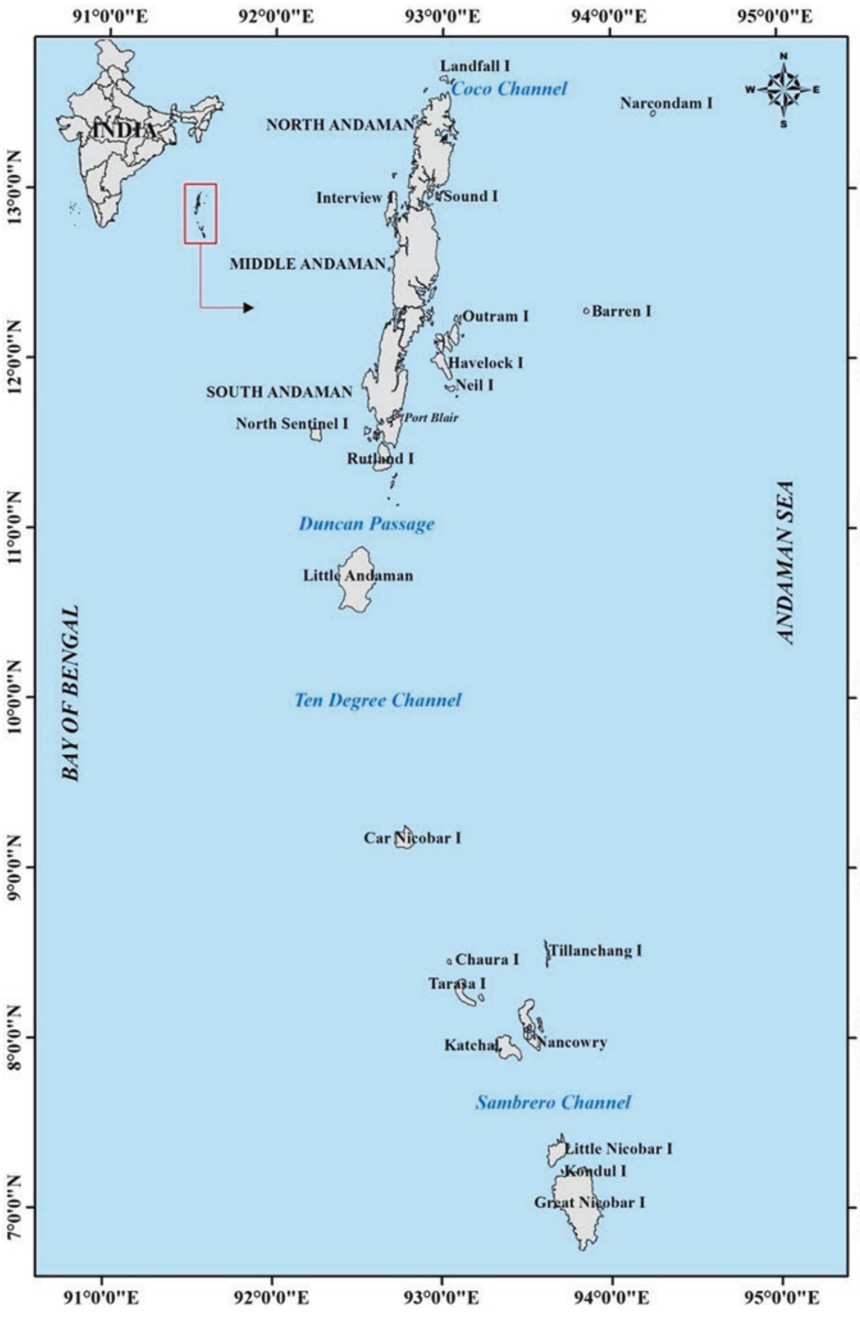


Fig. 3.1 Andaman and Nicobar Islands

3.2.1 Survey Location

Location	Latitudes	Longitudes
South Andaman		
Garacharma	11°37.055′ N	92°42.496′ E
Sippighat	11°36.749′ N	92°41.583′ E
Chouldhari	11°37.350′ N	92°40.108′ E
Ograbraj	11°39.463′ N	92°39.785′ E
Stewartgunj	11°43.617′ N	92°42.826′ E
Shoal Bay	11°52.484′ N	92°44.412′ E
Chidiya Tapu	11°30.688′ N	92°41.927′ E
Middle Andaman		
Baratang	12°05.567′ N	92° 44.992′ E
Yeratta	12°30.227′ N	92°54.166′ E
Sabari	12°29.165′ N	92°54.011′ E
Long Island	12°21.888′ N	92°55.434′ E
Changappa Island	12°23.857′ N	92° 53.931′ E
Lalaji Bay	12°24.435′ N	92° 56.806′ E
Guitar Island	12°20.493′ N	92° 54.484′ E
North Passage	12°17.282′ N	92°56.003′ E
Eratta	12°24.467′ N	92° 53.263′ E
Panchawati	12°24.467′ N	92° 53.263′ E
North Andaman		
Aerial Bay	13°16.368′ N	93°01.914′ E
Shibpur	13°14.035′ N	93°02.939′ E
Lamiya Bay	13°13.945′ N	93°03.155′ E
Saddle Peak	13°05.525′ N	93°00.326′ E
Kishori Nagar	13°12.150′ N	92°58.140′ E
Badur Tikrey	13°22.111′ N	92°57.792′ E
Kalipur	13°13.442′ N	93°02.725′ E
Durgapur	13°16.551′ N	93°01.971′ E
Kalighat	13°06.077′ N	92°59.469′ E
Bamboo Island	13°02.542′ N	93°56.092′ E
Ram Nagar	13°16.551′ N	93°01.117′ E
Khudirampur	13°90.901′ N	92°58.605′ E
Ross and Smith Island	13°19.358′ N	93º04.281′ E
Kalpong Dam	13º06.842′ N	92º59.826′ E
Little Andaman		
Hut Bay	10°35.667′ N	92°31.955′ E
Rabinder Nagar	10°42.483′ N	92°32.005′ E
Harminder Bay	10°36.207′ N	93°33.264′ E
Great Nicobar Island		
0 – Point	07°00.893′ N	93°56.158′ E
Laxman Beach	07°01.284′ N	93°55.058′ E
Magar Nallah	06°59.482′ N	93°54.952′ E

Location	Latitudes	Longitudes
Govind Nagar	07°00.242′ N	93°54.571′ E
Joginder Nagar	06°58.982′ N	93°54.851′ E
Vijay Nagar	06°52.371′ N	93°53.359′ E
Gandhi Nagar	07°00.242′ N	93°54.571′ E
Shastri Nagar	06°48.010′ N	93°53.073′ E
Galathea	06°49.024′ N	93°52.089′ E
Indira Point	06°47.527′ N	93°50.698′ E
Navy Dera	07°08.120′ N	93°53.042′ E
Little Nicobar Island		
Little Nicobar (Makachua)	07°24.506′ N	93°42.581′ E
Little Nicobar	07°24.134′ N	93°42.254′ E

3.3 Results and Discussion

A total of 101 species of herpetofauna were recorded, belonging to 22 families and 65 genera, which include 39 species of snakes, 19 species of amphibians, 15 species of gecko, 11 species of skink, 9 species of lizards, 7 species of turtle, and 1 species of crocodiles (Table 3.1; Plates 3.1 and 3.2). Taxonomic composition reveals that there is an occurrence of 62 herpetofauna from Andaman group, 66 were recorded from Nicobar group, while only 26 herpetofauna were found in both groups of islands (Table 3.1). Thirty eight taxa including a subspecies and species are endemic to Andaman and Nicobar Islands. The present checklist has a scope to be updated as many more species can be recorded as new records after rigorous faunistic surveys.

Among the recorded species of herpetofauna, the highest number of species was recorded from South Andaman (47 species), followe d by North Andaman (41 species) and Great Nicobar (40 species) (Table 3.2). The following species, namely, *Crocodylus porosus*, *Eretmochelys imbricata*, *Cyrtodactylus rubidus*, *Eutropis tytleri*, *Dendrelaphis andamanensis*, and *Laticauda laticaudata*, were recorded from all locations.

Herpetofauna of the Andaman and Nicobar Islands come under 24 families of 4 orders. Colubridae and Gekkonidae (15 species each) showed the highest number of species compared to other families, followed by Scincidae (11), Dicroglossidae (8), and Elapidae and Agamidae (7). Ten families represented only one species (Fig. 3.2). IUCN (2017) status of amphibians and reptiles of Andaman and Nicobar Islands shows that 44% are near threatened, 36% are of least concern, 10% are vulnerable, 7% are data deficient, and 2% are critically endangered (Fig. 3.3).

There are more than 6000 currently recognized species of extant amphibians, with representatives present in virtually all terrestrial and freshwater habitats, but absent from the coldest and driest regions, and from the most remote oceanic islands (Stuart et al. 2008). Of which 384 species of amphibians were reported from India (Dinesh et al. 2015). Only 19 species of amphibians were found in Andaman and

Table 3.1 Herpetofauna of the Andaman and Nicobar Islands with their status and distribution

Order/family/common name	Species name	A	N	IUCN	WPA
				Status	
Reptiles					
Order: Crocodilia (1)					
Family: Crocodylidae (1)					
Saltwater Crocodile	*Crocodylus porosus* Schneider 1801	✓	✓	LC	I
Order: Testudines (7)					
Family: Dermochelyidae (1)					
Leatherback sea turtle	*Dermochelys coriacea* (Vandelli, 1761)	✓	✓	VU	
Family: Cheloniidae (4)					
Loggerhead sea turtle	*Caretta caretta* Linnaeus, 1758	✓	✓	VU	
Green sea turtle	*Chelonia mydas* (Linnaeus, 1758)	✓	✓	EN	
Hawksbill sea turtle	*Eretmochelys imbricata* (Linnaeus, 1766)	✓	✓	CR	
Olive ridley sea turtle	*Lepidochelys olivacea* (Eschscholtz, 1829)	✓	✓	VU	
Family: Geoemydidae (1)					
Malayan box turtle	*Cuora amboinensis* (Riche in Daudin, 1801)		✓	VU	
Family: Trionychidae (1)					
Indian flapshell turtle	*Lissemys punctata andersoni* Webb, 1980	✓		LC	
Order: Squamata (74)					
Family: Gekkonidae (15)					
Kandy day gecko[E]	*Cnemaspis andersonii* (Annandale, 1905)	✓		LC	
	Cnemaspis sp.	✓	✓	NE	
Four-clawed gecko	*Gehyra mutilata* (Weigmann, 1853)	✓	✓	NE	
Andaman giant gecko[E]	*Gekko verreauxi* (Tytler, 1864)	✓		VU	
Smith's green-eyed gecko	*Gekko smithii* (Gray, 1842)		✓	LC	
Andaman bent-toed gecko[E]	*Cyrtodactylus rubidus* (Blyth, 1860)	✓		VU	
Alder's bow-fingered gecko[E]	*Cyrtodactylus adleri* Das, 1998		✓	LC	
Asian house gecko	*Hemidactylus frenatus* Dumeril and Bibron, 1836	✓	✓	LC	
Brook's house gecko	*Hemidactylus brookii* Gray, 1845	✓	✓	NE	
Indo-Pacific gecko	*Hemidactylus garnotii* (Dumeril and Bibron 1836)		✓	NE	
Oriental worm gecko	*Hemiphyllodactylus typus* (Bleeker 1860)	✓	✓	LC	
Flat-tailed gecko	*Hemidactylus platyurus* (Schneider, 1792)	✓		NE	
Common smooth-scaled gecko	*Lepidodactylus lugubris* (Dumeril and Bibron, 1836)	✓	✓	NE	
Andaman day gecko[E]	*Phelsuma andamanense* (Blyth 1860)	✓	✓	LC	

(continued)

Table 3.1 (continued)

Order/family/common name	Species name	A	N	IUCN Status	WPA
Nicobar gliding gecko[E]	*Ptychozoon nicobarensis* Das and Vijayakumar, 2009		✓	NE	
Family: Agamidae (7)					
Green-crested lizard	*Bronchocela cristatella* (Kuhl, 1820)		✓	NE	
Daniel's forest lizard[E]	*Bronchocela danieli* (Tiwari and Biswass, 1973)		✓	NE	
	[E]*Bronchocela rubrigularis* Hallermann, 2009		✓	NE	
Green crestless forest lizard[E]	*Pseudocalotes andamanensis* (Boulenger, 1891)	✓		NE	
Indian garden lizard	*Calotes versicolor* (Daudin, 1802)	✓		NE	
Bay Islands forest lizard[E]	*Coryphophylax subcristatus* (Blyth, 1860)	✓	✓	LC	
Short-tailed Bay Island forest lizard[E]	*Coryphophylax brevicaudus* Harikrishnan et al., 2012	✓		NE	
Family: Scincidae (11)					
Nicobar tree skink[E]	*Dasia nicobarensis* Biswas and Sanyal, 1977		✓	NE	
Olive tree skink	*Dasia olivacea* Gray, 1839		✓	LC	
Big-eared lipinia[E]	*Lipinia macrotympanum* (Stoliczka, 1873)	✓	✓	VU	
Christmas Island grass-skink	*Lygosoma bowringii* (Gunther, 1864)	✓		NE	
Andaman Islands grass skink[E]	*Eutropis andamanensis* Smith, 1935	✓		NE	
Tytler's mabuya[E]	*Eutropis tytleri* (Theobald, 1868)	✓		NE	
Rough mabuya or brown mabuya	*Eutropis rudis* (Boulenger, 1887)		✓	NE	
Common sun skink	*Eutropis multifasciata* (Kuhl, 1820)		✓	NE	
Rough-scaled sun skink	*Eutropis rugifera* (Stoliczka, 1870)		✓	NE	
Spotted forest skink	*Sphenomorphus maculatus* Blyth, 1853	✓	✓	NE	
Large-eared ground skink[E]	*Scincella macrotis* (Ftizinger, 1867)		✓	VU	
Family: Dibamidae (1)					
Nicobarese worm lizard[E]	*Dibamus nicobaricus* (Fitzinger, 1867)		✓	NE	
Family: Varanidae (1)					
Water monitor lizard	*Varanus salvator andamanensis* Deraniyagala, 1944	✓	✓	LC	
Family: Typhlopidae (3)					
Brahminy worm snake	*Indotyphlops braminus* (Daudin, 1803)	✓	✓	NE	IV
Andaman worm snake[E]	*Typhlops andamanensis* Stoliczka, 1871	✓		DD	IV
Oates' worm snake	*Asiatyphlops oatesii* (Boulenger, 1890)	✓		DD	IV

(continued)

Table 3.1 (continued)

Order/family/common name	Species name	A	N	IUCN Status	WPA
Family: Acrochordidae (1)					
File snake	*Acrochordus granulatus* (Schneider, 1779)		✓	LC	IV
Family: Xenopeltidae (1)					
Sunbeam snake	*Xenopeltis unicolor* ReinwardtBoie, 1827	✓	✓	LC	IV
Family: Pythonidae (1)					
Reticulated python	*Python reticulatus* (Schneider, 1801)		✓	NE	I
Family: Natricinae (3)					
Nicobar keelback[E]	*Amphiesma nicobariense* (Sclater, 1981)		✓	NE	IV
Triangle-spotted keelback	*Xenochrophis trianguligerus* (Boie, 1827)		✓	LC	IV
Andaman keelback water snake[E]	*Xenochrophis tytleri* (Blyth, 1863)	✓		NE	IV
Family: Colubridae (15)					
Andaman cat snake[E]	*Boiga andamanensis* (Wall, 1909)	✓		NE	IV
Nicobar cat snake[E]	*Boiga wallachi* Das, 1998		✓	DD	IV
Paradise flying snake	*Chrysopelea paradisie* Boie, 1827	✓		LC	IV
Andaman painted bronzeback tree snake[E]	*Dendrelaphis andamanensis* (Anderson, 1871)	✓		NE	IV
Nicobar bronzeback tree snake[E]	*Dendrelaphis humayuni* Tiwari and Biswas, 1973		✓	NE	IV
Yellow-striped trinket snake	*Coelognathus* sp.		✓	NE	IV
Black-tailed trinket snake	*Coelognathus flavolineatus* (Schlegel 1837)	✓		LC	IV
Red-tailed trinket snake	*Gonyosoma oxycephalum* (Boie, 1827)	✓		LC	
Andaman wolf snake[E]	*Lycodon hypsirhinoides* (Theobald, 1868)	✓		NE	IV
Malayan wolf snake	*Lycodon subcinctus* Boie, 1827		✓	LC	IV
Tiwari's wolf snake[E]	*Lycodon tiwarii* Biswas and Sanyal, 1965		✓	NE	IV
Yellow-striped kukri snake[E]	*Oligodon woodmasoni* (Sclater, 1981)		✓	NE	IV
Indian rat snake	*Ptyas mucosa* (Linnaeus, 1758)	✓		NE	IV
Günther's many-tooth snake	*Sibynophis bistrigatus* (Günther, 1868)		✓	DD	IV
Nicobar stripe-necked snake[E]	*Gongylosoma nicobarense* (Stoliczka, 1870)		✓	NE	IV
Family: Homalopsidae (3)					
Yellow-banded mangrove snake	*Cantoria violacea* Girard, 1857	✓		LC	IV
Dog-faced water snake	*Cerberus rynchops* (Schneider, 1799)	✓	✓	LC	II
Plumbeous smooth-scaled water snake	*Enhydris plumbea* (Boie, 1827)		✓	LC	IV

(continued)

Table 3.1 (continued)

Order/family/common name	Species name	A	N	IUCN Status	WPA
Family: Elapidae (7)					
Andaman krait[E]	*Bungarus andamanensis* Biswas and Sanyal, 1978	✓		VU	IV
Andaman cobra[E]	*Naja sagittifera* Wall, 1913	✓		NE	II
King cobra	*Ophiophagus hannah* (Cantor, 1836)	✓		VU	II
Yellow-lipped sea krait	*Laticauda colubrina* (Schneider, 1799)	✓	✓	LC	IV
Brown-lipped sea krait	*Laticauda laticaudata* (Linnaeus, 1758)	✓	✓	LC	IV
Cantor's narrow-headed sea snake	*Hydrophis cantoris* (Gunther, 1864)	✓		DD	IV
Black and yellow sea snake	*Pelamis platura* (Linnaeus, 1766)	✓	✓	LC	IV
Family: Viperidae (5)					
Andaman pit viper[E]	*Trimeresurus andersoni* (Theobald, 1868)	✓	✓	NE	IV
White-lipped pit viper	*Trimeresurus* cf. *albolabris* (Gray, 1842)		✓	NE	IV
Canto's pit viper[E]	*Trimeresurus cantori* (Blyth, 1846)		✓	NE	IV
Nicobar pit viper[E]	*Trimeresurus labialis* (Fitzinger, 1867)		✓	NE	IV
Nicobar bamboo pit viper[E]	*Trimeresurus mutabilis* Stoliczka, 1870		✓	NE	IV
Amphibians					
Order: **Anura (19)**					
Family: Dicroglossidae (8)					
Andaman wart frog[E]	*Fejervarya andamanensis* (Stoliczka, 1870)	✓		LC	
Crab-eating frog	*Fejervarya cancrivora* (Gravenhorst, 1829)	✓	✓	LC	
Nicobar cricket frog[E]	*Fejervarya nicobariensis* (Stoliczka, 1870)		✓	NE	
	Limnonectes hascheanus (Stoliczka, 1870)	✓		LC	
Charles Darwin's frog[E]	*Ingerana charlesdarwini* (Das, 1998)	✓		CR	
Red stream frog	*Limnonectes doriae* (Boulenger, 1887)	✓		DD	
Asian bullfrog	*Hoplobatrachus tigerinus* (Daudin, 1802)	✓		LC	IV
Shompen frog	*Limnonectes shompenorum* Das 1998		✓	LC	
Family: Microhylidae (5)					
Brown bullfrog[E]	*Kaloula baleata ghoshi* Cherchi, 1954	✓		NE	
Mayabunder rice frog	*Microhyla chakrapanii* Pillai, 1977	✓		DD	
Ant frog	*Microhyla ornata* (Dumeril and Bibron, 1841)	✓		LC	
Deli paddy frog	*Micryletta inornata* (Boulenger, 1890)	✓		LC	
Dark-sided chorus frog	*Microhyla heymonsi* Vogt, 1911		✓	LC	

(continued)

Table 3.1 (continued)

Order/family/common name	Species name	A	N	IUCN Status	WPA
Family: Bufonidae (2)					
Asian common toad	*Bufo melanostictus* Schneider, 1799	✓	✓	LC	
Andaman bush toad[E]	*Blythophryne beryet* Chandramouli et al. 2016	✓		NE	
Family: Ranidae (3)					
Copper-cheeked frog	*Hylarana chalconota* (Schlegel 1837)		✓	LC	
Red-eared frog	*Hylarana erythraea* (Schlegel 1837)		✓	LC	
Nicobar Island frog	*Hylarana nicobariensis* (Stoliczka 1870)		✓	LC	
Family: Rhacophoridae (1)					
Nicobarese tree frog[E]	*Polypedates insularis* Das, 1995		✓	EN	

A Andaman group of islands, N Nicobar group of islands
IUCN status: *LC* least concern, *NT* near threatened, *EN* endangered, *CR* critically endangered, *VU* vulnerable, *NE* not evaluated, *DD* data deficient, *E* endemic to Andaman and Nicobar Islands
The number in brackets denotes the number of species for each group

Nicobar Islands. Aengals et al. (2011) reported 518 species of reptiles which include 3 species of crocodiles, 34 species of turtles and tortoises, 202 species of lizards, and 279 species of snakes belonging to 28 families from India. Of these, 82 species are reptiles; this includes 39 species of snakes, 15 species of gecko, 11 species of skink, 9 species of lizards, 7 species of turtle, and 1 species of crocodiles. The composition of herpetofauna of Andaman and Nicobar Islands heavily supports reptiles (Table 3.1). Amphibians comprise only 18.8% of herpetofauna, whereas reptiles represent 81.2% of the recorded animals.

As is the case in other parts of Indian regions and the world, habitat loss is overwhelmingly the major threat to herpetofauna of this archipelago which is affecting the endemic and threatened species. The new constructions of settlements after tsunami 2004 in different islands and the newest road alignment in Great Nicobar Island from Campbell Bay to Indira Point are the major impacts of vegetation removal, and expanding croplands are the most severe types of habitat loss impacting the herpetofauna. If the proposed railway line for South Andaman to North Andaman is materialized, the herpetofaunal communities will be the first victims. The transportation infrastructure would affect the structure of ecosystems and the dynamics of ecosystem function and has direct effects on ecosystem components, including their species composition. Very little amount of ecological research have been carried on the reptiles and amphibians of this archipelago. Basic research and much more detailed ecological studies are required on reptiles and amphibians covering intensive and extensive fieldwork to build a better picture, and there is scope to estimate complete species occurrence and populations.

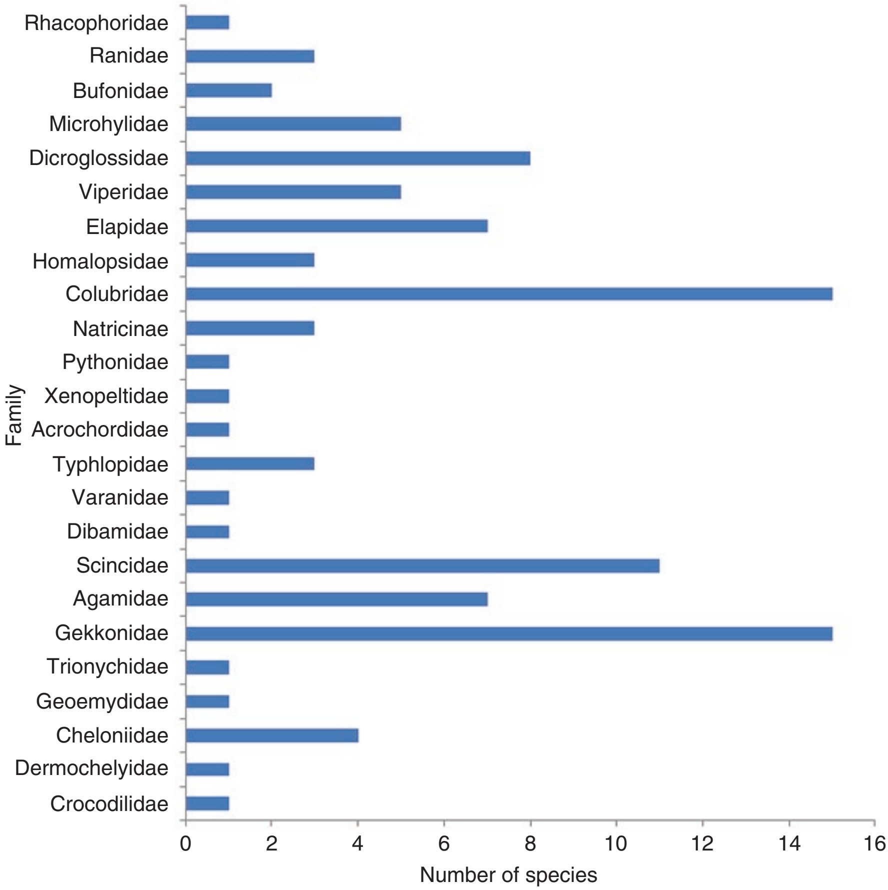


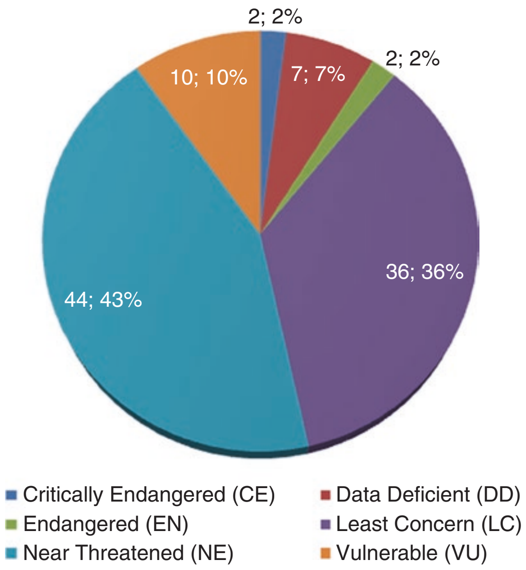
Plate 3.1 Reptiles of Andaman and Nicobar Islands. (**a**) *Ophiophagus hannah* (Cantor); (**b**) *Naja sagittifera* Wall; (**c**) *Gonyosoma oxycephalum* (Boie); (**d**) *Boiga wallachi* Das; (**e**) *Lipinia macrotympanum* (Stoliczka); (**f**) *Phelsuma andamanense* Blyth; (**g**) *Cuora amboinensis*; (**h**) *Gekko verreauxi* (Tytler); (**i**) *Dermochelys coriacea* (Vandelli)

3.3.1 Taxonomic Chaos of Few Herpetofauna Reported from Andaman and Nicobar Islands

Fejervarya limnocharis (Gravenhorst 1829) is removed from the present list. Das (1999) listed as *Limnonectes limnocharis* and Harikrishnan et al. (2010a, b) listed as *Fejervarya limnocharis* (from Andaman Islands), but Dubois (1984) documented the populations of former *Rana limnocharis* as *Rana andamanensis* (synonym of *Fejervarya andamanensis*) from Andaman Islands (source: http://www.reptile-database.org).

Pseudocalotes andamanensis (Boulenger 1891) is added in this list, but there was recent sighting in survey on North Andaman Islands.

Plate 3.2 Amphibians of Andaman and Nicobar Islands. (**a**) *Blythophryne beryet* Chandramouli et al.; (**b**) *Fejervarya andamanensis* (Stoliczka); (**c**) *Fejervarya nicobariensis* (Stoliczka); (**d**) *Polypedates insularis* Das; (**e**) *Hylarana nicobariensis* (Stoliczka); (**f**) *Hylarana chalconota* (Schlegel); (**g**) *Microhyla chakrapanii* Pillai; (**h**) *Microhyla heymonsi* Vogt; (**i**) *Hoplobatrachus tigerinus* (Daudin)



Eutropis multifasciata (Kuhl 1820) was reported from Andaman and Nicobar Islands but not listed by Das (1999), but recently it was collected and registered at the National Zoological Collections at Zoological Survey of India, Port Blair, Andaman and Nicobar Islands, Registration No. ZSI/ANRC (T)-4196.

Coelognathus flavolineatus was reported from Great Nicobar Islands by Daniel and David (1996), but Das (1999) did not list this species in his manuscript. *Coelognathus* sp. was documented from Great Nicobar by Harikrishnan et al. (2010a, b), but recently it was collected at Andaman Islands and registered at the National Zoological Collection at Zoological Survey of India, Port Blair, Andaman and Nicobar Islands, Registration No. ZSI/ANRC (T) -3440.

There is no recent sighting of *Cnemaspis andersonii* (Annandale 1905) since its type of locality (Narcondam Island, source: The reptile database) is in the sensitive area and no frequent surveys have been made. Recently it was collected and photographed at North and South Andaman by GK.

Ptychozoon nicobarensis Das and Vijayakumar 2009 was previously referred to as *Ptychozoon kuhli* Das, 1997. Single specimen of *Ptychozoon nicobarensis* was collected by Titus Immanuel, CIARI, Andaman and Nicobar Islands from Katchal Island, and it was deposited in National Zoological Collection at Zoological Survey of India as its previous name *Ptychozoon kuhli* Stejneger, 1902, Registration No. T 3295, date of registration February 28, 2014.

Dasia olivacea Gray, 1839, recent sighting is only from Great Nicobar Islands (per. observation) where it was collected and registered at the National Zoological Collection at Zoological Survey of India, Port Blair, Andaman and Nicobar Islands, Registration No. ZSI/ANRC (T) 3676.

There is no recent distributional record of *Xenochrophis tytleri* (Blyth 1863) in Nicobar group of islands (Harikrishnan et al. 2012).

Table 3.2 Distribution of amphibians and reptiles in A and N Islands

Species name	Island group						
	SA	MA	NA	LA	RA	LI	GN
Crocodylus porosus	✓	✓	✓	✓	✓	✓	✓
Dermochelys coriacea		✓	✓	✓			✓
Caretta caretta		✓	✓	✓			✓
Chelonia mydas			✓	✓			
Eretomochelys imbricata	✓	✓	✓	✓	✓	✓	✓
Lepidochelys olivacea							✓
Cuora amboinensis	✓		✓	✓	✓		
Lissemys punctata andersoni							✓
Cnemaspis andersonii	✓				✓	✓	✓
Cnemaspis sp.	✓	✓	✓	✓	✓	✓	
Gehyra mutilata							✓
Gekko verreauxi	✓	✓	✓	✓	✓	✓	
Gekko smithii							✓
Cyrtodactylus rubidus	✓	✓	✓	✓	✓	✓	✓
Cyrtodactylus adleri	✓					✓	
Hemidactylus frenatus	✓					✓	✓
Hemidactylus brookii	✓	✓	✓			✓	
Hemidactylus garnotii	✓			✓			✓
Hemiphyllodactylus typus	✓	✓	✓	✓	✓	✓	
Hemidactylus platyurus							✓
Lepidodactylus lugubris	✓	✓	✓			✓	
Phelsuma andamanense	✓	✓	✓	✓	✓		
Ptychozoon nicobarensis	✓	✓	✓	✓	✓	✓	
Bronchocela cristatella	✓	✓	✓	✓	✓		
Bronchocela danieli							✓
Bronchocela rubrigularis							✓
Pseudocalotes andamanensis	✓	✓	✓	✓	✓	✓	
Calotes versicolor	✓	✓	✓	✓	✓	✓	
Coryphophylax subcristatus	✓	✓	✓	✓		✓	
Coryphophylax brevicaudus							✓
Dasia nicobarensis							✓
Dasia olivacea							✓
Lipinia macrotympanum	✓	✓	✓		✓		
Lygosoma bowringii							✓
Eutropis andamanensis							✓
Eutropis tytleri	✓	✓	✓	✓	✓	✓	✓
Eutropis rudis	✓						✓
Eutropis multifasciata	✓						
Eutropis rugifera	✓	✓	✓		✓		
Sphenomorphus maculatus							

(continued)

Table 3.2 (continued)

Species name	Island group						
	SA	MA	NA	LA	RA	LI	GN
Scincella macrotis							✓
Dibamus nicobaricus							✓
Varanus salvator andamanensis							✓
Indotyphlops braminus	✓	✓	✓	✓	✓	✓	
Typhlops andamanensis	✓	✓	✓	✓		✓	
Asiatyphlops oatesii							✓
Acrochordus granulatus	✓	✓	✓	✓	✓	✓	
Xenopeltis unicolor							✓
Python reticulates							✓
Amphiesma nicobariense	✓						
Xenochrophis trianguligerus	✓	✓	✓				
Xenochrophis tytleri	✓	✓	✓	✓		✓	
Boiga andamanensis							✓
Boiga wallachi	✓	✓	✓			✓	
Chrysopelea paradisi		✓	✓				
Dendrelaphis andamanensis	✓	✓	✓	✓	✓	✓	✓
Dendrelaphis humayuni							✓
Coelognathus sp.	✓	✓	✓	✓		✓	
Coelognathus flavolineatus	✓	✓	✓	✓		✓	
Gonyosoma oxycephalum	✓	✓	✓	✓	✓	✓	
Lycodon hypsirhinoides	✓	✓	✓	✓	✓	✓	
Lycodon subcinctus	✓	✓	✓	✓			
Lycodon tiwarii	✓					✓	✓
Oligodon woodmasoni							✓
Ptyas mucosa	✓	✓	✓	✓	✓	✓	
Sibynophis bistrigatus	✓		✓	✓	✓	✓	
Gongylosoma nicobarense							
Cantoria violacea	✓	✓	✓	✓	✓	✓	
Cerberus rynchops							✓
Enhydris plumbea	✓	✓	✓	✓	✓	✓	
Bungarus andamanensis	✓	✓	✓	✓	✓	✓	
Naja sagittifera	✓						
Ophiophagus hannah	✓						
Laticauda colubrina							✓
Laticauda laticaudata	✓	✓	✓	✓	✓	✓	✓
Hydrophis cantoris	✓	✓	✓	✓	✓	✓	
Pelamis platurus							✓
Trimeresurus andersoni							✓
Trimeresurus cf. *albolabris*							✓
Trimeresurus cantor							✓

SA South Andaman, *MA* Middle Andaman, *NA* North Andaman, *LA* Little Andaman, *RA* Ritchie's Archipelago, *LI* Long Island, *GN* Great Nicobar

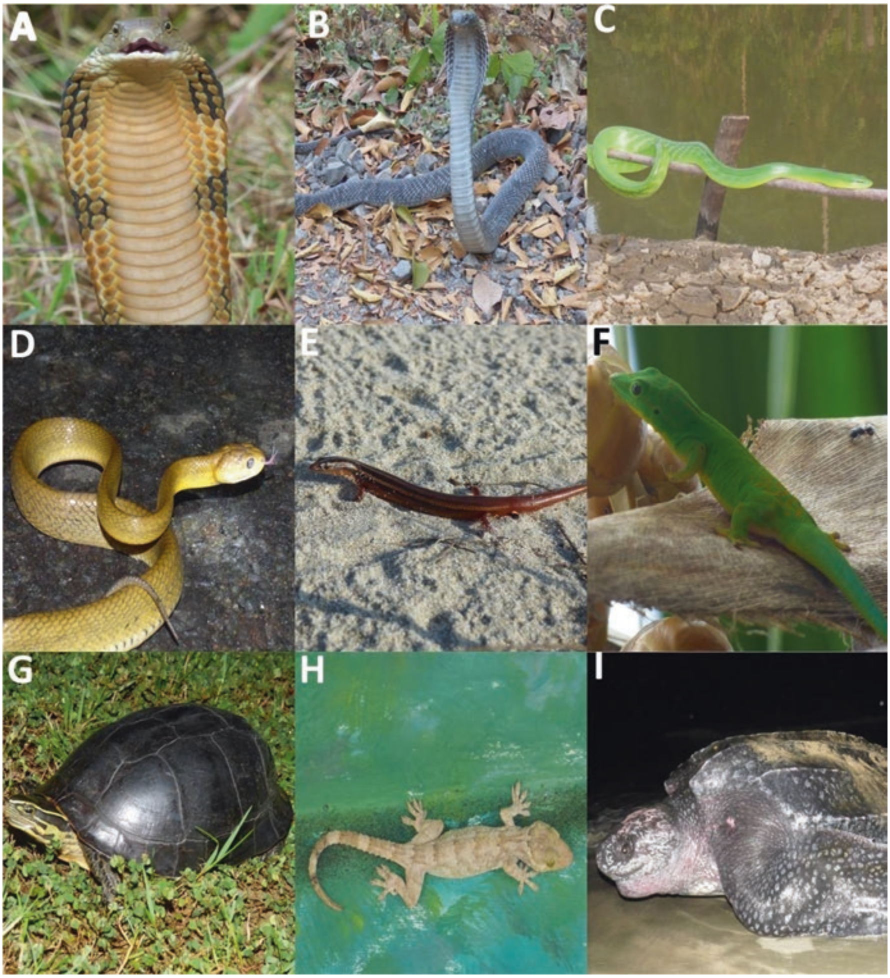


Fig. 3.2 Family-wise distribution of herpetofauna in A and N Islands

Boiga wallachi Das 1998, was recently recorded from Great Nicobar Islands (per. observation). *Dendrelaphis andamanensis* (Anderson 1871) was often confused with the species *Dendrelaphis cyanochloris* (Wall 1921) which is not reported from Andaman and Nicobar Islands.

Boiga cyanea (Dumeril and Bibron 1854) has not been sighted recently from Nicobar Islands (Harikrishnan et al. 2012).

Gonyosoma oxycephalum (Boie 1827) has not been sighted recently from Nicobar Islands *Oligodon woodmasoni* (Sclater 1981) by Harikrishnan et al. 2010a, b. But Das (1999) added this species in his list. However, *Gonyosoma oxycephalum* was recently collected from South and North Andaman Islands and registered in the

Fig. 3.3 IUCN status of herpetofauna of Andaman and Nicobar Islands

National Zoological Collection at Zoological Survey of India, Port Blair, Andaman and Nicobar Islands, Registration No. ZSI/ANRC 4533.

Enhydris plumbea (Boie 1827) was reported only from Great Nicobar Island (source: http://www.andamannicobarsnakes.com).

Trimeresurus albolabris (Gray 1842) was reported from Car Nicobar Islands, but no voucher specimens exist (Das 1999).

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4 Observations on Oviposition, Myiasis in Foam Nest, Egg Clutches, and Hatching in Endangered Tree Frog *Polypedates insularis* Das, 1995, from Great Nicobar Island, India

V. Rangasamy and C. Sivaperuman

Abstract

The Andaman and Nicobar archipelago hosts single tree frog species of the genus *Polypedates* that lives in pristine evergreen forest of Great Nicobar Islands. However, the reproductive biology of this species has received little attention. In this paper, we report the foam nest location, oviposition, Myiasis in foam nest and hatching of *Polypedates insularis.* Clutches of this species in different developmental stages were sighted in abandoned iron barrels and concrete water tanks. Clutch size ranged from 12 to 36. We documented a total of 7 and 12 foam nests of two populations from Galatea Bay and Govind Nagar 11th km area. Moreover, we document the arthropod predation on larva, seasonal color variation, road kill, and predator to this species. Our findings are important not only to understand the natural history of this species but also to conserve the endangered species.

Keywords

Great Nicobar Island · *Polypedates* · Oviposition · Myiasis, Foam nest · Tadpoles

4.1 Introduction

Andaman and Nicobar Islands, the largest archipelago situated in the Bay of Bengal, are endowed with a variety of flora and fauna (Das 1999). Great Nicobar Island is the only biosphere reserve in this union territory located at latitude 6°46′N–7°20′N

V. Rangasamy (✉)
Forest Survey of India, Eastern Zone, Salt Lake, Kolkata, India

C. Sivaperuman
Andaman and Nicobar Regional Centre, Zoological Survey of India, Port Blair, Andaman and Nicobar Islands, India

C. Sivaperuman, K. Venkataraman (eds.), *Indian Hotspots*,
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Table 4.1 Distributional data and number of individuals in different surveyed locality in Great Nicobar Island

Sl. No.	Locality	Males	Females	Latitude	Longitude
1.	Govind Nagar 6th km	2	3	06°59.945N	093°54.112E
2.	Amphibian road	2	1	07°00.151N	093°54.246E
3.	Govind Nagar shelter	1	1	07°00.127N	093°54.191E
4.	East-west road 11th km	16	10	06°59.945N	093°54.112E
5.	Afra Bay	1	1	07°11.898N	093°44′746E
6.	Shastri Nagar	2	0	06°36.300N	094°54.134E
7.	Galatea Bay 38th km	3	5	06°48′38.0N	093°52′51.9E

and longitude 93°37′E–93°56′E. Great Nicobar Island is characterized by a variety of ecosystems such as tropical wet evergreen forests, coastal plain area, estuaries, and grasslands. Diversity and natural history of amphibians and reptiles of this island are yet to be studied particularly in the northern central portions of Great Nicobar Island (Ranjit Daniels 1997). So far 19 species of amphibians were reported from this entire archipelagic island. The Rhacophorinae with 24 described species is one of the small subfamilies Frost (2017). Ten species of the genus *Polypedates* are present in India (subfamily, Rhacophorinae: *Polypedates insularis* Das 1995, *Polypedates assamensis* Mathew and Sen 2009, *Polypedates leucomystax* (Gravenhorst, 1829), *Polypedates maculatus* (Gray, 1830–1835), *Polypedates megacephalus* (Hallowell, 1861), *Polypedates occidentalis* Das and Dutta 2006, *Polypedates pseudocruciger* Das and Ravichandran 1998, *Polypedates subansiriensis* Mathew and Sen 2009, *Polypedates taeniatus* (Boulenger, 1906), and *Polypedates teraiensis* (Dubois, 1987)), and most of the species live in forests of mainland India. Rhacophorinae is represented by single species, *Polypedates insularis* Das 1995 (Chanda 2002), from this island. It differs from other species of the genus by several morphological characters such as a broader head, absence of the outer metatarsal tubercle, and smaller body size (Das 1995). Data on this species, behavior, and natural history are extremely scarce. Active individuals have been recorded in seven different localities of Great Nicobar Island during the survey period from 2013 to 2017 (Table 4.1). All individuals were found on trees, lower vegetation, on the ground, and near water bodies. It has nocturnal activity mostly, but active individuals (Female) have been sighted near the agricultural land during the day. The reproductive activities were noticed visually in Govind Nagar forested area (6th and 11th km) and Galatea Bay (38th km) mostly at night. Only males produced the advertisement calls. Until now the oviposition, foam nest location, hatching, larva, and threats were unknown. Parental care nest attendance was not observed.

4.2 Methods

All the surveys were performed during night time. The observations were made in two locations in Great Nicobar Island. It exhibits very dense forest with dense undergrowth vegetation; distributional data were collected during the period of

2013–2017. Using head lamps, we inspected the small water bodies, trees, bushes, perennial streams, and seasonal streams. The animals were captured by hand and kept in captivity for studying the oviposition and reproductive behavior. Tadpoles were collected and kept in natural environment for examination. The predation and color variation was observed opportunistically during the study period. The collected specimens were deposited at National Collection of Zoological Survey of India, Port Blair (Registration number: ZSI (T) 3314).

4.3 Results

Photographic records from different natural environment have been provided. The present study observes considerable color variation (dark brownish and pale brownish color of female, yellowish white patches on dorsum of male and female) (Fig. 4.1).

4.3.1 Oviposition

We located the amplex pair at 6.45 pm on 19th, 2017 and we kept in captivity at 7.10 pm in natural environment. Within 10 min the male mounted the female and held her below the armpit with its forelimb and forms axillary amplexus (Fig. 4.2). Both amplected pair remained for an hour. The pair was getting disturbed due to artificial light used to locate them in the cage, so we left the pair in undisturbed and predator-free condition. Within an hour, we observed the oviposition. Ovipositing females did not utilize the water sources but were observed to lay their eggs just above water level which varies from 1 foot to less than a centimeter. There is no record of the time of the day on which oviposition was documented. Communal nesting was not recorded; however, it is observed that the groups of foam nest were laid very near to each other in Galatea Bay population.

4.3.2 Egg Clutches and Myiasis in Foam Nest

We found seven egg clutches in different stages of development at 38th km road, Galatea Bay. All the clutches was laid on concrete water tanks built for road construction works filled with rainwater. Single clutch was laid on the leaf of a climber (Fig. 4.1). Moreover, 12 clutches were found in different stages of development in Govind Nagar 11th km area at April 18, 2017 (Fig. 4.2). The following day, the two new nests are discovered in the same locality.

All the clutches was in total shadow area covered by dense canopy of tree ferns and few other angiosperms mainly *Fagraea racemosa* species. Mostly clutches are laid on the wall of the abandoned iron barrels, but 5 out of 12 are located on the floor. There was no record of foam nest laid at or near the flowing stream. In order to estimate the number of eggs, we had to temporarily take out the clutch that was positioned on the stalk of tree fern leaf. The clutch of 15 yellowish white cream eggs

Fig. 4.1 Color, road kill, and habitat of *Polypedates insularis*. (**a**) Pale brownish color of female, (**b**) pale yellow dot on the dorsal side of the male, (**c**) road kill, (**d**) arthropod predation (order, Hemiptera; family, Veliidae), (**e**) visit of *Boiga wallachi* to the nesting site, (**f**) Site 1 near Govind Nagar 11th km area, (**g**) Site 2 Galatea Bay 38th km road

Fig. 4.2 Oviposition of *Polypedates insularis*. (**a**) Male and female before amplex, (**b**) amplex pair on trees, (**c**) amplex pair inside water body, (**d**) egg laying, (**e**) eggs, (**f**) male sitting near to foam nest

each measures 0.5 – 0.6 mm in size. Myasis is an infection by Dipteran fly larave in mammals and invertebrates where they depend host mainly for food. Myiasis in amphibians caused by three dipteran families called Sarcophagidae, Calliphoridae and Chlorophagidae mainly occuring in tropical and sub tropical regions (Kraus, 2007). Myiasis infection in somatic cells of *Bufo melanostictus caused by Lucilia pophyrina* (Dasgupta 1962). Though little information is available about Myiasis in amphibian fauna in India the present study reports, the Myiasis in foam nest by certain unidentified larvae (Fig. 4.3) (Maggots) of the Dipteran fly in the species *Polypedates insularis from Great Nicobar Island, India*.

4.3.3 Developmental Stages

Various developmental stages of larva and tadpoles were photographed, and staging of the tadpoles was assigned followed by Gosner 1960 (Fig. 4.3).

4.3.4 Predation and Threats

Boiga wallachi Das, 1998, and its consecutive visit to the nesting site, arthropod (order, Hemiptera; family, Veliidae) predation on its larval stage, and road mortality of *Polypedates insularis* (Male) are recorded during the study period (Fig. 4.1).

4.4 Discussion

Many aspects of the natural history of *Polypedates insularis* are still unknown. The period of metamorphosis of amphibians has been found to differ from species to species. The metamorphosis of *Polypedates leucomystax* is 60–61 days and that of *Polypedates maculates* is 55 days. Feeding, population, abundance, and particularly the reproductive biology of this species have yet to be studied. Parental care gives a level of protection from predation, desiccation, and fungal and other parasitic attacks. Parental cares in the form of nest attendance of this species have not been studied, but the single male was observed when it sits near the egg clutch (Fig. 4.2). Based on our observations, this species require microhabitats with water sources for oviposition. This species inhabits undisturbed, evergreen forest habitat for all needs. However, human activities are transforming the dense evergreen forest system. Habitat lost due to deforestation and overexploitation can threaten this species (Indraneil et al. 2004).

Fig. 4.3 Larval stages (**a**) Foam nest infected with maggots, (**b**) Maggots 3rd day (**c**) Stages 26–30 hind limb bud development stage. (**d**) Stage 39 well-developed hind limb. (**e**) Stage 44 tail shortened, well-developed forelimbs and hind limbs

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5 Diversity of Reptiles in the Indian Biodiversity Hotspots

Varadaraju

Abstract

The study deals with 406 species of reptiles in four Indian biodiversity hotspots. Of these, 200 species from Western Ghats, 175 species from Himalaya, 160 species from Indo-Burma, and 49 species from Sundaland. Of these, 107 species were endemic to Western Ghats, 21 species to Himalaya, 19 species to Indo-Burma, and 13 species to Sundaland. Among these, 1 species was listed as Extinct, 4 species as Critically Endangered, 15 species as Endangered, 25 species as Vulnerable, 16 species under Near Threatened, 53 species are Data Deficient and 168 species are listed as Least Concern IUCN (2017).

Keywords

Distribution · Diversity · Hotspots · Reptiles

5.1 Introduction

Globally there are 35 biodiversity hotspots identified, and in India there are four such hotspots, namely, Western Ghats, Himalaya, Indo-Burma, and Sundaland. The Western Ghats is known locally as the Sahyadri Hills, which are formed by the Malabar plains and the chain of mountains running parallel to India's western coast, about 30–50 km inland. They cover an area of about 160,000 km^2 and stretch for 1600 km from the country's southern tip to Gujarat in the north, interrupted only by the 30 km Palakkad Gap. The Himalaya is home to world's highest and largest

Varadaraju (✉)
Reptilia Section, Fire Proof Spirit Building, Indian Museum, Zoological Survey of India, 27, Jawaharlal Nehru Road, Kolkata, 700016, India

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mountains, covering the entire Indian Himalayan region. This immense mountain range, which covers nearly 750,000 km^2, has been divided into two regions: the Eastern Himalaya, which covers the northeast Indian states of West Bengal, Sikkim, Assam, and Arunachal Pradesh, and the Western Himalaya, covering the Kumaon-Garhwal and northwest Kashmir. Indo-Burma covers more than 2 million km^2 of Tropical Asia including the entire north-eastern India, except Assam and Andaman group of islands. The Sundaland includes the Nicobar group of islands of India.

There are about more than 566 species of reptiles reported from India, of which 3 species are crocodiles, 33 species are testudines, 234 species are lizards, and 296 species are snakes. Out of these 234 species, 42% of reptiles are endemic to the Indian subcontinent. In the present study, we listed around 406 species of reptiles in four biodiversity hotspots of India (Table 5.1). Of the recorded species, 107 species are endemic to Western Ghats, 13 species are endemic to Sundaland, 19 species are endemic to Indo-Burma, and 21 species are endemic to the Himalayan region.

5.2 Methods

The present work is based on the field studies carried out by the author and also consulted all the published work on reptiles by various scientists and researchers (Blyth 1846; Joshi and Kular 1970; Waltner 1974; Biswas and Sanyal 1977; Hussain and Ray 1995; Mathew 1995; Sanyal and Gayen 2006; Vijayakumar and David 2006; Ramakrishna and Alfred 2007; Saikia et al. 2007; Ahmed et al. 2009; Bahuguna 2010; Harikrishnan et al. 2010; Bhupathy and Sathishkumar 2013; Srinivasulu et al. 2014). The conservation status for each species listed is based on IUCN 2017.

5.2.1 Threats

Many species of reptiles completely disappeared in nature; some species declined in their population and are facing severe threats due to increasing human-based activities. The increased human population leads to increased demand for their skin and killing some species of poisonous snakes because of their venomous nature. Habitat loss and forest fire are other severe problems that threaten many species of reptiles in the wild. Crocodiles have been hunted for their skin, turtles have been killed for their eggs and meat, and many species of snakes have been killed for their skin in making ladies' bags, leather belts, etc. As per the IUCN, 2017, 1 species of reptiles is listed as extinct, 4 species are critically endangered, 15 species are endangered, 25 species are vulnerable, 16 species are near threatened, 53 species are data deficient, and 168 species are least concern.

Table 5.1 Reptiles of Indian biodiversity hotspot

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
1.	Crocodylidae	*Crocodylus palustris* Lesson, 1831	✓	✓	✓		VU
2.		*Crocodylus porosus* Schneider, 1801	✓			✓	LC
3	Gavialidae	*Gavialis gangeticus* (Gmelin, 1789)		✓	✓		CR
4	Bataguridae	*Melanochelys tricarinata* (Blyth, 1856)		✓	✓		VU
5		*Melanochelys trijuga* (Schweigger, 1812)	✓	✓	✓		NT
6		*Hardella thurjii* (Gray, 1831)			✓		VU
7		*Geoclemys hamiltonii* (Gray, 1831)		✓	✓		VU
8		*Pangshura smithii* Gray, 1863		✓	✓		NT
9		*Pangshura tectum* Gray, 1830		✓	✓		LC
10		*Batagur dhongoka* Gray, 1832		✓	✓		EN
11		*Batagur kachuga* (Gray, 1831)		✓			CR
12		*Cuora amboinensis* (Daudin, 1802)		✓	✓	✓	VU
13		*Cuora mouhotii* (Gray, 1862)		✓	✓		EN
14		*Pangshura sylhetensis* Jerdon, 1870		✓	✓		EN
15		*Pangshura tentoria* Gray, 1834		✓	✓		LC
16		*Morenia petersi* (Anderson, 1879)		✓	✓		VU
17		*Cyclemys gemelli* (Fritz et al. 2008)		✓	✓		LC
18		*Vijayachelys silvatica* (Henderson, 1812)	✓				LC
19	Testudinidae	*Indotestudo elongata* (Blyth, 1853)		✓			EN

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
20		*Indotestudo travancorica* (Boulenger, 1907)	✓				VU
21		*Geochelone elegans* (Schoepff, 1795)	✓				LC
22		*Manouria emys* (Schlegel & Muller, 1840)			✓		EN
23	Trionychidae	*Lissemys punctata* (Bonnaterre, 1789)		✓	✓		LC
24		*Amyda cartilaginea* (Boddaert, 1770)			✓		VU
25		*Chitra indica* (Gray, 1830)		✓	✓		CR
26		*Nilssonia gangetica* (Cuvier, 1825)		✓	✓		VU
27		*Nilssonia hurum* (Gray, 1830)		✓	✓		VU
28		*Nilssonia nigricans* (Anderson, 1875)		✓	✓		Extinct in the wild
29		*Chelonia mydas* (Linnaeus, 1758)				✓	EN
30		*Eretmochelys imbricata* (Linnaeus, 1766)				✓	CR
31		*Lepidochelys olivacea* (Eschescholtz, 1829)				✓	VU
32		*Dermochelys coriacea* (Vandelli, 1761)				✓	VU
33	Agamidae	*Draco maculatus* Gray, 1845		✓	✓		LC
34		*Draco norvillii* Alcock, 1895	✓				
35		*Bronchocela danieli* (Tiwari & Biswas, 1973)				✓	
36		*Bronchocela jubata* Dumeril & Bibron, 1837				✓	LC

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
37		*Bronchocela cristatella* (Kuhl, 1820)				✓	
38		*Japalura tricarinata* (Blyth, 1854)		✓			LC
39		*Japalura major* (Jerdon, 1870)		✓			
40		*Japalura kumaoensis* (Annandale, 1907)		✓			
41		*Japalura andersoniana* Annandale, 1905		✓	✓		
42		*Japalura variegata* Gray, 1853		✓	✓		LC
43		*Japalura planidorsata* Jerdon, 1870		✓	✓		
44		*Calotes aurantolabium* Krishnan, 2007	✓				DD
45		*Calotes mystaceus* Dumeril & Bibron, 1837			✓	✓	
46		*Calotes calotes* (Linnaeus, 1758)	✓				LC
47		*Calotes ellioti* Gunther, 1864	✓				LC
48		*Calotes grandisquamis* Gunther, 1875	✓				LC
49		*Calotes nemoricola* Jerdon, 1853	✓				LC
50		*Calotes rouxii* Dumeril & Bibron, 1837	✓				LC
51		*Calotes versicolor* (Daudin, 1812)	✓	✓	✓	✓	LC
52		*Calotes jerdoni* Gunther, 1871		✓	✓		
53		*Calotes emma* Gray, 1845		✓	✓		
54		*Draco dussumieri* Dumeril & Bibron, 1837	✓				LC

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
55		*Draco blanfordii* Boulenger, 1885			✓		
56		*Otocryptis beddomii* Boulenger, 1885	✓				EN
57		*Psammophilus blanfordanus* (Stoliczka,1871)	✓				LC
58		*Psammophilus dorsalis* Griffith & Pidgeon, 1831	✓				LC
59		*Salea anamallayana* (Beddome, 1878)	✓				LC
60		*Salea horsfieldii* Gray, 1845	✓				LC
61		*Sitana ponticeriana* Cuvier, 1829	✓				LC
62		*Laudakia tuberculata* (Hardwicke & Gray, 1827)		✓			
63		*Pseudocalotes austeniana* (Annandale, 1908)		✓	✓		
64		*Pseudocalotes microlepis* (Boulenger, 1888)			✓		
65		*Ptyctolaemus gularis* (Peters, 1864)		✓	✓		
66		*Oriocalotes paulus* Smith, 1935		✓			
67	Chamaeleonidae	*Chamaeleo zeylanicus* Laurentii, 1768	✓				LC
68	Eublepharidae	*Eublepharis fuscus* (Borner, 1981)	✓				LC
69	Gekkonidae	*Cyrtodactylus fasciolatus* (Blyth, 1860)		✓			
70		*Cyrtodactylus khasiensis* (Jerdon, 1870)		✓	✓		
71		*Cyrtodactylus gubernatoris* (Annandale, 1913)		✓			NT

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
72		*Cyrtodactylus lawderanus* (Stoliczka, 1871)		✓			
73		*Cnemaspis australis* Manamendra-Arachchi et al. 2007	✓				DD
74		*Cnemaspis beddomei* (Theobald, 1876)	✓				DD
75		*Cnemaspis goaensis* Sharma, 1976	✓				EN
76		*Cnemaspis gracilis* (Beddome, 1870)	✓				LC
77		*Cnemaspis heteropholis* Bauer, 2002	✓				NT
78		*Cnemaspis indica* Gray, 1846	✓				VU
79		*Cnemaspis indraneildasii* Bauer, 2002	✓				VU
80		*Cnemaspis jerdonii* (Theobald, 1868)	✓				VU
81		*Cnemaspis kolhapurensis* Giri et al. 2009	✓				DD
82		*Cnemaspis littoralis* (Jerdon, 1854)	✓				DD
83		*Cnemaspis monticola* Manamendra-Arachchi et al. 2007	✓				DD
84		*Cnemaspis mysoriensis* (Jerdon, 1854)	✓				LC
85		*Cnemaspis nairi* Inger, Marx & Koshi, 1984	✓				NT
86		*Cnemaspis nilagirica* Manamendra-Arachchi et al. 2007	✓				DD
87		*Cnemaspis ornata* (Beddome, 1870)	✓				NT

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
88		*Cnemaspis otai* Das & Bauer, 2000	✓				VU
89		*Cnemaspis assamensis* Das & Sengupta, 2000		✓	✓		
90		*Cnemaspis sisparensis* (Theobald, 1876)	✓				NT
91		*Cnemaspis wynadensis* (Beddome, 1870)	✓				EN
92		*Geckoella albofasciatus* (Boulenger, 1885)	✓				LC
93		*Geckoella collegalensis* (Beddome, 1870)	✓				LC
94		*Geckoella deccanensis* (Gunther, 1864)	✓				LC
95		*Gekko gecko* (Linnaeus, 1758)		✓	✓		
96		*Gehyra mutilata* (Weigmann, 1834)	✓			✓	LC
97		*Hemidactylus aaronbaueri* Giri, 2008	✓				LC
98		*Hemidactylus albofasciatus* Grandson & Soman, 1963	✓				VU
`99		*Hemidactylus anamallensis* (Gunther, 1875)	✓				NT
100		*Hemidactylus brookii* Gray, 1845	✓	✓	✓		LC
101		*Hemidactylus bowringii* (Gray, 1845)		✓	✓		
102		*Hemidactylus flaviviridis* Ruppell, 1835	✓	✓	✓		LC
103		*Hemidactylus frenatus* Dumeril & Bibron, 1836	✓	✓	✓	✓	LC

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
104		*Hemidactylus gracilis* Blanford , 1870	✓				LC
105		*Hemidactylus graniticolus* Agarwal et al. 2011	✓				LC
106		*Hemidactylus leschenaultii* Dumeril & Bibron, 1836	✓	✓			LC
107		*Hemidactylus maculatus* Dumeril & Bibron, 1836	✓				LC
108		*Hemidactylus prashadi* Smith, 1935	✓				LC
109		*Hemidactylus reticulatus* Beddome, 1870	✓				LC
110		*Hemidactylus sataraensis* Giri & Bauer, 2008	✓				VU
111		*Hemidactylus triedrus* (Daudin, 1802)	✓				LC
112		*Hemidactylus garnotii* Dumeril & Bibron, 1836		✓	✓	✓	
113		*Hemidactylus karenorum* (Theobald, 1868)		✓	✓		
114		*Hemidactylus platyurus* (Schneider, 1792)		✓	✓	✓	
115		*Ptychozoon lionotum* Annandale, 1905			✓		
116		*Ptychozoon kuhli* (Stejneger, 1902)				✓	
117		*Hemiphyllodactylus typus* Bleeker, 1860				✓	LC
118		*Hemiphyllodactylus aurantiacus* Beddome, 1870	✓				LC

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
119	Lacertidae	*Ophisops beddomei* (Jerdon, 1870)	✓				LC
120		*Ophisops jerdonii* Blyth, 1853	✓	✓			LC
121		*Ophisops leschenaultia* Milne-Edwards, 1829	✓				LC
122		*Ophisops microlepis* Blanford, 1870	✓				LC
123		*Takydromus khasiensis* (Boulemegr, 1917)		✓	✓		
124		*Takydromus haughtonianus* (Jerdon, 1870)		✓	✓		
125		*Takydromus sexlineatus* Daudin, 1802			✓		LC
126	Scincidae	*Chalcides pentadactylus* (Beddome, 1870)	✓				DD
127		*Dasia subcaeruleum* (Boulenger, 1891)	✓				EN
128		*Dasia nicobarensis* Biswas & Sanyal, 1977				✓	
129		*Dasia olivacea* Gray, 1839				✓	LC
130		*Eurylepis poonaensis* (Sharma, 1970)	✓				EN
131		*Eurylepis taeniolatus* Blyth, 1854		✓			
132		*Eutropis allapallensis* (Schmidt, 1926)	✓				LC
133		*Eutropis beddomii* (Jerdon, 1870)	✓				LC
134		*Eutropis carinata* (Schneider, 1801)	✓	✓	✓		LC
135		*Eutropis clivicola* (Inger et al. 1984)	✓				EN

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
136		*Eutropis gansi* (Das, 1991)	✓				DD
137		*Eutropis macularia* (Blyth, 1853)	✓	✓	✓		LC
138		*Eutropis trivittata* (Hardwicke & Gray, 1827)	✓				LC
139		*Eutropis rugifera* (Stoliczka, 1870)				✓	
140		*Eutropis rudis* (Boulenger, 1887)				✓	
141		*Eutropis multifasciata* (Kuhl, 1820)		✓	✓	✓	
142		*Eutropis quadricarinata* (Boulenger, 1887)		✓	✓		
143		*Eutropis dissimilis* (Hallowell 1857)			✓		
144		*Kaestlea beddomei* (Boulenger, 1887)	✓				LC
145		*Kaestlea bilineata* (Gray, 1846)	✓				LC
146		*Kaestlea laterimaculata* (Boulenger, 1887)	✓				VU
147		*Kaestlea palnica* (Boettger, 1892)	✓				DD
148		*Kaestlea travancorica* (Beddome, 1870)	✓				LC
149		*Lygosoma albopunctata* (Gray, 1846)	✓		✓		LC
150		*Lygosoma goaensis* (Sharma, 1976)	✓				DD
151		*Lygosoma guentheri* (Peteers, 1879)	✓				LC
152		*Lygosoma lineata* (Gray, 1839)	✓				LC
153		*Lygosoma punctata* (Gmelin, 1799)	✓	✓			LC
154		*Lygosoma bowringii* (Gunther, 1864)			✓		

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot				IUCN status
			Western Ghats	Himalaya	Indo-Burma	Sundaland	
155		*Ristella beddomii* (Boulenger, 1887)	✓				LC
156		*Ristella guentheri* (Boulenger, 1887)	✓				DD
157		*Ristella rurkii* Gray, 1839	✓				DD
158		*Ristella travancorica* (Beddome, 1870)	✓				DD
159		*Sphenomorphus dussumieri (*Dumeril & Bibron, 1834)	✓				LC
160		*Sphenomorphus indicus* (Gray, 1853)		✓	✓		
161		*Sphenomorphus maculatus* (Blyth, 1853)		✓	✓	✓	
162		*Sphenomorphus courcyanum* (Annandale, 1912)		✓	✓		
163		*Lipinia macrotympanum* (Stoliczka, 1873)				✓	
164		*Asymblepharus himalayanus* (Gunther, 1864)		✓			
165		*Tropidophorus assamensis* Annandale, 1912		✓	✓		
166		*Ablepharus pannonicus* (Fitzinger, 1823)		✓			
167	Anguidae	*Ophisaurus gracilis* (Gray, 1845)		✓	✓		
168	Dibamidae	*Dibamus nicobaricus* (Steindachner, 1867)				✓	LC
169	Varanidae	*Varanus bengalensis* (Daudin, 1802)	✓	✓	✓		LC
170		*Varanus flavescens* (Hardwicke& Gray, 1827)		✓	✓		LC

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
171		*Varanus salvator* (Laurenti, 1768)		✓	✓		LC
172		*Varanus salvator nicobarensis*				✓	
173	Typhlopidae	*Grypotyphlops acutus (*Dumeril & Bibron, 1844)	✓				LC
174		*Indotyphlops braminus* (Daudin, 1803)	✓		✓	✓	LC
175		*Indotyphlops exiguous* Jan, 1864	✓				DD
176		*Indotyphlops porrectus* Stoliczka, 1871	✓	✓			LC
177		*Indotyphlops thurstoni* Boetgger, 1890	✓				DD
178		*Indotyphlops bothriorhynchus* Gunther, 1864			✓		DD
179		*Indotyphlops diardii* Schlegel, 1839		✓	✓		LC
180		*Indotyphlops jerdoni* Boulenger, 1890		✓	✓		
181		*Indotyphlops oligolepis* Wall, 1909		✓			
182		*Indotyphlops tenuicollis* (Peters, 1864)		✓	✓		DD
183		*Indotyphlops meszoelyi* Wallach, 1999		✓			DD
184	Gerrhopilidae	*Gerrhopilus beddomii* Boulenger, 1890	✓				DD
185		*Gerrhopilus tindalli* (Smith, 1943)	✓				DD
186	Uropeltidae	*Brachyophidium rhodogaster* Wall, 1921	✓				LC

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
187		*Melanophidium bilineatum* Beddome, 1870	✓				VU
188		*Melanophidium punctatum* Beddome, 1871	✓				LC
189		*Melanophidium wynaudense* (Beddome, 1863)	✓				LC
190		*Platyplectrurus madurensis* Beddome, 1877	✓				EN
191		*Platyplectrurus trilineatus* (Beddome, 1867)	✓				DD
192		*Plectrurus aureus* Beddome, 1880	✓				DD
193		*Plectrurus canaricus* (Beddome, 1870)	✓				DD
194		*Plectrurus guentheri* Beddome, 1863	✓				DD
195		*Plectrurus perroteti* Dumeril & Bibroni, 1854	✓				LC
196		*Rhinophis fergusonianus* Boulenger, 1892	✓				DD
197		*Rhinophis sanguineus* Beddome, 1863	✓				LC
198		*Rhinophis travancoricus* Boulenger, 1892	✓				EN
199		*Teretrurus sanguineus* (Beddome, 1867)	✓				LC
200		*Uropeltis arcticeps* (Gunther, 1875)	✓				LC
201		*Uropeltis beddomii* (Gunther, 1862)	✓				DD
202		*Uropeltis bicatenata* (Gunther, 1864)	✓				NT

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
203		*Uropeltis broughami* (Beddome, 1878)	✓				DD
204		*Uropeltis ceylanica* Cuvier, 1829	✓				LC
205		*Uropeltis dindigalensis* (Beddome, 1877)	✓				DD
206		*Uropeltis ellioti* (Gray, 1858)	✓				LC
207		*Uropeltis liura* (Gunther, 1875)	✓				DD
208		*Uropeltis macrolepis* (Peters, 1862)	✓				LC
209		*Uropeltis macrorhyncha* (Beddome, 1877)	✓				DD
210		*Uropeltis maculata* (Beddome, 1878)	✓				DD
211		*Uropeltis myhendrae* (Beddome, 1886)	✓				DD
212		*Uropeltis nitida* (Beddome, 1878)	✓				DD
213		*Uropeltis ocellatus* (Beddome, 1863)	✓				LC
214		*Uropeltis petersi* (Beddome, 1878)	✓				DD
215		*Uropeltis phipsonii* (Mason, 1888)	✓				VU
216		*Uropeltis pulneyensis* (Beddome, 1863)	✓				LC
217		*Uropeltis rubrolineatus* (Gunther, 1875)	✓				LC
218		*Uropeltis rubromaculatus* (Beddome, 1867)	✓				LC
219		*Uropeltis smithi* Gans, 1966	✓				NT
220		*Uropeltis woodmasoni* (Theobald, 1876)	✓				LC

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
221	Xenopeltidae	*Xenopeltis unicolor* Boie, 1827				✓	LC
222	Pythonidae	*Python molurus* (Linnaeus, 1758)	✓	✓			NT
223		*Python molurus bivittatus* Kuhl, 1820			✓		VU
224		*Python reticulatus* (Schneider, 1801)		✓	✓	✓	
225	Boidae	*Eryx johnii* (Russell, 1801)	✓	✓			NT
226		*Eryx whitakeri* Das, 1991	✓				NT
227		*Gongylophis conicus* (Schneider, 1801)	✓	✓			NT
228	Acrochordidae	*Acrochordus granulatus* (Schneider, 1799)				✓	LC
229	Colubridae	*Pareas macularius* Theobald, 1868		✓			
230		*Pareas monticola* (Cantor, 1839)		✓	✓		
231		*Coelognathus flavolineatus* (Schlegel, 1837)				✓	LC
232		*Elaphe prasina* (Blyth, 1854)		✓			
233		*Ahaetulla prasina* (Boie, 1827)		✓	✓		LC
234		*Ahaetulla fronticincta* (Gunther, 1858)		✓	✓		LC
235		*Ahaetulla dispar* (Gunther, 1864)	✓				NT
236		*Ahaetulla nasuta* (Lacepede, 1789)	✓	✓	✓		LC
237		*Ahaetulla perroteti* (Dumeril et al. 1854)	✓				EN
238		*Ahaetulla pulverulenta* (Dumeril et al. 1854)	✓				LC

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
239		*Argyrogena fasciolata* (Shaw, 1802)	✓				LC
240		*Boiga beddomei* (Wall, 1909)	✓				DD
241		*Boiga ceylonensis* (Gunther, 1858)	✓				LC
242		*Boiga dightoni* (Boulenger, 1894)	✓				DD
243		*Boiga forsteni* (Dumeril et al. 1854)	✓	✓			LC
244		*Boiga nuchalis* Gunther, 1875)	✓		✓		DD
245		*Boiga trigonata* (Bechstein, 1802)	✓	✓			LC
246		*Boiga ochracea* (Gunther, 1868)		✓	✓		
247		*Boiga gokool* (Gray, 1834)		✓	✓		
248		*Boiga cyanea* (Dumeril et al. 1854)		✓	✓	✓	
249		*Boiga multifasciata* (Blyth, 1861)		✓			DD
250		*Boiga quincuciata* (Wall, 1908)		✓	✓		
251		*Boiga multomaculata* (Boie, 1827)			✓		
252		*Boiga siamensis* Nutaphand, 1971			✓		
253		*Boiga wallachi* Das 1997				✓	DD
254		*Psammodynastes pulverulentus* (Boie, 1827)		✓	✓		
255		*Blythia reticulata* (Blyth, 1854)		✓	✓		DD
256		*Psammophis condanarus* (Merrem, 1820)					LC
257		*Psammophis leithii* (Gunther, 1869)					LC

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
258		*Psammophis longifrons* Boulenger, 1896					LC
259		*Calamaria pavimentata* Dumeril et al. 1854		✓	✓		LC
260		*Macrophistodon plumbicolor* (Cantor, 1839)		✓			
261		*Chrysopelea ornata* (Shaw, 1802)	✓		✓		LC
262		*Coelognathus helena* (Daudin, 1803)	✓	✓	✓		LC
263		*Coelognathus radiatus* Boie, 1827		✓	✓		LC
264		*Coluber gracilis* (Gunther , 1862)	✓				DD
265		*Coronella brachyura* (Gunther, 1866)	✓				LC
266		*Dendrelaphis ashoki* Rooijen & Vogel, 2011	✓				LC
267		*Dendrelaphis caudolineatus* (Gunther, 1869)	✓				DD
268		*Dendrelaphis chairecaeos* (Boie, 1827)	✓				DD
269		*Dendrelaphis gorei* (Wall, 1910)	✓	✓	✓		LC
270		*Dendrelaphis grandoculis* (Boulenger, 1890)	✓				LC
271		*Dendrelaphis tristis* (Daudin, 1803)	✓				LC
272		*Dendrelaphis pictus* (Gmelin, 1789)			✓	✓	
273		*Dendrelaphis cyanochloris* (Wall, 1921)		✓	✓		LC
274		*Dendrelaphis subocularis* (Boulenger, 1888)			✓		LC

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
275		*Dendrelaphis humayuni* Tiwari & Biswas, 1973				✓	
276		*Cyclophiops doriae* (Boulenger, 1888)			✓		
277		*Dryocalamus gracilis* (Gunther, 1864)	✓				DD
278		*Dryocalamus nympha* (Daudin, 1803)	✓				LC
279		*Elachistodon westermanni* Reinhardt, 1863	✓	✓			LC
280		*Liopeltis calamaria* (Gunther, 1858)	✓	✓			LC
281		*Liopeltis stoliczkae* (Sclater, 1891)		✓	✓		LC
282		*Liopeltis rappii* (Gunther, 1860)		✓			DD
283		*Liopeltis frenatus* (Gunther, 1858)		✓	✓		LC
284		*Lycodon aulicus* (Linnaeus, 1754)	✓	✓	✓		LC
285		*Lycodon flavomaculatus* (Wall, 1907)	✓				LC
286		*Lycodon striatus* (Shaw, 1802)	✓	✓			LC
287		*Lycodon travancoricus* (Beddome, 1870)	✓				LC
288		*Lycodon jara* (Shaw, 1802)		✓	✓		LC
289		*Lycodon mackinnoni* (Wall, 1906)		✓			
290		*Lycodon fasciatus* (Anderson, 1870)		✓	✓		
291		*Lycodon zawi* Slowinski et al. 2001		✓	✓		LC
292		*Lycodon laoensis* (Gunther, 1864)			✓		LC

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
293		*Lycodon tiwari* Biswas & Sanyal, 1965				✓	
294		*Lycodon subcinctus* Boie, 1827				✓	LC
295		*Dinodon septentrionalis* (Gunther, 1875)		✓	✓		
296		*Dinodon gammiei* (Blanford, 1878)		✓	✓		
297		*Sibynophis collaris* (Gray, 1853)		✓	✓		LC
298		*Sibynophis sagittarius* (Cantor, 1839)		✓			
299		*Amphiesma parallelum* (Boulenger, 1890)		✓	✓		
300		*Rhabdophis himalayanus* (Gunther, 1864)		✓	✓		
301		*Rhabdophis subminiatus* (Schlegel, 1837)		✓	✓		LC
302		*Rhabdophis nuchalis* (Boulenger, 1891)		✓	✓		LC
303		*Rhadinophis frenatum* (Gray, 1853)		✓	✓		
304		*Rhadinophis prasinum* (Blyth, 1854)		✓	✓		
305		*Xenochrophis piscator* (Schneider, 1799)		✓	✓		
306		*Xenochrophis sancti-johannis* (Boulenger, 1890)		✓	✓		
307		*Xenochrophis cerasogaster* (Cantor, 1839)			✓		
308		*Xenochrophis flavipunctatus* (Hallowell, 1860)			✓		LC

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
309		*Xenochrophis schrurrenbergeri* Kramer, 1977			✓		
310		*Xenochrophis trianguligerus* (Boie, 1827)				✓	LC
311		*Xenochrophis nicobarensis*				✓	
312		*Stoliczkia khasiensis* Jerdon, 1870			✓		
313		*Sinomatrix percarinata* (Boulenger, 1899)			✓		LC
314		*Amphiesma khasiense* (Boulenger, 1890)		✓	✓		
315		*Amphiesma platyceps* (Blyth, 1854)		✓	✓		
316		*Amphiesma stolatum* (Linnaeus, 1758)		✓	✓		
317		*Amphiesma modesta* (Gunther, 1875)		✓	✓		
318		*Amphiesma pealii* (Sclater, 1891)		✓	✓		
319		*Amphiesma xenura* (Wall, 1907)		✓	✓		
320		*Amphiesma sieboldii* (Gunther, 1860)			✓		
321		*Amphiesma beddomei* (Gunther, 1864)			✓		LC
322		*Amphiesma monticola* (Jerdon, 1853)			✓		LC
323		*Atretium schistosum* (Daudin, 1803)			✓		LC
324		*Pseudoxenodon macrops* (Blyth, 1854)		✓	✓		LC

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
325		*Trachischium fuscum* (Blyth, 1854)		✓	✓		
326		*Trachischium guentheri* (Boulenger, 1890)		✓			LC
327		*Trachischium tenuiceps* (Blyth, 1854)		✓	✓		
328		*Trachischium leave* Peracea, 1904		✓			
329		*Trachischium monticola* (Cantor, 1839)		✓	✓		
330		*Oligodon affinis* Gunther, 1862	✓				LC
331		*Oligodon arnensis* (Shaw, 1802)	✓	✓			LC
332		*Oligodon brevicauda* (Gunther, 1862)	✓				VU
333		*Oligodon nikhili* Whitaker & Dattatri, 1982	✓				DD
334		*Oligodon taeniolatus* Jerdon, 1853	✓				LC
335		*Oligodon travancoricus* Beddome, 1877	✓				DD
336		*Oligodon venustus* Jerdon, 1853	✓				LC
337		*Oligodon jagalandifer* (Wall, 1909)	✓	✓			VU
338		*Oligodon melaneus* Wall, 1909	✓	✓			
339		*Oligodon erythrogaster* Boulenger, 1907	✓	✓			
340		*Oligodon cinereus* (Gunther, 1864)	✓	✓	✓		LC
341		*Oligodon melanzonatus* (Wall, 1922)	✓	✓	✓		

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
342		*Oligodon cyclurus* (Cantor, 1839)	✓	✓	✓		LC
343		*Oligodon albocinctus* (Cantor, 1839)	✓	✓	✓		
344		*Oligodon dorsalis* (Gray & Hardwicke, 1834)	✓	✓	✓		
345		*Oligodon erythrorachis* Wall 1910	✓	✓	✓		DD
346		*Oligodon catenatus* (Blyth, 1854)			✓		
347		*Oligodon theobaldi* (Gunther, 1868)			✓		LC
348		*Oligodon woodmasoni* (Sclater, 1891)				✓	
349		*Orthriophis taeniurus* (Cope, 1861)		✓	✓		
350		*Orthriophis hodgsoni* (Gunther, 1860)		✓	✓		
351		*Orthriophis cantoris* (Cantor, 1839)		✓	✓		
352		*Oreocryptophis porphyraceus* (Cantor, 1839)		✓	✓		
353		*Ptyas mucosa* (Linnaeus, 1758)	✓	✓	✓		LC
354		*Ptyas korros* (Schlegel, 1857)		✓	✓		
355		*Ptyas nigromarginata* (Blyth, 1854)		✓	✓		
356		*Spalerosophis diadema* (Schlegel, 1837)		✓			
357		*Platyceps ventromaculatus* (Gray, 1834)		✓			

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
358		*Platyceps rhodorachis* (Jan, 1865)		✓			
359		*Rhabdops olivaceus* (Beddome, 1863)	✓				LC
360		*Rhabdops bicolour* (Blyth, 1854)		✓	✓		
361		*Sibynophis subpunctatus* (Dumeril et al. 1854)	✓				LC
362		*Euprepiophis mandarinus* (Cantor, 1840)			✓		LC
363		*Fordonia leucobalia* (Schlegel, 1837)				✓	LC
364		*Xylophis captaini* Gower & Winkler, 2007	✓				LC
365		*Xylophis perroteti* (Dumeril et al. 1854)	✓				LC
366		*Xylophis stenorhynchus* (Gunther, 1875)	✓				DD
367	Homolopsidae	*Enhydris enhydris* (Schneider, 1799)		✓	✓		LC
368		*Enhydris sieboldii* (Schlegel, 1837)		✓	✓		LC
369		*Enhydris dussumieri* (Dumeril et al. 1854)		✓			LC
370		*Cerberus rynchops* (Schneider, 1799)				✓	LC
371		*Gerarda prevostiana* (Eydoux & Gervais, 1822)				✓	LC
372	Elapidae	*Bungarus caeruleus* (Schneider, 1801)	✓	✓			LC
373		*Calliophis beddomei* Smith, 1943	✓				DD

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
374		*Calliophis bibroni* (Jan, 1858)	✓				LC
375		*Calliophis melanurus* (Shaw, 1802)	✓				LC
376		*Calliophis nigrescens* (Gunther, 1862)	✓				LC
377		*Naja naja* (Linnaeus, 1758)	✓	✓	✓		LC
378		*Ophiophagus Hannah* (Cantor, 1836)	✓	✓	✓		VU
379		*Bungarus bungaroides* (Cantor, 1839)		✓	✓		
380		*Bungarus fasciatus* (Schneider, 1801)		✓	✓		LC
381		*Bungarus niger* Wall 1908		✓	✓		
382		*Bungarus lividus* Cantor, 1839			✓		
383		*Sinomicrurus macclellandi* (Reinhardt, 1844)		✓	✓		
384		*Naja oxiana* (Eichwald, 1831)		✓			DD
385		*Naja kaouthia* Lesson, 1831		✓	✓		LC
386	Hydrophiidae	*Laticauda colubrina* (Schneider, 1799)				✓	LC
387		*Pelamis platura* (Linnaeus, 1766)				✓	LC
388	Viperidae	*Daboia russelii* (Shaw & Nodder, 1797)	✓	✓	✓		LC
389		*Echis carinatus* (Schneider, 1801)	✓	✓			LC
390		*Hypnale hypnale* (Merrem, 1820)	✓				LC
391		*Trimeresurus macrolepis* Beddome, 1862	✓				NT

(continued)

Table 5.1 (continued)

Sl. No.	Family	Species name	Biodiversity hotspot: Western Ghats	Himalaya	Indo-Burma	Sundaland	IUCN status
392		*Trimeresurus gramineus* (Shaw, 1802)	✓				LC
393		*Trimeresurus malabaricus* (Jerdon, 1854)	✓				LC
394		*Trimeresurus strigatus* Gray, 1842	✓				DD
395		*Macrovipera lebetina* (Linnaeus, 1758		✓			
396		*Gloydius himalayanus* (Gunther, 1864)		✓			LC
397		*Ovophis monticola* (Gunther, 1864)		✓	✓		LC
398		*Trimeresurus popeiorum* Smith , 1937		✓	✓		
399		*Trimeresurus albolabris* Gray, 1842			✓	✓	
400		*Trimeresurus erythrurus* (Cantor, 1839)		✓	✓		
401		*Trimeresurus andersoni* Theobald, 1868				✓	
402		*Trimeresurus cantor* (Blyth, 1846)				✓	
403		*Trimeresurus labialis* Fitzinger, 1867				✓	
404		*Protobothrops mucrosquamatus* (Cantor, 1839)		✓			LC
405		*Protobothrops jerdonii* (Gunther, 1875)			✓		LC
406		*Protobothrops kaulbacki* (Smith, 1940)			✓		DD

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Avifauna of Andaman and Nicobar Islands with an Updated Checklist

6

Chandrakasan Sivaperuman, G. Gokulakrishnan, P. C. Rasmussen, and P. Parthipan

Abstract

The Andaman and Nicobar archipelago consists of 572 islands, islets and rocky outcrops extending over 800 km. Biodiversity is very rich in this archipelago and endemism is also high due to isolation. The studies on the avifauna of this region were carried out by the authors from 2008 through 2017 covering extensive field survey in various islands. This paper was prepared based on the field surveys and available literature. A total of 349 species/subspecies of birds were recorded from Andaman and Nicobar Islands in this paper.

Keywords

Avifauna · Checklist · Distribution · Conservation · Andaman · Nicobar

6.1 Introduction

Birds are widely used as the best indicators of the ecosystem, ecological evaluation and conservation planning (Cody 1985; Wiens 1989; Canterbury et al. 2000). Identifying areas of high biodiversity value is of greatest importance in conservation and management of any ecologically significant and sensitive area. Birds are one of the better studied groups of vertebrates and they play an important role in the ecosystem. The island ecosystems are highly vulnerable because of their fragile nature and many island species are threatened globally. An assessment of current status, distribution and habitat

C. Sivaperuman (✉) · G. Gokulakrishnan · P. Parthipan
Andaman and Nicobar Regional Centre, Zoological Survey of India, Port Blair, Andaman and Nicobar Islands, India

P. C. Rasmussen
Department of Integrative Biology and MSU Museum, Michigan State University, East Lansing, MI, USA

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would benefit from the past surveys, natural history observations, community studies and abundance estimates. The tropical lowland forests are predominant in the islands and support most of the endemics and threatened birds in the world. Over 11% of all bird species in the world and about 12% in Asia are threatened with extinction; the majority of these are found in tropical forests and islands (Collar 1994; Stattersfield et al. 1998; BirdLife International 2001). The single most important forest type is tropical lowland moist forests with about 70% of threatened forest birds (BirdLife International 2001). The Andaman and Nicobar Islands constitute a globally important biodiversity hotspot. Because they are off the mainland and isolated, endemism is very high in all taxa, but especially in reptiles, plants, fish and corals (Rao et al. 1980; Das 1999a, b and Andrews 2001). According to the BirdLife International, 31% of the endemic or restricted-range bird species of the world is threatened and 19% near threatened (Stattersfield et al. 1998). These islands are one of the endemic bird areas (Stattersfield et al. 1998). A total of 30 species are considered to be restricted in distribution in the Islands of which 21 species were reported from Andaman group of islands and 9 species were reported from Nicobar group of islands (Stattersfield et al. 1998). The diversity at the subspecies level is very high, with different subspecies present in different islands on account of their geographical separations (Gandhi 2000). The description of the structure and functioning of bird communities is useful in ecological theory and conservation practice (DeSante 1990; Kremen 1992; Chettri et al. 2001). Inventory of status and population of wildlife is an integral part of their management (Mendoza 1986). A plan for conservation of a species can only be developed if there is adequate biological information about the species (Alcala 1976).

Therefore, an attempt was made to compile the available information and provide conservation measures. The present paper reports a total of 343 species based on extensive field survey carried out on various parts of this archipelago and available literature. The increased intensive and extensive field survey on avifaunal research in the Islands in recent years has culminated in numerous new records, namely, the slaty-legged crake, pheasant-tailed jacana, grey-faced buzzard, mugimaki flycatcher, blue-winged pitta, blue-and-white flycatcher and grey-bellied cuckoo (Raman et al. 2013; Sivaperuman et al. 2013; Zaibin et al. 2014; Das 2014; Manchi and Kumar 2014; Rajeshkumar et al. 2012, 2014; Thompson 2014). Recently the authors reported several new records to these islands; the notable sightings are Chinese egret from South Andaman and corncrake from Great Nicobar Island (Sivaperuman et al. 2010, 2012, 2013, 2014a, b, c; 2015a, b, c, d; 2016a, b, c; Sivaperuman and Gokulakrishnan 2016, 2017). Bharadwaj (2015) has reported a rare sighting of Great Nicobar crake from the southernmost island Great Nicobar Island.

6.1.1 Study Area

The Andaman and Nicobar archipelago consists of 572 islands extending over 800 km (Fig. 6.1). Andaman and Nicobar Islands, one of the major island archipelagos of India, are well known for their rich biodiversity (Saldanha 1989; Tikader 1984; Vijayan et al. 2000; Jayaraj and Andrews 2005). These are truly oceanic islands, never having been connected to the mainland during Pleistocene glaciations

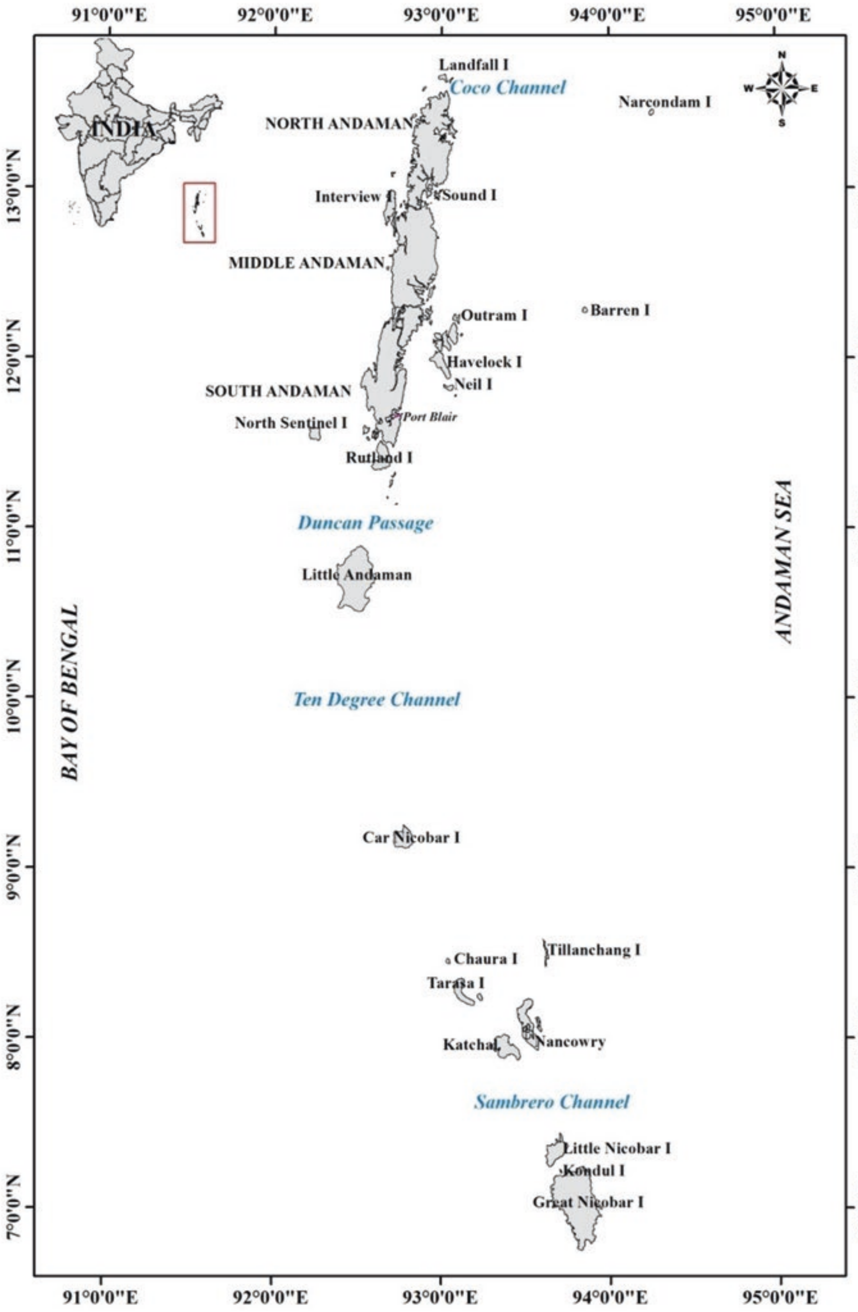


Fig. 6.1 Map of Andaman and Nicobar Islands

(Ripley and Beehler 1989). These islands were once a part of the Asian mainland but got detached some 100 million years ago during the Upper Mesozoic Period due to geological upheaval. The existing groups of islands constitute the physiographic continuation of the mountainous ranges of Naga and Lushai Hills and Arakan Yoma of Burma through Cape Negrais to the Andaman and Nicobar Islands and southeast of Sumatra. The chains of these islands are in fact the camel backs of the submerged mountain ranges projecting above the sea level running north to south between 6° 45′ and 13° 30′ N latitudes and 90° 20′ and 93° 56′ E longitudes with an extent of 8249 km^2. The Andaman and Nicobar Islands can be broadly divided into two groups, namely, the Andamans and the Nicobars. The Andaman group has 324 islands, of which 25 are inhabited, and the Nicobar group is made up of 28 islands, of which 13 are inhabited (Jayaraj and Andrews 2005). These two groups are separated by the Ten Degree Channel which is about 150 km wide 400 fathoms deep. Average annual temperature varies from 24 ° C to 28 ° C. The elevations range from 0 to 732 m at Saddle Peak in North Andaman and 642 m at Mount Thullier in Great Nicobar Island. The rainfall is slightly higher in Nicobar with an annual average of 3000 to 3500 mm.

6.1.2 Geography

The Andaman group of islands is made up of North, Middle and South Andaman Islands. The Ritchie's Archipelago is to the east of Middle Andaman and the Tarmugli group of islands lies to the southwest of South Andaman. The Rutland Island is situated off the southern coast of South Andaman and Little Andaman forms the southern end of the Andaman group of islands. The Nicobar group has 24 islands, which cluster into three identifiable groups. The northern section has two islands: Car Nicobar and, to its south, the small island of Battimalv. The middle section of the group is made up of nine islands, with Chowra, Teressa, Bompoka and Katchall to the west and Nancowry, Camorta and Trinket to the east. Tillangchong and the Isle of Man lie slightly to the northeast. The southern section consists of two large islands, Little and Great Nicobar, together with the eight smaller islands of Meroe, Trak, Treis, Pulo Milo, Kabra, Menchal, Kondul and Megapode which are smaller islands (Saldanha 1989).

6.1.3 Biogeographic Classification

The biogeographic history of the Andaman and Nicobar Islands indicates their uniqueness. The scattered islands, covering a small area, have been divided into 11 biogeographic subdivisions (Rodgers and Panwar 1988). There are two levels of variation in the Andaman and Nicobar Islands. One is an ecological separation into different biomes: beach and reef systems, mangroves, littoral forests, deciduous forests, semievergreen, valley evergreen and hill slope evergreen forests, with further variation between calcium-rich and calcium-poor strata. The second is a separation by species composition, with each island having its own characteristic community composition, with its own proportion of endemics.

6.1.4 Ecosystems

An extraordinary variety of habitat types, ranging from sandy beaches to coral reefs, mangroves and mountains with dense forests, characterize the Andaman and Nicobar Islands. They are located in the equatorial belt and have been endowed with an abundance of flora and fauna. A number of species are endemic and restricted to small areas because of the islands geographic isolation. The land area of the island chain is restricted but the diversity of forest types, each with its own distinctive floral and faunal composition, is staggering. Some of the larger islands display a veritable mosaic of forest types. The tropical forest ecosystem continuously recycles water. Since most of the islands have very few perennial rivers and streams, the inland wetlands are restricted. Basically, small ponds formed by rainwater accumulate inside the forests. The ponds are valuable sources of freshwater for wildlife, and they also serve as a refuge for endangered species, such as the Andaman teal and several endemic amphibians that are habitat specialists. The least disturbed and the best preserved mangroves in India can be found on the Andaman and Nicobar Islands. Along with the inland forests, the mangroves are the predominant terrestrial ecosystem of the islands. These mangroves support a rich diversity of fauna and in particular provide breeding and spawning habitats for many aquatic species, the saltwater crocodile and several species of birds and reptiles (Rao and Khan 1990). The Andaman and Nicobar coral reefs are the second richest found in the world (Turner et al. 2001). They consist mainly of fringing reefs with a barrier reef only on the western side. Seagrass beds occur in shallow coastal waters and sheltered bays, where clear water allows light penetration. Highly threatened marine animals, such as dugongs and marine turtles, use this habitat essentially as a feeding ground (Das 1996).

6.1.5 Vegetation

All the major islands are supported with luxuriant and rich vegetation, and the total geographical area is under forest land, i.e., 6751 km^2 (82.28%), and tree cover is 37 km^2 per the State Forest Report of 2015. Of these, 84.22% is dense forest, 10.15% is moderately dense and 5.63% is open forest (FSI 2015). Mangrove forest is 9.14% of the total forest area (FSI 2015). It is the second largest in the country in terms of area. The forests of Andaman and Nicobar Islands are rich in cane and bamboo. Different types of forest are found in this archipelago, namely, the giant evergreen forest, Andaman tropical evergreen forest, southern hilltop tropical evergreen forest, canebrakes forest, wet bamboo brakes, Andaman semievergreen forest, Andaman moist deciduous forest, Andaman secondary moist deciduous forest, littoral forest and submontane hill valley swamp forest.

6.1.6 History of Ornithological Studies in A and N Islands

Andaman and Nicobar Islands constitute a globally important biodiversity hotspot. Due to isolation from the mainland, the endemism is very high in all taxa including avifauna (Rao et al. 1980; Das 1999a, b; Andrews 2001). This archipelago is one of the endemic bird areas (EBA), and 19 sites were identified as important bird areas (IBA), and 30 species are considered endemic to these islands (Stattersfield et al. 1998). Ornithology in the Andaman and Nicobar Islands has a long history, and it was started by many British researchers during the middle of the nineteenth century (Blyth 1845, 1846a, b, 1863 and 1866; Walden 1866, 1873; Barbe 1846; Flower 1860; Tytler 1864, 1867; Beavan 1867; Tytler 1867; Ball 1870, 1872, 1873; Hume 1873a, b, 1874a, b, 1876; Prain 1892; St. John 1898; Butler 1899a, b, c, 1900; Cory 1902; Richmond 1902; Wilson 1904; Osmaston 1905, 1906a, b, c, 1907, 1908, 1932, 1933, 2001; Wickham 1910; Fleming 1911; Whitehead 1912; Oberholser 1915, 1917, 1919; Ferrar 1931; Stapylton 1933, 1934a, b; Whistler 1940; Gibson-Hill 1949; Thothathri 1962; Abdulali 1964a, b, 1965, 1966, 1967a, b, 1971, 1976, 1977, 1978a, b, 1979, 1981a, b; Voous 1965; Thangam 1966; Bailey et al. 1968; Abdulali and Grubh 1970).

More recently, many researchers have contributed to knowledge of the avifauna of Andaman and Nicobar Islands (Das 1971; Mukherjee and Dasgupta 1975; Dasgupta 1976; Whitaker 1976, 1982, 1985, 2000; Frith 1978; Ali 1980; Saha and Dasgupta 1980; Bhaskar 1981a, b; Altevogt and Davis 1981; Mees 1981; Mukherjee 1981; Ali and Ripley 1983, 1987; Hussain 1977, 1984, 1991, 1992; Tikader 1984; Saldanha 1988, 1989; Balakrishnan 1989; Ripley and Beehler 1989; Steadman 1991; Kazmierczak 1991; Santharam 1991, 1996, 1997; Sebastian 1991; Anon 1992, 1996, 2004a, b, c, 2008; Sankaran 1993, 1995a, b,c,d,e, 1997, 1998a, b, c, d, e, 2001, 2005; Sankaran and Vijayan 1993; Vijayan 1993, 1996, 1999, 2006, 2007; Chandra and Rajan 1994; Chandra and Kumar 1994; Prakash et al. 1994; Saxena 1994; Davidar et al. 1995, 1996, 2001, 2007; Prakash 1995; Robertson 1995; Wahal 1995; Davidar 1996; Davidar et al. 1996; Prashanth and Veenakumari 1996; Unnithan 1996; Vijayan 1996, 2007; Thiollay 1997; Grimmett et al. 1998; Rasmussen 1998, 2000, 2005a, b, c; Stattersfield et al. 1998; Relton 1999; Sankaran and Sivakumar 1999; Gandhi 2000; Sivakumar 2000, 2003a, b, 2007; Yoganand and Davidar 2000; Vijayan et al. 2000; Vijayan et al. 2000, 2005; Vijayan and Sankaran 2001; Dasgupta et al. 2002; Sivakumar and Sankaran 2002, 2003, 2005; Ali 2003, 2007; IIRS 2003; Kulkarni and Chandi 2003; Vivek and Vijayan 2003; Yahya and Zarri 2002a, b; Islam and Rahmani 2004; Rasmussen and Anderton 2005; Ezhilarsi and Vijayan 2006; Ashraf 2006; Andrews et al. 2006; Samaraweera 2006; Pande et al. 2007; Pande 2007; Vijayan and Ezhilarasi 2007; Sankaran and Manchi 2008; Mamannan and Vijayan 2009; Manchi and Sankaran 2009; Bhopale 2010; Sivaperuman et al. 2010, 2012; Sundaramoorthy 2010; Pande et al. 2011; Rajan and Pramod 2011a, b, 2013; Manchi 2013; Raman et al. 2013; Gokulakrishnan et al. 2014; Manchi and Kumar 2014; Rajeshkumar et al. 2014; Thompson 2014; Zaibin et al. 2014; Gokulakrishnan et al. 2015; Gokulakrishnan and Sivaperuman 2016; Praveen et al. 2016; Sridharan et al. 2017).

6.2 Methods

The bird surveys have been carried out in various parts of the islands by the authors since 2008 using different census techniques. Data was collected from all the habitats representing tropical forests, mangroves, plantations, wetlands and agricultural fields. Although several studies have been carried out on various aspects of avifauna, no attempt has been made to compile the checklist of avifauna of Andaman and Nicobar Islands except the publication of Sivaperuman et al. (2010). Therefore, we made an attempt to prepare the updated checklist based on the field surveys and available literatures. The migratory status of birds has been classified based on Ali and Ripley (1983), Kumar et al. (2005) and Rasmussen and Anderton (2012). The common and scientific names were followed by Rasmussen and Anderton (2005) and order and family followed by BirdLife International (2015), Praveen et al. (2016) and Clements et al. (2016).

6.3 Results and Discussion

6.3.1 Avifaunal Diversity in Andaman and Nicobar Islands

A total of 349 species/subspecies (262 species and 87 subspecies) of birds were recorded from Andaman and Nicobar Islands, these belonging to 67 families under 20 orders (Tables 6.1, 6.3 and 6.4; Fig. 6.4). Sivaperuman et al. (2010) reported 284 species of birds from this archipelago. In this present paper, we added 65 species to the existing checklist as a new sighting/report from this region by various researchers. Among the orders, the Passeriformes had the highest number of bird species (111 species; 31.8%), followed by Charadriiformes (60 species; 17.2%); Accipitriformes (29 species; 8.3%); Pelecaniformes (20 species; 5.7%); Coraciiformes (16 species; 4.6%); Gruiformes, Columbiformes and Cuculiformes (15 species; 4.3%); and Anseriformes (12 species; 3.4%). Podicipediformes was represented by only one species; two species in Bucerotiformes; and three species in Phaethontiformes and Piciformes. Among the families Scolopacidae had the highest number of species (29), followed by Accipitridae (28), Ardeidae (18) and the Rallidae, Laridae, Cuculidae and Columbidae families (15), respectively. Nineteen families were reported with single species (Table 6.4). Of the recorded species, 145 (41.55%) were resident; 125 (35.82%) were winter migrant; 24 (6.88%) were vagrant; 18 (5.16%) were resident with local migrants; 13 (3.72%) were summer migrant; and 12 (3.44%) were passage migrant (Fig. 6.2).

According to BirdLife International (2015), 1 species is listed as critically endangered (CR), 4 species are endangered (EN) and data deficient (DD), 34 species are near threatened (NT), and 5 species are vulnerable (VU). Only one critically endangered species, Christmas Island frigatebird, is recorded from these Islands. The abundance status of birds shows that 16 (4.58%) species were abundant, 31 (8.88%) species were common, 74 (21.20%) species were fairly common, 101 (28.94%) species were uncommon, 68 (19.48%) species were rare, 32 (9.17%) species were very rare, and 27 (7.77%) species were irregular (Table 6.1). According to the Indian Wildlife (Protection) Act, 1972, 13 species were listed under the Schedule I; and 219 species were included in the Schedule IV. Taxonomic composition of avifauna of this archipelago reveals that 182 were found only in Andaman group of islands, 62 were restricted to Nicobar group and 103 birds were common in both these groups (Fig. 6.3). This shows the distinct nature of avifauna of this archipelago from both groups.

Table 6.1 Updated checklist of avifauna of Andaman and Nicobar Islands

Sl. No.	Common name*	Scientific name*	Status: Residential	IUCN	Abundance	WPA	Distribution: AN	NI
	Podicipediformes							
	Podicipedidae							
1.	Little grebe	*Tachybaptus ruficollis* (Pallas, 1764)	WM	LC	U	IV	✓	
	Procellariiformes							
	Procellariidae							
2	Wedge-tailed shearwater	*Ardenna pacifica* (Gmelin, 1789)	SM	LC	VR		✓	
3.	Short-tailed shearwater	*Puffinus tenuirostris* (Temminck, 1835)	V	LC	I		#✓	
	Hydrobatidae							
4.	Wilson's storm petrel	*Oceanites oceanicus* (Kuhl, 1820)	SM	LC	VR			✓
5.	White-faced storm petrel	*Pelagodroma marina* (Latham, 1790)	V	LC	VR			✓
6.	White-bellied storm petrel	*Fregetta grallaria* (Vieillot, 1818)	WM	LC	I		#✓	
7.	Black-bellied storm petrel	*Fregetta tropica* (Gould, 1844)	V	LC	I			#✓
8.	Swinhoe's storm petrel	*Hydrobates monorhis* (Swinhoe, 1867)	WM	NT	R		✓	
	Phaethontiformes							
	Phaethontidae							
9.	Red-billed tropicbird	*Phaethon aethereus* Linnaeus, 1758	WM	LC	I		#✓	
10.	Red-tailed tropicbird	*Phaethon rubricauda* Boddaert, 1783	V	LC	VR			✓
11.	White-tailed tropicbird	*Phaethon lepturus* Daudin, 1802	V	LC	VR		✓	
	Suliformes							
	Sulidae							
12.	Red-footed booby	*Sula sula* (Linnaeus, 1766)	V	LC	VR			✓
13.	Masked booby	*Sula dactylatra* Lesson, 1831	V	LC	R			✓
	Phalacrocoracidae							
14.	Little cormorant	*Microcarbo niger* (Vieillot, 1817)	PM/WM	LC	VR	IV	✓	

	Fregatidae							
15.	Great frigatebird	*Fregata minor* (Gmelin, 1789)	V	LC	VR		✓	
16.	Lesser frigatebird	*Fregata ariel* (G.R. Gray, 1845)	SM	LC	R		✓	✓
17.	Christmas frigatebird	*Fregata andrewsi* Mathews, 1914	V	CR	VR		✓	
	Pelecaniformes							
	Pelecanidae							
18.	Spot-billed pelican	*Pelecanus philippensis* Gmelin, 1789	WM	NT	I	IV		#✓
	Ardeidae							
19.	Little egret	*Egretta garzetta* (Linnaeus, 1766)	R/LM	LC	C	IV	✓	✓
20.	Pacific reef-egret	*Egretta sacra* (Gmelin, 1766)	R	LC	FC	IV	✓	✓
21.	Grey heron	*Ardea cinerea* Linnaeus, 1758	R/WM	LC	FC	IV	✓	
22.	Great-billed heron	*Ardea sumatrana* Raffles, 1822	R	LC	I			#✓
23.	Purple heron	*Ardea purpurea* Linnaeus, 1766	R/LM	LC	FC	IV	✓	✓
24.	Great egret	*Egretta alba* (Linnaeus, 1758)	R/LM	LC	A	IV	✓	✓
25.	Intermediate egret	*Egretta intermedia* (Wagler, 1829)	R/WM	LC	C	IV	✓	✓
26.	Eastern cattle egret	*Bubulcus coromandus* (Boddaert, 1783)	R/LM	LC	A	IV	✓	✓
27.	Chinese egret	*Egretta eulophotes* (Swinhoe, 1860)	WM	VU	U		✓	✓
28.	Indian pond heron	*Ardeola grayii* (Sykes, 1832)	R/WM	LC	U	IV	✓	✓
29.	Chinese pond heron	*Ardeola bacchus* (Bonaparte, 1855)	WM	LC	FC	IV	✓	✓
30.	Andaman little green heron[ENS]	*Butorides striatus spodiogaster* Sharpe, 1894	R	NE	FC	IV	✓	
31.	Nicobar little green heron[ENS]	*Butorides striatus spodiogaster* Sharpe, 1894	R	NE	FC	IV		✓
32.	Black-crowned night heron	*Nycticorax nycticorax* (Linnaeus, 1758)	PM	LC	VR	IV	✓	✓
33.	Nicobar Malayan night heron[ENS]	*Goraschius melanolophus minor* Hachisuka, 1926	R	DD	U	IV	✓	✓
34.	Yellow bittern	*Ixobrychus sinensis* (Gmelin, 1789)	WM	LC	FC	IV	✓	✓
35.	Chestnut bittern	*Ixobrychus cinnamomeus* (Gmelin, 1789)	R	LC	U	IV	✓	✓

(continued)

Table 6.1 (continued)

Sl. No.	Common name*	Scientific name*	Status Residential	IUCN	Abundance	WPA	Distribution AN	NI
36.	Black bittern	*Dupetor flavicollis* (Latham, 1790)	WM	LC	U	IV	✓	
	Threskiornithidae							
37.	Glossy ibis	*Plegadis falcinellus* (Linnaeus, 1766)	PM	LC	VR	IV	✓	
	Anseriformes							
	Anatidae							
38.	Lesser whistling duck	*Dendrocygna javanica* (Horsfield, 1821)	R/LM	LC	A	IV	✓	✓
39.	Ruddy shelduck	*Tadorna ferruginea* (Pallas, 1764)	WM	LC	VR	IV	✓	
40.	Knob-billed duck[IN]	*Sarkidiornis melanotos* Pennant, 1769	R/LM	LC	R	IV	✓	
41.	Cotton teal	*Nettapus coromandelianus* (Gmelin, 1789)	R	LC	C	IV	✓	✓
42.	Eurasian wigeon	*Mareca penelope* Linnaeus, 1758	WM	LC	R	IV	✓	
43.	Mallard[IN#]	*Anas platyrhynchos* Linnaeus, 1758	R	LC	I	IV	#✓	
44.	Spot-billed duck[IN#]	*Anas poecilorhyncha* J.R. Forester, 1781	R	LC	I	IV	#✓	
45.	Andaman teal[E]	*Anas albogularis* (Muller, 1842)	R	NT	A	I	✓	
46.	Northern pintail	*Anas acuta* Linnaeus, 1758	WM	LC	R	IV	✓	
47.	Garganey	*Querquedula querquedula* Linnaeus, 1758	WM	LC	U	IV	✓	✓
48.	Common teal	*Anas crecca* Linnaeus, 1758	WM	LC	VR	IV	✓	
49.	Ferruginous pochard	*Aythya nyroca* (Guldenstadt, 1770)	WM	NT	VR	IV	✓	
	Accipitriformes							
	Accipitridae							
50.	Andaman black baza[ENS]	*Aviceda leuphotes andamanica* Abdulali, 1817	R	NE	R	I	✓	
51.	Jerdon's baza	*Aviceda jerdoni* (Blyth, 1842)	R/LM	LC	R	I		✓
52.	Oriental honey buzzard	*Pernis ptilorhynchus* (Temminck, 1821)	R	LC	VR		✓	
53.	Black kite	*Milvus migrans* (Boddaert, 1783)	SM	LC	VR		✓	
54.	Brahminy kite	*Haliastur indus* (Boddaert, 1783)	R/LM	LC	U	I	✓	✓

55.	White-bellied sea eagle	*Haliaeetus leucogaster* (Gmelin, 1788)	R	LC	FC	I	✓	✓
56.	Andaman serpent eagle[E]	*Spilornis elgini* (Blyth, 1863)	R	NT	U		✓	
57.	Andaman crested serpent eagle[ENS]	*Spilornis cheela davisoni* Hume, 1873	R	NE	U		✓	
58.	Nicobar crested serpent eagle[ENS]	*Spilornis cheela malayensis* Swann, 1920	R	NE	R			✓
59.	Central Nicobar serpent eagle[E]	*Spilornis minimus* Hume, 1873	R	NE	R			✓
60.	Great Nicobar serpent eagle[E]	*Spilornis klossi* Richmond, 1903	R	NT	U			✓
61.	Western marsh harrier	*Circus aeruginosus* (Linnaeus, 1758)	WM	LC	R	I	✓	
62.	Pallid harrier	*Circus macrourus* (S.G. Gmelin, 1770)	WM	NT	I		#✓	
63.	Pied harrier	*Circus melanoleucos* (Pennant, 1769)	WM	LC	VR		✓	
64.	Montagu's harrier	*Circus pygargus* (Linnaeus, 1758)	WM	LC	I		#✓	
65.	Shikra	*Accipiter badius* (Gmelin, 1788)	R	LC	U		✓	
66.	Nicobar sparrowhawk[E]	*Accipiter butleri* (Gurney, 1898)	R	VU	R			✓
67.	Car Nicobar sparrowhawk[ENS]	*Accipiter butleri butleri* (Gurney, 1898)	R	NE	R			✓
68.	Katchal sparrowhawk[ENS]	*Accipiter butleri obsoletus* Richmond, 1903	R	NE	R			✓
69.	Chinese sparrowhawk	*Accipiter soloensis* (Horsfield, 1821)	WM	LC	U			✓
70.	Japanese sparrowhawk	*Accipiter gularis* (Temminck & Schlegel, 1845)	WM	LC	U		✓	
71.	Besra sparrowhawk	*Accipiter virgatus* (Temminck 1822)	WM	LC	U		✓	✓
72.	Eurasian sparrowhawk	*Accipiter nisus nisosimilis* (Tickell, 1833)	V	NE	VR		✓	
73.	Grey-faced buzzard	*Butastur indicus* (Gmelin, 1788)	WM	LC	R		✓	✓
74.	Long-legged buzzard	*Buteo rufinus* (Cretzschmar, 1827)	WM	LC	VR		✓	
75.	Black eagle	*Ictinaetus malayensis* (Temminck, 1822)	R	LC	I		#✓	

(continued)

Table 6.1 (continued)

Sl. No.	Common name*	Scientific name*	Status				Distribution	
			Residential	IUCN	Abundance	WPA	AN	NI
76.	Booted eagle	*Hieraaetus pennatus* (Gmelin, 1788)	WM	LC	VR		✓	
77.	Changeable hawk-eagle[ENS]	*Nisaetus limnaeetus andamanensis* Tytler, 1865	R	NE	U		✓	
	Pandionidae							
78.	Western osprey	*Pandion haliaetus* (Linnaeus, 1758)	V	LC	R	I	✓	✓
	Falconiformes							
	Falconidae							
79.	Lesser kestrel	*Falco naumanni* Fleischer, 1818	WM	LC	I		#✓	
80.	Common kestrel	*Falco tinnunculus* Linnaeus, 1758	WM	LC	U		✓	✓
81.	Amur falcon	*Falco amurensis* Radde, 1863	WM	LC	R			✓
82.	Saker falcon	*Falco cherrug* J.E. Gray, 1834	SM	EN	I		#✓	
83.	Peregrine falcon	*Falco peregrinus calidus* Latham, 1790	WM	LC	U	I	✓	✓
84.	Shaheen falcon	*Falco peregrinus peregrinator* Sundevall, 1837	WM	LC	VR		✓	
	Galliformes							
	Megapodiidae							
85.	Nicobar megapode[E]	*Megapodius nicobariensis* Blyth, 1846	R	VU	R	I		✓
86.	South Nicobar megapode[ENS]	*Megapodius nicobariensis abbotti* Oberholser, 1919	R	NE	U	IV		✓
	Phasianidae							
87.	Grey francolin[IN]	*Francolinus pondicerianus* (Gmelin, 1789)	R	LC	U		✓	
88.	Nicobar blue-breasted quail[ENS]	*Excalfactoria chinensis trinkutensis* (Richmond, 1902)	R	LC	R	IV		✓

89.	Indian peafowl[IN]	*Pavo cristatus* Linnaeus, 1758	R	LC	C	I	✓	
	Gruiformes							
	Rallidae							
90.	Andaman crake[E]	*Rallina canningi* (Blyth, 1863)	R	NT	U	IV	✓	
91.	Great Nicobar crake	*Rallina* sp.	R	NE	R			✓
92.	Slaty-legged crake	*Rallina eurizonoides* (Lafresnaye, 1845)	R	LC	R	IV	✓	
93.	Andaman blue-breasted rail[ENS]	*Gallirallus striatus obscurior* Hume, 1874	R	NE	U	IV	✓	✓
94.	Nicobar blue-breasted rail[ENS]	*Gallirallus striatus nicobariensis* Abdulali, 1967	R	DD	U	IV		✓
95.	Corncrake	*Crex crex* (Linnaeus, 1758)	V	LC	R	IV	✓	✓
96.	Andaman white-breasted waterhen[ENS]	*Amaurornis phoenicurus insularis* Sharpe, 1894	R	NE	FC	IV	✓	
97.	Great Nicobar white-breasted waterhen[ENS]	*Amaurornis phoenicurus midnicobaricus* Abdulali, 1979	R	NE	FC	IV		✓
98.	Car Nicobar white-breasted waterhen[ENS]	*Amaurornis phoenicurus leucocephalus* Abdulali, 1964	R	NE	FC	IV		✓
99.	Eastern Baillon's crake	*Porzana pusilla* (Pallas, 1776)	WM	LC	FC	IV	✓	✓
100.	Ruddy-breasted crake	*Porzana fusca* (Linnaeus, 1766)	WM	LC	U	IV	✓	
101.	Watercock	*Gallicrex cinerea* (Gmelin, 1789)	R/LM	LC	FC	IV	✓	✓
102.	Purple moorhen	*Porphyrio porphyrio* (Linnaeus, 1758)	R	LC	A	IV	✓	
103.	Common moorhen	*Gallinula chloropus* (Linnaeus, 1758)	R	LC	A	IV	✓	✓
104.	Common coot	*Fulica atra* Linnaeus, 1758	R/LM	LC	U	IV	✓	✓
	Charadriiformes							
	Jacanidae							
105.	Pheasant-tailed jacana	*Hydrophasianus chirurgus* (Scopoli, 1786)	WM	LC	U	IV	✓	

(continued)

Table 6.1 (continued)

Sl. No.	Common name*	Scientific name*	Status			WPA	Distribution	
			Residential	IUCN	Abundance		AN	NI
	Charadriidae							
106.	Pacific golden plover	*Pluvialis fulva* (Gmelin, 1789)	WM	LC	C	IV	✓	✓
107.	Grey plover	*Pluvialis squatarola* (Linnaeus, 1758)	WM	LC	U	IV	✓	✓
108.	Little ringed plover	*Charadrius dubius* Scopoli, 1786	WM	LC	U	IV	✓	✓
109.	Kentish plover	*Charadrius alexandrinus* Linnaeus, 1758	WM	LC	U	IV	✓	✓
110.	Lesser sand plover	*Charadrius mongolus* Pallas, 1776	WM	LC	A	IV	✓	✓
111.	Greater sand plover	*Charadrius leschenaultii* Lesson, 1826	WM	LC	FC	IV	✓	✓
112.	Oriental plover	*Charadrius veredus* Gould, 1848	V	LC	VR	IV	✓	
113.	White-faced plover	*Charadrius dealbatus* (Swinhoe, 1870)	V	DD	VR		✓	
114.	Grey-headed lapwing	*Vanellus cinereus* (Blyth, 1842)	WM	LC	U	IV	✓	✓
	Scolopacidae							
115.	Eurasian woodcock	*Scolopax rusticola* Linnaeus, 1758	WM	LC	VR	IV	✓	
116.	Pintail snipe	*Gallinago stenura* (Bonaparte, 1830)	WM	LC	C	IV	✓	✓
117.	Swinhoe's snipe	*Gallinago megala* Swinhoe, 1861	WM	LC	I	IV	#✓	
118.	Great snipe	*Gallinago media* (Latham, 1787)	WM	NT	I	IV	#✓	
119.	Common snipe	*Gallinago gallinago* (Linnaeus, 1758)	WM	LC	U	IV	✓	
120.	Jack snipe	*Lymnocryptes minimus* (Brunnich, 1764)	PM	LC	VR	IV	✓	
121.	Western black-tailed godwit	*Limosa limosa* (Linnaeus, 1758)	WM	NT	U	IV	✓	
122.	Bar-tailed godwit	*Limosa lapponica* (Linnaeus, 1758)	WM	NT	U	IV	✓	✓
123.	Eurasian whimbrel	*Numenius phaeopus* (Linnaeus, 1758)	WM	LC	C	IV	✓	✓
124.	Eastern whimbrel	*Numenius phaeopus variegatus* (Scopoli, 1786)	V	LC	I	IV		#✓
125.	Eurasian curlew	*Numenius arquata* (Linnaeus, 1758)	WM	NT	FC	IV	✓	✓
126.	Spotted redshank	*Tringa erythropus* (Pallas, 1764)	WM	LC	R	IV	✓	✓

127.	Common redshank	*Tringa totanus* (Linnaeus, 1758)	WM	LC	C	IV	✓	✓
128.	Marsh sandpiper	*Tringa stagnatilis* (Bechstein, 1803)	WM	LC	U	IV	✓	
129.	Common greenshank	*Tringa nebularia* (Gunner, 1767)	WM	LC	U	IV	✓	✓
130.	Green sandpiper	*Tringa ochropus* Linnaeus, 1758	WM	LC	R	IV	✓	
131.	Wood sandpiper	*Tringa glareola* Linnaeus, 1758	WM	LC	C	IV	✓	✓
132.	Terek sandpiper	*Xenus cinereus* (Guldenstadt, 1775)	WM	LC	FC	IV	✓	✓
133.	Common sandpiper	*Actitis hypoleucos* Linnaeus, 1758	WM	LC	FC	IV	✓	✓
134.	Ruddy turnstone	*Arenaria interpres* (Linnaeus, 1758)	WM	LC	FC	IV	✓	✓
135.	Great knot	*Calidris tenuirostris* (Horsfield, 1821)	WM	EN	U	IV	✓	
136.	Sanderling	*Ereunetes albus* (Pallas, 1764)	WM	LC	U	IV	✓	✓
137.	Little stint	*Ereunetes minutus* (Leisler, 1812)	WM	LC	R	IV	✓	
138.	Rufous-necked stint	*Ereunetes ruficollis* (Pallas, 1776)	WM	NT	FC	IV	✓	✓
139.	Temminck's stint	*Ereunetes temminckii* (Leisler, 1812)	WM	LC	R	IV	✓	
140.	Long-toed stint	*Ereunetes subminuta* (Middendorff, 1853)	WM	LC	C	IV	✓	✓
141.	Curlew sandpiper	*Erolia ferruginea* (Pontoppidan, 1813)	WM	NT	C	IV	✓	✓
142.	Broad-billed sandpiper	*Limicola falcinellus* (Pontoppidan, 1763)	WM	LC	FC	IV	✓	
143.	Ruff	*Philomachus pugnax* (Linnaeus, 1758)	WM	LC	U	IV	✓	
	Turnicidae							
144.	Nicobar yellow-legged buttonquail[ENS]	*Turnix tanki blanfordii* Blyth, 1843	R	LC	R		✓	✓
	Recurvirostridae							
145.	Black-winged stilt	*Himantopus himantopus* (Linnaeus, 1758)	WM	LC	U	IV	✓	
	Dromadidae							
146.	Crab-plover	*Dromas ardeola* Paykull, 1805	R/WM	LC	R		✓	✓
	Burhinidae							
147.	Beach thick-knee	*Esacus magnirostris* (Vieillot, 1818)	R	NT	U		✓	

(continued)

Table 6.1 (continued)

Sl. No.	Common name*	Scientific name*	Status				Distribution	
			Residential	IUCN	Abundance	WPA	AN	NI
	Glareolidae							
148.	Collared pratincole	*Glareola pratincola* (Linnaeus, 1766)	PM	LC	VR		✓	
149.	Oriental pratincole	*Glareola maldivarum* J.R. Forster, 1795	WM	LC	FC		✓	✓
	Laridae							
150.	Common black-headed gull	*Chroicocephalus ridibundus* Linnaeus, 1766	WM	LC	R	IV	✓	
151.	Common gull-billed tern	*Gelochelidon nilotica* (Gmelin, 1789)	WM	LC	R	IV	✓	
152.	Lesser crested tern	*Thalasseus bengalensis* Lesson, 1831	WM	LC	FC	IV	✓	✓
153.	Greater crested tern	*Thalasseus bergii velox* (Cretzschmar, 1827)	WM	LC	U	IV	✓	✓
154.	Roseate tern	*Sterna dougallii* Montagu, 1813	SM	LC	C	IV	✓	✓
155.	Black-naped tern	*Sterna sumatrana* Raffles, 1822	R/LM	LC	A	IV	✓	✓
156.	Little tern	*Sternula albifrons* Pallas, 1764	WM	LC	FC	IV	✓	✓
157.	Bridled tern	*Onychoprion anaethetus* Scopoli, 1786	R/LM	LC	R	IV	✓	
158.	Sooty tern	*Onychoprion fuscatus* Linnaeus, 1766	R/WM	LC	R	IV	✓	
159.	Whiskered tern	*Chlidonias hybrida* (Pallas, 1811)	WM	LC	FC	IV	✓	✓
160.	White-winged tern	*Chlidonias leucopterus* (Temminck, 1815)	WM/PM	LC	R	IV	✓	
161.	Brown noddy	*Anous stolidus* (Linnaeus, 1758)	WM	LC	FC	IV	✓	✓
162.	Black noddy	*Anous minutus* Boie, 1844	WM	LC	I	IV		#✓
163.	Lesser noddy	*Anous tenuirostris* (Temminck, 1823)	S	LC	I		#✓	
164.	White tern	*Gygis alba* (Sparrman, 1786)	V	LC	R		✓	
	Columbiformes							
	Columbidae							
165.	Blue rock pigeon[IN]	*Columba livia* Gmelin, 1789	R	LC	A		✓	✓
166.	Andaman wood pigeon[E]	*Columba palumboides* (Hume, 1873)	R	NT	R	IV	✓	

167.	Nicobar wood pigeon[ENS]	*Columba palumboides nicobaria* (Abdualali, 1964)	R	NE	U	IV		✓
168.	Laughing dove[IN#]	*Spilopelia senegalensis* (Linnaeus, 1766)	R	LC	I	IV	#✓	
169.	Red-collared dove	*Streptopelia tranquebarica* (Hermann, 1804)	R	LC	A	IV	✓	
170.	Andaman cuckoo-dove[E]	*Macropygia rufipennis* Blyth, 1846	R	NT	U	IV	✓	
171.	Nicobar cuckoo-dove[ENS]	*Macropygia rufipennis tiwarii* Abdulali, 1979	R	LC	U	IV		✓
172.	Andaman emerald dove[ENS]	*Chalcophaps indica maxima* Hartert, 1931	R	LC	U	IV	✓	
173.	Nicobar emerald dove[ENS]	*Chalcophaps indica augusta* Bonapate, 1855	R	NE	U	IV		✓
174.	Nicobar pigeon	*Caloenas nicobarica* (Linnaeus, 1758)	R	NT	FC	I	✓	✓
175.	Andaman green pigeon[E]	*Treron chloropterus* (Blyth, 1840)	R	NT	C	IV	✓	
176.	Nicobar green pigeon[ENS]	*Treron chloroptera* (Blyth, 1846)	R	NE	FC	IV		✓
177.	Andaman green-imperial pigeon[ENS]	*Ducula aenea andamanica* (Abdualali, 19 64)	R	LC	FC	IV	✓	
178.	Nicobar imperial pigeon[E]	*Ducula nicobarica* Blyth, 1858	R	LC	FC	IV		✓
179.	Pied imperial pigeon	*Ducula bicolor* (Scopoli, 1786)	R	LC	FC	IV	✓	✓
	Psittaciformes							
	Psittaculidae							
180.	Vernal hanging parrot	*Loriculus vernalis* (Sparrman, 1787)	R	LC	FC		✓	
181.	Andaman alexandrine parakeet[ENS]	*Psittacula eupatria magnirostris* (Ball, 1872)	R	NT	C	IV	✓	
182.	Andaman red-breasted parakeet[ENS]	*Psittacula alexandri abbotti* (Oberholser, 1919)	R	NT	A	IV	✓	
183.	Nicobar parakeet[E]	*Psittacula caniceps* (Blyth, 1846)	R	NT	FC	IV		✓

(continued)

Table 6.1 (continued)

Sl. No.	Common name*	Scientific name*	Status				Distribution	
			Residential	IUCN	Abundance	WPA	AN	NI
184.	Andaman red-cheeked parakeet[ENS]	*Psittacula longicauda tytleri* (Hume, 1874)	R	NT	C	IV	✓	
185.	Nicobar red-cheeked parakeet[ENS]	*Psittacula longicauda nicobarica* (Gould, 1857)	R	NE	FC	IV		✓
	Cuculiformes							
	Cuculidae							
186.	Jacobin cuckoo	*Clamator jacobinus* (Boddaert, 1783)	V	LC	U	IV	✓	
187.	Large hawk-cuckoo	*Hierococcyx sparverioides* (Vigors, 1832)	WM	LC	R	IV		✓
188.	Common hawk-cuckoo	*Hierococcyx varius* (Vahl, 1797)	SM	LC	I	IV	#✓	
189.	Indian cuckoo	*Cuculus micropterus* Gould, 1837	R	LC	U	IV	✓	✓
190.	Common cuckoo	*Cuculus canorus* Linnaeus, 1758	SM	LC	U	IV	✓	
191.	Himalayan cuckoo	*Cuculus saturatus* Blyth, 1843	WM	LC	U	IV	✓	✓
192.	Small cuckoo	*Cuculus poliocephalus* Latham, 1790	WM	LC	R	IV	✓	
193.	Asian emerald cuckoo	*Chrysococcyx maculatus* (Gmelin, 1788)	V	LC	R	IV		✓
194.	Banded bay cuckoo	*Cacomantis sonneratii* (Latham, 1790)	R	LC	R	IV	✓	
195.	Grey-bellied cuckoo	*Cacomantis passerinus* (Vahl, 1797)	PM	LC	U	IV	✓	
196.	Violet cuckoo	*Chrysococcyx xanthorhynchus* (Horsfield, 1821)	R/WM	LC	U	IV	✓	
197.	Square-tailed drongo-cuckoo	*Surniculus lugubris* (Horsefield, 1821)	WM	LC	U	IV	✓	✓
198.	Andaman Asian koel[ENS]	*Eudynamys scolopacea dolosus* Ripley, 1946	WM	LC	FC	IV	✓	✓
199.	Andaman coucal[E]	*Centropus andamanensis* (Beavan, 1867)	R	LC	FC	IV	✓	
200.	Lesser coucal	*Centropus bengalensis* (Gmelin, 1788)	R	LC	R	IV	✓	

	Strigiformes							
	Tytonidae							
201.	Andaman barn owl[E]	*Tyto deroepstorffi* (Hume, 1875)	R	LC	U	IV	✓	
	Strigidae							
202.	Andaman scops owl[E]	*Otus balli* (Hume, 1873)	R	NT	U	IV	✓	
203.	Andaman oriental scops owl[ENS]	*Otus sunia modestus* (Walden, 1874)	R	LC	U	IV	✓	
204.	Nicobar oriental scops owl[ENS]	*Otus sunia nicobaricus* (Hodgson, 1836)	R	LC	U	IV		✓
205.	Nicobar scops owl[E]	*Otus alius* Rasmussen, 1998	R	DD	FC	IV		✓
206.	Andaman Hume's boobook[E]	*Ninox obscura* Hume, 1872	R	LC	FC	IV	✓	
207.	Nicobar brown boobook[ENS]	*Ninox scutulata rexpimenti* (Abdulali, 1979)	R	LC	U	IV		✓
208.	Andaman Boobook[E]	*Ninox affinis* Beavan, 1867	R	NT	U	IV	✓	
	Caprimulgiformes							
	Caprimulgidae							
209.	Grey nightjar	*Caprimulgus jotaka* Temminck & Schlegel, 1844	WM	LC	R	IV	✓	✓
210.	Andaman nightjar[E]	*Caprimulgus andamanicus* Hume, 1873	R	LC	U	IV	✓	
	Apodidae							
211.	White-bellied swiftlet[ENS]	*Collocalia esculenta affinis* Beavan 1867	R	LC	A		✓	✓
212.	Himalayan swiftlet	*Aerodramus brevirostris innominatus* Hume, 1873	R	NE	U		✓	
213.	Andaman edible-nest swiftlet[ENS]	*Àerodramus fuciphaga inexpectatus* Hume, 1873	R	LC	A	I	✓	✓
214.	Brown-throated needletail	*Hirundapus giganteus indicus* (Hume, 1873)	R/LM	LC	C		✓	
215.	Common swift	*Apus apus* (Linnaeus, 1758)	SM	LC	VR		✓	
216.	Fork-tailed swift	*Apus pacificus* (Latham, 1802)	R	LC	R		✓	

(continued)

Table 6.1 (continued)

Sl. No.	Common name*	Scientific name*	Status				Distribution	
			Residential	IUCN	Abundance	WPA	AN	NI
217.	Little swift	*Apus affinis* (J.E. Gray, 1830)	SM	LC	R		✓	✓
	Coraciiformes							
	Alcedinidae							
218.	Common kingfisher	*Alcedo atthis* (Linnaeus, 1758)	WM	LC	U	IV	✓	✓
219.	Andaman blue-eared kingfisher[ENS]	*Alcedo meninting rufigastra* Walden, 1873	R	NE	U	IV	✓	
220.	Andaman oriental dwarf kingfisher[ENS]	*Ceyx erithaca macrocarus* Oberholser, 1917	R	NE	R	IV	✓	
221.	Nicobar oriental dwarf kingfisher[ENS]	*Ceyx erithaca macrocarus* Oberholser, 1917	R	NE	U	IV		✓
222.	Andaman stork-billed kingfisher[ENS]	*Pelargopsis capensis osmastoni* (Baker, 1934)	R	NE	U	IV	✓	
223.	Nicobar stork-billed kingfisher[ENS]	*Pelargopsis capensis intermedia* Hume, 1874	R	NE	U	IV		✓
224.	Andaman ruddy kingfisher[ENS]	*Halcyon coromanda mizorhina* (Oberholser, 1915)	R	NE	U	IV	✓	
225.	Andaman white-throated kingfisher[ENS]	*Halcyon smyrnensis saturatior* Hume, 1874	R	LC	FC	IV	✓	✓
226.	Black-capped kingfisher	*Halcyon pileata* (Boddaert, 1783)	R/LM	LC	U	IV	✓	✓
227.	Andaman collared kingfisher[ENS]	*Todiramphus chloris davisoni* Sharpe, 1892	R	NE	FC	IV	✓	
228.	Nicobar white-collared kingfisher[ENS]	*Todiramphus chloris occipitalis* (Blyth, 1846)	R	NE	FC	IV		✓
	Meropidae							
229.	Little green bee-eater	*Merops orientalis* Latham, 1801	SM	LC	R		✓	
230.	Blue-tailed bee-eater	*Merops philippinus* Linnaeus, 1766	WM	LC	U		✓	✓

231.	Andaman chestnut-headed bee-eater[ENS]	*Merops leschenaulti andamanensis* Marien, 1950	R	LC	U		✓	
	Coraciidae							
232.	Andaman dollarbird[ENS]	*Eurystomus orientalis gigas* Stesemann, 1913	R	LC	U	IV	✓	✓
233.	European roller	*Coracias garrulus* Linnaeus, 1758	PM	LC	R	IV	✓	
	Bucerotiformes							
	Upupidae							
234.	Common hoopoe	*Upupa epops* Linnaeus, 1758	WM	LC	R		✓	
	Bucerotidae							
235.	Narcondam hornbill[E]	*Rhyticeros narcondami* (Hume, 1873)	R	EN	C	I	✓	
	Piciformes							
	Picidae							
236.	Eurasian wryneck	*Jynx torquilla* Linnaeus, 1758	SM	LC	R	IV	✓	
237.	Andaman spot-breasted woodpecker[ENS]	*Dendrocopos analis andamanensis* (Blyth, 1859)	R	LC	FC	IV	✓	
238.	Andaman woodpecker[E]	*Dryocopus hodgei* (Blyth, 1860)	R	NT	FC	IV	✓	
	Passeriformes							
	Alaudidae							
239.	Greater short-toed lark	*Calandrella brachydactyla dukhunensis* (Sykes, 183)	PM	LC	R	IV	✓	
	Pittidae							
240.	Nicobar hooded pitta[ENS]	*Pitta sordida abbotti* Richmond, 1903	R	LC	FC			✓
241.	Blue pitta	*Pitta cyaneus* Blyth, 1843	V	LC	R		✓	
	Hirundinidae							
242.	Common sand martin	*Riparia riparia* (Linnaeus, 1758)	WM	LC	I		#✓	
243.	Barn swallow	*Hirundo rustica* Linnaeus, 1758	WM	LC	C		✓	✓
244.	House swallow	*Hirundo tahitica* Gmelin, 1789	R	LC	FC		✓	

(continued)

Table 6.1 (continued)

Sl. No.	Common name*	Scientific name*	Status: Residential	IUCN	Abundance	WPA	Distribution: AN	NI
245.	Red-rumped swallow	*Cecropis daurica* Linnaeus, 1771	WM	LC	U		✓	✓
246.	Asian house martin	*Delichon dasypus* (Bonaparte, 1850)	SM	LC	I		#✓	
	Motacillidae							
247.	Forest wagtail	*Dendronanthus indicus* (Gmelin, 1789)	WM	LC	U	IV	✓	✓
248.	White wagtail	*Motacilla alba leucopsis* Gould, 1838	WM	NE	U	IV	✓	
249.	Eastern yellow wagtail	*Motacilla tschutschensis* Linnaeus, 1758	WM	LC	C	IV	✓	
250.	Grey-headed yellow wagtail	*Motacilla flava thunbergi* Billberg, 1828	WM	LC	C	IV	✓	
251.	Western yellow wagtail	*Motacilla flava bema* (Sykes, 1832)	WM	LC	FC	IV	✓	✓
252.	Grey wagtail	*Motacilla cinerea* Tunstall, 1771	WM	LC	FC	IV	✓	✓
253.	Citrine wagtail	*Motacilla citreola* Pallas, 1776	WM	LC	R	IV	✓	
254.	Richard's pipit	*Anthus richardi* Vieillot, 1818	PM/WM	LC	R	IV	✓	
255.	Blyth's pipit	*Anthus godlewskii* (Taczanowski, 1876)	PM	LC	R	IV	✓	
256.	Red-throated pipit	*Anthus cervinus* (Pallas, 1811)	PM	LC	C	IV	✓	✓
	Campephagidae							
257.	Andaman large cuckoo-shrike[ENS]	*Coracina macei andamanensis* Whistler, 1940	R	LC	FC		✓	
258.	Andaman cuckoo-shrike[E]	*Coracina dobsoni* (Ball, 1872)	R	LC	FC		✓	
259.	Nicobar pied triller[ENS]	*Lalage nigra davisoni* (Kloss, 1926)	R	VU	R			✓
260.	Ashy minivet	*Pericrocotus divaricatus* (Raffles, 1822)	S	LC	U	IV	✓	✓
261.	Small minivet	*Pericrocotus cinnamomeus* (Linnaeus, 1776)	R	LC	C	IV	✓	
262.	Andaman scarlet minivet[ENS]	*Pericrocotus speciosus andamanensis* Beavan, 1867	R	LC	FC	IV	✓	

	Pycnonotidae							
263.	Andaman bulbul[E]	*Microtarsus fuscoflavescens* (Hume, 1875)	R	LC	U	IV	✓	
264.	Andaman red-whiskered bulbul[ENS]	*Pycnonotus jocosus whistleri* Deignan, 1948	R	NE	A	IV	✓	✓
265.	Nicobar bulbul[E]	*Ixos nicobariensis* Moore, 1854	R	NT	U	IV		✓
	Irenidae							
266.	Andaman Asian fairy bluebird[ENS]	*Irena puella andamanica* Abdulali, 1964	R	LC	FC	IV	✓	
	Laniidae							
267.	Brown shrike	*Lanius cristatus* (Linnaeus, 1758)	WM	LC	FC		✓	✓
268.	Philippine shrike	*Lanius cristatus lucionensis* Linnaeus, 1766	WM	LC	U		✓	✓
	Turdidae							
269.	Blue rock thrush	*Monticola solitarius* (Linnaeus, 1758)	WM	LC	U	IV	✓	
270.	Andaman orange-headed thrush[ENS]	*Geokichla citrina andamanensis* (Walden, 1874)	R	LC	C	IV	✓	
271.	Nicobar orange-headed thrush[ENS]	*Geokichla citrina albogularis* (Blyth, 1847)	R	NT	FC	IV		✓
272.	Siberian thrush	*Geokichla sibirica* (Pallas, 1776)	WM	LC	R	IV	✓	
273.	Eyebrowed thrush	*Turdus obscurus* Gmelin, 1789	WM	LC	U	IV	✓	✓
	Muscicapidae							
274.	Bluethroat	*Luscinia svecica* (Linnaeus, 1758)	V	LC	R		✓	
275.	Siberian blue robin	*Luscinia cyane* (Pallas, 1776)	V	LC	VR		✓	
276.	Andaman oriental magpie-robin[ENS]	*Copsychus saularis andamanensis* Hume, 1874	R	LC	FC		✓	
277.	Andaman shama[E]	*Copsychus albiventris* (Blyth, 1858)	R	LC	FC		✓	
278.	Blue-fronted blue robin	*Cinclidium frontale* Blyth, 1842	WM	LC	VR		✓	
279.	Common stonechat	*Saxicola stejnegeri* (Parrot, 1908)	WM	LC	FC		✓	✓

(continued)

Table 6.1 (continued)

Sl. No.	Common name*	Scientific name*	Status				Distribution	
			Residential	IUCN	Abundance	WPA	AN	NI
	Cisticolidae							
280.	Zitting Cisticola	*Cisticola juncidis cursitans* (Franklin, 1831)	R	LC	C			✓
281.	Andaman pale-footed bush warbler[ENS]	*Urosphena pallidipes osmastoni* (Hartert, 1908)	R	LC	U		✓	
	Locustellidae							
282.	Rusty-rumped warbler	*Locustella certhiola* (Pallas, 1811)	WM	LC	I		#✓	
283.	Lanceolated warbler	*Locustella lanceolata* (Temminck, 1840)	WM	LC	U		✓	✓
284.	Black-browed reed warbler	*Acrocephalus bistrigiceps* Swinhoe, 1860	WM	LC	U		✓	✓
285.	Blyth's reed warbler	*Acrocephalus dumetorum* Blyth, 1849	WM	LC	I		#✓	
286.	Oriental reed warbler	*Acrocephalus orientalis* (Temminck & Schlegel, 1847)	WM	LC	FC		✓	✓
287.	Clamorous reed warbler	*Acrocephalus stentoreus* (Hemprich & Ehrenberg, 1833)	WM	LC	FC		✓	
288.	Eastern thick-billed warbler	*Acrocephalus aedon* (Pallas, 1776)	WM	LC	FC		✓	
	Phylloscopidae							
289.	Dusky warbler	*Phylloscopus fuscatus* (Blyth, 1842)	WM	LC	FC		✓	✓
290.	Hume's leaf warbler	*Phylloscopus humei* (Brooks, 1878)	WM	LC	R		✓	
291.	Yellow-browed warbler	*Phylloscopus inornatus* (Blyth, 1842)	WM	LC	R		✓	
292.	Arctic leaf warbler	*Phylloscopus borealis* (Blasius, 1858)	V	LC	R		✓	✓
293.	Greenish leaf warbler	*Phylloscopus trochiloides* (Sundevall, 1837)	WM	LC	R		✓	
294.	Pale-legged leaf warbler	*Phylloscopus tenellipes* Swinhoe, 1860	V	LC	R		✓	✓
295.	Large-billed leaf warbler	*Phylloscopus magnirostris* Blyth, 1843	PM	LC	R		✓	
	Muscicapidae							
296.	Nicobar jungle flycatcher[E]	*Cyornis nicobaricus* Richnond, 1903	R	VU	U			✓
297.	Asian Brown flycatcher	*Muscicapa latirostris* (Raffles, 1822)	WM	LC	U		✓	✓

298.	Taiga flycatcher	*Ficedula albicilla* (Pallas, 1811)	WM	LC	U		✓	
299.	Tickell's blue flycatcher	*Cyornis tickelliae* Blyth, 1843	WM	LC	VR		✓	
300.	Mugimaki flycatcher	*Ficedula mugimaki* (Temminck, 1835)	WM/PM	LC	U		✓	
	Monarchidae							
301.	Nicobar paradise flycatcher[ENS]	*Terpsiphone paradisi nicobarica* Oates, 1890	R/LM	LC	R		✓	✓
302.	Andaman black-naped monarch flycatcher[ENS]	*Hypothymis azurea tytleri* (Beavan, 1867)	R	NE	FC		✓	
303.	Car Nicobar black-naped monarch flycatcher[ENS]	*Hypothymis azurea idiochroa* (Oberholser, 1911)	R	NE	U			✓
304.	Nicobar black-naped monarch flycatcher[ENS]	*Hypothymis azurea nicobarica* (Bianchi, 1907)	R	NE	FC			✓
	Stenostiridae							
305.	Grey-headed canary-flycatcher	*Culicicapa ceylonensis* (Swainson, 1820)	WM	LC	VR		✓	
	Pachycephalidae							
306.	Mangrove whistler	*Pachycephala cinerea* (Blyth, 1847)	R	LC	FC		✓	
	Dicaeidae							
307.	Andaman flowerpecker[E]	*Dicaeum virescens* Hume, 1873	R	LC	U	IV	✓	
	Nectariniidae							
308.	Andaman olive-backed sunbird[ENS]	*Cinnyris jugularis andamanicus* (Hume, 1873)	R	LC	U	IV	✓	
309.	Nicobar olive-backed sunbird[ENS]	*Cinnyris jugularis klossi* (Richmond, 1902)	R	NE	FC	IV		✓
310.	Car Nicobar olive-backed sunbird[ENS]	*Cinnyris jugularis proselia* (Oberholser, 1923)	R	NE	U	IV		✓
311.	Nicobar crimson sunbird[ENS]	*Aethopyga siparaja nicobarica* Hume, 1873	R	LC	U	IV		✓

(continued)

Table 6.1 (continued)

Sl. No.	Common name*	Scientific name*	Status				Distribution	
			Residential	IUCN	Abundance	WPA	AN	NI
	Zosteropidae							
312.	Oriental white-eye	*Zosterops palpebrosus* (Temminck, 1824)	R	LC	FC	IV	✓	
313.	Nicobar white-eye[ENS]	*Zosterops palpebrosus nicobaricus* Blyth, 1845	R	LC	U	IV		✓
	Emberizidae							
314.	Little bunting	*Emberiza pusilla* Pallas, 1776	WM	LC	R	IV	✓	
315.	Yellow-breasted bunting	*Emberiza aureola* Pallas, 1773	V	EN	R	IV		✓
316.	Chestnut bunting	*Emberiza rutila* Pallas, 1776	WM	LC	R	IV	✓	
	Estrildidae							
317.	Red avadavat[IN#]	*Amandava amandava* (Linnaeus, 1758)	R	LC	I	IV	#✓	
318.	Andaman white-rumped munia[ENS]	*Lonchura striata fumigata* (Waldeen, 1873)	R	LC	FC	IV	✓	
319.	Nicobar white-rumped munia[ENS]	*Lonchura striata semistriata* (Hume, 1874)	R	LC	C	IV		✓
320.	Scaly-breasted munia	*Lonchura punctulata* (Linnaeus, 1758)	R	LC	FC	IV	✓	
	Passeridae							
321.	House sparrow[IN]	*Passer domesticus* (Linnaeus, 1758)	R	LC	C		✓	✓
322.	Eurasian tree sparrow [IN#]	*Passer montanus* (Linnaeus, 1758)	R	LC	I		#✓	
	Sturnidae							
323.	Andaman glossy starling[ENS]	*Aplonis panayensis tytleri* (Hume, 1873)	R/LM	LC	C	IV	✓	
324.	Nicobar glossy starling[ENS]	*Aplonis panayensis albiris* Abdulali, 1967	R/LM	LC	A	IV		✓
325.	Andaman white-headed starling[E]	*Sturnia erythropygia* (Blyth, 1846)	R	LC	C	IV	✓	
326.	Nicobar white-headed starling[ENS]	*Sturnia erythropygia erythropygius* (Blyth, 1846)	R	NT	U	IV		✓

327.	Katchal white-headed starling[ENS]	*Sturnia erythropygia katchalensis* (Richmond, 1902)	R	NT	U	IV		✓
328.	Daurian starling	*Agropsar sturninus* (Pallas, 1776)	WM	LC	C	IV	✓	✓
329.	Rosy starling	*Pastor roseus* (Linnaeus, 1758)	WM	LC	U	IV	✓	✓
330.	Common starling	*Sturnus vulgaris* Linnaeus, 1758	PM	LC	R	IV	✓	
331.	Common myna[IN]	*Acridotheres tristis* (Linnaeus, 1766)	R	LC	A	IV	✓	✓
332.	Jungle myna[IN#]	*Acridotheres fuscus* (Wagler, 1827)	R	LC	I	IV	#✓	
333.	Andaman hill myna[ENS]	*Gracula religiosa andamanensis* (Beavan, 1867)	R	NT	FC	IV	✓	
334.	Great Nicobar hill myna[ENS]	*Gracula javensis halibrecta* Oberholser 1926	R	NT	FC	IV		✓
	Oriolidae							
335.	Indian golden oriole	*Oriolus kundoo* Sykes, 1832	WM	LC	U	IV	✓	
336.	Andaman black-naped oriole[ENS]	*Oriolus chinensis andamanensis* (Tytler, 1867)	R	LC	FC	IV	✓	
337.	Nicobar black-naped oriole[ENS]	*Oriolus chinensis macrourus* Blyth, 1846	R	LC	U	IV		✓
338.	Andaman black-hooded oriole[ENS]	*Oriolus xanthornus reubeni* Abdulali, 1977	R/LM	LC	U	IV	✓	
	Dicruridae							
339.	Black drongo	*Edolius macrocercus* Vieillot, 1817	WM	LC	U	IV	✓	✓
340.	Ashy drongo	*Edolius leucophaeus salangensis* Reichenow, 1890	WM	LC	R	IV	✓	✓
341.	Crow-billed drongo	*Dicrurus annectans* (Hodgson, 1836)	PM	LC	VR	IV		✓
342.	Andaman drongo[E]	*Dicrurus andamanensis* Beavan, 1867	R	NT	FC	IV	✓	
343.	Large Andaman drongo[ENS]	*Dicrurus andamanensis dicruriformis* (Hume, 1873)	R	LC	FC	IV	✓	

(continued)

Table 6.1 (continued)

Sl. No.	Common name*	Scientific name*	Status				Distribution	
			Residential	IUCN	Abundance	WPA	AN	NI
344.	Andaman racket-tailed drongo[ENS]	*Dicrurus paradiseus otiosus* (Richmond, 1903)	R	LC	FC	IV	✓	
345.	Nicobar racket-tailed drongo[ENS]	*Dicrurus paradiseus nicobariensis* (Baker, 1918)	R	LC	C	IV		✓
	Artamidae							
346.	White-breasted woodswallow	*Artamus leucorynchus* (Linnaeus, 1771)	R	LC	U		✓	
	Corvidae							
347.	Andaman treepie[E]	*Dendrocitta bayleyi* Blyth, 1863	R	NT	C		✓	
348.	House crow[IN]	*Corvus splendens* Vieillot, 1817	R	LC	FC	IV	✓	
349.	Eastern jungle crow	*Corvus levaillantii* Lesson, 1831	R	LC	FC		✓	

Residential status: *R* resident, *R/LM* resident with local movements, *R/WM* resident with winter migrant, *WM* winter migrant, *WM/PM* winter migrant as well as passage migrant, *PM* passage migrant, *PM/SM* passage migrant with summer migrant, *PM/WM* passage migrant with winter movements, *SM* summer migrant, *SM/R* summer migrant with resident, *S* straggler, and *V* vagrant Residential status followed by Ali and Ripley (1983); Tikader (1984); Grimmett et al. (2008), Kazmierczak and van Perlo (2000); Kumar et al. (2005); Rasmussen and Anderton (2012)

IUCN status: *LC* least concern, *NT* near threatened, *EN* endangered, *VU* vulnerable, *NE* not evaluated, *DD* data deficient (BirdLife International 2015)

Endemic status: *E* endemic to Andaman and Nicobar Islands, *ENS* endemic subspecies, *IN* introduced, *IN#* introduced and no recent sighting, *#✓* unconfirmed and no recent sightings

Abundance status: *A* abundant (50 or more birds seen per day), *C* common (seen 10 to 49 per day), *Fc* fairly common (usually encountered less than 10 per day), *U* uncommon (present in small numbers, but not certain to be seen, 1–12 birds per fortnight), *R* rare (occurs annually in very small numbers in suitable habitat, i.e., 1–5 records in a season), *Vr* very rare or casual (generally not recorded every year but likely to occur within a few years, i.e., 1 or 2 records per season for an island), *I* irregular (abundance varies year to year, can be less numerous or absent some year)

Common and scientific name followed by Rassmusen and Anderton (2005); order and family followed by BirdLife International 2015; Praveen et al. (2016); Clement et al. (2016)

Table 6.2 List of bird species introduced in Andaman and Nicobar Islands

Sl. No.	Name of the species	Year introduced	Remarks
1.	Jungle myna	1860	Introduced from Burma in Port Blair by Col. R.C. Tytler and there is no recent sighting
2.	House crow	1862 and 1864	Introduced for sanitary purposes but failed to establish. However, accidentally reached recently and established well in Andaman Islands
3.	Rose-ringed parakeet	1863	No recent sighting
4.	Eurasian tree sparrow	1866	No recent sighting
5.	Common myna	1867	Introduced in Ross Island. This species is well established in different parts of Andaman and Nicobar Islands
6.	Peafowl	1868	Introduced only in the Ross Island and few individuals are established
7.	Red avadavat	1873	No recent sighting
8.	House sparrow	1882 and 1895	Introduced in the Ross Island. However, established well in all parts of Andaman and Nicobar Islands
9.	Laughing dove	1899	No recent sighting
10.	Black-headed munia	1906	No recent sighting
11.	Grey partridge	1890	Recently, established around Port Blair
12.	Spot-billed duck	1960	Escaped from mesh enclosure from Ross Island during a storm, but not sightings
13.	Common quail	1961	Brought from Madras and released into Ross Island. No recent records. Possibly died out
14.	Jungle bush quail	1961	No recent records
15.	Painted bush quail	1961	No recent records
16.	Knob-billed duck	1961	Brought from Calcutta and released into Neil Island. Recently reported from South Andaman Islands by the authors
17.	Open-billed stork	1964	Introduced from Calcutta and released into South Andaman for the control of African giant snail. But failed to establish in these islands. No recent sighting
18.	Blue rock pigeon		Distributed well in Andaman and Nicobar Islands
19.	Chinese francolin	1964	Released in Andaman and no recent sighting

Sources: Rajan and Pramod (2013)

Table 6.3 Taxonomic composition in birds of Andaman and Nicobar Islands

Order	Family	Genus	Species	Subspecies
Podicipediformes	1	1	1	0
Procellariiformes	2	6	7	0
Phaethontiformes	1	1	3	0
Suliformes	3	3	6	0
Pelecaniformes	3	10	20	3
Anseriformes	1	8	12	0
Accipitriformes	2	12	29	7
Falconiformes	1	1	6	2
Galliformes	2	4	5	2
Gruiformes	1	9	15	5
Charadriiformes	9	31	60	3
Columbiformes	1	8	15	5
Psittaciformes	1	2	6	4
Cuculiformes	1	9	15	1
Strigiformes	2	3	8	3
Caprimulgiformes	2	5	9	4
Coraciiformes	3	9	16	11
Bucerotiformes	2	2	2	0
Piciformes	1	3	3	1
Passeriformes	28	59	111	30
	67	**186**	**349**	**81**

BirdLife International identified 218 endemic bird areas, of which 19 are found in Andaman and Nicobar Islands (Birdlife International 2000). There are 111 taxa including subspecies which are endemic to Andaman and Nicobar Islands, and the following 30 species are endemic to Andaman and Nicobar Islands, namely, *Anas gibberifrons*, *Spilornis elgini*, *Rallina canningi*, *Columba palumboides*, *Macropygia rufipennis*, *Treron chloropterus*, *Centropus andamanensis*, *Tyto deroepstorffi*, *Otus balli*, *Ninox obscura*, *Ninox affinis*, *Caprimulgus andamanicus*, *Rhyticeros narcondami*, *Dryocopus hodgei*, *Coracina dobsoni*, *Microtarsus fuscoflavescens*, *Copsychus albiventris*, *Dicaeum virescens*, *Sturnus erythropygius*, *Dicrurus andamanensis*, *Dendrocitta bayleyi*, *Spilornis klossi*, *Spilornis minimus*, *Accipiter butleri*, *Megapodius nicobariensis*, *Ducula nicobarica*, *Psittacula caniceps*, *Otus alius*, *Hypsipetes nicobariensis* and *Cyornis nicobaricus.* Nineteen species of birds were introduced into these islands (Table 6.2).

According to IUCN (2016), 1 species is categorized as critically endangered, 4 species were categorized as endangered and data deficient, 33 species were listed as near threatened, 5 species were listed as vulnerable, 36 species were listed as not evaluated and the rest of the 260 species are categorized as of least concern. The Christmas frigatebird is the only species found in the endangered category in these Islands. Among these threatened birds, 19 species were endemic to these Islands (Fig. 6.4).

Table 6.4 Family-wise distribution of bird species

Family	No. of species	Family	No. of species
Podicipedidae	1	Meropidae	3
Procellariidae	2	Coraciidae	2
Hydrobatidae	5	Upupidae	1
Phaethontidae	3	Bucerotidae	1
Sulidae	2	Picidae	3
Phalacrocoracidae	1	Alaudidae	1
Fregatidae	3	Pittidae	2
Pelecanidae	1	Hirundinidae	5
Ardeidae	18	Motacillidae	10
Threskiornithidae	1	Campephagidae	6
Anatidae	12	Pycnonotidae	3
Accipitridae	28	Irenidae	1
Pandionidae	1	Laniidae	2
Falconidae	6	Turdidae	5
Megapodiidae	2	Muscicapidae	6
Phasianidae	3	Cisticolidae	2
Rallidae	15	Locustellidae	7
Jacanidae	1	Phylloscopidae	7
Charadriidae	9	Muscicapidae	5
Scolopacidae	29	Monarchidae	4
Turnicidae	1	Stenostiridae	1
Recurvirostridae	1	Pachycephalidae	1
Dromadidae	1	Dicaeidae	1
Burhinidae	1	Nectariniidae	4
Glareolidae	2	Zosteropidae	2
Laridae	15	Emberizidae	3
Columbidae	15	Estrildidae	4
Psittaculidae	6	Passeridae	2
Cuculidae	15	Sturnidae	12
Tytonidae	1	Oriolidae	4
Strigidae	7	Dicruridae	7
Caprimulgidae	2	Artamidae	1
Apodidae	7	Corvidae	3
Alcedinidae	11		

6.3.2 Additional Data/Confirmation Required

Certain species of bird listed in this checklist need further confirmation for site-specific record as there is no recent sighting of these species, namely, short-tailed shearwater, white-bellied storm petrel, black-bellied storm petrel, red-billed tropic-bird, spot-billed pelican, great-billed heron, mallard, spot-billed duck, Swinhoe's snipe, great snipe, eastern whimbrel, black noddy, lesser noddy, laughing dove,

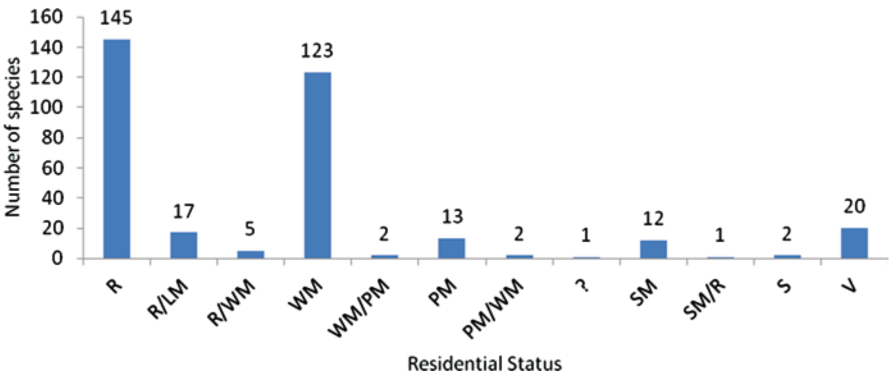
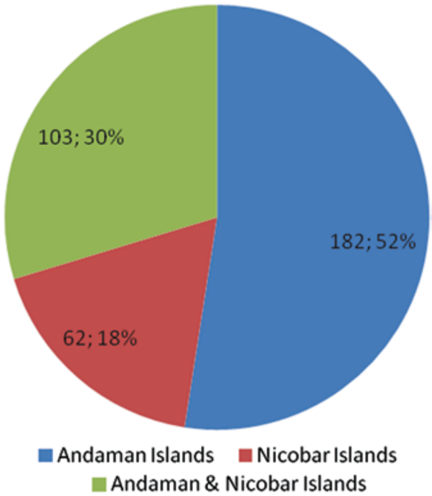


Fig. 6.2 IUCN status of birds of Andaman and Nicobar Islands

Fig. 6.3 Residential status of bird species of Andaman and Nicobar Islands



common hawk-cuckoo, common sand martin, Asian house martin, rusty-rumped warbler, Blyth's reed warbler, red avadavat, Eurasian tree sparrow and jungle myna (Table 6.1).

6.4 Conclusion

This result is based on the field surveys carried out during last 10 years in these islands by the authors. The high avian species richness recorded from these islands is due to presence of diverse habitats and extensive field surveys carried out by various researchers. The Indian subcontinent, a part of the vast Oriental biogeographic regions, is very rich in biodiversity. Out of the more than 9000 birds of the world, the Indian subcontinent contains about 1300 species or over 13% of the world's

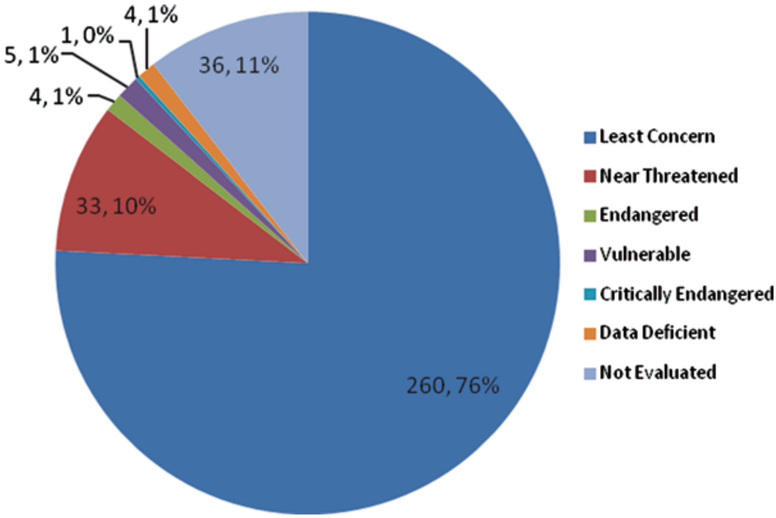


Fig. 6.4 Taxonomic composition of Andaman and Nicobar Islands

birds (Grimmett et al. 1998). This subcontinent, rich in avifauna, also boasts of 48 bird families out of the total 75 families in the world. Ali and Ripley (1987) consider 176 species of birds which are endemic to the Indian subcontinent. Of the 176 species that are endemic, 30 are endemic to the Andaman and Nicobar Islands. The Andaman and Nicobar Islands account for only 0.2% of the landmass of South Asia but support 17% of the endemic avifauna, thus making the islands a high priority area in the conservation of India's avifauna. This archipelago comes under the East Asian-Australasian Flyway and supports good numbers of transcontinental migratory during the month of September to March. The migratory bird species are another important group contributing towards the overall avifauna of these Islands. Seasonal changes in bird composition are very evident because of winter migratory birds especially waders (Chopra and Kamal 2012). A total of 123 winter migrants are reported from Andaman and Nicobar Islands, of which 59 species are recorded from Andaman Islands and 34 species recorded from Nicobar Islands. Coastal wetlands in India provide winter protection for migratory waterfowl from different parts of the world such as Asia, Europe and Mediterranean regions (Balachandran 2012). Andaman and Nicobar Islands are no exception; these islands also support good numbers of wetland birds during migratory season, especially the tsunami-inundated wetlands in South Andaman. Out of 61 migratory species in these islands, 38 species are winter migratory water birds.

The continuous monitoring of the important habitats is imperative for the complete understanding of the patterns of movement of migratory shore birds in the Islands. Despite the studies to date, there are still large gaps in the knowledge needed to effectively solve the problems related to bird conservation in this archipelago. Areas of avian ecological research are lacking which is needed substantially. Only small amount of quantitative information is available on the distribution and habitat preference of birds. Long-term research is needed on the effects of the agricultural disturbances on nesting colonies, isolated roosting sites and areas that are regularly concentrated with large numbers of birds. Studies on seasonal changes in bird diets can make an important contribution to understanding the dynamics of the island ecosystem. Detailed ecological studies on the migratory birds, endemic threatened birds and their importance are needed in this island using bird banding/radio telemetry (Plates 6.1 and 6.2).

Plate 6.1 Birds of Andaman and Nicobar Islands (Endemic bird species). (**a**) Nicobar megapode; (**b**) Narcondam hornbill; (**c**) Nicobar bulbul; (**d**) Andaman wood pigeon; (**e**) Andaman teal; (**f**) Andaman crake

Plate 6.2 Birds of Andaman and Nicobar Islands. (**a**) Lesser frigatebird; (**b**) brown noddy; (**c**) Chinese egret; (**d**) corncrake; (**e**) edible-nest swiftlet; (**f**) lanceolated warbler

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Does Southern Spotted Owlet *Athene brama brama* (Temminck, 1821) Serve as a Biocontrol Agent of Agricultural Pests? A Case Study from Cauvery Deltaic Region of Southern India

7

Varadharajan Vanitha, Krishnamoorthy Thiyagesan, and Nagarajan Baskaran

Abstract

Owl species congregate at pest-infested areas, and their role in biological control of agricultural pests has become significant. India is endowed with 62 species of owls, of which the spotted owlet *Athene brama* is the commonest and a widely distributed species. The species is regarded as a biocontrol agent of agricultural pests in India. To determine whether the southern spotted owlet *Athene brama brama* is serving as a biocontrol agent of agricultural pests in the Cauvery deltaic region of Tamil Nadu, southern India, we assessed their roost site selection and diet composition during 2007–2008. Roost selection was studied based on roost site characteristics observed from 22 roost sites. The results showed that the spotted owlets roosted more frequently close to human habitation (mean distance 41 ± 12.8 m) than agricultural fields (218 ± 50.7 m). All the roost sites observed have used trees as substrate. Among the six tree species used as substrate, *Albizia saman* (rain tree) was the most commonly used roost tree species. Tree species with 20–30 m height and 1–3 m gbh were most frequently used for roosting, likely due to the presence of more number of branches and dense foliage than nearby non-roost trees. Availability of suitable locations with better protection from weather and concealment to avoid the disturbance from humans and other birds appeared to influence the selection of roost species and size class by the

V. Vanitha (✉)
Dharmapuram Gnanambigai Government Arts College (Women), Mayiladuthurai, Tamil Nadu, India

Post Graduate and Research Department of Zoology and Wildlife Biology, A.V.C. College (Autonomous), Mannampandal Mayiladuthurai, Tamil Nadu, India

K. Thiyagesan · N. Baskaran
Post Graduate and Research Department of Zoology and Wildlife Biology, A.V.C. College (Autonomous), Mannampandal Mayiladuthurai, Tamil Nadu, India

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southern spotted owlet. Diet composition was assessed indirectly, analyzing 55 regurgitated pellets collected from 12 roost sites. Diet items identified based on the undigested food remains in the pellet revealed that insects constituted the bulk of the owls' diet (57%) followed by mammals (rodents) (24.4%), reptiles (7.8%), and birds (7.3%). However, among the prey groups, the mammalian prey contains more flesh per unit of body mass than insect, which is digestible by owl; thus, it is argued that mammals in the form of digestible part could have contributed more to the diet of owlet than any other taxa. The higher consumption of rodents and insects, which are potential pests of the agriculture ecosystems, by spotted owlets indicates the importance of the species as a prospective biocontrol agent of insect and rodent pests of agriculture in the study area. Despite their higher dependence on agricultural pests as food resources, reason for roosting closer to the human habituation could be due to inadequate roosting sites (mature trees) in agricultural areas. Thus creating awareness among local communities about the role of spotted owlets and the importance of maintaining a few mature trees in agricultural areas, as roost sites for owlets, would not only improve their population and ensure long-term conservation but also help controlling the agricultural pests effectively, without the rampant use of pesticide, which causes detrimental effect to the environment and biodiversity including the human beings.

Keywords

Agricultural pest · Diet composition and roost site · Southern spotted owlet

7.1 Introduction

Owl species congregate at pest-infested areas, and their role in biological control of agricultural pests has become significant (Hudson 1874; Goddart 1935; McWilliam 1941; Banfield 1947; Lockie 1955; Pitelka et al. 1955a, b; Sweetman 1958; Wood 1974; Clark 1975). Their role in controlling rodent population cannot be underestimated, as rats eat away a third of India's total food produce (Sridhar 1981). The southern spotted owlet *Athene brama brama* (Temminck 1821), a least concern species (IUCN Red List 2015), is one of the most common out of the 62 species of owls found in India. This species is also found in Bangladesh, Bhutan, Cambodia, Iran, Laos, Myanmar, Nepal, Pakistan, Thailand, and Vietnam ranging across wide habitats from forest to savanna, shrub land, grassland, and desert. It has adapted to varied environments such as parks, groves, agricultural fields, and abandoned buildings in garden and villages, towns, and crowded cities, indeed any open area with trees substantial enough to provide adequate roosts (Sridhar 1981). The species is nocturnal and is considered commensal (Fletcher 1936). It is a carnivorous raptor, and its food consists of rodents, birds, reptiles, amphibians, annelids, and arthropods (Mason and Lefroy 1912; Ali and Ripley 1969; Sridhar 1981; Vanitha et al. 2014). Therefore, it is recognized as an efficient biocontrol agent of small mammals and insect pests of agricultural importance (Kumar 1985) both economically and eco-friendly (Jain and Advani 1984). Thus, understanding the species ecology and enhancing its survival are not only important for their conservation but also for the economic value the spotted owlet accrues to the society by feeding on the agricultural pests such as insects and rodents, which cause a significant loss to agriculture and stored grains (Prakash and Mathur 1987). In addition, the rodents are also reservoirs of large number of pathogens, many of which cause outbreak of diseases to human and livestock, often with high morbidity and mortality (Gratz 1994). However, in India, most of the published data available on the species are from prior to 1950 and/or from multi-species focus in nature (Dewar 1929; Bekar 1930; Ali 1933; Fletcher 1936, Ali and Ripley 1969; Ganguli 1975; Sridhar 1981). There have been a few long-term ecological studies (Kumar 1985; Santhanakrishnan et al. 2010, 2011; Pande et al. 2007) and short-term or anecdotal observations on feeding, nesting, and breeding (Jain and Advani 1984; Jadhav and Parasharya 2003; Ramanujam and Verzhutskii 2004; Pande et al. 2004, 2006, 2011). Nevertheless, site-specific ecological data essential to understand the species status and its requirements are still lacking in many parts of India including areas where agriculture drives the regional economy. Nagapattinam district in Tamil Nadu is a part of Cauvery deltaic region, which is known as "Rice Bowl" of the state. Agriculture being the predominant source of economy of this region, site-specific ecological data on the southern spotted owlet, which are lacking still, would contribute vital information to the agricultural economy of the area. To determine whether the southern spotted owlet *Athene brama brama* is serving as a biocontrol agent of agricultural pests in the Cauvery deltaic region of Tamil Nadu, southern India, this study was carried out on roost site selection and diet species composition of southern spotted owlet.

7.2 Methods

Profile of Study Area The study was carried out in the Cauvery deltaic region of Mannampandal (18°18′ N and 79°50′ E), Nagapattinam district, southern India, during December 2007–March 2008. The area is characterized by large-scale cultivation of paddy *Oryza sativa*, sugarcane *Saccharum* sp., black gram *Vigna mungo* and green gram *V. radiata*, and cotton *Gossypium* sp. with groundnut *Arachis hypogaea* and other cereals grown as minor crops. Woody vegetation is mostly restricted to the riverbank of Cauvery, the A.V.C. College campus, either sides of the highway, and human settlements. Tree species like *Tamarindus indica*, *Mangifera indica*, *Albizia saman*, *Madhuca indica*, and *Azadirachta indica* are common in the study area. This area has a prolonged summer or dry season from March to August, a short monsoon or wet season lasting from September to November, and winter lasting from December to February. The area in and around the study site is under Cauvery-based canal-fed irrigation, with two-thirds of this area being cultivated with single wet crop – paddy – followed by a cultivation of dry crop of pulses mostly black and green grams, while the rest of the area (one-third), using bore-well irrigation facility, goes for two-wet crop cultivation. Rat damages the paddy and cereal crops severely. Farmers take considerable effort to reduce the rat damage, sometimes even placing electrified lines in all the four sides of crop field after a meter distance from bunds to control the rat population.

Evaluation of Roost Sites and Their Characteristics The southern spotted owlet is known to roost in natural hollows found in tree trunks, in holes in dilapidated walls, between ceiling and roof in deserted or occupied dwellings, in eaves of houses, in nest boxes, in holes in stone wall of open wells, and in earth cuttings (Jerdon 1862; Ali and Ripley 1969; Kumar 1985; Naik 2004; Jadhav and Parasharya 2003; Pande et al. 2006). Through a systematic survey, examining the above-listed sites across human habitation, crop field, and riverbanks, spotted owlets roosting/nesting were identified using indirect signs such as regurgitated pellets, droppings, and prey remains with confirmation of the species by direct sightings during the late evening time when the owls leave the roosts. In addition, inquiry with local people about the roost sites enabled locating the spotted owlets easily. In total, 22 roost sites were located during the study period. On locating each roost site, we recorded the roost perch and, in case of roost tree, roost tree species name and its gbh (m) and distance to the nearest agricultural field, human habitation, footpath, road, electric post (acted as perch pole), and water source. In addition, we have quantified the roost tree characteristics such as tree height, its gbh (m), roost height (m) from ground, type of branch used for nesting (primary/secondary), branch thickness, and number of live and dead branches. To find out how the roosting trees are different from non-roosting ones, we assessed tree height, gbh, and number of live and dead branches of a nearest non-nest tree with similar characteristic features within the vicinity of each roost tree, and this exercise was restricted only for six roosting sites.

Data Analysis Data on land use parameters from 22 roosts were pooled to arrive at mean distance (± SE) of roost to each land use attribute. Similarly, all the roost and non-roost tree characteristics recorded were pooled separately to arrive at mean value (± SE) for each characteristic. Differences in characteristics between roost and non-roost trees were tested using “T” test following the methods described by Sokal and Rohlf (1981).

Diet Composition Evaluation In general, owls swallow their prey whole or at times the head alone based on the size of the prey, the fleshy portions of the prey eaten are digested, and undigested fur and bones are cast-up and regurgitated as pellets (Welty 1982). In this study, we adapted the analyses of regurgitated pellet method, which is a more reliable technique to study the diet composition of owls (Errington 1932; Glading et al. 1943). In total, 12 roost sites, located within the study area, were identified during the first quarter of December 2007. On locating each roost site, the remains of prey parts and old pellets accumulated at the roost were cleared first, carefully without disturbing the owls. Subsequently, the roost site was visited on an alternate day interval until February 2008, and 52 freshly regurgitated pellets were collected from all the roost sites. The pellets were collected in separate polythene bags labeled with details (date, site name, and texture of pellets) and oven-dried at 70 °C for 24 h to kill the associated invertebrate parasites (Santhanakrishnan 1987). They were eventually analyzed individually following Schueler (1972) by dissolving each pellet in 3% NaOH solution held at 60–65 °C. Hair and other debris were dissolved in sodium hydroxide, leaving the hard parts of prey. The hard prey parts were segregated broadly into invertebrates (insects), using chitinous exoskeleton of head, elytra, mandibles, legs, proboscis, pedipalps, and stings, and vertebrates, based on their distinctive cutaneous, dental, cranial, and other skeletal characteristics (Errington 1932), dried and stored for further segregation. The insect remains were further identified and segregated up to order level, scanning through a binocular microscope or hand lens comparing their structural characteristics with standard literature on insects (Mani 1980). Identification of small mammals, especially rodents, was following Neelanarayanan et al. (1998) and Agarwal (2000). To understand the contribution of each prey species in the diet of spotted owlet, the segregated items were weighed (dry weight) and the percent composition of various food items was calculated.

7.3 Observations and Results

7.3.1 Roost Site Selection

In total, 22 roosting sites were located during the study period. The data on distance from roost site to various land use elements showed that all the roosts, except for one within 100 m, were closer to human habitation with a mean distance of <50 m (Fig. 7.1). While the proximity to agricultural land was within 100 m distance to nearly 50% of the roosts (10 out of 22), followed by 250–500 m to 27% (6) of the roosts and 100–250 m to 18% (4) of the roosts, only 2 roosts (9%) were located at a range of 500–1000 m away from the agricultural lands. The estimated mean distance to agricultural land was about 220 m (Fig. 7.1). Further, majority of the roosts were close (within 100 m distance) to walkways (100%, mean distance 13 m) and roads (82%, mean distance 51 m). All the roost sites were having electric post within 100 m (mean 30 m) distance. These results show that the species roosts closer to human habitation than agricultural lands and do not get disturbed much with human activities in the nearby areas.

All the 22 roost sites observed in this study were located in tree cavities, with rain tree *Albizia saman* being the most commonly used (41%) tree species, followed by *Alangium* sp. (23%). Other tree species such as neem *Azadirachta indica* (14%), tamarind *Tamarindus indica* (9%), banyan *Ficus benghalensis* (9%), and the peepal tree *Ficus religiosa* (5%) were used rarely (Table 7.1).

The roost trees selected by owlets varied in height from 10 to 35 m (mean 24.4 ± 1.67) with a strong preference to 20–30 m height class trees, as 13 (60%) out of 22 roots were on this height class trees. Over 85% of the roost trees were 1–3 m

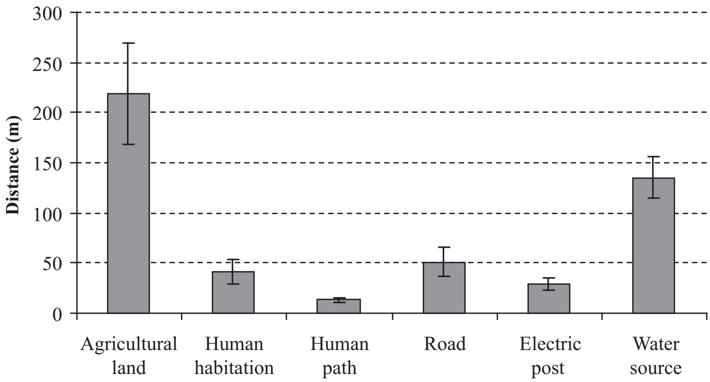

Fig. 7.1 Mean distance to various land use patterns observed around 22 roost sites of spotted owlets in Cauvery deltaic region of southern India during 2007–2008

Table 7.1 Tree species used for roosting by spotted owlets in Cauvery deltaic region of southern India during 2007–2008

S. No.	Tree species name		% of roosts (n = 22)
	Scientific	Common	
1	*Albizia saman*	Rain tree	40.9
2	*Alangium* sp.	Alangium	22.7
3	*Azadirachta indica*	Neem tree	13.6
4	*Tamarindus indica*	Tamarind tree	9.1
5	*Ficus benghalensis*	Banyan tree	9.1
6	*Ficus religiosa*	Peepal tree	4.5

gbh classes (2.1 ± 0.19). Of the 22 roosts, over two-thirds (64%) were in secondary branches, mostly at 15–20 and 20–25 m height from the ground (mean 16.6 ± 1.32), with mean roost branch thickness of 1 ± 0.16 m. Comparison of the tree characteristics of roost trees with nearest non-roost trees revealed that roost trees were significantly taller than the nearby non-roost trees in height (roost tree 29.5 ± 2.39 m, non-roost tree 27.3 ± 3.55 m, $t = 5.87$, $df = 10$, $P > 0.05$), gbh (roost tree 2.2 ± 0.53 m and non-roost tree 1.1 ± 0.13 m, $t = 1.93$, $df = 10$, $P > 0.05$), and the number of live branches (roost trees 6.5 ± 2.78 and non-roost trees 4.5 ± 0.53, $t = 2.78$, $df = 10$, $P > 0.05$) and dead branches (roost tree 3.75 ± 0.59 and non-roost tree 1.08 ± 0.34, $t = 3.19$, $df = 10$, $P > 0.05$), indicating their strong preference to larger height and gbh class trees with thicker canopy.

7.3.2 Diet Composition

The analyses of 52 pellets reveal that invertebrates formed the bulk (57%) of the diet during December–February with the rest being constituted of vertebrates (39.6%) and unidentified items (3.4%) (Fig. 7.2). The invertebrate prey parts represented

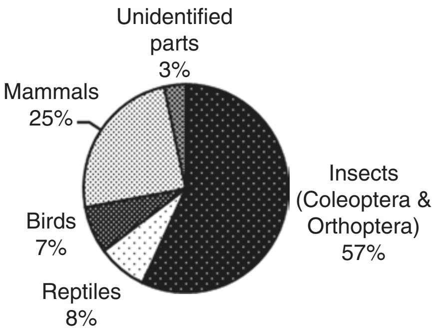

Fig. 7.2 Diet composition of spotted owlets recorded from 52 regurgitated pellets collected in Cauvery deltaic region of southern India during December 2007–February 2008

were insects belonging to orders Coleoptera (beetles) and Orthoptera (crickets and grasshoppers), and the vertebrates included mammals (24.4%), reptiles (7.8), and birds (7.3). Among the vertebrate prey parts, only the mammal body parts could be identified as musk shrew (*Suncus murinus*) and field mouse (*Mus booduga*); the prey parts belonging to other vertebrate taxa could not be identified up to genus level but were categorized as reptiles and birds. The finding highlights the importance of the species as biocontrol agent of insects and rodents, which are the potential pests of agriculture ecosystems in the study area.

7.4 Discussion

The present study shows that two-thirds of the roost sites (64%) of the southern spotted owlets were located within 250 m or 91% within 500 m distance from agricultural lands similar to the observations on the same species elsewhere in Tamil Nadu (Naranthiran 1989) and Andhra Pradesh (Kumar 1985). A similar finding was also reported in long-eared owls in southwestern Idaho (Marks and Marti 1984). In addition, the species were also found to roost near (<50 m) human habitations. The spotted owlets mainly fed on rodents and insects (results from present study and Naranthiran 1989), which are found both in agricultural fields and human habitations (Sivaprakasam 1988, Neelanarayanan et al. 1996). Roosting in such areas would be appropriate to optimize the food intake that could enhance the life history strategy of reproductive success of the species. Therefore, closer proximity shown to agricultural land and human habitation could be related to food abundance. The other possible reason for the closer proximity of roost site to human habitation (mean 41 m) than agricultural land (mean 218 m) could be the greater availability of suitable roost trees in the human habitation compared to agricultural land, as farmers do not grow large trees in agricultural areas, as tree canopy reduces the exposure of sunlight to crop field, which affects the growth and yield of crops.

The species being widely distributed in nature has extensively adapted to roost itself in natural hollows in tree trunks, in holes in dilapidated walls, between ceiling and roof, in deserted or occupied dwellings (Ali and Ripley 1969; Pande et al. 2006), in eaves of houses (Jerdon 1862), in nest boxes (Naik 2004; Jadhav and

Parasharya 2003; Mahmood-ul-Hassan 2008), in holes in stone walls of open wells (Kumar 1985), in ravines (Ramanujam and Verzhutskii 2004), or in earth cuttings (Pande et al. 2006). However, in the present study, all the roosts were recorded in tree cavities, possibly due to common availability of mature trees in our study area, especially at the A.V.C. College campus, which has a large number of mature trees. The findings of roost selection revealed that spotted owlets in the study area depend only on mature tree for roosting, unlike in southern Tamil Nadu, where the species partly rely on man-made structures for roosting (Santhanakrishnan et al. 2011). The results of the present study further show that owlets selected most frequently the *A. saman* tree for roosting (41%) followed by *Alangium* sp. (23%), *Azadirachta indica* (14%), *Tamarindus indica* (9%), *Ficus benghalensis* (9%), and *Ficus religiosa* (5%). The tree species selection for roosting recorded in the present study area is different from that of in southern Tamil Nadu that showed *Ficus benghalensis* (48%), *Enterolobium saman* which is presently renamed as *Albizia saman* (30%), *Cocos nucifera* (15%), and *Tamarindus indica* (7%) (Santhanakrishnan et al. 2011). The observed differences in roost substrate and in tree species selection could be related to spatial difference in mature trees and availability of various tree species. *A. saman* is a fast-growing softwood species, grows larger in height, and branches highly with broad canopy and thick foliage. Above all, the mature trees of *A. saman* also have a large number of natural cavities formed mostly in primary branches due to the damage of any secondary branch, and these are large enough to accommodate the owlets. Apart from the availability of natural cavities, larger trees with wide canopy and thick foliage could also provide better protection from weather conditions like rain, sunlight, and wind and concealment for escaping from other bird species like crow (*Corvus splendens*) and human being during the daytime as reported elsewhere (Forsman et al. 1984; Kumar 1985; Naranthiran 1989). Therefore, *A. saman* was used by southern spotted owlets more commonly than any other tree species for roosting in the present study area.

Data on diet composition show that southern spotted owlets selected prey items in the order insects (57%), mammals (24.4%), reptiles (7.8%), and birds (7.3%) during December 2007 to February 2008 in the Cauvery delta of Nagapattinam district. The present findings on the proportion of invertebrates versus vertebrates in the diet of spotted owlets are similar to the trend reported for the species from the adjoining states of Andhra Pradesh (Kumar 1985). A similar pattern in the diet composition of spotted owlets has been reported from the adjoining district of the Cauvery delta, insects 86%, mammals 7%, reptiles 1.26%, and birds 0.025% with unidentified food items being the rest (5.71%), based on analysis of 590 pellets (Naranthiran 1989), and in Pondicherry, insects 94%, reptiles 2%, and mammals 4%, based on 197 pellets (Ramanujam and Verzhutskii 2004). However, the actual difference in the percent composition of various prey items between the present study and the earlier studies (Naranthiran 1989; Ramanujam and Verzhutskii 2004) could be due to shorter duration (3 months) and smaller sample size (52 pellets) of the present study. It is evident from the earlier studies as well as from the present study that the species with an opportunistic feeding strategy, preying upon wide spectrum of prey species available locally, are able to thrive widely across the Indian subcontinent (Kumar 1985; Ramanujam and Verzhutskii 2004). Based on the indigestible food remains in the pellets, the invertebrates in the form of insects contributed the highest proportion of owlets' diet. However, it is likely that vertebrates, especially mammals, may have actually added a higher quantum of digestible parts to the diet of owlets, as vertebrates have a higher biomass of weight (as observed by Kumar 1985) in the form of flesh per unit of body mass, compared to invertebrates, that is digested in the process, as reported elsewhere (Ramanujam and Verzhutskii 2004). These findings suggest that spotted owlets play an important role in controlling agricultural pests like rats and insects. Thus, conserving this species is important not only for ecological balance but also as a biological agent in controlling agricultural pests that cause a significant economic loss to the country.

Overall, the present study reveals that the southern spotted owlet is serving as a potential biological agent in controlling agricultural pest in the Cauvery deltaic regions of Nagapattinam district, Tamil Nadu, similar to that reported elsewhere (Kumar 1985). Despite their higher dependence on agricultural pests as food resources, reason for roosting closer to the human habituation could be due to inadequate roosting sites (mature trees) in agricultural areas. Thus creating awareness among local communities about the potential role of spotted owlets in controlling agricultural pests and the importance of maintaining a few mature trees in agricultural areas, as roost sites for owlets, would not only improve their population but also help in controlling the agricultural pests effectively, without the use of much pesticide.

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Mammals of Andaman and Nicobar Islands

8

C. Sivaperuman, G. Gokulakrishnan, and P. Parthipan

Abstract

An updated checklist of the mammals of Andaman and Nicobar Islands including their present status and distribution is provided in this chapter. Data were collected from available literature and field work carried out during 2008 through 2016. This checklist comprises of 58 species of mammals occurring in this archipelago belonging to 7 orders, 18 families and 31 genera.

Keywords

Andaman · Checklist · Endemism · Mammals · Vertebrates · Nicobar

8.1 Introduction

The Andaman and Nicobar Islands are situated in the south of Burmese peninsula, in the Bay of Bengal. The Andaman group of islands are located between 13°41′ and 10°30′N latitudes and 92°11′ and 93°07′E longitudes, while Nicobars lie between 6°40′ and 9°30′ N latitudes and 92°30′ and 94°10′E longitudes (Fig. 8.1). Due to high precipitation and their tropical location, the predominant vegetation type in these islands is evergreen forest. There are 11 major forest types in these islands (Champion and Seth 1968). These are giant evergreen forest, Andaman tropical evergreen forest, southern hilltop tropical evergreen forest, cane brakes, wet bamboo brakes, Andaman semi-evergreen forest, Andaman moist deciduous forest, Andaman secondary moist deciduous forest, littoral forest, tidal swamp forest and sub-mountain hill valley swamp forest (Champion and Seth 1968). These islands form parts of two biodiversity hotspots; i.e. the Andaman Islands are a part of the Indo-Burma hotspot, and the

C. Sivaperuman (✉) · G. Gokulakrishnan · P. Parthipan
Andaman and Nicobar Regional Centre, Zoological Survey of India,
Port Blair, Andaman and Nicobar Islands, India

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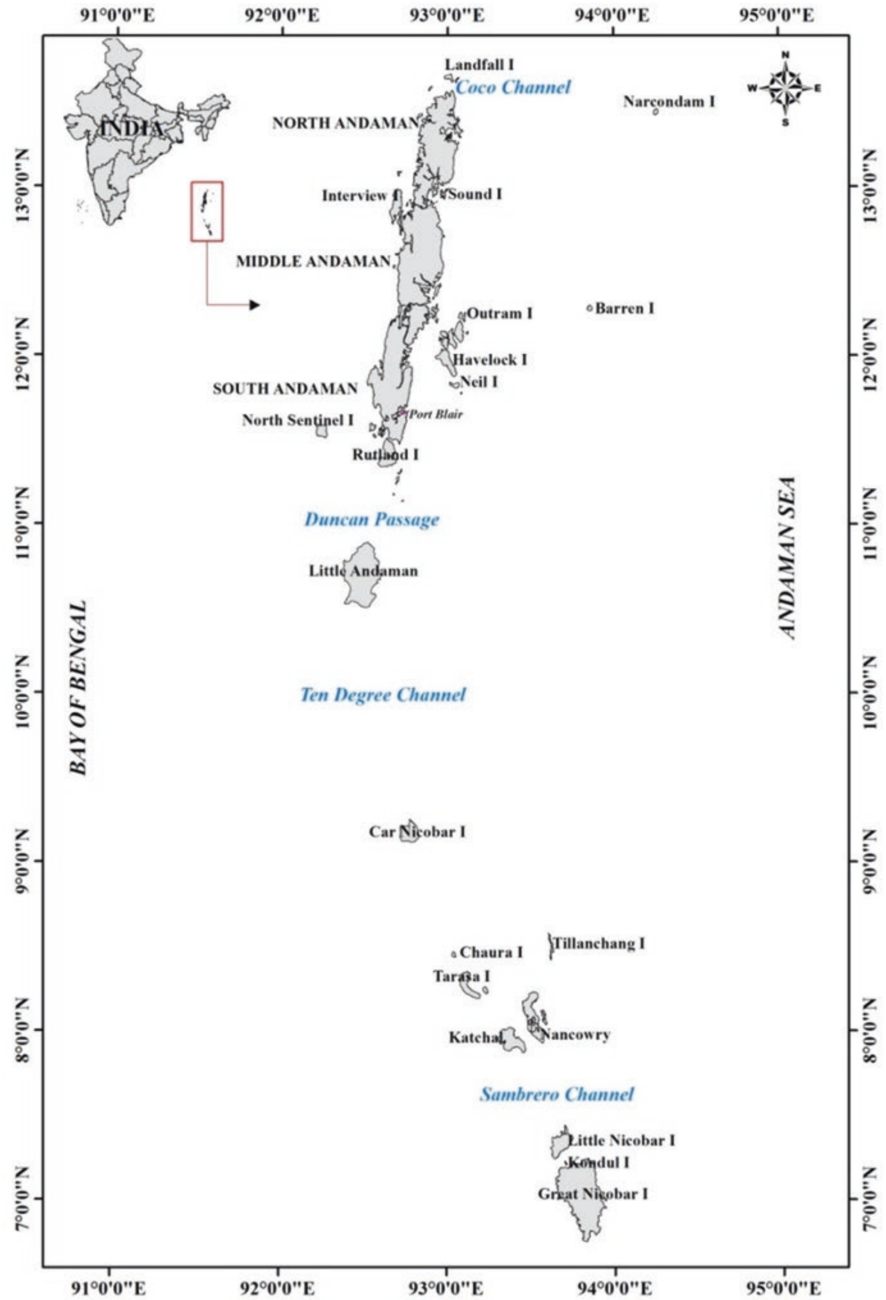

Fig. 8.1 Andaman and Nicobar Islands

Nicobar Islands are part of the Sundaland hotspot (Myers et al. 2000). The Andaman and Nicobar Islands remained separated by the Ten Degree Channel which is about 150 km wide and 400 fathoms deep (Lee and Lowver 1995). Andaman group of islands covers 6408 km^2, while Nicobar group covers 1841 km^2. The highest peak in the Andaman and Nicobar Archipelago is Saddle Peak in North Andaman, which reaches 732 m and 642 m at Mount Thulier in Great Nicobar Island. There are 105 protected areas (9 national parks and 96 wildlife sanctuaries), and the Great Nicobar is the only biosphere reserve. The precipitation is slightly higher in Nicobar group of islands with an average annual rainfall of 3000–3500 mm. The highest amount of rainfall is in southernmost islands with no major dry season, whereas the northern islands have more seasonal variation (Biswas and Sanyal 1980).

8.1.1 History of Mammalian Studies in Andaman and Nicobar Islands

The first systematic account of the mammals of Andaman and Nicobar Islands was made with a report on the fauna of the Nicobar (Blyth 1846). Alexander (1927) studied skulls of Andaman wild pig, and a drawing of the same was also presented in his paper. Many researchers reported mammals of South Andaman (Blyth 1858, 1859, 1860; Bartlett 1869). Blyth (1863) and Miller (1902) provided a detailed description of mammals of Andaman and Nicobar Islands. Description of a new civet cat from Andaman Islands was published by Tytler (1864), and the macaque was described by Sclater (1869). Dobson (1871, 1872, 1873) made short accounts of bats occurring in Andaman and Nicobar; later he has provided more detailed information on bats (Dobson 1876, 1878). Hume (1874) reported *Pteropus nicobaricus* from Jolly Boy Island. Anderson (1881) recorded 13 species of bats, and Blanford (1888, 1891) documented 18 species of mammals. Out of 39 species of mammals, 4 of them were doubtful (Miller 1902; Mason 1908). Hill (1967) summarised and published report on bats of the Andaman and Nicobar Islands based on the collection of Mr. Humayun Abdulali. A new house rat was described by Chaturvedi (1966a, b, 1969, 1980), Mandal and Nair (1973) followed by Nath and Chaturvedi (1875). Bhattacharyya (1975) reported Dobson's long-tongued fruit bat *Eonycteris spelaea* in Andaman Islands. Abdulali (1976) studied the wildlife of the Bay Islands. Saha (1980) documented some mammals of this archipelago. Tikader and Das (1985) provided a detail account on the animal life of Andaman and Nicobar Islands. Das (1990) reported the occurrence of *Pipistrellus comortae* in the Andaman Islands. Rosalind (1999) assessed the status and distribution of the Andaman wild pig and its interrelationship. Das (1999) assessed the mammalian diversity of Mount Harriet National Park. Alfred et al. (2002, 2006a, b) studied and reported checklist of mammals of India which includes mammals of Andaman and Nicobar Islands. Chandra and Rajan (2004) studied the fauna of Mount Harriet National Park, South Andaman. An attempt to study the ecology and conservation of bats of Andaman and Nicobar Island was made by Aul (2007), Aul et al. (2014) and Aul and Chakravarty (2016). Srinivasulu and Srinivasulu (2012) gave a detailed account of

South Asian mammals and their distribution. This chapter was prepared based on the field surveys carried out by the authors in different parts of Andaman and Nicobar Islands. The available literatures are also consulted to prepare the updated checklist of mammals of Andaman and Nicobar Islands.

8.1.2 Results and Discussion

A total of 58 species of mammals were found in Andaman and Nicobar Islands, which belong to 7 orders, 18 families and 31 genera (Table 8.1). The family Pteropodidae had the highest number of species (11), followed by Muridae (8), Vespertilionidae (7) and Soricidae (6). Eight families were represented with single species (Table 8.1). Of the recorded species, 28 species/subspecies are endemic to Andaman and Nicobar Islands, i.e. 14 from Andaman group and 13 from Nicobar group. The following 14 species are endemic to Andaman, namely, *Crocidura andamanensis*, *Crocidura hispida*, *Crocidura jenkinsi*, *Cynopterus brachyotis brachysoma*, *Pteropus hypomelanus geminorum*, *Pteropus hypomelanus satyrus*, *Pteropus melanotus melanotus*, *Rhinolophus affinis andamanensis*, *Rhinolophus cognatus famulus*, *Rhinolophus cognatus*, *Paguma larvata tytleri*, *Sus scrofa andamanensis* and *Rattus stoicus*, and 13 species are endemic from Nicobar Islands, namely, *Crocidura nicobarica*, *Tupaia nicobarica*, *Tupaia nicobarica surda*, *Cynopterus sphinx scherzeri*, *Pteropus faunulus*, *Pteropus melanotus tytleri*, *Hipposideros diadema nicobarensis*, *Hipposideros nicobarulae*, *Macaca fascicularis umbrosa*, *Sus scrofa nicobarica*, *Rattus burrus* and *Rattus palmarum.*

According to IUCN (2017), three species are listed as critically endangered (CR), six species are endangered (EN), two species are near threatened (NT), eight species are vulnerable (VU) and one species is data deficient (Fig. 8.2). As per Wildlife (Protection) Act, 1972, four species were listed under Schedule I, and one species each was listed under Schedules II, III and IV. Taxonomic composition of Andaman and Nicobar Islands reveals the occurrence of 33 species in Andaman group and 23 in Nicobar group. Sixteen species were sharing both groups of islands.

The mammals of India are represented by 426 species belonging to 52 families and 14 orders, including 394 species of terrestrial mammals belonging to 43 families and 12 orders and 31 species of aquatic, both freshwater and marine, mammals belonging to 9 families and 2 orders (Srinivasulu and Srinivasulu 2012; Sharma et al. 2013). The Andaman and Nicobar Islands harbour 58 species and subspecies of mammals (Tikader and Das 1985); however, Alfred et al. (2002) reported only 43 species and subspecies due to synonymisation of many species. A comparison of mammals from Southeast Asia and India is presented in Table 8.4.

Table 8.1 Mammals of Andaman and Nicobar Islands

	Common name	Species name	AN	NI	IUCN status	WPA
	Order: Eulipotyphla					
	Family: Soricidae					
1.	Andaman white-toothed shrew	*Crocidura andamanensis* Miller, 1902[E]	√		CR	
2.	Andaman shrew	*Crocidura hispida* Thomas, 1913[E]	√		VU	
3.	Jenkin's Andaman spiny shrew	*Crocidura jenkinsi* Chakraborty, 1978[E]	√		CR	
4.	Nicobar shrew	*Crocidura nicobarica* Miller, 1902[E]		√	CR	
5.	Nicobar treeshrew	*Tupaia nicobarica* (Zelebor, 1869)[E]		√	EN	
6.	Nicobar treeshrew	*Tupaia nicobarica surda* Miller, 1902[E]		√	NE	
	Order: Chiroptera					
	Family: Pteropodidae					
7.	Lesser short-nosed fruit bat	*Cynopterus brachyotis brachysoma* Dobson, 1871[E]	√		LC	
8.	Greater short-nosed fruit bat	*Cynopterus sphinx scherzeri* Zelebor, 1869[E]		√	LC	
9.	Long-tongued fruit bat	*Eonycteris spelaea* (Dobson 1871)	√		LC	
10.	Indian flying fox	*Pteropus giganteus* (Brunnich 1782)[E]	√	√	LC	
11.	Nicobar flying fox	*Pteropus faunulus* Miller 1902[E]		√	VU	
12.	Island flying fox	*Pteropus hypomelanus geminorum* (Miller, 1903) [E]	√		VU	
13.	Narcondam Island flying fox	*Pteropus hypomelanus satyrus* Andersen 1908[E]	√		VU	
14.	Black-eared flying fox	*Pteropus melanotus tytleri* Mason 1908[E]		√	NE	
15.	Blyth's flying fox	*Pteropus melanotus melanotus* Blyth 1863[E]	√		NE	
16.	Large flying fox	*Pteropus vampyrus* (Linnaeus 1758)	√	√	NT	
17.	Dobson's long-tongued fruit bat	*Eonycteris spelaea* (Dobson 1871)		√	LC	
	Family: Emballonuridae					
18.	Black-bearded tomb bat	*Taphozous melanopogon* Temminck 1841		√	LC	
19.	Naked-rumped pouched bat	*Taphozous saccolaimus* Temminck, 1838		√	LC	

(continued)

Table 8.1 (continued)

	Common name	Species name	AN	NI	IUCN status	WPA
	Family: Megadermatidae					
20.	Lesser false vampire bat	*Megaderma spasma* (Linnaeus 1758)	√		LC	
	Family: Hipposideridae					
21.	Diadem leaf-nosed bat	*Hipposideros diadema nicobarensis* (Dobson 1871) [E]		√	LC	
22.	Nicobar leaf-nosed bat	*Hipposideros nicobarulae* Miller 1902 [E]		√	LC	
23.	Fulvous leaf-nosed bat	*Hipposideros fulvus* Gray 1838		√	LC	
	Family: Rhinolophidae					
24.	Intermediate horseshoe bat	*Rhinolophus affinis andamanensis* Dobson 1872[E]	√		NE	
25.	Andaman horseshoe bat	*Rhinolophus cognatus* Andersen 1906 [E]	√		EN	
26.	Andaman horseshoe bat	*Rhinolophus cognatus famulus* (Andersen 1918[E])	√		NE	
	Family: Vespertilionidae					
27.	Tickell's bat	*Hesperoptenus tickelli* (Blyth 1851)	√		LC	
	Family: Miniopteridae					
28.	Small long-fingered bat	*Miniopterus pusillus* Dobson 1876		√	LC	
	Family: Vespertilionidae					
29.		*Myotis horsfieldii dryas* Andersen 1907	√		LC	
30.		*Pipistrellus javanicus camortae* Miller 1902[E]			LC	
31.	Coromandel pipistrelle	*Pipistrellus coromandra* (Gray 1838)	√	√	LC	
32.	Lesser Asiatic yellow house bat	*Scotophilus kuhlii* Leech 1821	√	√	LC	
33.	Black-bearded tomb bat	*Taphozous melanopogon* Temminck 1841	√		LC	
	Family: Emballonuridae					
34.	Naked-rumped pouched bat	*Saccolaimus saccolaimus* Temminck 1838	√	√	LC	
	Family: Vespertilionidae					
35.	Lesser bamboo bat	*Tylonycteris pachypus* (Temminck 1840)	√		LC	
	Family: Rhinolophidae					
36.	Andaman horseshoe bat	*Rhinolophus cognatus* Andersen 1906 [E]	√		EN	

(continued)

Table 8.1 (continued)

	Common name	Species name	AN	NI	IUCN status	WPA
	Order: Primate					
	Family: Cercopithecidae					
37.	Crab-eating macaque	*Macaca fascicularis umbrosa* Miller 1902[E]		√	VU	I
	Order: Carnivora					
	Family: Viverridae					
38.	Andaman masked palm civet	*Paguma larvata tytleri* (Tytleri 1864)[E]	√		LC	II
	Order: Cetartiodactyla					
	Family: Cervidae					
39.	Spotted deer	*Axis axis* (Erxleben 1777)	√		LC	III
40.	Northern red muntjak	*Muntiacus vaginalis* (Boddaert 1785)	√		LC	
	Family: Dugongidae					
41.	Dugong	*Dugong dugon* (Muller 1776)	√	√	VU	I
	Family: Delphinidae					
42.	Short-beaked saddleback dolphin	*Delphinus delphis* Linnaeus 1758	√	√	LC	
43.	Indo Pacific humpback dolphin	*Sousa chinensis* (Osbeck 1765)	√		NT	
44.	Blue whale	*Balaenoptera musculus* (Linnaeus 1758)			EN	
45.	False Killer Whale	*Pseudorca crassidens* (Owen 1846)	√	√	DD	
	Family: Physeteridae					
46.	Sperm whale	*Physeter catodon* Linnaeus 1758			VU	
	Order: Proboscidea					
	Family: Elephantidae					
47.	Asian elephant	*Elephas maximus* Linnaeus 1758	√		EN	I
	Order: Artiodactyla					
	Family: Suidae					
48.	Andaman wild pig	*Sus scrofa andamanensis* Blyth 1858[E]	√		LC	I
49.	Nicobar wild pig	*Sus scrofa nicobarica* Miller 1902[E]		√	LC	
	Order: Rodentia					
	Family: Sciuridae					
50.	Northern palm squirrel	*Funambulus pennantii* Wroughton 1905	√		LC	IV
	Family: Muridae					
51.	Southeastern Asian house mouse	*Mus musculus castaneus* (Waterhouse 1843)	√		LC	
52.	Fawn-coloured mouse	*Mus cervicolor* Hodgson 1845	√		LC	

(continued)

Table 8.1 (continued)

	Common name	Species name	AN	NI	IUCN status	WPA
53.	Miller's Nicobar rat	*Rattus burrus* (Miller 1902)[E]		√	EN	
54.	Car Nicobar rat	*Rattus palmarum* (Zelebor 1869)[E]		√	VU	
55.	House rat	*Rattus rattus* (Linnaeus 1758)	√	√	LC	
56.	Indochinese forest rat	*Rattus andamanensis* (Blyth 1960)	√		LC	
57.	Andaman rat	*Rattus stoicus* (Miller 1902)[E]	√		VU	
58.	Oriental house rat	*Rattus tanezumi* (Temminck 1844)	√	√	LC	

AN Andaman group of islands, *NI* Nicobar group of islands
IUCN status: *LC* least concern, *NT* near threatened, *CR* critically endangered, *EN* endangered, *VU* vulnerable, *NE* not evaluated, *DD* data deficient
The Indian Wildlife (Protection) Act, 1972

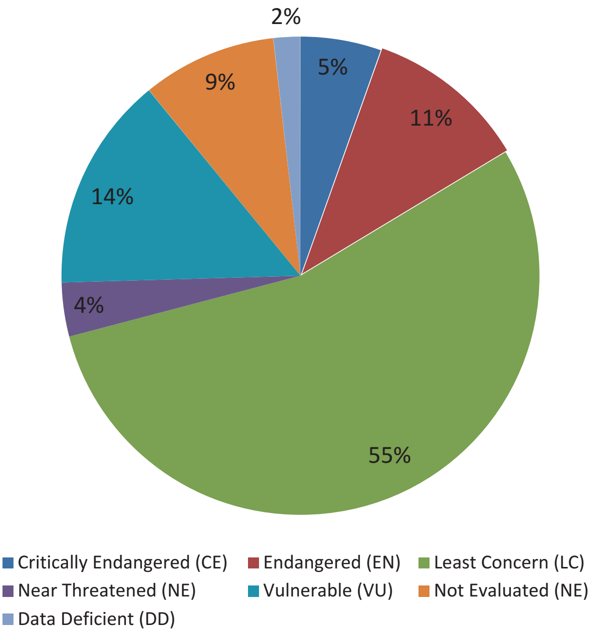

Fig. 8.2 IUCN status of mammals of Andaman and Nicobar Islands

The major terrestrial mammals are the Andaman wild pig, Andaman masked palm civet, Andaman spiny shrew, Nicobar tree shrew, Andaman horseshoe bat and Lesser short-nosed bat. The only primate, the crab-eating macaque, occurs in the southern group of Nicobar Islands, namely, Great Nicobar, Little Nicobar and Katchal islands. From the faunistic point of view, the most interesting feature is the

Table 8.2 Introduced species mammals in Andaman Islands

Sl. no.	Name of the species	Year	Remarks
1.	Five-striped palm squirrel *Funambulus pennantii*	1940	This species had been possibly brought as pets into this archipelago. However, they thrived well in Andaman group of islands
2.	Rodents *Rattus* sp.		The species *Rattus rattus* and several other rodent pests have come with human settlers
3.	Domestic dog *Canis lupus*	1850	The feral dogs living and breeding in the forest of Interview Island. These animals are very serious threat to the native species of Andaman wild pig and other small animals
4.	Domestic cat *Felis catus*	1850	This species is introduced in this islands and it is a serious threat to the endemic ground and bush-dwelling vertebrates
5.	Spotted deer *Axis axis*	1905–1930	This has been brought from Indian mainland and released in Andaman Islands and spread throughout Andaman Islands and Little Andaman
6.	Barking deer *Muntiacus muntjak*	1905–1930	This species is very rarely found in some pockets of Middle Andaman Islands
7.	Indian hog deer *Axis porcinus*	1905–1930	This has been released during the 1930s, and sighting of this species is very rare
8.	Leopard *Panthera pardus*	1950	Two females in released in Middle Andaman but never seen again, presumed dead thereafter
9.	Domestic goat *Capra* sp.	1700	This has been released in Barren, Cinque and Narcondam islands
10.	Elephant *Elephas maximus*	1960	Released in Interview Island when timber company folded up, now a breeding herd of 80–90 survivors and few more live in the forests of North Andaman

absence of large mammals and the presence of a considerable number of endemics among the inland vertebrates (Ellis et al. 2000). About ten species of mammals were introduced in different year for various purposes (Table 8.2). Only few species, namely, five-striped palm squirrel, spotted deer and elephant, survived and spread across Andaman group of islands. Jeyakumar et al. (2012) reported 15 species of domestic animals from Andaman and Nicobar Islands; they are Desi (Jungli) cattle, Trinket cattle, Crossbred cattle, Buffalo, Andaman local goat, feral/Barren Island goat, Teressa goat, Malabari goat, Boer cross goat, Andaman pig, Desi pigs, Large White Yorkshire pigs, Nicobari pig, rabbit and donkey (Table 8.3).

Although many studies are available on mammals of Andaman and Nicobar Islands, only few detailed investigations have been carried out on long-tailed macaque and to some extent on bats, and the knowledge on the distribution, abundance and conservation status of many mammals is still very limited. The endemic species such as tree shrews, wild pig, etc. needs future attention immediately. Among the small mammals, only few studies are available on bats which are limited to a few sites. This group required further investigation (Table 8.4).

Table 8.3 Domestic mammals of Andaman and Nicobar Islands and their distribution

Sl. No.	Common name	Description
1.	Desi (Jungli) cattle	The local cattle of Andaman is nondescriptive type and represents an admixture of different Indian breeds that had been brought to these islands in different phases of inhabitation and rehabilitation of migrated people. The inheritance from Red Sindhi, Sahiwal and Haryana could be traced. They are found in Andaman group of islands and a small group in Kamorata in Nancowry group of islands (Kamorta)
2.	Trinket cattle	This is a separate group found in Trinket Island. The Swedish people, who had settled in a part of Nancowry group of islands, had left some cattle of exotic origin in Trinket Island
3.	Crossbred cattle	During the 1980s the Department of Animal Husbandry and Veterinary Services of Andaman and Nicobar administration has introduced cross-breeding programme to improve the local/Desi cattle through artificial insemination technology using pure breed semen of Jersey and Holstein Friesian cattle. This programme has significantly improved the performance of cattle and milk production status in the islands
4.	Buffalo	The buffaloes of these islands do not belong to any definite or descriptive breed. However, the inheritance of Murrah, Nagpuri, Bhadawari and Marathwade could be traced. It appears that the British officials used to import buffaloes from Acheen and the coast of Pedi to fulfil their meat requirements
5.	Andaman local goat	This goat was brought from Bengal and adjacent areas in different phases of inhabitation and rehabilitation of migrated/settled people. These goats are well adapted to the island condition and are widely distributed throughout Andaman Islands
6.	Feral/Barren Island goat	The country's only active volcano is at Barren Island, which harbours unique feral goat surviving in harsh inhabitable environment condition. Current status of this goat population at Barren Island is not known
7.	Teressa goat	This group of goat is mainly found in Teressa Island and other Nicobar islands. Scarce population of this goat is available in Nancowry and Little Andaman (Harminder Bay) islands. These goats generally resemble the Kambing Katchang of Indonesia, and Nicobari tribes rear them for meat
8.	Malabari goat	The Malabari goat introduced from Kerala and Tamil Nadu during 7th Five-Year Plan by the Department of Animal Husbandry and Veterinary Services, A and N administration. These goats were mainly introduced for upgradation of indigenous goats
9.	Boer cross goat	The Boer cross goat is a cross-breed between male Boer goat and female Andaman local goat produced through artificial insemination technology in 2006 at Division of Animal Science, CARI (Jeyakumar et al. 2007). These goats are well adapted to the island condition, and their performance is higher than that of Andaman local goat
10.	Andaman Pig	The Andaman pig is probably a feral population. They live in the forest of Andaman group of islands since time immemorial. The Andaman wild pig is also available in the Jarawa reserve forest area. They are being poached by the primitive tribes, and exact population status is not known

(continued)

Table 8.3 (continued)

Sl. No.	Common name	Description
11.	Desi pigs	They are reared by the local settlers from Bengal, Ranchi, Burma, Tamils and other parts of Northern India. They are available mainly in Middle and North Andaman and in certain areas of South Andaman
12.	Large White Yorkshire pigs	This is a popular English Bacon breed. Large White Yorkshire pigs are being maintained by the Department of Animal Husbandry and Central Agricultural Research Institute. Phenotypically they appear as entirely white in colour, with head markedly long, face slightly dished and snout broad and wide between the ears. They possess a long back which is levelled and wide from the neck to rump with straight and well-set legs
13.	Nicobari pig	The Nicobari pig is a separate group of pig and found in Nicobar group of islands. Nicobari pigs are exclusively reared by Nicobari tribes, and they form a well-knit socioecological milieu of their society. They are reared mainly for meat purpose under free-range/semi-intensive system
14.	Rabbit	Very few farmers rear rabbit for pet/meat purpose
15.	Donkey	There is only one donkey present at Teressa Island. History says that many donkeys were brought by the sea traders for carrying load and they left few numbers in the island

Source: Jeyakumar et al. (2007, 2012)

Table 8.4 Comparison of mammals from Southeast Asia, India and Andaman and Nicobar Islands

Order	Family	Southeast Asia[a]	India[a]	ANI
Proboscidea	Elephantidae	1	1	1
Primate	Cercopithecidae	23	21	1
Rodentia	Sciuridae	29	26	1
	Muridae	71	55	8
Eulipotyphla	Soridae	39	30	6
Chiroptera	Pteropodidae	14	13	11
	Hipposideridae	16	14	3
	Megadermatidae	2	2	1
	Rhinopomatidae	3	2	4
	Emballonuridae	6	6	3
	Vespertilionidae	66	57	7
	Miniopteridae	3	3	1
Carnivora	Viverridae	12	6	1
Cetartiodactyla	Cervidae	8	8	2
	Dugongidae	1	1	1
	Delphinidae	16	16	4
	Physeteridae	3	1	1
Artiodactyla	Suidae	2	2	2

[a]Srinivasulu and Srinivasulu (2012)

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9 Mammals of Arunachal Pradesh, India

Anil Kumar

Abstract

Arunachal Pradesh is an important part of Himalayan global biodiversity hotspot and known for its rich diversity of mammals. Field surveys were undertaken in different areas during April 2005 to June 2010. Analysis of the data revealed the occurrence of 55 species belonging to 10 orders and 20 families, including a few unidentified species of bats. All the sightings were based on direct observations (22 species) and indirect evidences such as pugmarks, dung/pallets, carcass and skins. Order Carnivora was the most dominant group, represented by 20 species belonging to 6 families. Habitat degradation due to increasing anthropogenic pressure in terms of harvesting of fuelwood, timber, foliage and medicinal plants is a possible threat for sustainability of mammals of Arunachal Pradesh.

Keywords

Arunachal Pradesh · Mammal · Primates · Conservation · Tawang · Itanagar Wildlife Sanctuary

9.1 Introduction

Arunachal Pradesh (26°28′-29°30′N and 91°30′-97°30′E) is located in north-east India in the transition zone between the Himalayan and Indo-Burmese region and has 83,743 km^2 geographical area (Sinha 2008; Kumar 2014) (Fig. 9.1). The entire territory forms a complex hill system with varying elevations ranging from 50 m in the foothills and gradually ascending to about 7000 m. It is mostly hilly and mountainous covered with highly varied and dense vegetation (Kaul and Haridasan 1987), which supports fairly large populations of most taxonomic

A. Kumar (✉)
Northern Regional Centre, Zoological Survey of India, Dehradun, Uttarakhand, India

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Fig. 9.1 Map of the Arunachal Pradesh is showing the general topography and surveyed localities

groups (Editor-Director 2006a, b; Kumar 2014). During the last one decade, several new species of vertebrates and invertebrates have been discovered from the state (Mishra and Datta 2007; Sureshan 2010).

The state of Arunachal Pradesh has a predominantly mountainous landscape with nearly 64% of the total area lying above 1200 m, 13% located between 300 and 1200 m and 8.87% below 300 m. The topography of Arunachal Pradesh forms a complex hill system of Siwalik and Himalayan origin and is crisscrossed by six major rivers (namely Kameng, Subansiri, Siang, Dibang, Lohit and Tirap) and secondary streams flowing from west to east. These rivers are fed by snow from the Himalayas (Kalita and Haridasan 2001; Editor-Director 2006a). Based on the satellite imagery, a total of 21 types of vegetation and land cover classes were identified by Roy and Behera (2005). This can be classified into five major categories of vegetation, namely, tropical forests, sub-tropical forests, temperate forests and sub-alpine and alpine forests (Kaul and Haridasan 1987).

The state has 68,621 km^2 of forest occupying nearly 82% of the total geographic area (83,743 km^2). This includes 54,510 km of closed forest and 14,151 km of open forest (Kaul and Haridasan 1987; FSI 2000). Out of this, unclassified forest is 70.25%, and the protected forest is merely 0.02% (FSI 2000). An area of 9527.99 km^2, representing nearly 11.68% of the geographic area of the state, has been brought under protected area network for conservation and development of biodiversity resource, which includes 2 national parks and 11 wildlife sanctuaries (Sinha 2008).

Review of literature revealed that studies on the mammals of Arunachal Pradesh are limited. Choudhury (2003) published a book on the mammals of Arunachal Pradesh, which enclosed a checklist of 206 species based upon both primary and secondary sources, along with another 38 species that are likely to occur or are recorded in adjacent areas. Observations on mammals of Sessa Orchid, Itanagar, Eaglenest and D'Ering Wildlife Sanctuaries were carried out (Kumar 2011; 2015a, b). Mishra et al. (2006) undertook an expedition in the high-altitude areas of Tawang and West Kameng districts and documented the occurrence of 34 mammalian species including Chinese goral *Naemorhedus caudatus* which is a new addition to the list of large mammals of the Indian subcontinent. Arunachal macaque *Macaca munzala* was a recently discovered species of primate (Mishra et al. 2006). Borang (2001) reported 214 mammalian species from Arunachal Pradesh, belonging to 12 orders, 34 families and 116 genera. However, as per the ZSI records, the mammalian fauna of the state is represented by 105 species and subspecies under 85 genera, 25 families, and 9 orders (Editor-Director 2006a, b).

9.2 Methods

Field surveys were undertaken in different areas, during April 2005 to June 2010, to document the mammals of Arunachal Pradesh (Table 9.1). During the field work, observations were made daily starting from 6:00 am to 3:00 pm (except during

Table 9.1 Details of the different areas and localities of Arunachal Pradesh covered in field surveys

Sl. No.	Areas surveyed for faunal studies	Duration	Location
1	Pakke Tiger Reserve and adjacent localities	09.11.2005–21.11.2005	Surrounding area of Seijusa and Upper Seijusa, Khari, Bhalukpong and Tipi
2	D'Ering Memorial Wildlife Sanctuary	03.10.2006–23.10.2006	Anchalghat, Namsing and Borguli ranges and Mebo area
3	Sessa Orchid Sanctuary and Eaglenest Wildlife Sanctuary	07.03.2007–23.03.2007	Bhalukpong, Tipi, Sessa and Lama Camp, Eaglenest pass, Sundarview and Ramalingam area in Eaglenest Wildlife Sanctuary
4	Tawang Chu Valley and Dirang and surrounding area	23.10.2007–02.11.2007	P.Tso, Tawang town, Surbhi village, Kitpi village, Jung and Dirang area
5	Mouling National Park and adjacent areas	02.06.2008–15.06.2008	Ramsing locality
6	D'Ering Memorial Wildlife Sanctuary and adjacent areas	11.02.2009–18.02.2009	Anchalghat, Namsing and Borguli ranges
7	Tawang Chu Valley and adjacent areas	09.05.2009–26.05.2009	P.Tso, Y-junction lakes, surrounding of Tawang town, Surbhi village, Kitpi village, Jung, Mirba, Mukto, LGG and MJG area
8	Tawang Chu Valley	10.05.2010–28.05.2010	-do-
9	Itanagar Wildlife Sanctuary and adjacent areas	During 2006–2009 in local surveys	Hati Nullah, Poma village, Basar Nullah, Ganga lake

harsh environmental conditions) with the help of prismatic field binocular (10 × 50), and identification of species was carried out with the help of field guide and taxonomic key characteristics (Menon 2003). Indirect evidences such as pugmarks, dung/pallets, carcass and skins were also considered to infer the occurrence of a species. With the help of local field guide, a questionnaire was also carried out to assess the mammals. The presence/absence of species was also discussed with forest officials, and relevant information was incorporated in data. In case of inadequate sightings/doubtful identification, the data was excluded from the present study.

9.3 Results and Discussion

In the present study, a total of 55 species belonging to 10 orders and 20 families were recorded (Table 9.2; Fig. 9.2a–f). Order Carnivora was the most dominant group, represented by 20 species belonging to 6 families. Efforts were made mainly on large mammals' species due to lack of identification of smaller mammals. Recently discovered species of mammals, i.e. Arunachal macaque, was observed frequently in all four surveys in Tawang Chu valley.

9.3.1 Mammals of D'Ering M. Wildlife Sanctuary

On the basis of direct sightings and indirect evidences such as pugmarks, and interview with local people, 23 species of mammals were recorded in D'Ering M. Wildlife Sanctuary (Table 9.2). Apart from this three species of bats were also seen during dusk. Pugmarks of Sambar *Cervus unicolor*, Indian muntjac *Muntiacus muntijak* and Jackal *Canis aureus* were seen inside the sanctuary. Pugmarks of a cat species (most probably Jungle cat *Felis chaus*) were also observed. On the basis of indirect evidences, it is observed that Indian hare *Lepus nigricollis* commonly inhabited the area, while the presence of Hispid hare *Caprolagus hispidus* is still unconfirmed due to lack of proper evidences. As per forest guards, they have seen this species in sanctuary; however it may be a case of misidentification.

Some other interesting species such as Chinese pangolin, *Manis pentadactyla*; Asiatic black bear, *Ursus thibetanus*; and porcupine, *Hystrix* sp., have been reported by villagers during interview, outside the sanctuary area. As reported by villagers, a Clouded leopard was hunted in the nearby forest of Celuk village just 15 days before my survey in the area. Three species of squirrels (order, Rodentia; family, Sciuridae) were seen. Himalayan striped squirrel, *Tamiops macclellandi*, was common. Orange-bellied Himalayan squirrel, *Dremomys lokriah*, was observed in the forest near Mebo town foraging upon the inflorescences of banana trees. This was a medium-sized (about 40 cm long), brownish-coloured and arboreal species. It is also a fairly common species of forests of NE. Hoary-bellied Himalayan squirrel *Callosciurus pygerythrus* was also observed in the same area. Two individuals were seen near the road side. Two rat species and one otter species were also seen by villagers but could not be confirmed.

Table 9.2 Checklist of the species confirmed on the basis of direct sightings and indirect evidences

Sl. No.	Common name	Species	Observations	Localities
	Order: Primates			
	Family: Hylobatidae			
1	Western hoolock gibbon	*Hoolock hoolock*	Indirect evidence	MNP
	Family: Cercopithecidae			
2	Arunachal macaque	*Macaca munzala*	Direct sightings	TD
3	Assamese macaque	*Macaca assamensis*	Direct sightings	DWS, IWS, TD, ESOS, PTR, MNP
4	Rhesus macaque	*Macaca mulatta*	Direct sightings	IWS, TD, ESOS, MNP
5	Capped langur	*Trachypithecus pileatus*	Indirect evidence	IWS, TD
	Order: Proboscidea			
	Family: Elephantidae			
6	Asian Elephant	*Elephas maximus*	Direct sighting and indirect evidence	DWS, IWS, ESOS, PTR
	Order: Artiodactyla			
	Family: Cervidae			
7	Sambar	*Cervus unicolor*	Indirect evidence	DWS, TD, ESOS, PTR
8	Indian muntjac	*Muntiacus muntijak*	Indirect evidence	DWS, IWS, PTR, TD, MNP
9	Hog deer	*Axis porcinus*	Indirect evidence	DWS
	Family: Bovidae			
10	Asiatic wild buffalo	*Bubalus arnee*	Indirect evidence	DWS
11	Mithun	*Bos frontalis*	Direct sightings	Wide spread and semi-domesticated
12	Takin	*Budorcas taxicolor*	Indirect evidence	ESOS, MNP
13	Gaur	*Bos gaurus*	Indirect evidence	IWS
14	Goral	*Naemorhedus goral*	Direct sighting	TD, ESOS
15	Mainland serow	*Naemorhedus sumatraensis*	Indirect evidence	ESOS, MNP
	Family: Suidae			
16	Wild pig	*Sus scrofa*	Indirect evidence	DWS, IWS, TD, ESOS, PTR, MNP
	Order: Carnivora			
	Family: Ursidae			
17	Red panda	*Ailurus fulgens*	Indirect evidence	ESOS
18	Asiatic black bear	*Ursus thibetanus*	Indirect evidence	DWS, IWS, MNP

(continued)

Table 9.2 (continued)

Sl. No.	Common name	Species	Observations	Localities
	Family: Canidae			
19	Jackal	*Canis aureus*	Indirect evidence	DWS, IWS, ESOS, PTR
20	Wild dog	*Cuon alpinus*	Indirect evidence	DWS, IWS, TD, ESOS, PTR, MNP
21	Indian fox	*Vulpes bengalensis*	Indirect evidence	IWS
22	Red fox	*Vulpes vulpes*	Direct sighting	TD
	Family: Felidae			
23	Tiger	*Panthera tigris*	Indirect evidence	DWS, ESOS, PTR, MNP
24	Common leopard	*Panthera pardus*	Indirect evidence	IWS, ESOS, PTR, MNP
25	Clouded leopard	*Neofelis nebulosa*	Indirect evidence	DWS, TD, MNP
26	Marbled cat	*Pardofelis marmorata*	Direct sighting	DWS, IWS, TD, ESOS, MNP
27	Golden cat	*Catopuma temminckii*	Indirect evidence	WDS, IWS, TD
28	Jungle cat	*Felis chaus*	Indirect evidence	DWS, IWS, ESOS, PTR, MNP
29	Leopard cat	*Prionailurus bengalensis*	Indirect evidence	MNP
	Family: Mustelidae			
30	Small-toothed ferret badger	*Melogale moschata*	Indirect evidence	IWS
31	Yellow-throated marten	*Martes flavigula*	Direct sighting	TD, MNP
	Family: Viverridae			
32	Common palm civet	*Paradoxurus hermaphroditus*	Indirect evidence	IWS
33	Himalayan palm civet	*Paguma larvata*	Indirect evidence	IWS, TD, PTR, MNP
34	Spotted linsang	*Prionodon pardicolor*	Indirect evidence	MNP
35	Binturong	*Arctictis binturong*	Indirect evidence	IWS
	Family: Herpestidae			
36	Small Indian mongoose	*Herpestes juvanicus*	Direct sightings	IWS, PTR
	Order: Pholidota			
	Family: Manidae			
37	Chinese pangolin	*Manis pentadactyla*	Indirect evidence	DWS, IWS, ESOS, MNP
	Order: Lagomorpha			
	Family: Ochotonidae			
38	Large-eared pika	*Ochoto namacrotis*	Direct sighting	TD
	Family: Leporidae			
39	Indian hare	*Lepus nigricollis*	Indirect evidence	DWS
40	Hispid hare	*Caprolagus hispidus*	Indirect evidence	DWS

(continued)

Table 9.2 (continued)

Sl. No.	Common name	Species	Observations	Localities
	Order: Rodentia			
	Family: Sciuridae			
41	Himalayan striped squirrel	*Tamiops macclellandi*	Direct sighting	DWS, IWS, TD, ESOS, PTR, MNP
42	Orange-bellied Himalayan squirrel	*Dremomys lokriah*	Direct sighting	DWS, TD, ESOS, MNP
43	Hoary-bellied Himalayan squirrel	*Callosciurus pygerythrus*	Direct sighting	DWS, IWS, TD, ESOS, PTR
44	Pallas's squirrel	*Callosciurus erythraeus*	Indirect evidence	IWS
45	Malayan giant squirrel	*Ratufa bicolor*	Indirect evidence	IWS, MNP
	Family: Muridae			
46	House rat	*Rattus rattus*	Direct sighting	IWS, TD, PTR
47	Himalayan rat	*Rattus nitidus*	Direct sighting	MNP
48	House mouse	*Mus musculus*	Direct sighting	IWS
	Family: Hystricidae			
49	Asiatic brush-tailed porcupine	*Atherurus macrourus*	Direct evidence	MNP
50	Himalayan crestless porcupine	*Hystrix brachyura*	Indirect evidence	DWS IWS, ESOS, PTR
	Order: Eulipotyphla			
	Family: Soricidae			
51	Asian house shrew	*Suncus murinus*	Direct sightings	IWS
	Order: Chiroptera	At least three species were sighted but could not be identified	Direct sightings	DWS, IWS, ESOS
52	Unidentified Bat	*Pteropus* sp.	Direct sightings	wide spread
53	Unidentified Bat	*Pipistrellus* sp.	Direct sightings	wide spread
54	Unidentified Bat	*Murina* sp.	Direct sightings	wide spread
	Order: Cetacea			
	Family: Platanistidae			
55	Ganges River dolphin	*Platanista gangetica*	Indirect evidence	DWS

Abbreviations: *DWS* D'Ering Memorial Wildlife Sanctuary, *IWS* Itanagar Wildlife Sanctuary, *TD* Tawang District, *ESOS* Eaglenest and Sessa Orchid Sanctuary, *PTR* Pakkee Tiger Reserve and *MNP* Mouling National Park

Fig. 9.2 Photographs of some mammals of Arunachal Pradesh taken during the field work. (**a**) Asiatic black bear *Ursus thibetanus,* (**b**) Sambar *Cervus unicolor*, (**c**) Western hoolock gibbon *Hoolock hoolock*, (**d**) Arunachal macaque *Macaca munzala*, (**e**) Asiatic brush-tailed porcupine *Atherurus macrourus* and (**f**) Chinese pangolin *Manis pentadactyla*

9.3.2 Mammals of Tawang District

On the basis of direct sightings and indirect evidences, 20 species of mammals belonging to 5 orders and 11 families were recorded in the area. Three species of macaques and one species of marten were sighted directly apart from sightings of three species of squirrels. Large-eared pika *Ochoton macrotis* was observed and photographed in P.Tso area. On October 24, 2007, one individual Red fox *Vulpes vulpes* was sighted about 7.0–8.0 km from Jang towards Sela Pass. One pair of Yellow-throated marten *Martes flavigula* was observed in a four-bridge area near Jang. Interestingly, on May 12, 2009, one Marbled cat *Pardofelis marmorata* was sighted on the outskirts of Tawang town. The recently discovered species, i.e. Arunachal macaque, was also observed at different places. It was often seen between Lumla and Jimithang.

One troop of Rhesus macaques was also sighted (nine individuals) about 6.0 km. from Jang towards Tawang. Among squirrels (order, Rodentia; family, Sciuridae), three species were sighted. Himalayan striped squirrel *Tamiops macclellandi* was common. Hoary-bellied Himalayan squirrel *Callosciurus pygerythrus* was also observed. The digging signs of Wild boars *Sus scrofa* were also seen at some places. I saw the skins of Goral *Naemorhedus goral* and Sambar *Cervus unicolor* in a house. Skulls of Indian muntjac *Muntiacus muntijak* were also showed. The occurrence of Clouded leopard *Neofelis nebulosa*, Golden cat *Catopuma temminckii* and Marbled cat *Pardofelis marmorata* was also reported by villagers. The presence of Yellow-throated marten *Martes flavigula*, Himalayan palm civet *Paguma larvata*, Capped langur *Trachypithecus pileatus* and Wild dog *Cuon alpinus* was also confirmed by villagers. Sightings of one species of otter were also reported but could not be confirmed at species level.

9.3.3 Mammals of Itanagar Wildlife Sanctuary

On the basis of direct sightings and indirect evidences such as pugmarks and interview with local people, 30 (including 2 unidentified species of bats) species of mammals belonging to 8 orders and 16 families were recorded in the area (Table 9.2). There is no recent evidence for the occurrence of tiger. However, previously it is seen in the area by local residents. In cases of most large mammals, the situation is same most probably due to rapidly declining populations.

9.3.4 Mammals of Pakke Tiger Reserve

A total of 16 species of mammals belonging to 5 orders and 11 families were observed in PTR with the help of direct sighting and indirect evidences. Two species of bats and two species of rodents (rats/mouse) were also seen but could not be identified. This protected area is known for the occurrence of large mammals such as Tiger, Common leopard and Asian elephant. The squirrels are also commonly seen in the area. Himalayan striped squirrel *Tamiops macclellandi* and Hoary-bellied Himalayan squirrel *Callosciurus pygerythrus* were observed on pathways close to Khari village.

9.3.5 Mammals of Eaglenest and Sessa Orchid Sanctuaries

On the basis of direct sightings, indirect evidences and interview with local people, occurrence of 21 species of mammals was recorded in the area except 2 unidentified species of bats. These were sighted during dusk in Tipi area. Asiatic elephant is common in the Tipi area. Five individuals were sighted, when they were crossing the Kameng River. One troop of Assamese macaque, *Macaca assamensis*, and two troops of Rhesus macaque, *Macaca mulatto*, were also seen about 3.0 km. and

5.0 km. from Tipi (to words Sessa), respectively. During the interview, occurrence of Tiger and Leopard in Bhalukpong and Tipi area is also indicated by local people. Local people reported the presence of some species such as Chinese pangolin, *Manis pentadactyla*; Asiatic black bear, *Ursus thibetanus*; and porcupine, *Hystrix* species. Three species of squirrels (order, Rodentia; family, Sciuridae) were also observed. Orange-bellied Himalayan squirrel, *Dremomys lokriah*, was observed near road side close to Tipi. Hoary-bellied Himalayan squirrel, *Callosciurus pygerythrus,* was also observed.

9.3.6 Mammals of Mouling National Park

This area is known for the assemblage of fairly good populations of different species of mammals. However, forest is thick and mostly inaccessible. A total of 24 species belonging to 5 orders and 14 families were identified based on secondary information collected from locals, inspection of specimens and skins present in the collection of forest department and direct observations in the field. The occurrence of Asiatic brush-tailed porcupine *Atherurus macrourus* was confirmed on the basis of a skin present in a house. It is a little known, rare species of porcupine. Discussion with forest personnel revealed that it lives in the group of three to five individuals in burrows. Squirrels were commonly seen in the area.

9.3.7 Conservation Issues

Arunachal Pradesh is considerably rich in mammalian diversity. Despite the occurrence of over 200 species, the state is facing conservation threats as in most other parts of the country (Kumar 2013, 2014). Hunting practices of locals and unplanned developmental activities are the major threats for mammals. Poaching of large mammals for meat, skin and traditional medicines is quite a serious conservation issue throughout the state (Bhuyan et al. 2010). Most mammal species have been reported to be actively hunted. Primates and ungulates are mainly killed for meat and carnivores for skin (Selvan et al. 2013a, b). The species such as Black bear *Ursus thibetanus* and Musk deer *Moschus* sp. are hunted for their gallbladders and musk pods, respectively (Mishra et al. 2006). Local communities still like it as a daily routine of their life. However, recently, owing to increasing education level and wildlife awareness, interest in hunting activities is decreasing in some people. Unplanned developmental activities lead to forest degradation and habitat shrinking/loss and have direct and/or indirect impact on sustainability of mammals. Shifting cultivation and felling of trees are other major issues. In remote rural villages of the state, it is only a means of livelihood and very closely associated with the tribal culture such as social gathering, traditions and festivals (namely Boori Boot, Nyokum, Mopin, Solung, etc.). On the basis of scientific reasons, now it has been well proven that shifting cultivation is environmentally destructive and faulty land use practice.

It is estimated that Arunachal Pradesh has a potential of about 40% of the country's total hydropower generation potential. Recently, the state government has signed Memorandum of Understanding (MoU) with 25 developers for development of over 27,000 MW of hydropower potential in the state. At least 88 projects with a capacity of 31,587.5 MW are in the private sector (Kumar 2014). It is speculated that in the future it may create another major threat, owing to possible ignorance of conservation measures. It is speculated that, due to construction of major dams, large forest areas will be submerged and infrastructural development will further destroy/disturb the forest habitats. Engaged manpower (mainly labourers) will directly/indirectly impose anthropogenic pressure in terms of exploitation of natural resources for their daily need.

9.4 Conclusions

In the present study, more than 55 species of mammals were recorded on the basis of direct sightings/indirect evidences, excluding some unidentified species. However, state supports more than 200 species of mammals including a large number of smaller mammals and rodents. In the present study, emphasis was made mainly on large mammals' species due to lack of proper identification of smaller mammals. Recently discovered species of mammals, i.e. Arunachal macaque, was observed frequently in all four surveys in Tawang Chu valley. There are evidences that it is being tamed by local residents. Squirrels were common throughout the study areas except high-altitude areas. It is suggested that there is a need for further extensive long-term surveys for the detailed documentation and to understand the conservation status of mammals of the state.

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Diversity and Distribution of Mammals in the Indian Himalayas

10

M. Kamalakannan, C. Venkatraman, and Lalit Kumar Sharma

Abstract

A systematic review has been carried out for preparing the checklist of mammalian species of the Indian Himalayan region (IHR), based on field surveys, available published literature, and IUCN database. A total of 282 species representing 36 families and 11 orders that were reported in the IHR. The diversity of mammalian species is high (66.5%) in Himalayan region followed by Indo-Burma region (44.8%). The information on many species is not available for majority of the PAs in the IHR. Hence, it is recommended that efforts should be made toward assessing the conservation status of species which are under unfavorable condition and with endangered conservation status.

Keywords

Distribution · Diversity · Himalaya · Hotspot · Mammals

10.1 Introduction

India is one of the most biodiverse regions of the world, representing four biodiversity hotspots. It represents 7.90% of the diversity (424 species, 48 families, and 13 orders) (Wilson and Reeder 2005; Das and Parida 2016). Himalayan mountains are the most magnificent and youngest mountain systems in the world which form a broad continuous arc for nearly 2600 km along the northern fringes of the Indian subcontinent making a physical barrier between the high plateaus of Tibet and Central Asia and the Indian plains extending from River Indus in the west to River Brahmaputra in the east. The proportion of endemic taxa is substantial in the entire Himalayan range, and this eco-region has been designated as a global biodiversity

M. Kamalakannan (✉) · C. Venkatraman · L. K. Sharma
Zoological Survey of India, Prani Vigyan Bhawan, M-Block, New Alipore, Kolkata, India

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hotspot (Negi and Banyal 2015). The Indian Himalayan ranges extend from the Jammu and Kashmir in the north to Arunachal Pradesh in the east. The wide variation in altitude and geo-climatic variability throughout the mountain ranges makes them one of the most biologically rich areas in the world. The undulations and topography of mountain ranges of Himalaya provide habitat for variety of life forms in general but specifically to the faunal groups.

Rodgers and Panwar (1988) classified the land mass of Himalayas under two biogeographic zones, viz., Zone-1 and Zone-2, which is further classified into six biotic provinces (1A, 1B, 2A, 2B, 2C, and 2D). The biogeographic Zone-1 (Trans-Himalayas) covers about 184,823 km^2 area representing about 5.62 percent of the total geographic area of the country. The Trans-Himalayan zones are further classified into two biotic provinces, i.e., 1A and 1B, which covers cold deserts of Ladakh, Kargil in Jammu and Kashmir, Lahaul and Spiti Valley, and Pooh region of Himachal Pradesh, some section of rain shadow areas of the Nanda Devi range in Uttarakhand and northern mountains of Khangchendzonga range in Sikkim. The Himalayas Zone-2 is further subdivided into four biotic provinces, i.e., (Northwestern Himalayas, 2A; Western Himalayas, 2B; Central Himalayas, 2C; and Eastern Himalayas, 2D). The Indian Himalayan region (IHR) is represented by five states, viz., Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, and Arunachal Pradesh. Considering the high level of biological richness in the IHR, Government of India has emptily notified a large number of protected areas (PAs) with the aim of long-term conservation of biological diversity. Wildlife Institute of India (2015) has been notified 18 national parks, 68 wildlife sanctuaries, and 41 conservation reserves in Indian Himalayan region (IHR). The forest cover in this region is about 132,529 km^2 (about 38.81% of the total forest cover of India) out of which 33,343 km^2 is very dense forest, 62,259 km^2 is medium dense forest, and 36,927 km^2 is an open forest (ISFR 2015).

The variability in climate and topography in the Himalayas has resulted in high level of faunal diversity. Moreover, the rich biological diversity in the Himalayas is can be attributed with high species turnover associated with altitudinal variation in habitat, as well as variation in species composition along the ranges. The Himalayas are formed after the collision of the Indian plate with the Eurasian plate about 52–55 million years ago (mya) (Beck et al. 1995). After the collision of the two plates (Indian and Eurasian) the upliftment of the Himalayas is going on which is resulting in speciation and, consequently, making the region megadiverse. The protected areas' (PAs) network of the regions is represented by some of the well-known biologically rich PAs of the Himalayas, viz., the Great Himalayan National Park, Nanda Devi Biosphere Reserve, Khangchendzonga Biosphere Reserve, Dihang-Dibang Biosphere Reserve, Cold Desert Biosphere Reserve, Namdapha National Park, Hemis National Park, Kedarnath Wildlife Sanctuary, Dachigam National Park, Kishtwar High Altitude National Park, and Askot Wildlife Sanctuary (Rawal and Dhar 2001). These PAs provide habitat to threatened and endangered species such as snow leopard (*Panthera uncia*), hangul (*Cervus elaphus hanglu*), Himalayan brown bear (*Ursus arctos isabellinus*), four species of musk deer (*Moschus chrysogaster*, *M. cupreus*, *M. fuscus*, and *M. leucogaster*), serow (*Capricornis thar*), wild yak (*Bos mutus*), red panda (*Ailurus fulgens*), clouded leopard (*Neofelis nebulosa*), Himalayan wolf (*Canis lupus chanco*), etc.

The diversity of different groups of wild animals in these PAs has been well documented in various publications, viz., status and conservation of wildlife in Himachal Pradesh (Gaston et al. 1983); mammals of the Great Himalayan National Park (Vinod and Sathyakumar 1999); mammals of Nanda Devi National Park (Sathyakumar 2004); mammals of the high altitudes of western Arunachal Pradesh, Eastern Himalaya (Mishra et al. 2006); mammals of Neora Valley National Park (Chakraborty et al. 2008); and mammals of Khangchendzonga Biosphere Reserve (Sathyakumar et al. 2011). However, majority of the faunal surveys have documented the large mammalian diversity except the study by Saikia et al. (2011) and Saikia and Boro (2013) which have attempted to provide information on bats of Himachal Pradesh and Western Himalaya. Moreover, the diversity of the smaller mammals like rodents and insectivores is not sufficiently known from the Indian Himalayan regions.

10.2 Methods

A systematic review has been carried out for developing the checklist of mammalian species of IHR. For the review, relevant published information in the form of scientific papers and technical reports available using Internet search engines was downloaded and reviewed. The IUCN Red List 2017-1 version was also referred for collecting information pertaining to their present status in IHR by using the distribution maps available on IUCN portal. Furthermore, efforts were also made to consult the ZSI library rich in faunal literature and historical publications.

10.2.1 Mammalian Diversity of Indian Himalayas

The mammalian fauna list for the present study of IHR was based on the following studies: Vinod and Sathyakumar (1999), Alfred et al. (2006), Mishra et al. (2006), Chakraborty et al. (2008), Sathyakumar et al. (2011), Saikia et al. (2011), Saikia and Boro (2013), Johnsingh and Manjrekar (2013, 2015), Menon (2014), Sharma et al. (2015), and using IUCN Red List of Threatened Species (2017-1) (IUCN 2017). As per Wilson and Reeder (2005), a total of 5416 mammal species have been reported from the globe, out of which about 424 (8%) species found to be present in India representing 13 orders and 48 families. Based on the review of published literature and IUCN database, about 283 species representing 36 families and 11 orders of mammals are reported to be present in IHR (Table 10.1). Out of which Namdapha flying squirrel *Biswamoyopterus biswasi* and many subspecies, such as *Ursus thibetanus laniger*, *Capra falconeri falconeri*, *Paradoxurus hermaphroditus vellerosus*, *Lutra lutra aurobrunneus*, *Mustela kathiah caporiaccoi*, *Mustela sibirica hodgsonii*, *Mustela sibirica canigula*, *Ochotona macrotis macrotis*, *Ochotona nubrica nubrica*, *Ochotona thibetana sikimaria*, *Myotis muricola caliginosus*, etc., are endemic to Himalayan region (Sharma et al. 2015). The diversity of mammalian species is high (66.5%) in the Himalayan region followed by Indo-Burma region (44.8%) (Fig. 10.1). Most of the mammalian species of the Himalayas are given protection under different schedules of the Wildlife (Protection) Act 1972 and also listed in IUCN Red List of Threatened Species and CITES (Convention on International Trade in Endangered Species) (Table 10.1). The number of threatened mammalian species is high (41) in Himalayan region followed by Indo-Burma region (37) (Fig. 10.2).

10.2.2 Endemism

Out of 424 species of Indian mammals, 44 species are known as endemic to India. Of which 26 endemic species were distributed in all the hotspot, viz., 15 species restricted to the Western Ghats, 2 species to Eastern Himalayas, 5 species to Indo-Burma, and 5 species to Sundaland (Table 10.1).

10.2.3 Species Generalist Found in All Indian Hotspots

Of the 396 species of mammals found in Indian biodiversity hotspots, there are only 7 species (Chiropterans) found in all four Indian biodiversity hotspots such as *Cynopterus brachyotis* (Müller 1838) lesser short-nosed fruit bat, *Cynopterus sphinx* (Vahl 1797) greater short-nosed fruit bat, *Eonycteris spelaea* (Dobson 1871) lesser dawn bat, *Hipposideros pomona* K. Andersen, 1918, Pomona leaf-nosed bat, *Pipistrellus javanicus* (Gray 1838) Java pipistrelle, *Tylonycteris pachypus* (Temminck 1840) lesser bamboo bat, and *Murina cyclotis* Dobson, 1872, round-eared rube-nosed bat.

Table 10.1 Checklist of mammals found in the Indian biodiversity hotspots and their conservation status

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
Order Proboscidea								
Family Elephantidae								
1.	*Elephas maximus* Linnaeus, 1758, Asiatic elephant	+	+	+		EN	I	I
Order Sirenia								
Family Dugongidae								
2.	*Dugong dugon* (Muller, 1776) Dugong			+	+	VU	I	I
Order Scandentia								
Family Tupaiidae								
3.	*Anathana ellioti* (Waterhouse, 1850) Madras treeshrew	+				LC		II
4.	*Tupaia belangeri* (Wagner, 1841) Northern treeshrew		+	+		LC		II
5.	*Tupaia nicobarica* (Zelebor, 1869) Nicobar treeshrew				+ (E)	EN		II
Order Primates								
Family Lorisidae								
6.	*Loris lydekkerianus* Cabrera, 1908, Gray slender loris	+				LC	I	II
7.	*Nycticebus bengalensis* (Lacepede, 1800) Bengal slow loris		+	+		VU	I	I
Family Cercopithecidae								
8.	*Macaca arctoides* (I. Geoffroy, 1831) Stump-tailed macaque			+		VU	II	II
9.	*Macaca assamensis* (Mc Clelland, 1840) Assam macaque		+	+		NT	II	II
10.	*Macaca fascicularis* (Raffles, 1821) Crab-eating macaque				+	LC		
11.	*Macaca mulatta* (Zimmermann, 1780) Rhesus macaque		+	+		LC	II	II
12.	*Macaca munzala* Sinha et al., 2005, Arunachal macaque		+			EN		II
13.	*Macaca leonina* (Blyth, 1863) Northern pig-tailed macaque		+	+		VU	II	II
14.	*Macaca radiata* (E. Geoffroy, 1812) Bonnet macaque	+				LC	II	II
15.	*Macaca silenus* (Linnaeus, 1758) Lion-tailed macaque	+ (E)				EN	I	I
16.	*Semnopithecus ajax* (Pocock, 1928) Kashmir gray langur		+			EN		I
17.	*Semnopithecus dussumieri* I. Geoffroy, 1843, Southern plains gray langur	+				LC		I

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
18.	*Semnopithecus hector* (Pocock, 1928) Tarai gray langur		+			NT		I
19.	*Semnopithecus hypoleucos* Blyth, 1841, Black-footed gray langur	+				VU		I
20.	*Semnopithecus priam* Blyth, 1844, Tufted gray langur	+				NT		I
21.	*Semnopithecus schistaceus* Hodgson, 1840, Nepal gray langur		+			LC		I
22.	*Trachypithecus johnii* (J. Fischer, 1829) Nilgiri langur	+ (E)				VU	I	II
23.	*Trachypithecus phayrei* (Blyth, 1847) Phayre's leaf-monkey			+		EN	I	II
24.	*Trachypithecus pileatus* (Blyth, 1843) Capped langur		+	+		VU	I	I
Family Hylobatidae								
25.	*Hoolock hoolock* (Harlan, 1834) Western hoolock gibbon		+	+		EN	I	I
26.	*Hoolock leuconedys* (Groves, 2005) Eastern hoolock gibbon		+			VU		I
Order Rodentia **Family Sciuridae**								
27.	*Ratufa bicolor* (Sparrmann, 1778) Black giant squirrel		+	+		NT	II	II
28.	*Ratufa indica* (Erxleben, 1777) Indian giant squirrel	+				LC	II	II
29.	*Ratufa macroura* Pennant, 1769, Sri Lankan giant squirrel	+				NT	I	II
30.	*Belomys pearsonii* (Gray, 1842) Hairy-footed flying squirrel		+	+		DD	II	
31.	*Biswamoyopterus biswasi* Saha, 1981, Namdapha flying squirrel		+ (E)			CR		
32.	*Eoglaucomys fimbriatus* (Gray, 1837) Kashmir flying squirrel		+			LC		
33.	*Eupetaurus cinereus* Thomas, 1888, Woolly flying squirrel		+			EN	II	
34.	*Hylopetes alboniger* (Hodgson, 1836) Particolored flying squirrel		+	+		LC		
35.	*Petaurista elegans* (Muller, 1840) Spotted giant flying squirrel		+			LC	II	
36.	*Petaurista magnificus* (Hodgson, 1836) Hodgson's giant flying squirrel		+			LC	II	
37.	*Petaurista nobilis* (Gray, 1842) Bhutan giant flying squirrel		+			NT	II	

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
38.	*Petaurista petaurista* (Pallas, 1766) Red giant flying squirrel		+			LC	II	
39.	*Petaurista philippensis* (Elliot, 1839) Indian giant flying squirrel	+	+			LC	II	
40.	*Petinomys fuscocapillus* (Jerdon, 1847) Travancore flying squirrel	+				NT	I	
41.	*Callosciurus erythraeus* (Pallas, 1779) Pallas's squirrel		+	+		LC		
42.	*Callosciurus pygerythrus* (I. Geoffroy Saint Hilaire, 1833) Irrawaddy squirrel		+	+		LC		
43.	*Dremomys lokriah* (Hodgson, 1836) Orange-bellied Himalayan squirrel		+	+		LC		
44.	*Dremomys pernyi* (Milne-Edwards, 1867) Perny's long-nosed squirrel		+	+		LC		
45.	*Dremomys rufigenis* (Blanford,1878) Asian red-cheeked squirrel		+	+		LC		
46.	*Funambulus sublineatus* (Waterhouse, 1838) Dusky striped squirrel	+				VU		
47.	*Funambulus tristriatus* (Waterhouse, 1837) Jungle palm squirrel	+ (E)				LC		
48.	*Funambulus palmarum* (Linnaeus, 1766) Common palm squirrel	+				LC		
49.	*Funambulus pennantii* Wroughton, 1905, Northern palm squirrel	+	+	+		LC	IV	
50.	*Tamiops macclellandii* (Horsfield, 1840) Himalayan striped squirrel		+	+		LC		
51.	*Marmota caudata* (Geoffroy, 1844) Long-tailed marmot		+			LC	II	III
52.	*Marmota himalayana* (Hodgson, 1841) Himalayan marmot		+			LC	II	III
Family Dipopidae								
53.	*Sicista concolor* (Buchner, 1892) Chinese birch mouse		+			LC	V	
Family Platacanthomyidae								
54.	*Platacanthomys lasiurus* Blyth, 1859, Spiny tree mouse	+ (E)				VU	V	
Family Spalacidae								
55.	*Cannomys badius* (Hodgson,1841) Lesser bamboo rat			+		LC	V	
56.	*Rhizomys pruinosus* Blyth, 1851, Hoary bamboo rat		+	+		LC	V	

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
Family Cricetidae								
57.	*Alticola albicaudus* (True, 1894) White-tailed mountain vole		+			DD	V	
58.	*Alticola argentatus* (Severtzov, 1879) Silver mountain vole		+			LC	V	
59.	*Alticola montosa* (True, 1894) Kashmir mountain vole		+			VU	V	
60.	*Alticola roylei* (Gray,1842) Royle's mountain vole		+ (E)			NT	V	
61.	*Alticola stoliczkanus* (Blanford, 1875) Stoliczka's mountain vole		+			LC	V	
62.	*Eothenomys melanogaster* (Milne-Edwards, 1871) Père David's red-backed vole		+			LC	V	
63.	*Hyperacrius fertilis* (True, 1894) Subalpine Kashmir vole		+			NT	V	
64.	*Hyperacrius wynnei* (Blanford, 1881) Conifer Kashmir vole		+			LC	V	
65.	*Neodon sikimensis* Horsfield, 1841, Sikkim mountain vole		+			LC	V	
66.	*Phaiomys leucurus* Blyth, 1863, Blyth's mountain vole		+			LC	V	
67.	*Cricetulus alticola* Thomas, 1917, Ladakh dwarf hamster		+			LC	V	
68.	*Cricetulus migratorius* (Pallas, 1773) Gray dwarf hamster		+			LC	V	
Family Muridae								
69.	*Tatera indica* (Hardwicke, 1807) Indian gerbil	+	+			LC	V	
70.	*Apodemus draco* (Barret-Hamilton, 1900) South China field mouse		+			LC	V	
71.	*Apodemus latronum* Thomas, 1911, Large-eared field mouse		+			LC	V	
72.	*Apodemus pallipes* (Barrett-Hamilton, 1900) Himalayan field mouse		+			LC	V	
73.	*Apodemus rusiges* Miller, 1913, Kashmir field mouse		+			LC	V	
74.	*Apodemus uralensis* (Pallas, 1811) Herb field mouse		+			LC	V	
75.	*Bandicota bengalensis* (Gray, 1835) Indian mole rat	+	+	+		LC	V	
76.	*Bandicota indica* (Bechstein, 1800) Greater bandicoot rat	+	+	+		LC	V	

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
77.	*Berylmys bowersi* (Anderson, 1879) Bower's berylmys		+	+		LC	V	
78.	*Berylmys mackenziei* (Thomas, 1916) Mackenzie's berylmys		+	+		DD	V	
79.	*Berylmys manipulus* (Thomas, 1916) Manipur berylmys		+	+		DD	V	
80.	*Chiropodomys gliroides* (Blyth, 1856) Indomalayan pencil-tailed tree mouse		+	+		LC	V	
81.	*Cremnomys cutchicus* Wroughton, 1912, Cutch rock rat	+				LC	V	
82.	*Diomys crumpi* Thomas, 1917, Crump's diomys			+		DD	V	
83.	*Dacnomys millardi* Thomas, 1916, Millard's dacnomys		+	+		DD	V	
84.	*Golunda ellioti* Gray, 1837, Indian bush rat	+	+			LC	V	
85.	*Hadromys humei* (Thomas,1886) Hume's hadromys			+		EN	V	
86.	*Leopoldamys edwardsi* (Thomas, 1882) Edward's rat		+	+		LC	V	
87.	*Leopoldamys sabanus* (Thomas, 1887) Long-tailed giant rat		+			LC	V	
88.	*Madromys blanfordi* (Thomas, 1881) Blanford's rat	+				LC	V	
89.	*Micromys minutus* (Pallas, 1771) Harvest mouse		+	+		LC	V	
90.	*Millardia kondana* Mishra & Dhanda, 1975, Kondana rat	+ (E)				CR		
91.	*Millardia meltada* (Gray, 1837) Common metad	+	+			LC	V	
92.	*Mus booduga* (Gray, 1837) Little Indian field mouse	+	+			LC	V	
93.	*Mus cervicolor* Hodgson, 1845, Fawn-colored mouse		+	+	+	LC	V	
94.	*Mus cookii* Ryley, 1914, Cook's mouse	+	+	+		LC	V	
95.	*Mus famulus* Bonhote,1898, Bonhote's mouse	+ (E)				EN	V	
96.	*Mus musculus* Linnaeus, 1758, House mouse	+	+	+		LC	V	
97.	*Mus pahari* Thomas, 1916, Sikkim mouse		+	+		LC	V	
98.	*Mus phillipsi* Wroughton,1912, Phillips's mouse	+				LC	V	

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
99.	*Mus platythrix* Bennett, 1832, Brown spiny mouse	+				LC		
100.	*Mus saxicola* Elliot, 1839, Elliot's spiny mouse	+	+			LC	V	
101.	*Mus terricolor* Blyth, 1851, Earth-colored mouse	+	+			LC	V	
102.	*Nesokia indica* (Gray, 1830) Short-tailed mole rat		+			LC	V	
103.	*Niviventer brahma* (Thomas, 1914) Brahman niviventer		+			LC	V	
104.	*Niviventer eha* (Wroughton, 1916) Smoke-bellied niviventer		+			LC	V	
105.	*Niviventer fulvescens* (Gray, 1847) Chestnut rat		+	+		LC	V	
106.	*Niviventer langbianis* (Robinson & Kloss, 1922) Indochinese arboreal niviventer		+			LC	V	
107.	*Niviventer niviventer* (Hodgson, 1836) Himalayan niviventer		+	+		LC	V	
108.	*Rattus andamanensis* (Blyth, 1860) Indochinese forest rat		+	+	+	LC	V	
109.	*Rattus burrus* (Miller, 1902) Miller's Nicobar rat				+ (E)	EN	V	
110.	*Rattus nitidus* (Hodgson, 1845) Himalayan field rat		+	+		LC	V	
111.	*Rattus norvegicus* (Berkenhout, 1769) Norway rat	+				LC	V	
112.	*Rattus palmarum* (Zelebor, 1869) Zelebor's Nicobar rat				+ (E)	VU		
113.	*Rattus pyctoris* (Hodgson, 1845) Himalayan rat		+			LC	V	
114.	*Rattus ranjiniae* Agrawal & Ghosal, 1969, Ranjini's rat	+ (E)				EN	V	
115.	*Rattus rattus* (Linnaeus, 1758) Common house rat	+	+	+		LC	V	
116.	*Rattus stoicus* (Miller, 1902) Andaman archipelago rat			+		VU	V	
117.	*Rattus tanezumi* (Temminck, 1844) Oriental house rat		+	+	+	LC	V	
118.	*Vandeleuria nilagirica* Jerdon, 1867, Nilgiri vandeleuria	+ (E)				EN	V	
119.	*Vandeleuria oleracea* (Bennett, 1832) Indomalayan vandeleuria	+	+	+		LC	V	

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
Family Hystricidae								
120.	*Atherurus macrourus* (Linnaeus, 1758) Asiatic brush-tailed porcupine		+	+		LC	II	
121.	*Hystrix brachyura* Linnaeus, 1758, Himalayan crestless porcupine		+			LC	II	
122.	*Hystrix indica* Kerr, 1792, Indian crested porcupine	+	+	+		LC	IV	
Order Lagomorpha **Family Ochotonidae**								
123.	*Ochotona curzoniae* (Hodgson, 1858) Plateau pika		+			LC		
124.	*Ochotona forresti* Thomas, 1923, Forrest's pika		+			LC		
125.	*Ochotona ladacensis* (Günther, 1875) Ladakh pika		+			LC		
126.	*Ochotona macrotis* (Günther, 1875) Large-eared pika		+			LC		
127.	*Ochotona nubrica* Thomas, 1922, Nubra pika		+			LC		
128.	*Ochotona roylei* (Ogilby, 1839) Royle's pika		+			LC	IV	
129.	*Ochotona thibetana* (Milne-Edwards, 1871) Moupin pika		+			LC		
Family Leporidae								
130.	*Caprolagus hispidus* (Pearson, 1839) Hispid hare		+			EN	I	I
131.	*Lepus nigricollis* F. Cuvier, 1823, Indian hare	+	+	+		LC	IV	
132.	*Lepus capensis* Linnaeus, 1758, Cape hare		+			LC	IV	
133.	*Lepus oiostolus* Hodgson, 1840, Woolly hare		+			LC		
Order Eulipotyphla **Family Erinaceidae**								
134.	*Paraechinus micropus* (Blyth, 1846) Indian hedgehog	+				LC		
135.	*Paraechinus nudiventris* (Horsfield, 1851) Bare-bellied hedgehog	+				LC		
Family Soricidae								
136.	*Crocidura andamanensis* Miller, 1902, Andaman shrew			+		CR		
137.	*Crocidura attenuata* Milne-Edwards, 1872, Asian gray shrew		+	+		LC		

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
138.	*Crocidura fuliginosa* (Blyth, 1855) Southeast Asian shrew		+	+		LC		
139.	*Crocidura hispida* Thomas, 1913, Andaman spiny shrew			+ (E)		VU		
140.	*Crocidura jenkinsi* Chakraborty, 1978, Jenkin's shrew			+ (E)		CR		
141.	*Crocidura nicobarica* Miller, 1902, Nicobar shrew				+ (E)	CR		
142.	*Crocidura horsfieldii* (Tomes, 1856) Horsfield's shrew	+	+			DD		
143.	*Crocidura pergrisea* Miller, 1913, Pale gray shrew		+			DD		
144.	*Crocidura pullata* Miller, 1911, Kashmir white-toothed shrew		+			DD		
145.	*Crocidura vorax* G. Allen, 1923, Voracious shrew		+	+		LC		
146.	*Crocidura rapax* G. Allen, 1923, Chinese white-toothed shrew			+		DD		
147.	*Feroculus feroculus* (Kelaart, 1850) Kelaart's long-clawed shrew	+				EN		
148.	*Suncus dayi* (Dobson, 1888) Day's shrew	+ (E)				EN		
149.	*Suncus etruscus* (Savi, 1822) Etruscan shrew	+	+	+		LC		
150.	*Suncus murinus* (Linnaeus, 1766) Asian musk shrew	+	+	+		LC		
151.	*Suncus niger* (Horsfield, 1851) Indian highland shrew	+						
152.	*Suncus stoliczkanus* (Anderson, 1877) Anderson's shrew	+	+			LC		
153.	*Anourosorex assamensis* Anderson, 1875, Assam mole shrew		+	+		LC		
154.	*Anourosorex schmidi* Petter, 1963, Giant mole shrew		+			DD		
155.	*Anourosorex squamipes* Milne-Edwards, 1872, Chinese mole shrew		+	+		DD		
156.	*Chimarrogale himalayica* (Gray, 1842) Himalayan water shrew		+			LC		
157.	*Episoriculus caudatus* (Horsefield, 1851) Hodgson's brown-toothed shrew		+			LC		
158.	*Episoriculus leucops* (Horsefield, 1855) Long-tailed brown-toothed shrew		+			LC		

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
159.	*Episoriculus macrurus* (Blanford, 1888) Long-tailed mountain shrew		+			LC		
160.	*Nectogale elegans* Milne-Edwards, 1870, Elegant water shrew		+			LC		
161.	*Soriculus nigrescens* (Gray, 1842) Himalayan Shrew		+			LC		
162.	*Sorex minutus* Linnaeus, 1766, Eurasian pygmy shrew		+			LC		
163.	*Sorex planiceps* Miller, 1911, Kashmir pygmy shrew		+			LC		
Family Talpidae								
164.	*Euroscaptor micrura* (Hodgson, 1841) Himalayan mole		+			LC		
165.	*Parascaptor leucura* (Blyth, 1850) White-tailed mole		+			LC		
Order Chiroptera **Family Pteropodidae**								
166.	*Cynopterus brachyotis* (Müller, 1838) Lesser short-nosed fruit bat	+	+	+	+	LC	V	
167.	*Cynopterus sphinx* (Vahl, 1797) Greater short-nosed fruit bat	+	+	+	+	LC	V	
168.	*Eonycteris spelaea* (Dobson, 1871) Lesser dawn bat	+	+	+	+	LC	V	
169.	*Latidens salimalii* Thonglongya, 1972, Salim Ali's fruit bat	+ (E)				EN	I	
170.	*Macroglossus sobrinus* K. Andersen, 1911, Greater long-nosed fruit bat		+	+		LC	V	
171.	*Megaerops ecaudatus* (Temminck, 1837) Temminck's tailless fruit bat		+			LC	V	
172.	*Megaerops niphanae* Yenbutra & Felten, 1983, Ratanaworabhan's fruit bat		+			LC	V	
173.	*Pteropus faunulus* Miller, 1902, Nicobar flying fox				+ (E)	VU	V	II
174.	*Pteropus giganteus* (Brünnich, 1782) Indian flying fox	+	+			LC	V	II
175.	*Pteropus hypomelanus* Temminck, 1853, Variable flying fox				+	LC	V	II
176.	*Pteropus melanotus* Blyth, 1863, Black-eared flying fox			+	+	VU	V	II
177.	*Rousettus leschenaultii* (Desmarest, 1820) Leschenault's rousette	+	+			LC	V	

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
178.	*Sphaerias blanfordi* (Thomas, 1891) Blanford's fruit bat		+			LC	V	
Family Rhinolophidae								
179.	*Rhinolophus affinis* Horsfield, 1823, Intermediate horseshoe bat		+	+		LC		
180.	*Rhinolophus beddomei* Andersen, 1905, Beddome's horseshoe bat	+				LC		
181.	*Rhinolophus cognatus* K. Andersen, 1906, Andaman horseshoe bat			+ (E)		EN		
182.	*Rhinolophus ferrumequinum* (Schreber, 1774) Greater horseshoe bat		+			LC		
183.	*Rhinolophus hipposideros* (Bechstein, 1800) Lesser horseshoe bat		+			LC		
184.	*Rhinolophus lepidus* Blyth, 1844, Blyth's horseshoe bat	+	+			LC		
185.	*Rhinolophus luctus* Temminck, 1834, Woolly horseshoe bat	+	+			LC		
186.	*Rhinolophus macrotis* Blyth, 1844, Big-eared horseshoe bat		+			LC		
187.	*Rhinolophus pearsonii* Horsfield, 1851, Pearson's horseshoe bat		+			LC		
188.	*Rhinolophus pusillus* Temminck, 1834, Least horseshoe bat	+	+			LC		
189.	*Rhinolophus rouxii* Temminck, 1835, Rufous horseshoe bat	+	+			LC		
190.	*Rhinolophus shortridgei* K. Andersen, 1918, Shortridge's horseshoe bat		+			LC		
191.	*Rhinolophus sinicus* K. Andersen, 1905, Chinese rufous horseshoe bat		+	+		LC		
192.	*Rhinolophus subbadius* Blyth, 1844, Little Nepalese horseshoe bat		+	+		LC		
193.	*Rhinolophus trifoliatus* Temminck, 1834, Trefoil horseshoe bat		+			LC		
194.	*Rhinolophus yunanensis* Dobson, 1872, Dobson's horseshoe bat		+			LC		

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
Family Hipposideridae								
195.	*Coelops frithii* Blyth, 1848, East Asian tailless leaf-nosed bat		+	+		LC		
196.	*Hipposideros armiger* (Hodgson, 1835) Great leaf-nosed bat		+	+		LC		
197.	*Hipposideros ater* Templeton, 1848, Dusky leaf-nosed bat	+		+	+	LC		
198.	*Hipposideros cineraceus* Blyth, 1853, Ashy leaf-nosed bat		+	+		LC		
199.	*Hipposideros diadema* (E.Geoffroy, 1813) Diadem leaf-nosed bat				+	LC		
200.	*Hipposideros fulvus* Gray, 1838, Fulvus leaf-nosed bat		+			LC		
201.	*Hipposideros galeritus* Cantor, 1846, Cantor's leaf-nosed bat	+				LC		
202.	*Hipposideros hypophyllus* Kock & Bhat, 1994, Leafletted leaf-nosed bat	+ (E)				EN		
203.	*Hipposideros larvatus* (Horsfield, 1823) Intermediate leaf-nosed bat		+	+	+	LC		
204.	*Hipposideros lankadiva* Kelaart, 1850, Kelaart's leaf-nosed bat	+	+	+		LC		
205.	*Hipposideros pomona* K. Andersen, 1918, Pomona leaf-nosed bat	+	+	+	+	LC		
206.	*Hipposideros speoris* (Schneider, 1800) Schneider's leaf-nosed bat	+	+			LC		
Family Megadermatidae								
207.	*Megaderma lyra* É. Geoffroy, 1810, Greater false vampire bat	+	+	+		LC		
208.	*Megaderma spasma* (Linnaeus, 1758) Lesser false vampire bat	+		+	+	LC		
Family Rhinopomatidae								
209.	*Rhinopoma hardwickii* Gray, 1831, Lesser mouse-tailed bat	+	+			LC		
210.	*Rhinopoma microphyllum* (Brünnich, 1792) Greater mouse-tailed bat	+				LC		
211.	*Rhinopoma muscatellum* Thomas, 1903, Small mouse-tailed bat	+				LC		

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
Family Emballonuridae								
212.	*Saccolaimus saccolaimus* (Temminck, 1838) Naked-rumped pouched bat	+				LC		
213.	*Taphozous longimanus* Hardwicke, 1825, Long-winged tomb bat	+	+			LC		
214.	*Taphozous melanopogon* Temminck, 1841, Black-bearded tomb bat	+	+	+		LC		
215.	*Taphozous nudiventris* Cretzschmar, 1830, Naked-rumped tomb bat	+	+			LC		
216.	*Taphozous theobaldi* Dobson, 1872, Theobald's tomb bat	+				LC		
Family Molossidae								
217.	*Chaerephon plicatus* (Buchannan, 1800) Wrinkle-lipped free-tailed bat	+		+		LC		
218.	*Otomops wroughtoni* (Thomas, 1913) Wroughton's giant mastiff bat	+		+		DD	I	
219.	*Tadarida aegyptiaca* (E. Geoffroy, 1818) Egyptian free-tailed bat	+				LC		
Family Vespertilionidae								
220.	*Arielulus circumdatus* (Temminck, 1840) Bronze sprite		+	+		LC		
221.	*Eptesicus bottae* (Peters, 1869) Botta's serotine		+			LC		
222.	*Eptesicus gobiensis* Bobrinskii, 1926, Gobi big brown bat		+			LC		
223.	*Eptesicus pachyotis* (Dobson, 1871) Thick-eared bat			+		LC		
224.	*Eptesicus serotinus* (Schreber, 1774) Common serotine		+	+		LC		
225.	*Eptesicus tatei* Ellerman & MorrisonScott, 1951, Sombre bat		+			DD		
226.	*Hesperoptenus tickelli* (Blyth, 1851) Tickell's bat	+		+	+	LC		
227.	*Falsistrellus affinis* (Dobson, 1871) Chocolate pipistrelle	+	+			LC		
228.	*Ia io* Thomas, 1902, Great evening bat		+	+		LC		

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
229.	*Harpiocephalus mordax* Thomas, 1923, Greater hairy-winged bat		+	+		LC		
230.	*Harpiola grisea* Peters, 1872, Peters's tube-nosed bat		+ (E)			DD		
231.	*Scotoecus pallidus* (Dobson, 1876) Desert yellow lesser house bat		+			LC		
232.	*Scotophilus heathii* (Horsfield, 1831) Greater Asiatic yellow house bat	+	+	+		LC		
233.	*Scotophilus kuhlii* Leach, 1821, Lesser Asiatic yellow bat	+	+	+		LC		
234.	*Scotomanes ornatus* (Blyth, 1851) Harlequin bat		+	+		LC		
235.	*Nyctalus leisleri* (Kuhl, 1817) Leisler's noctule		+			LC		
236.	*Nyctalus montanus* (BarrettHamilton, 1906) Mountain noctule		+			LC		
237.	*Nyctalus noctula* (Schreber, 1774) Noctule		+	+		LC		
238.	*Pipistrellus abramus* (Temminck, 1838) Japanese pipistrelle			+		LC		
239.	*Pipistrellus cadornae* (Thomas, 1916) Cadorna's pipistrelle		+	+		LC		
240.	*Pipistrellus ceylonicus* (Kelaart, 1852) Kelaart's pipistrelle	+				LC		
241.	*Pipistrellus coromandra* (Gray, 1838) Indian pipistrelle	+	+	+		LC		
242.	*Pipistrellus javanicus* (Gray, 1838) Java pipistrelle	+	+	+	+	LC		
243.	*Pipistrellus kuhlii* (Kuhl, 1817) Kuhl's pipistrelle		+			LC		
244.	*Pipistrellus paterculus* Thomas, 1915, Mount Popa pipistrelle		+	+		LC		
245.	*Pipistrellus pipistrellus* (Schreber, 1774) Common pipistrelle		+			LC		
246.	*Pipistrellus savii* (Bonaparte, 1837) Savi's pipistrelle		+	+		LC		
247.	*Pipistrellus tenuis* (Temminck, 1840) Least pipistrelle	+	+	+		LC		
248.	*Scotozous dormeri* Dobson, 1875, Dormer's pipistrelle	+	+			LC		

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
249.	*Barbastella leucomelas* (Cretzschmar, 1826) Eastern barbastelle		+			LC		
250.	*Otonycteris hemprichii* Peters, 1859, Hemprich's desert bat		+			LC		
251.	*Plecotus auritus* (Linnaeus, 1758) Brown long-eared bat		+	+		LC		
252.	*Tylonycteris pachypus* (Temminck, 1840) Lesser bamboo bat	+	+	+	+	LC		
253.	*Tylonycteris robustula* Thomas, 1915, Greater bamboo bat			+		LC		
254.	*Myotis annectans* (Dobson, 1871) Hairy-faced myotis		+	+		LC		
255.	*Myotis blythii* (Tomes, 1857) Lesser mouse-eared myotis		+	+		LC		
256.	*Myotis daubentonii* (Kuhl, 1817) Daubenton's bat			+		LC		
257.	*Myotis formosus* (Hodgson, 1835) Hodgson's myotis		+	+		LC		
258.	*Myotis horsfieldii* (Temminck, 1840) Horsfield's myotis	+		+		LC		
259.	*Myotis laniger* Peters, 1871, Chinese water myotis		+	+		LC		
260.	*Myotis montivagus* (Dobson, 1874) Burmese whiskered myotis	+	+			LC		
261.	*Myotis longipes* (Dobson, 1873) Kashmir cave myotis		+	+		DD		
262.	*Myotis muricola* (Gray, 1846) Nepalese whiskered myotis		+	+		LC		
263.	*Myotis nipalensis* (Dobson, 1871) Nepal myotis		+	+		LC		
264.	*Myotis sicarius* Thomas, 1915, Mandelli's mouse-eared myotis		+			VU		
265.	*Myotis siligorensis* (Horsfield, 1855) Himalayan whiskered myotis		+	+		LC		
266.	*Miniopterus schreibersii* (Kuhl, 1817) Schreibers's long-fingered bat	+	+	+		NT		
267.	*Miniopterus magnater* Sanborn, 1931, Western long-fingered bat		+	+		LC		
268.	*Miniopterus pusillus* Dobson, 1876, Small long-fingered bat	+			+	LC		

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
269.	*Harpiocephalus harpia* (Temminck, 1840) Lesser hairy-winged bat	+	+	+		LC		
270.	*Harpiocephalus mordax* Thomas, 1923, Greater hairy-winged bat			+				
271.	*Murina aurata* Milne-Edwards, 1872, Little tube-nosed bat		+	+		LC		
272.	*Murina cyclotis* Dobson, 1872, Round-eared tube-nosed bat	+	+	+	+	LC		
273.	*Murina huttoni* (Peters, 1872) Hutton's tube-nosed bat		+			LC		
274.	*Murina leucogaster* Milne-Edwards, 1872, Greater tube-nosed bat			+		DD		
275.	*Murina tubinaris* (Scully, 1881) Scully's tube nosed bat		+			LC		
276.	*Harpiola grisea* Peters, 1872, Peters's tube-nosed bat			+		DD		
277.	*Kerivoula hardwickii* (Horsfield, 1824) Hardwicke's woolly bat	+	+	+		LC		
278.	*Kerivoula picta* (Pallas, 1767) Painted woolly bat	+	+			LC		
279.	*Tylonycteris robustula* Thomas, 1915, Greater bamboo bat		+	+		LC		
280.	*Philetor brachypterus* Temminck, 1840, Rohu's bat		+			LC		
Order Pholidota Family Manidae								
281.	*Manis crassicaudata* E. Geoffroy, 1803, Indian pangolin	+	+			EN	I	II
282.	*Manis pentadactyla* Linnaeus, 1758, Chinese pangolin		+	+		CR	I	I
Order Carnivora Family Felidae								
283.	*Catopuma temminckii* (Vigors & Horsfield, 1827) Asiatic golden cat		+	+		NT	I	I
284.	*Felis chaus* Schreber, 1777, Jungle cat	+	+	+		LC	II	II
285.	*Otocolobus manul* Pallas, 1776, Pallas's cat		+			NT	I	II
286.	*Lynx lynx* (Linnaeus, 1758) Eurasian lynx		+			LC	I	II

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
287.	*Pardofelis marmorata* (Martin, 1837) Marbled cat		+	+		VU	I	I
288.	*Prionailurus bengalensis* (Kerr, 1792) Leopard cat	+	+	+		LC	I	I
289.	*Prionailurus rubiginosus* (I. Geoffroy Saint-Hilaire, 1831) Rusty-spotted cat	+				VU	I	I
290.	*Prionailurus viverrinus* (Bennett, 1833) Fishing cat	+		+		EN	I	II
291.	*Neofelis nebulosa* (Griffith, 1821) Clouded leopard		+	+		VU	I	I
292.	*Panthera pardus* (Linnaeus, 1758) Leopard	+	+	+		NT	I	I
293.	*Panthera tigris* (Linnaeus, 1758) Tiger	+	+	+		EN	I	I
294.	*Panthera uncia* (Schreber, 1775) Snow leopard		+			EN	I	I
Family Viverridae								
295.	*Arctictis binturong* (Raffles, 1821) Binturong		+	+		VU	I	III
296.	*Arctogalidia trivirgata* (Gray, 1832) Small-toothed palm civet		+	+		LC	II	
297.	*Paguma larvata* (C. E. H. Smith, 1827) Masked palm civet		+	+	+	LC	II	III
298.	*Paradoxurus hermaphroditus* (Pallas, 1777) Asian palm civet	+	+	+		LC	II	III
299.	*Paradoxurus jerdoni* Blanford, 1885, Jerdon's palm civet	+ (E)				LC	II	III
300.	*Prionodon pardicolor* Hodgson, 1842, Spotted linsang		+	+		LC	I	I
301.	*Viverra civettina* Blyth, 1862, Malabar large-spotted civet	+ (E)				CR	I	III
302.	*Viverra zibetha* Linnaeus, 1758, Large Indian civet		+	+		NT	II	III
303.	*Viverricula indica* (E. Geoffroy Saint Hilaire, 1803) Small Indian civet	+	+	+		LC	II	III
Family Herpestidae								
304.	*Herpestes palustris* Ghose, 1965, Bengal marsh mongoose							
305.	*Herpestes edwardsii* (É. Geoffroy SaintHilaire, 1818) Gray mongoose	+	+			LC	II	III
306.	*Herpestes javanicus* (É. Geoffroy Saint Hilaire, 1818) Javan mongoose		+	+		LC	II	III

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
307.	*Herpestes smithii* Gray, 1837, Ruddy mongoose	+				LC	II	III
308.	*Herpestes urva* (Hodgson, 1836) Crab-eating mongoose		+	+		LC	II	III
309.	*Herpestes vitticollis* Bennett, 1835, Stripe-necked mongoose	+				LC	II	III
Family Hyaenidae								
310.	*Hyaena hyaena* (Linnaeus, 1758) Striped hyena	+	+			NT	III	III
Family Canidae								
311.	*Canis aureus* Linnaeus, 1758, Golden jackal	+	+	+		LC	II	III
312.	*Canis lupus chanco* Gray, 1863, Himalayan wolf	+	+			LC	I	I
313.	*Cuon alpinus* (Pallas, 1811) Dhole	+	+	+		EN	II	II
314.	*Vulpes bengalensis* (Shaw, 1800) Bengal fox	+	+			LC	II	III
315.	*Vulpes ferrilata* Hodgson, 1842, Tibetan sand fox		+			LC	I	
316.	*Vulpes vulpes* (Linnaeus, 1758) Red fox		+	+		LC		
Family Ursidae								
317.	*Melursus ursinus* (Shaw, 1791) Sloth bear	+	+	+		VU	I	I
318.	*Ursus arctos* Linnaeus, 1758, Himalayan brown bear		+			LC	I	I
319.	*Ursus thibetanus* G.[Baron] Cuvier, 1823, Asiatic black bear		+	+		VU	II	I
320.	*Helarctos malayanus* (Raffles, 1821) Sun bear		+	+		VU	I	I
Family Mustelidae								
321.	*Aonyx cinerea* (Illiger, 1815) Oriental small-clawed otter	+	+	+		VU	I	II
322.	*Lutra lutra* (Linnaeus, 1758) European otter	+	+	+		NT	II	I
323.	*Lutrogale perspicillata* (I.Geoffroy SainHilaire, 1826) Smooth-coated otter	+	+	+		VU	II	II
324.	*Arctonyx collaris* F.G. Cuvier, 1825, Hog badger		+	+		NT	I	
325.	*Martes flavigula* (Boddaert, 1785) Yellow-throated marten		+			LC	II	III
326.	*Martes foina* (Erxleben, 1777) Beech marten		+	+		LC		III

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
327.	*Martes gwatkinsii* Horsfield, 1851, Nilgiri marten	+ (E)				VU	II	III
328.	*Mellivora capensis* (Schreber, 1776) Honey badger	+	+			LC	I	
329.	*Melogale moschata* (Gray, 1831) Chinese ferret-badger		+	+		LC	II	
330.	*Melogale personata* I. Geoffroy SaintHilaire, 1831, Burmese ferret-badger		+	+		DD	II	
331.	*Mustela altaica* Pallas, 1811, Mountain weasel		+			NT	II	III
332.	*Mustela erminea* Linnaeus, 1758, Ermine		+			LC	I	
333.	*Mustela kathiah* Hodgson, 1835, Yellow-bellied weasel		+			LC	II	III
334.	*Mustela sibirica* Pallas, 1773, Siberian weasel		+	+		LC	II	III
335.	*Mustela strigidorsa* Gray, 1853, Back-striped weasel		+	+		LC		
Family Ailuridae								
336.	*Ailurus fulgens* F.G. Cuvier, 1825, Red panda		+			VU	I	I
Order Perissodactyla **Family Equidae**								
337.	*Equus kiang* Moorcroft, 1841, Kiang		+			LC	I	II
Order Artiodactyla **Family Suidae**								
338.	*Sus scrofa* Linnaeus, 1758, Wild pig	+	+	+		LC	III	
Family Tragulidae								
339.	*Moschiola indica* Gray, 1852, Indian chevrotain	+				LC	I	
Family Moschidae								
340.	*Moschus chrysogaster* (Hodgson, 1839) Alpine musk deer		+			EN	I	I
341.	*Moschus cupreus* Grubb, 1982, Kashmir musk deer		+			EN		I
342.	*Moschus fuscus* Li, 1981, Black musk deer		+			EN		I
343.	*Moschus leucogaster* Hodgson, 1839, Himalayan musk deer		+			EN		I
Family Cervidae								
344.	*Axis axis* (Erxleben, 1777) Spotted deer	+	+	+		LC	III	

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
345.	*Axis porcinus* (Zimmermann, 1780) Hog deer		+	+		EN	III	
346.	*Cervus elaphus* Linnaeus, 1758, Red deer		+			LC		
347.	*Muntiacus muntjak* (Zimmermann, 1780) Indian muntjac	+	+	+		LC	III	
348.	*Rucervus eldii* (Mc Clelland, 1842) Eld's deer			+		EN	I	I
349.	*Rusa unicolor* (Kerr, 1792) Sambar	+	+	+		VU	III	
Family Bovidae								
350.	*Antilope cervicapra* (Linnaeus, 1758) Blackbuck	+				NT	I	
351.	*Gazella bennettii* (Sykes, 1831) Indian gazelle	+				LC	I	
352.	*Procapra picticaudata* Hodgson, 1846, Tibetan gazelle		+			NT	I	
353.	*Bos gaurus* C. H. Smith, 1827, Gaur	+	+	+		VU	I	I
354.	*Bos mutus* (Przewalski, 1883) Wild yak		+			VU	I	I
355.	*Boselaphus tragocamelus* (Pallas, 1766) Nilgai	+	+			LC	III	
356.	*Bubalus arnee* (Kerr, 1792) Wild water buffalo			+		EN	I	
357.	*Tetracerus quadricornis* (de Blainville, 1816) Four-horned antelope	+	+			VU	I	
358.	*Budorcas taxicolor* Hodgson, 1850, Takin		+			VU	I	II
359.	*Capra falconeri* (Wagner, 1839) Markhor		+			EN	I	I
360.	*Capra sibirica* (Pallas, 1776) Siberian ibex		+			LC	I	
361.	*Capricornis thar* (Hodgson, 1831) Himalayan serow		+	+		NT	I	I
362.	*Hemitragus jemlahicus* (C.H. Smith, 1826) Himalayan tahr		+			NT	I	
363.	*Naemorhedus baileyi* Pocock, 1914, Red goral		+			VU		I
364.	*Naemorhedus goral* (Hardwicke, 1825) Himalayan goral		+			NT	III	I
365.	*Naemorhedus griseus* (MilneEdwards, 1871) Chinese goral		+	+		VU		I

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
366.	*Nilgiritragus hylocrius* (Ogilby, 1838) Nilgiri tahr	+ (E)				EN	I	
367.	*Ovis ammon* (Linnaeus, 1758) Argali		+			NT		
368.	*Ovis orientalis* Gmelin, 1774, Urial		+			VU		
369.	*Pantholops hodgsonii* (Abel, 1826) Chiru		+			NT	I	I
370.	*Pseudois nayaur* (Hodgson, 1833) Bharal		+			LC	I	
Order Cetacea **Family Balaenopteridae**								
371.	*Balaenoptera acutorostrata* Lacépède, 1804, Common minke whale			+	+	LC	II	I
372.	*Balaenoptera borealis* Lesson, 1828, Sei whale			+	+	EN	II	I
373.	*Balaenoptera edeni* Anderson, 1879, Bryde's whale			+	+	DD	II	I
374.	*Balaenoptera musculus* (Linnaeus, 1758) Blue whale			+	+	EN	II	I
375.	*Balaenoptera physalus* (Linnaeus, 1758) Fin whale			+	+	EN	II	I
376.	*Megaptera novaeangliae* (Borowski, 1781) humpback whale			+	+	LC	II	I
Family Delphinidae								
377.	*Feresa attenuata* Gray, 1875, Pygmy killer whale			+	+	DD	II	II
378.	*Globicephala macrorhynchus* Gray, 1846, Short-finned pilot whale			+	+	DD	II	II
379.	*Grampus griseus* (G Cuvier, 1812) Risso's dolphin			+	+	LC	II	II
380.	*Lagenodelphis hosei* Fraser, 1956, Fraser's dolphin			+	+	LC	II	II
381.	*Orcinus orca* (Linnaeus, 1758) Killer whale			+	+	DD	II	II
382.	*Peponocephala electra* (Gray, 1846) Melon-headed whale			+	+	LC	II	II
383.	*Pseudorca crassidens* (Owen, 1846) False killer whale			+	+	DD	II	II

(continued)

Table 10.1 (continued)

Sl. no.	Name of the species	WG[a]	EH	IB	SL	IUCN	IWPA	CITES
384.	*Stenella attenuata* (Gray, 1846) Pantropical spotted dolphin			+	+	LC	II	II
385.	*Stenella coeruleoalba* (Meyen, 1833) Striped dolphin			+	+	LC	II	II
386.	*Stenella longirostris* (Gray, 1828) Spinner dolphin			+	+	DD	II	II
387.	*Steno bredanensis* (G. Cuvier *in* Lesson, 1828) Rough-toothed dolphin			+	+	LC	II	II
388.	*Tursiops aduncus* (Ehrenberg, 1833) Indo-Pacific bottlenose dolphin			+	+	DD	II	II
389.	*Tursiops truncatus* (Montagu, 1821) Bottlenose dolphin			+	+	LC	II	II
Family Physeteridae								
390.	*Kogia breviceps* (Blainville, 1838) Pygmy sperm whale			+	+	DD	II	II
391.	*Kogia sima* (Owen, 1866) Dwarf sperm whale			+	+	DD	II	II
392.	*Physeter macrocephalus* Linnaeus, 1758, Sperm whale			+	+	VU	II	I
Family Ziphiidae								
393.	*Indopacetus pacificus* (Longman, 1926) Indo-Pacific beaked whale			+	+	DD	II	II
394.	*Mesoplodon densirostris* (Blainville, 1817) Blainville's beaked whale			+	+	DD	II	II
395.	*Mesoplodon ginkgodens* Nishiwaki & Kamiya, 1958, Ginkgo-toothed beaked whale			+	+	DD	II	II
396.	*Ziphius cavirostris* G. Cuvier, 1823, Cuvier's beaked whale			+	+	LC	II	II
Total number of species		**134**	**282**	**190**	**53**			

WG Western Ghats, *EH* Eastern Himalayas, *IB* Indo-Burma (including Andaman Islands), *SL* Sundaland (Nicobar Islands), *(E)* endemic to particular hotspot

IUCN – *CR* critically endangered, *EN* endangered, *VU* vulnerable, *NT* near threatened, *LC* least concern, *DD* data deficient

IWPA Indian Wildlife (Protection) Act, 1972 (Schedule I, II, III, IV, and V)

CITES Convention on International Trade in Endangered Species of Wild Fauna and Flora (Appendix I, II, and III)

[a]Source: Nameer et al. (2001)

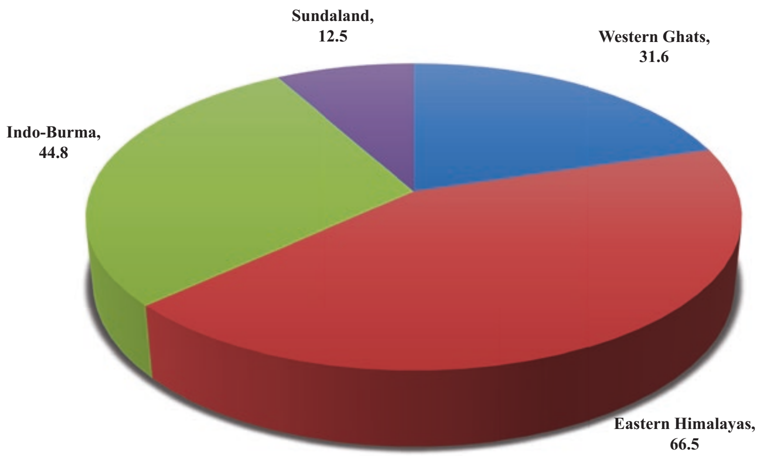

Fig. 10.1 Percentage frequency of mammalian diversity in the Indian biodiversity hotspots ($n = 424$)

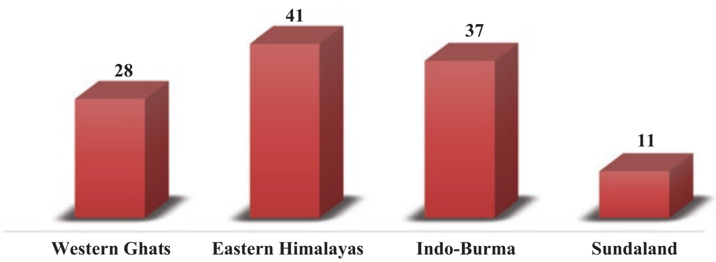

Fig. 10.2 Number of threatened mammals found in the Indian biodiversity hotspots as per the IUCN Red List of Threatened Species (CR, EN, and VU)

10.2.4 Conservation Threats

Based on the published information, following major threats have been identified to the mammalian fauna of IHR:

1. *Habitat loss due to land use change*: In IHR due to rapid population expansion, forest areas are getting converted into other land use types mainly for human habitation and expansion of farmland to enhance productivity. The increasing human population is exhibiting tremendous pressure due to increased demand for food, fuel, fodder, and building materials on natural resources which are leading to habitat degradation.

2. *Unsustainable livestock grazing*: In the absence of National Grazing Policy, the wildlife habitats of the Himalayan region are getting degraded. Grazing by livestock leads to degradation of soil in forested areas which negatively impacts the regeneration of plant species which are important food species of wild animals. Further, grazing in a forested area and overutilization of pastures by livestock is also leading to plant community structure change and alteration of habitat. It has been reported by many studies that competition between livestock and wild ungulates in the Himalayas is leading to deterioration of habitat and reduction of herbivorous wild animals.
3. *Illegal wildlife trade*: Illegal wildlife trade in the Himalayan region is a major threat to the long-term conservation of large mammals. Since, in the IHR international land borders are porous through which illegal wildlife trade takes place from India to neighboring countries such as China, Nepal, and Bangladesh where wildlife products are in demand for various uses.
4. *Forest fire*: In IHR forest fire has become a recurring phenomenon impacting the populations of wild animals as forest fires result in the destruction of forested habitat which is formed after long successional stages. In the Himalayan states of Uttarakhand and Himachal Pradesh, forest fire is engulfing vital wildlife habitats every year.
5. *Climate change*: The Himalayas are fragile ecosystems and vulnerable to climate change increasing the temperature in the regions which is impacting the behavioral ecology of many species which are climate sensitive such as Asiatic black bear, snow leopard, marmot, etc. Its direct impact is visible as distribution range shifts are predicted for many large mammals in IHR. Also, it is resulting in changing the forest cover composition of the habitats which support a large number of mammals.

10.3 Conclusions

The present review provides an updated list of mammals distributed in the IHR out of which many are endangered and threatened. During the literature review, it was observed that scientific data on many species is not available which is imperative for making informed conservation and management decisions. The present study also narrates the major conservation threats to the mammals of IHR. Moreover, information on many species is not available for majority of the PAs in the IHR. Hence, it is recommended that efforts should be made toward assessing the conservation status of species which are under unfavorable condition and with endangered conservation status.

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An Update on the Mammals of Western Ghats

11

C. Venkatraman, M. Kamalakannan, and Debashree Dam

Abstract

Western Ghats (WG) is one of the 35 hotspots of the world and home to several endemic and endangered vertebrate fauna. The mammalian fauna of Western Ghats includes 133 species representing 10 orders and 31 families of class Mammalia, which is about 31% of the total Indian mammalian fauna. Twenty-six species of endemic mammals were reported from the Western Ghats, out of 44 species of endemic mammals known from the different regions of India. The habitat loss and degradation due to industrial activities, human encroachment, poaching, livestock grazing, man-wildlife conflict, plantations and logging are considered as major threats.

Keywords

Distribution · Diversity · Hotspots · Mammals · Status

11.1 Introduction

The Western Ghats (WG) is one of the biodiversity hotspots of the world identified by the Conservation International (Myers et al. 2000). The Western Ghats is also one of the world's eight "Hottest biodiversity hotspots". Of the Global 200 priority ecoregions designated by the World Wide Fund for Nature (WWF), the Southwestern Ghats' moist forests and the rivers and streams of Western Ghats fall under the Critically Endangered category. The World Conservation Monitoring Centre (WCMC) has identified the Western Ghats region as one of the important areas of freshwater biodiversity.

C. Venkatraman (✉) · M. Kamalakannan · D. Dam
Zoological Survey of India, Kolkata, India

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The Western Ghats constitutes a 1600 km long and about 45–65 million years old mountain chain along the west coast of India, originating from the south of the Tapti River (near the border of Gujarat and Maharashtra) and extending up to Kanyakumari, at the southernmost tip of the Indian Peninsula (between 20°N lat. and 8°N long). The extent of the area is 160,000 km^2 and covers six states, namely, Gujarat, Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala. The average elevation of the northern part of the Western Ghats is 1,220 m, and the southern part of the hills has higher elevation. The massive mountain chain is interrupted by a few gaps/passes, the most prominent one being the Palghat Gap, at the Tamil Nadu/Kerala border between the Nilgiri Hills and the Anaimalai Hills. The southern part of the Western Ghats harbours the Nilgiri Hills which is the meeting point of the Western Ghats with the Eastern Ghats.

Wilson and Reeder (2005) and Sharma et al. (2015) reported 424 species of mammals belonging to 48 families and 13 orders from India. The present checklist provides the revised and updated list of mammalian fauna with valid nomenclature of species and the distribution of mammal species among the six states of Western Ghats and their conservation status.

11.2 Methods

The checklist of mammals of Western Ghats was compiled based on the field surveys conducted by the authors and available literatures (Bates and Harrison 1997; Mudappa 1998; Shanker and Sukumar 1998; Nameer et al. 2001; Wilson and Reeder 2005; Karanth et al. 2008; Meegaskumbura and Schneider 2008; Molur and Singh 2009; Nandini and Mudappa 2010; Nag et al. 2011; Dissanayake and Oshida 2012; Janardhanan et al. 2014; Sharma et al. 2015; IUCN 2017). The nomenclature and taxonomic arrangement of the species were followed as per Wilson and Reeder (2005).

11.2.1 Mammals of Western Ghats

A total of 133 species of mammals were recorded from the Western Ghats belonging to 10 orders and 31 families. Among the reported species, the highest number of species were reported from the order Chiroptera (47 species) followed by Rodentia (32 species). The order Carnivora represents 23 species followed by Artiodactyla (11 species), Eulipotyphla (9 species), Primates (7 species) and 1 species in each of the orders Lagomorpha, Scandentia, Pholidota and Proboscidea (Fig. 11.1).

According to Nameer et al. (2001), there are 135 species of mammals reported from the Western Ghats, of which 8 species, namely, *Semnopithecus entellus*, *Suncus montanus*, *Herpestes brachyurus*, *Funambulus layardi*, *Hipposideros schistaceus* (synonyms of *H. lankadiva*), *Rhinopoma muscatellum*, *Lutra lutra* and *Prionailurus viverrinus*, are not found in the Western Ghats and other species such as *Semnopithecus dussumieri*, *Semnopithecus hypoleucos*, *Semnopithecus priam*,

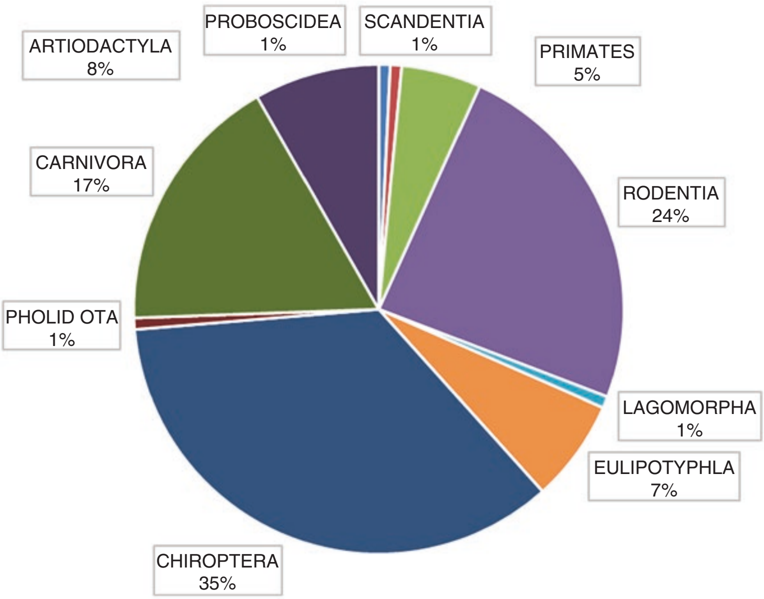

Fig. 11.1 Percentage frequency of different orders of mammals of the Western Ghats

Vandeleuria nilagirica, *Suncus niger* and *Herpestes fuscus* have been included in this list. This paper presents the updated list of 133 species of mammals of the Western Ghats (Table 11.1).

11.2.2 Distribution Among the States of Western Ghats

The mountain range of Western Ghats runs parallel to the western coast covering six Indian states, viz. Tamil Nadu, Kerala, Karnataka, Maharashtra, Goa and Gujarat. Out of 133 mammal species of Western Ghats, 117 species are found in Karnataka, 106 species in Tamil Nadu, 103 species in Kerala, 97 species in Maharashtra, 85 species in Goa and 67 species in Gujarat (Fig. 11.2).

11.2.3 Endemism and Conservation Status

Out of 44 endemic mammals of India, 26 species are known from the Western Ghats (Sharma et al. 2015). Of the 26 endemic species, one species belongs to order Scandentia, five species are Primates, eleven species are Rodentia, three species are Eulipotyphla, two species are Chiroptera, three species are Carnivora and one species is Artiodactyla, of which 3 genera, i.e. *Anathana*, *Latidens* and *Nilgiritragus*, are monotypic and found only in the Western Ghats (Table 11.1).

Table 11.1 List of mammalian fauna found in the Western Ghats and their conservation status

Sl. No.	Name of the species	Western Ghats states						Conservation status		
		TN	KL	KA	MH	GA	GJ	IUCN	IWPA	CITES
Order Proboscidea										
Family Elephantidae										
1.	*Elephas maximus* Linnaeus, 1758 Asiatic elephant	+	+	+	+	+		EN	I	I
Order Scandentia										
Family Tupaiidae										
2.	*Anathana ellioti* (Waterhouse, 1850) Madras tree shrew (E)	+	+	+	+	+		LC		II
Order Primates										
Family Lorisidae										
3.	*Loris lydekkerianus* Cabrera, 1908 Grey slender loris	+	+	+				LC	I	II
Family Cercopithecidae										
4.	*Macaca radiata* (E. Geoffroy, 1812) Bonnet macaque (E)	+	+	+	+	+	+	LC	II	II
5.	*Macaca silenus* (Linnaeus, 1758) Lion-tailed macaque (E)	+	+	+				EN	I	I
6.	*Semnopithecus dussumieri* I. Geoffroy, 1843 Southern plains grey langur (E)		+	+				LC		I
7.	*Semnopithecus hypoleucos* Blyth, 1841 Black-footed grey langur (E)			+				VU		I
8.	*Semnopithecus priam* Blyth, 1844 Tufted grey langur	+	+	+				NT		I
9.	*Trachypithecus johnii* (J. Fischer, 1829) Nilgiri langur (E)	+	+	+				VU	I	II
Order Rodentia										
Family Sciuridae										
10.	*Ratufa indica* (Erxleben,1777) Indian giant squirrel (E)	+	+	+	+	+	+	LC	II	II
11.	*Ratufa macroura* Pennant,1769 Sri Lankan giant squirrel	+	+					NT	I	II
12.	*Petaurista philippensis* (Elliot, 1839) Indian giant flying squirrel	+	+	+	+	+	+	LC	II	

(continued)

Table 11.1 (continued)

Sl. No.	Name of the species	Western Ghats states						Conservation status		
		TN	KL	KA	MH	GA	GJ	IUCN	IWPA	CITES
13.	*Petinomys fuscocapillus* (Jerdon, 1847) Travancore flying squirrel	+	+	+				NT	I	
14.	*Funambulus sublineatus* (Waterhouse, 1838) Dusky striped squirrel	+	+	+				VU		
15.	*Funambulus tristriatus* (Waterhouse, 1837) Jungle palm squirrel (E)	+	+	+	+	+		LC		
16.	*Funambulus palmarum* (Linnaeus, 1766) Common palm squirrel	+	+	+	+	+	+	LC		
17.	*Funambulus pennantii* Wroughton, 1905 Northern palm squirrel			+	+	+	+	LC	IV	
Family Platacanthomyidae										
18.	*Platacanthomys lasiurus* Blyth,1859 Spiny tree mouse (E)	+	+	+				VU		
Family Muridae										
19.	*Tatera indica* (Hardwicke, 1807) Indian gerbil	+	+	+	+	+	+	LC		
20.	*Bandicota bengalensis* (Gray, 1835) Indian mole rat	+	+	+	+	+	+	LC		
21.	*Bandicota indica* (Bechstein, 1800) Greater bandicoot rat	+	+	+	+	+	+	LC		
22.	*Cremnomys cutchicus*Wroughton, 1912 Cutch rock rat (E)			+	+	+	+	LC		
23.	*Golunda ellioti* Gray, 1837 Indian bush rat	+	+	+	+	+	+	LC		
24.	*Madromys blanfordi* (Thomas, 1881) Blanford's rat	+	+	+	+	+	+	LC		
25.	*Millardia kondana* Mishra & Dhanda, 1975 Kondana rat (E)				+			CR		
26.	*Millardia meltada* (Gray, 1837) Common metad	+	+	+	+	+	+	LC		
27.	*Mus booduga* (Gray, 1837) Little Indian field mouse	+	+	+	+	+	+	LC		
28.	*Mus cookii* Ryley, 1914 Cook's mouse	+		+	+			LC		

(continued)

Table 11.1 (continued)

Sl. No.	Name of the species	Western Ghats states						Conservation status		
		TN	KL	KA	MH	GA	GJ	IUCN	IWPA	CITES
29.	*Mus famulus* Bonhote,1898 Bonhote's mouse (E)	+	+					EN		
30.	*Mus musculus* Linnaeus, 1758 House mouse	+	+	+	+	+	+	LC		
31.	*Mus phillipsi* Wroughton, 1912 Phillips's mouse (E)	+		+				LC		
32.	*Mus platythrix* Bennett, 1832 Brown spiny mouse (E)	+	+	+	+	+		LC		
33.	*Mus saxicola* Elliot, 1839 Elliot's spiny mouse	+		+	+	+	+	LC		
34.	*Mus terricolor* Blyth, 1851 Earth-coloured mouse	+	+	+	+	+	+	LC		
35.	*Rattus norvegicus* (Berkenhout, 1769) Norway rat	+	+	+	+	+	+	LC		
36.	*Rattus ranjiniae* Agrawal & Ghosal, 1969 Ranjini's field rat (E)		+					EN		
37.	*Rattus rattus* (Linnaeus, 1758) Common house rat	+	+	+	+	+	+	LC		
38.	*Rattus satarae* Hinton, 1918 Sahyadris forest rat (E)	+	+	+	+			VU		
39.	*Vandeleuria nilagirica* Jerdon, 1867 Nilgiri long-tailed tree mouse (E)	+		+				EN		
40.	*Vandeleuria oleracea* (Bennett, 1832) Asiatic long-tailed tree mouse			+	+	+	+	LC		
Family Hystricidae										
41.	*Hystrix indica* Kerr, 1792 Indian crested porcupine	+	+	+	+	+	+	LC	IV	
Order Lagomorpha										
Family Leporidae										
42.	*Lepus nigricollis* F. Cuvier, 1823 Indian hare	+	+	+	+	+	+	LC	IV	
Order Eulipotyphla										
Family Erinaceidae										
43.	*Paraechinus micropus* (Blyth, 1846) Indian hedgehog				+			LC		
44.	*Paraechinus nudiventris* (Horsfield, 1851) Bare-bellied hedgehog (E)	+	+					LC		

(continued)

Table 11.1 (continued)

Sl. No.	Name of the species	Western Ghats states						Conservation status		
		TN	KL	KA	MH	GA	GJ	IUCN	IWPA	CITES
Family Soricidae										
45.	*Crocidura horsfieldii* (Tomes, 1856) Horsfield's shrew			+				DD		
46.	*Feroculus feroculus* (Kelaart, 1850) Kelaart's long-clawed shrew	+	+					EN		
47.	*Suncus dayi* (Dobson, 1888) Day's shrew (E)	+	+					EN		
48.	*Suncus etruscus* (Savi, 1822) Etruscan shrew	+	+	+	+	+	+	LC		
49.	*Suncus murinus* (Linnaeus, 1766) Asian musk shrew	+	+	+	+	+	+	LC		
50.	*Suncus niger* (Horsfield, 1851) Indian highland shrew (E)	+	+	+						
51.	*Suncus stoliczkanus* (Anderson, 1877) Anderson's shrew			+	+	+		LC		
Order Chiroptera										
Family Pteropodidae										
52.	*Cynopterus brachyotis* (Müller, 1838) Lesser short-nosed fruit bat	+	+	+	+	+	+	LC		
53.	*Cynopterus sphinx* (Vahl, 1797) Greater short-nosed fruit bat	+	+	+	+	+	+	LC		
54.	*Eonycteris spelaea* (Dobson, 1871) Lesser dawn bat	+		+				LC		
55.	*Latidens salimalii* Thonglongya, 1972 Salim Ali's fruit bat (E)	+	+					EN	I	
56.	*Pteropus giganteus* (Brünnich, 1782) Indian flying fox	+	+	+	+	+	+	LC		II
57.	*Rousettus leschenaultii* (Desmarest, 1820) Leschenault's rousette	+	+	+	+	+	+	LC		
Family Rhinolophidae										
58.	*Rhinolophus beddomei* Andersen, 1905 Beddomme's horseshoe bat		+	+	+	+		LC		
59.	*Rhinolophus lepidus* Blyth, 1844 Blyth's horseshoe bat	+	+	+	+	+	+	LC		
60.	*Rhinolophus pusillus* Temminck, 1834 Least horseshoe bat		+	+				LC		

(continued)

Table 11.1 (continued)

Sl. No.	Name of the species	Western Ghats states						Conservation status		
		TN	KL	KA	MH	GA	GJ	IUCN	IWPA	CITES
61.	*Rhinolophus rouxii* Temminck, 1835 Rufous horseshoe bat	+	+	+	+	+		LC		
Family Hipposideridae										
62.	*Hipposideros ater* Templeton, 1848 Dusky leaf-nosed bat	+	+	+	+	+		LC		
63.	*Hipposideros galeritus* Cantor, 1846 Cantor's leaf-nosed bat			+	+	+		LC		
64.	*Hipposideros fulvus* Gray, 1838 Fulvus leaf-nosed bat	+	+	+	+	+	+	LC		
65.	*Hipposideros hypophyllus* Kock & Bhat, 1994 Leafletted leaf-nosed bat (E)			+				EN		
66.	*Hipposideros lankadiva* Kelaart, 1850 Kelaart's leaf-nosed bat			+	+	+		LC		
67.	*Hipposideros pomona* K. Andersen, 1918 Pomona leaf-nosed bat	+	+	+				LC		
68.	*Hipposideros speoris* (Schneider, 1800) Schneider's leaf-nosed bat	+	+	+	+	+	+	LC		
Family Megadermatidae										
69.	*Megaderma lyra* É. Geoffroy, 1810 Greater false vampire bat	+	+	+	+	+	+	LC		
70.	*Megaderma spasma* (Linnaeus, 1758) Lesser false vampire bat	+	+	+	+	+		LC		
Family Rhinopomatidae										
71.	*Rhinopoma hardwickii* Gray, 1831 Lesser mouse-tailed bat	+		+				LC		
72.	*Rhinopoma microphyllum* (Brünnich, 1792) Greater mouse-tailed bat				+		+	LC		
Family Emballonuridae										
73.	*Saccolaimus saccolaimus* (Temminck, 1838) Naked-rumped pouched bat	+	+	+	+	+		LC		
74.	*Taphozous longimanus* Hardwicke, 1825 Long-winged tomb bat	+	+	+	+	+	+	LC		

(continued)

Table 11.1 (continued)

Sl. No.	Name of the species	Western Ghats states						Conservation status		
		TN	KL	KA	MH	GA	GJ	IUCN	IWPA	CITES
75.	*Taphozous melanopogon* Temminck, 1841 Black-bearded tomb bat	+	+	+	+	+	+	LC		
76.	*Taphozous nudiventris* Cretzschmar, 1830 Naked-rumped tomb bat			+	+	+	+	LC		
77.	*Taphozous theobaldi* Dobson, 1872 Theobald's tomb bat	+	+	+	+	+		LC		
Family Molossidae										
78.	*Chaerephon plicatus* (Buchannan, 1800) Wrinkle-lipped free-tailed bat			+	+	+		LC		
79.	*Otomops wroughtoni* (Thomas, 1913) Wroughton's giant mastiff bat			+				DD	I	
80.	*Tadarida aegyptiaca* (E. Geoffroy, 1818) Egyptian free-tailed bat	+	+	+	+	+	+	LC		
Family Vespertilionidae										
81.	*Hesperoptenus tickelli* (Blyth, 1851) Tickell's bat	+	+	+	+	+		LC		
82.	*Falsistrellus affinis* (Dobson, 1871) Chocolate pipistrelle	+	+	+				LC		
83.	*Scotophilus heathii* (Horsfield, 1831) Greater Asiatic yellow house bat	+	+	+	+	+	+	LC		
84.	*Scotophilus kuhlii* Leach, 1821 Lesser Asiatic yellow bat	+	+	+	+	+	+	LC		
85.	*Pipistrellus ceylonicus* (Kelaart, 1852) Kelaart's pipistrelle	+	+	+	+	+	+	LC		
86.	*Pipistrellus coromandra* (Gray, 1838) Indian pipistrelle	+	+	+	+	+	+	LC		
87.	*Pipistrellus javanicus* (Gray, 1838) Javan pipistrelle				+			LC		
88.	*Pipistrellus tenuis* (Temminck, 1840) Least pipistrelle	+	+	+	+	+	+	LC		
89.	*Scotozous dormeri* Dobson, 1875 Dormer's pipistrelle	+	+	+	+		+	LC		
90.	*Tylonycteris pachypus* (Temminck, 1840) Lesser bamboo bat		+	+				LC		

(continued)

Table 11.1 (continued)

Sl. No.	Name of the species	Western Ghats states						Conservation status		
		TN	KL	KA	MH	GA	GJ	IUCN	IWPA	CITES
91.	*Myotis horsfieldii* (Temminck, 1840) Horsfield's bat	+	+	+	+	+		LC		
92.	*Myotis montivagus* (Dobson, 1874) Burmese whiskered bat		+	+				LC		
93.	*Miniopterus schreibersii* (Kuhl, 1817) Schreibers' long-fingered bat				+			NT		
94.	*Miniopterus pusillus* Dobson, 1876 Small long-fingered bat	+	+	+				LC		
95.	*Harpiocephalus harpia* (Temminck, 1840) Lesser hairy-winged bat	+	+					LC		
96.	*Murina cyclotis* Dobson, 1872 Round-eared tube-nosed bat							LC		
97.	*Kerivoula hardwickii* (Horsfield, 1824) Hardwicke's woolly bat			+				LC		
98.	*Kerivoula picta* (Pallas, 1767) Painted woolly bat	+	+	+	+	+		LC		
Order Pholidota										
Family Manidae										
99.	*Manis crassicaudata* E. Geoffroy, 1803 Indian pangolin	+	+	+	+	+	+	EN	I	II
Order Carnivora										
Family Felidae										
100.	*Felis chaus* Schreber, 1777 Jungle cat	+	+	+	+	+	+	LC	II	II
101.	*Prionailurus bengalensis* (Kerr, 1792) Leopard cat	+	+	+	+	+	+	LC	I	I
102.	*Prionailurus rubiginosus* (I. Geoffroy Saint-Hilaire, 1831) Rusty-spotted cat	+	+	+	+	+	+	VU	I	I
103.	*Panthera pardus* (Linnaeus, 1758) Leopard	+	+	+	+	+	+	NT	I	I
104.	*Panthera tigris* (Linnaeus, 1758) Tiger	+	+	+	+	+		EN	I	I
Family Viverridae										
105.	*Paradoxurus hermaphroditus* (Pallas, 1777) Asian palm civet	+	+	+	+	+	+	LC	II	III
106.	*Paradoxurus jerdoni* Blanford, 1885 Jerdon's palm civet (E)	+	+	+	+	+		LC	II	III

(continued)

Table 11.1 (continued)

Sl. No.	Name of the species	Western Ghats states						Conservation status		
		TN	KL	KA	MH	GA	GJ	IUCN	IWPA	CITES
107.	*Viverra civettina* Blyth, 1862 Malabar large-spotted civet (E)		+	+				CR	I	III
108.	*Viverricula indica* (E. Geoffroy Saint-Hilaire, 1803) Small Indian civet	+	+	+	+	+	+	LC	II	III
Family Herpestidae										
109.	*Herpestes edwardsii* (É. Geoffroy Saint-Hilaire, 1818) Grey mongoose	+	+	+	+	+	+	LC	II	III
110.	*Herpestes fuscus* Waterhouse, 1838 Indian brown mongoose	+	+	+				VU	II	III
111.	*Herpestes smithii* Gray, 1837 Ruddy mongoose	+	+	+	+	+	+	LC	II	III
112.	*Herpestes vitticollis* Bennett, 1835 Stripe-necked mongoose	+	+	+	+	+		LC	II	III
Family Hyaenidae										
113.	*Hyaena hyaena* (Linnaeus, 1758) Striped hyena		+	+	+	+	+	NT	III	III
Family Canidae										
114.	*Canis aureus* Linnaeus, 1758 Golden jackal	+	+	+	+	+	+	LC	II	III
115.	*Canis lupus* Linnaeus, 1758 Grey wolf	+		+	+					I
116.	*Cuon alpinus* (Pallas, 1811) Dhole	+	+	+	+	+	+	EN	II	II
117.	*Vulpes bengalensis* (Shaw, 1800) Bengal fox	+	+	+	+	+	+	LC	II	III
Family Ursidae										
118.	*Melursus ursinus* (Shaw, 1791) Sloth bear	+	+	+	+	+	+	VU	I	I
Family Mustelidae										
119.	*Aonyx cinerea* (Illiger, 1815) Oriental small-clawed otter	+	+	+	+			VU	I	II
120.	*Lutrogale perspicillata* (I. Geoffroy Saint-Hilaire, 1826) Smooth-coated otter	+	+	+	+	+	+	VU	II	II
121.	*Martes gwatkinsii* Horsfield, 1851 Nilgiri marten (E)	+	+	+				VU	II	III
122.	*Mellivora capensis* (Schreber, 1776) Honey badger	+	+	+	+	+	+	LC	I	

(continued)

Table 11.1 (continued)

Sl. No.	Name of the species	Western Ghats states						Conservation status		
		TN	KL	KA	MH	GA	GJ	IUCN	IWPA	CITES
Order Artiodactyla										
Family Suidae										
123.	*Sus scrofa* Linnaeus, 1758 Wild pig	+	+	+	+	+	+	LC	III	
Family Tragulidae										
124.	*Moschiola indica* Gray, 1852 Indian chevrotain	+	+	+	+	+		LC	I	
Family CERVIDAE										
125.	*Axis axis* (Erxleben, 1777) Spotted deer	+	+	+	+	+	+	LC	III	
126.	*Muntiacus muntjak* (Zimmermann, 1780) Indian muntjac	+	+	+	+	+	+	LC	III	
127.	*Rusa unicolor* (Kerr, 1792) Sambar	+	+	+	+	+	+	VU	III	
Family Bovidae										
128.	*Antilope cervicapra* (Linnaeus, 1758) Blackbuck	+	+	+	+	+	+	NT	I	
129.	*Gazella bennettii* (Sykes, 1831) Indian gazelle				+		+	LC	I	
130.	*Bos gaurus* C. H. Smith, 1827 Gaur	+	+	+	+			VU	I	I
131.	*Boselaphus tragocamelus* (Pallas, 1766) Nilgai			+	+		+	LC	III	
132.	*Tetracerus quadricornis* (de Blainville, 1816) Four-horned antelope	+	+	+	+	+	+	VU	I	
133.	*Nilgiritragus hylocrius* (Ogilby, 1838) Nilgiri tahr (E)	+	+					EN	I	
	Total	117	106	103	97	85	67			

TN Tamil Nadu, *KL* Kerala, *KA* Karnataka, *MH* Maharashtra, *GA* Goa, *GJ* Gujarat *CR* Critically Endangered, *EN* Endangered, *VU* Vulnerable, *NT* Near Threatened, *LC* Least Concern, *DD* Data Deficient, *IWPA* Indian Wildlife (Protection) Act, 1972 (Schedules I, II, III, IV and V) *CITES*, Convention on International Trade in Endangered Species of Wild Fauna and Flora (Appendixes I, II and III), *E* Endemic

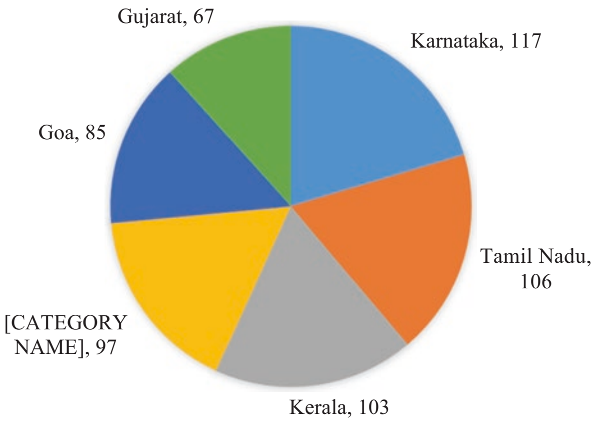

Fig. 11.2 Total number of mammals species distributed in the various states of Western Ghats

Species like Nilgiri tahr, lion-tailed macaque and Malabar civet have declined in number and have been added to the IUCN Vulnerable and Endangered categories. As per the IUCN, except *Suncus niger*, the remaining 132 species have been classified under Critically Endangered to Data Deficient, viz. 2 species as Critically Endangered, 14 species as Endangered, 12 species as Vulnerable, 7 species as Near Threatened, 94 species as Least Concern and 2 species are Data Deficient (Fig. 11.3). The Indian Wildlife (Protection) Act (IWPA) listed 48 species of mammals under Schedules I to IV, and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) listed 12 species in each of Appendixes I, II and III (Figs. 11.4 and 11.5).

11.2.4 Threats

The uniqueness and the high rate of endemicity of the mammalian fauna of the Western Ghats are gradually decreasing, and it becomes very important to highlight the possible threats that the fauna in general and mammals in particular of the Western Ghats are facing. The major threats that pose a challenge for their survival are habitat loss due to fragmentation of forests and degradation thereof. When we look into the history of Western Ghats we find that the dense forests were once inaccessible. During the British rule in the nineteenth century, large stretches of forests were cleared for agriculture and timber produce which caused a major ecological imbalance. Further overexploitation and degradation of forests resulted due to the rapid expanding human populations and the pressures created as a result. Habitat loss and fragmentation of forests can be attributed as two major threats resulting in loss of mammalian diversity in the Western Ghats. Fragmentation of forests restricts the free movement of the animals from one part of the forest to the other resulting in isolation of populations, thereby decreasing their population numbers and restricting their distribution which has a drastic effect on the diversity of mammals.

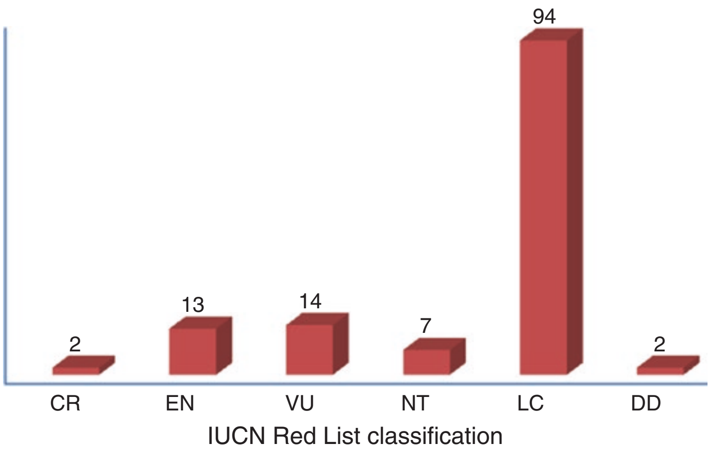

Fig. 11.3 Total number of mammal species of Western Ghats under different categories of the IUCN Red List of Threatened Species (n = 133)

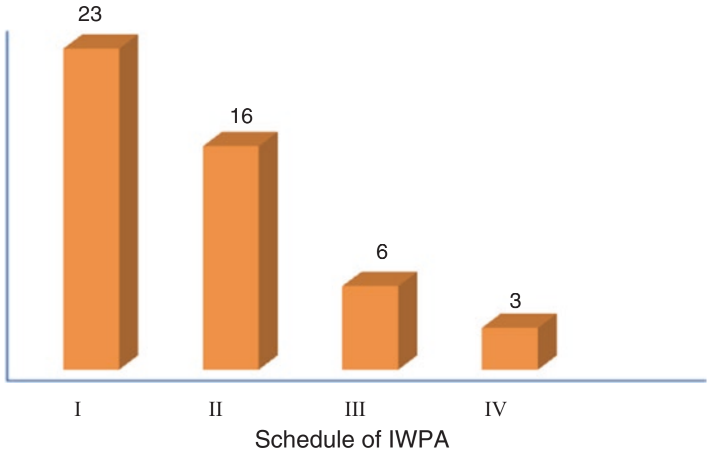

Fig. 11.4 Total number of mammal species of Western Ghats listed under Schedules I–V of the Indian Wildlife (Protection) Act, 1972 (n = 48)

Killing of animals due to various reasons is another threat to the population of mammals here. There is killing of animals resulting from man-animal conflict especially in case of tigers, leopards and elephants, whereas many mammals mainly giant fruit bats and Nilgiri langurs are extensively killed for use as medicines. It is reported that mammals like giant fruit bat, Nilgiri langur, giant squirrel and jungle cat are killed for food, and some like rodents, shrews and wild boars are killed as pests. Wildlife trade can be attributed as a major threat as animals both dead and alive are used for this purpose. Poaching of mammals like civets, cats, elephant,

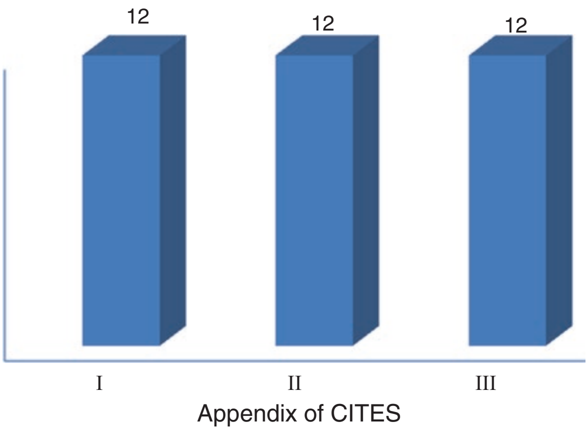

Fig. 11.5 Total number of mammal species of Western Ghats listed under Appendixes I–III of CITES ($n = 36$)

lion-tailed macaque, mongoose, shrews, sloth bear and porcupines regularly takes place as these are used extensively in the trade.

The mammalian diversity of the Western Ghats is also under threat due to the invasive alien species which are dominating over the natives, and also the introduction of exotic species is posing a threat to the natives. Different communities of human populations reside within or surrounding the protected areas and pose a threat to the mammals of the Western Ghats. For their livelihood they extract non-timber forest products (NTFPs), fuelwood and fodder for the domesticated livestock and practice livestock grazing, humus collection and monoculture. Man-made fires, slash-and-burn methods and illegal felling of trees are also some of the threats which cannot be ignored.

Changes in the microhabitat, habitat quality, vegetation types, rainfall pattern, etc. arising due to climate change also pose a threat to the mammalian diversity of the Western Ghats which need to be monitored on a regular long-term basis. Developmental activities like construction of dams, wind farms, roads and railway tracks attribute as a threat which cannot be undermined. Pollution, siltation and sedimentation of the aquatic bodies also have an indirect effect on the mammalian population. Besides these, forest fire and natural calamities like floods, erosion and landslides are also factors of threat to the unique mammalian diversity of the Western Ghats.

11.2.5 Conservation

Conservation measures have been adequately taken in the Western Ghats, and about 10% of the total area has been brought under Protected Areas category. The Western Ghats and Andaman and Nicobar islands are the two biogeographic zones in the country that have the highest level of area under conservation. To name a few the Bandipur National Park in Karnataka is the largest protected area in the Western Ghats. The Silent Valley National Park in Kerala and the Kudremukh National Park in Karnataka are very important areas as they have virgin tropical evergreen forest and are also home of a globally threatened primate species, the lion-tailed macaque, which is endemic to the Western Ghats. There are currently five tiger reserves in the Western Ghats, and the single largest population of tigers is present in the Nilgiri Biosphere Reserve of the Nagarhole-Bandipur-Mudumalai-Wayanad complex.

But the Western Ghats is facing a lot of challenges as threats have increased manifold in the recent years. Efforts are on by the conservation managers and different stakeholders to save the unique fauna of this region. Efforts are on to reduce the man-elephant conflict through amicable mitigations with the locals and finding practical conservation measures and solutions to this problem. The impact of modernisation in terms of strengthening the network of roads have resulted in building roads which pass through major protected areas of Western Ghats, and it results in road kills of a number of mammalian species every year. Lion-tailed macaque, slow loris, leopard cats and many small mammals like rodents and shrews get killed every year. Limiting the speed of the vehicles, installing speed breakers at strategic locations and caution signboards and hoardings, and retaining the native vegetation and the tree canopy on the roadside are some of the conservation measures that are to be strictly adopted and imposed.

Plantation of different varieties of plants and trees that form the rainforest is another step that needs to be taken to conserve the unique mammalian fauna. Awareness and sensitization programmes for conservation managers, forest guards and officials, local people who reside in and around the protected areas, students and locals need to be implemented on a regular basis by all stakeholders to educate the different sections of the people to stop the killing of animals and also to make the masses aware of their importance in maintaining the ecological balance. Ecotourism should also be encouraged more. Smaller mammals like rodents, shrews, bats and smaller carnivores play a very important role in maintaining the ecological balance; hence studies based on their ecology and habitat and efforts for their conservation should be given focus in addition to bigger flagship species like tigers and elephants. Use of molecular tools should be also implemented and extensively used wherever applicable especially for species where direct sighting is not possible because of rough terrain and for illusive and shy species. The distributional patterns, habit and habitat of the different mammals especially the endemic ones and the range distribution and conservation status of the smaller carnivores, rodents and shrews need to be more strongly and systematically studied to identify the gap areas as these issues pose a major challenge to conservation efforts in the Western Ghats.

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12 Population Status, Group Size, Distribution and Human Disturbances on the Nilgiri Langur (*Trachypithecus johnii*) in the Upper Nilgiris, Western Ghats, Southern India

B. Ramakrishnan and A. Samson

Abstract

In this chapter, we presented the population status and distribution of the Nilgiri Langur *Trachypithecus johnii* from Nilgiris of Western Ghats. The studies were carried out in the Nilgiri North Forest Division from December 2011 to March 2012.

Keywords

Distribution · Nilgiri Langur · Population · Western Ghats

12.1 Introduction

The Nilgiri Langur *Trachypithecus johnii* Fisher (1829) occurs only in the Western Ghats in South Western India (Karnataka, Kerala, and Tamil Nadu). It is found, rather unevenly, in the hill country of the Western Ghats from the Aramboli Pass (8°16′N near the southern tip of India) north to Srimangala (12°01′N, 75°58′E) (Groves 2001). In Tamil Nadu the distribution is in the Nilgiris, Anamalai, Tirunelveli Hills, and Palani Hills (Prater 2005). They are capable of living in higher altitudes from 1915 to 2200 m of above mean sea level (MSL) and also seen in low elevation in riverine habitats of the Mundanthurai Plateau at an elevation of 180 m above MSL in Kalakkad Mundanthurai Tiger Reserve in Tamil Nadu (Sunderraj and Johnsingh 1998). They are listed under the order of primates and belonging to the Family Cercopithecidae and subfamily Colobinae. The Nilgiri Langur is in the category of vulnerable species both at the national (ZSI 1994) and global levels (IUCN 2000). The status of the species was reassessed in 2004, and they are continued to

B. Ramakrishnan (✉) · A. Samson
Mammalogy and Forest Ecology Lab, Department of Zoology and Wildlife Biology, Government Arts College, Udhagamandalam, The Nilgiris, Tamil Nadu, India

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be listed under the vulnerable category (IUCN 2006 and 2010) and endangered at national level. The Nilgiri Langur is a glossy black or blackish brown head (Prater 2005). This species is sexual dimorphic in the canine teeth where adult males have larger Canines than adult females (Poirier 1969), the average body mass of an adult male Nilgiri Langur around 14.80 kg, and female is around 11 kg (Harvey et al. 1987). Newborns have an average body mass of 0.5 kg (Sankala and Desai 1969). Nilgiri Langurs are mainly found in shoals, which are narrow tracts of forest with streams running through it (Parthasarathy 1995; Poirier 1968b; Oates 1979). The diet includes flowers buds, seeds, bark, stem, insects and soil (Roonwal and Mohnot 1977; Poirier 1968a, 1969; Oates et al. 1980). This species prefers to eat immature leaves over more mature ones (Oates et al. 1980). The home range of the group depends on the size of the group with larger groups having larger home ranges (Parthasarathy 1995; Poirier 1968c, 1969). The earlier studies were made mainly in protected areas. Although previous studies were attempted in the reserve forest areas, still there are some good reserve forests areas have Nilgiri Langur population have not been attempted. The Nilgiri North Forest Division is one of such reserve forest divisions where a study on Nilgiri Langur was not been attempted so far. Considering the lacunae the present study was carried out in the Nilgiri North Forest Division.

12.2 Methods

12.2.1 Population and Distribution Pattern

A population survey was carried out in the Nilgiri North Forest Division between December 2011 and March 2012. Questionnaire was conducted to the forest field staff, forest range officers, and residents of peripheral and inside villages for information on the occurrence of Nilgiri Langur. Total count was used to cover all areas in the forest division (NRC 1981). Repeat surveys were conducted on foot, recording group size and demography. All Langur sighting location coordinates were recorded using Global Positioning System (GPS); subsequently Langurs were classified into three age categories, viz., male, female, and infant, based on their morphological differences described by Sunderraj (2001).

12.2.2 Impact of Human Distribution on Nilgiri Langur

The impact of human beings on Nilgiri Langur was estimated depending on various distances between human habitation locations and occurrence of Langur groups. Correlation between these two variables was statically analyzed using the following method:

$$\text{Correlation r} = \frac{\text{€dxdy}}{\text{v€dx2x€dy2}}$$

r=correlation
dx=Presence of human habitation in different distances
dy=Occurrence of Black leaf monkey

12.2.3 Secondary Data Collection

Apart from field data collection, secondary data has been collected through questionnaire method to obtain more information. The questionnaire had two sets of information, i.e., data on occurrence of Nilgiri Langur by “precise and closed” method. Detailed information were collected through “broad and open-ended” questions giving the respondent an opportunity to express their views without any inhibition (Ramakrishnan and Saravanamuthu 2012). The interview was carried out within a 5.0 km radius from the forest area.

12.3 Results

12.3.1 Population and Distribution Pattern

The surveys covered 178 km in nine different locations (Table 12.1). Most of the groups sighted were at altitudes ranging between 1700 and 2738 m of above MSL. A total of 16 groups were recorded, and all of them were found at higher elevation of Nilgiri Hills. The maximum number of groups ($n = 4$) and individuals ($n = 61$) was

Table 12.1 Numbers and average size of the group and population density of Nilgiri Langur

Sl. No.	Name of the beat	Total hours spent	Total km walked	Total number of troops sighted	Total number of individuals sighted	Relative abundance (groups/10 km)	Average group of size
1.	Thalakundah	12	24	3	39	0.12	13
2.	Sholur	10	20	4	61	0.2	15.25
3.	Glenmorgan	15	30	3	29	0.1	9.67
4.	Doddabetta	8	16	1	17	0.06	17.0
5.	Aramby	12	24	1	11	0.04	11.0
6.	Ralliya	8	16	1	13	0.06	13.0
7.	Kukkalthorai	10	20	1	5	0.05	5.0
8.	Beragani	8	16	1	10	0.1	10.0
9.	Hulikkal west	6	12	1	7	0.08	7.0

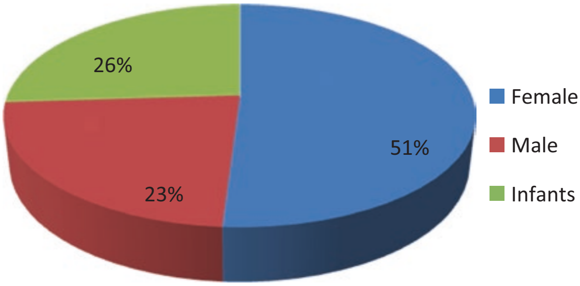

Fig. 12.1 Demographical structure of Nilgiri Langur recorded in Nilgiri North Division

sighted at Sholur beat. Group size ranged from 5 to 23, with an average of 11.2 individuals per group (Table 12.1). Relative abundance of groups at every 10 km was high (*n* = 0.2) in Sholur beat followed by Glenmorgan (*n* = 0.1) and Beragani (0.1). Out of seven administrative ranges of the Nilgiri North Forest Division, Nilgiri langur was recorded from just three ranges, of which Udhagai North Range alone contributed 157 individuals belonging to 5 beats followed by Kattabettu range (28 individuals from 3 beats) and Coonoor range (7 individuals from just 1 group). Among the beats Sholur beat attributed highest number of Nilgiri langurs (*n* = 61) followed by Thalakundah (*n* = 39) and Glenmorgan (*n* = 29). On the contrary, Kukkalthorai beat represented lowest individuals (*n* = 5) and Hulikkal beat (*n* = 7).

12.3.2 Group Composition

The group structure and composition of Nilgiri Langurs are shown in Fig. 12.1. Nearly 90% of the population was recorded in one adult male with multifemale social system except one group that has been sighted at Sholur beat. The adult male and female sex ratio for identified individuals was 1:2.4. Similarly adult female and infant sex ratio was 1:0.4. A group size of four to ten individuals was most commonly sighted (Table 12.2).

12.3.3 Presence of Nilgiri Langur in Relation to Human Occupation

Nilgiri Langur groups were recorded at various distances from human habitations. Out of 16 groups, 6 groups were sighted 1000 m distance from human habitations, viz., Thalakundah, Doddabetta, Aramby, and Beragani beats. Four groups were sighted at 3000 m from human habitation. Similarly three groups were sighted in 5000 m, and two groups were sighted in 2000 m distance from human habitations (Table 12.3). The correlation between the occurrences of Nilgiri Langur groups versus presence of human habitations is found significant. Most of the Nilgiri Langur individuals were recorded between 1000 m and 1999 m distance from human habitations followed by 3000–3999 m and 5000–5999 m (Fig. 12.2). The result clearly

Table 12.2 Status of Nilgiri Langur distributed with respect to administrative units

Sl. No.	Name of the range	Name of the beat	Total number of troops sighted	Total number of individuals sighted	Demography		
1.	Udhagai North Range	Thalakundah	3	39	12	19	8
2.	Udhagai North Range	Sholur	4	61	17	31	13
3.	Udhagai North Range	Glenmorgan	3	29	6	15	8
4.	Udhagai North Range	Doddabetta	1	17	4	9	4
5.	Udhagai North Range	Aramby	1	11	2	5	4
6.	Kattabettu range	Ralliya	1	13	3	7	3
7.	Kattabettu range	Kukkalthorai	1	5	1	3	1
8.	Kattabettu range	Beragani	1	5	1	3	1
9.	Coonoor range	Hulikkal west	1	7	2	4	1

Table 12.3 Occurrence of Nilgiri Langur with respect to human habitations

Sl. No.	Name of the beat	Average distance to human habitation in meters	Total number of troops sighted	Total number of individuals recorded	Demography		
1.	Thalakundah	1000	3	39	12	19	8
2.	Sholur	3000	4	61	17	31	13
3.	Glenmorgan	5000	3	29	6	15	8
4.	Doddabetta	1000	1	17	4	9	4
5.	Aramby	1000	1	11	2	5	4
6.	Ralliya	2000	1	13	3	7	3
7.	Kukkalthorai	2000	1	5	1	3	1
8.	Beragani	1000	1	10	3	5	2
9.	Hulikkal west	4000	1	17	2	4	1

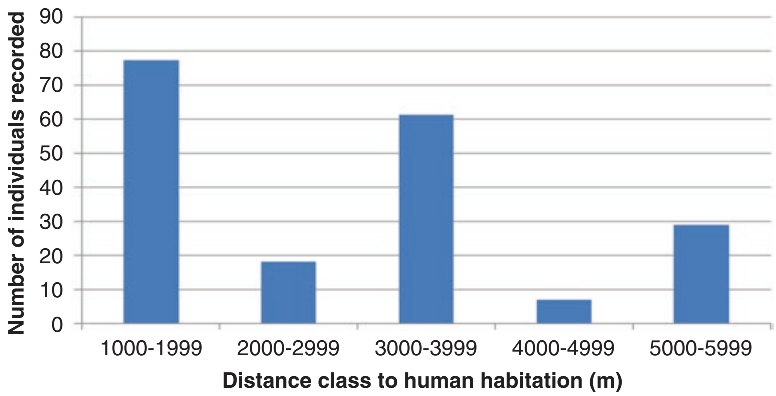

Fig. 12.2 Occurrence of Nilgiri Langur individuals with special reference to human habitation

Fig. 12.3 Occurrence of Nilgiri Langur Troops with special reference to human habitation

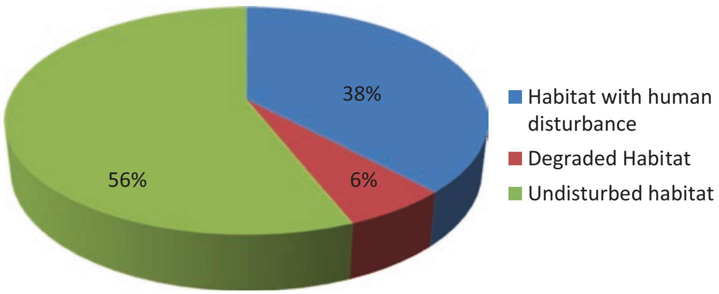

Fig. 12.4 Composition of Nilgiri Langur different habitat types

showed that occurrence of Nilgiri Langur species also did not have significant influence on the presence of human beings. Similar trend was noticed among troops also in 1000–1999 m (six troops) and 3000–3999 m (four troops) except lowest number of troops. Only one troop was recorded between 4000 and 4999 m of human habitation. Three troops were recorded between 5000 and 5999 meters of human habitation (Fig. 12.3).

12.3.4 Habitat Utilization

Undisturbed shola habitats were efficiently used (56%) by Nilgiri Langurs followed by habitats with human disturbance (38%) and degraded habitat (6%). Here the degraded forests are mainly caused by the invasion of exotic tree plantations such as eucalyptus, wattle, and pine etc. (Fig. 12.4).

12.4 Discussion

Several studies have concluded on the problem of loss of undisturbed forests and its threats to the survival of rain forest primates (Marsh et al. 1987; Kumar 1987; Hohmann and Sunderraj 1990; Sunderraj and Singh 2001). Forest areas in India are under various forms of increasing biotic threats. The major pressure is due to fuel wood collection and non-timber forest product (NTFP) collection. These activities gradually alter forest cover and its composition and could have a deleterious effect on arboreal mammals. Sunderraj and Singh (2001) found that fire wood cutting resulted loss of understory vegetation of Nilgiri Langur in Mundanthurai Plateau. These disturbances have serious impact on habitat and will eventually affect the Nilgiri Langurs habitat utilization. This present study also found that disturbances (38%). Habitat alternation is another serious threat that would affect arboreal mammals. The present study also found that the Nilgiri Langurs used just (6%) in the habitat altered with eucalyptus, wattle, pine, etc. Habitat loss and modifications can lead to loss of preferred habitats, smaller population sizes, a higher exposure to poaching, and considerable loss to stochastic events like floods and disease outbreak. Also, with an increase in fragmentation, there is a definite risk of isolating populations that will ultimately face problems of in breeding. Most of the Langur groups were recorded between 400 m and 1500 m above mean sea level. The Nilgiri Langurs are capable of living in higher altitudes from 915 m to 2200 m above MSL (Prater 2005). Sunderraj and Johnsingh (1998) have recorded the presence of Nilgiri Langurs at very low altitude (180 m) in Thamirabarani riverine habitats of the Mundanthurai Plateau. This present study discovered the occurrence of Nilgiri Langurs in Doddabetta which is the highest point (2623 MSL) of the Nilgiri and also highest point of the Nilgiri Langur presence ever recorded.

However, there was difference in the ranging of group sizes between 4–12 recorded by webb people (1972), oneto14 individuals by Ramachandran and Joseph (2001), this present study recorded one to 23 individuals as minimum and maximum per group, with an average of 12.00 individuals per group. Hohmann and Sunderraj (1990) recorded 4.36 in KMTR, 7.24 in Srivilliputhur, 5.40 in Ulanidhi area of Anamalais, 8.00 in Avalanche, and 10.00 in Mundanthurai Plateau. When compared to earlier studies, the present study attributed highest average number of individuals (12.00) per group than all Nilgiri Langur distributional ranges. This is mainly because the vast continuity of shola forest cover is intact in the Nilgiri North Forest Division. Among the ranges, Udhagai North Range alone attributed 157 individuals in 5 beats; on the other hand, Kukkalthorai and Hulikkal beats contributed 5 and 7 individuals, respectively. The Udhagai North range area extending in higher altitudes of the Nilgiris. Other ranges are falling partly in higher altitude with the absence of shola forests and riverine forests.

Nilgiri Langur groups were sighted at various distances from human habitations. The distribution of Nilgiri Langur was negatively dependent on human habitations.

The result showed that the most important factor determining the present distribution on Nilgiri Langur is the presence of human influences which has a negative impact. In determining the distribution of the Nilgiri Langur, nearly 90% of the population was recorded one adult male with multi females. The sex ratio determined during this study period revealed female-based sex ratio, with 1:2,4, between adult male and female. Sunderraj (2001) found 1:2,5 sex ratio between adult male and adult female in Mundanthurai Plateau. A similar proportion was reported by Ramachandran and Joseph (2001), with 1:2 from the silent valley national park. This is rather a highly skewed sex ratio when compared with Poirier's (1970) study (100 females, 83 males).

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13 The Conservation of the Nilgiri tahr (*Nilgiritragus hylocrius*), an Endangered Mountain Goat Endemic to Western Ghats

P. S. Easa and Mohan Alembath

Abstract

The Nilgiri tahr, *Nilgiritragus hylocrius*, is an endangered mountain goat endemic to Western Ghats. It is a social animal with strong preference for high altitude grassland shola habitat. Literature on the status, distribution, ecology and behaviour were referred. Personal discussions were held with researchers and officials of tahr areas and field visits were made to most of the tahr habitats. A workshop was organized with active involvement of all the concerned for information on distribution and conservation status of tahr and identifying priority areas for conservation. The tahr population exists in several metapopulations. These data were compiled in geographic information system databases (Arcview–GIS) and distribution mapped. Based on the geographical continuity, three landcsapes are identified and Tahr Conservation Units demarcated. Conservation challenges are identified, discussed and suggestions made for conservation of Nilgiri tahr.

Keywords

Nilgiri tahr · Nilgiritragus hylocrius · Western Ghats · Endemic · Conservation · Endangered · Caprini · Sholagrassland

P. S. Easa (✉)
Care Earth Trust, No. 3, Sixth Street, Thillaiganga Nagar, Chennai 600061, India

M. Alembath
Asia Biodiversity Conservation Trust, 14/453 Alembath, MLA Road, Nadakavu P.O., Cochin 682307, Kerala, India

C. Sivaperuman, K. Venkataraman (eds.), *Indian Hotspots*,
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13.1 Introduction

The Nilgiri tahr belonging to the tribe Caprini is confined to the Western Ghats. It was Gray who described it first from a drawing and notes of General Hardwicke. He gave the specific name *Tamul*, the word for rock or precipice goat. The sportsmen in Madras called it Ibex (Jerdon 1874). Rice (1984) has given a detailed description on the taxonomic history of tahr. The Nilgiri tahr was first named *Kemas hylocrius* by Ogilby (1838). Later in 1842, Gray named it *Capra warryato*, which was then changed to *Kemas warryato* in 1852 (Lydekker 1898). In 1859, Blyth included it in the genus *Hemitragus* and named it *Hemitragus hylocrius.* However, Ropiquet and Hassanin (2005), based on molecular phylogenetic analysis, proposed the name *Nilgiritragus hylocrius*.

Nilgiri tahr is a social animal and usually found in herds of two or more. According to Scahller (1970), the average herd size is around 23 and may vary between 6 and more than 100 depending on the season and habitat. Varying group sizes have been reported from different locations (Sterndale 1884; Kinloch 1926; Fischer 1915). Two basic types of social groups, mixed and all male groups, are observed (Rice 1984). The mixed groups have all the sex and age classes. But they are predominantly of adult females and their subadult offspring. Adult males join the group during rut and leave them at other times of the year. The unstable male groups are of adult males. Mixed groups were most frequently encountered (Madhusudan 1995) and had 2 to 150 animals with an average size of 42. Male groups ranged from 2 to 20 with an average size of 3 (Rice 1988a). The normally observed sex ratio was favouring females than males in the population (Davidar 1978). Observations of Rice (1984) indicated 60 males for every 100 females.

Differential use of space and habitat types was reported by Rice (1984) and Madhusudan (1995). While the females were seen on the rocky terrain of higher slope angles closer to cliffs, the males were restricted to higher elevation areas. Large males spent more time in resting and females had been always on the move. The shrubby country below the steep cliffs and sholas was normally avoided by mixed groups, and they never penetrated the thick tall growths of *Eupatorium and Chrysopogon.* However, the shola fringes were made use of by the mixed groups occasionally browsed in smaller sholas. Rice (1984) had no sighting of tahr in the central portion of the plateau in Eravikulam National Park, though these areas were utilized for movement between areas. In Nilgiris, Murugan (1997) observed variations in the areas utilized by different tahr groups. Tahrs are grazers in Eravikulam National Park (Rice 1984). However, Davidar (1978) observed them to be browsers in lower drier areas (Davidar 1978).

The rutting is during monsoon and the birth occurs mostly from January to mid-February. However, calving has also been reported throughout the year (Stockley 1928; Willet 1968). The calving season varies in different areas (Kinloch 1926; Prater 1965; Lydekker 1898; Schaller 1970; Davidar 1978; Rice 1984). Infant mortality is considerably higher during the first 2 weeks after birth and among those born during monsoon (Rice 1988b). The tahr females presumably give birth twice in a year. However, the mortality rate of the second one is high (Rice 1988b). The observed annual variation in the production can have short-term impact on the population level. Higher mortality rates have been observed among males compared to females (Rice 1988b). According to Schaller (1970), as many as 1/6 of the adults die each year. Annual mortality in Eravikulam was estimated to be 44–52% for young, 31–37% for yearlings and 17–24% for adults. Most of the mortality at Eravikulam is attributed to predation, disease, accidents and injury during intraspecific combat (Rice 1988b). A detailed study in Eravikulam by Easa (1995) doesn't agree with the observation of Rice (1986) that predation by leopard is an important mortality factor. Rice (1988b) reported ova of strongyle nematodes were 75% and evidences of coccidiosis were 49% of the faecal samples examined. Ova from tapeworms were seen in 25% and from whipworm nematodes in 17%.

13.2 Abundance and Distribution

The information on historic distribution is mostly from the reports of hunting in different areas. Most of the reports on the past distribution of Nilgiri tahr are from Davidar (1963, 1971, 1972, 1975, 1976, 1978). According to Davidar (1978), the tahr once ranged through most of the Western Ghats. The entire southern half of Peninsula extending up to most of Karnataka was considered as tahr range in historic times. Tahr presence was confirmed in the Agumbe Ghat in Karnataka as late as 1954, as confirmed by Mr. G. J. Rajasingh, Conservator of Forests (Davidar 1978). Davidar noted that the tahr was found in a few isolated localities along the crest of the ranges between 11°30′ and 8°20′N at elevations ranging from 1300 m to 2600 m. There are a few locations at lower elevations also.

A number of authors have contributed to the information on the status and distribution of tahr in the range (Russell 1900; Phythian-Adams 1927, 1939, 1950; Schaller 1970; Davidar 1978). Davidar (1976, 1978) reported the status and assessed the conservation threats in different areas. The most recent estimates of Nilgiri tahr include those in Eravikulam National Park Kerala Forest Department (KFD 1989), Tamil Nadu Forest Department in Anamalai Tiger Reserve, Arumugam (unpublished 2004) in Mukurthi National Park, Bala (2001) in Palani Hills, Abraham et al. (2006) in Kerala parts, Daniels et al. (2006) for entire range, Sharon (2010) in the Agasthyamala part in Kerala and Predit (2009) for most of the areas. The literature and the information from researchers and officials indicated lacunae in information on the distribution and status of Nilgiri tahr and also the conservation challenges. The present paper is based on Easa et al. (2010).

13.3 The Process

The literature on the status, distribution, ecology and behaviour were referred for information. In addition, personal discussions were held with the researchers and officials of tahr areas, and field visits were made to most of the tahr habitats. A workshop was organized with active involvement of forest officials, researchers and

Table 13.1 The number of tahr locations and population estimates from the workshop

Division	Number of locations	Number (approx.)
Kanyakumari	9	290–385
KMTR	11	435–445
Thiruvananthapuram (Wildlife)	2	50–65
Thiruvananthapuram	1	20–25
Thirunelveli	18	405–505
Srivilliputhur GS Sanctuary	16	317–347
Theni	8	320–360
Ranni	1	40–50
Anamalai Tiger Reserve	41	368
Eravikulam National Park	1	747
Palnis	4	40–60
Munnar	6	60–80
Nilgiris	16	350–400
Silent valley	3	40–50
Parambikulam–Nelliampathis	7	90–120
Mannarkad, Walayar and Olavakod	12	100–120
Chalakudy, Vazhachal, Malayatur	5	60–105
Total	161	2617–4232

NGO representatives with the objective of assessing the state of knowledge about the distribution and conservation status of tahr and identifying priority areas for conservation. During the workshop, the participants referred to an area map and the available information based on the published literature. Each participant was assumed to be able to identify tahr locations on the map with minimum error. The workshop participants provided the geographic extent of tahr distribution, whether or not tahrs are present in an area ("extent of knowledge"); the area where tahrs are currently present ("known, currently occupied range"); important areas for tahr conservation ("Tahr Conservation Units"); and locations where tahr have been observed during the current period and the basis of population figures. The information obtained from the workshop is summarized in Table 13.1.

The data were further examined systematically in regional groups to resolve discrepencies and arrive at a consensus information base. These were later verified with field visits and corrections made based on the discussions with officials who had in turn collected more detailed information after the workshop. These data were compiled in geographic information system databases (Arcview–GIS). Subjective assessments were necessary because of lack of detailed information for many areas. This subjectivity was however based on the information by the workshop participants and from personal experience. The habitat suitability model suggested by Easa and Sivaram (2002) was considered for delineating suitable habitat. All habitat types used by the tahr were assumed to be necessary for their population viability. However, the habitats between two cliffs were considered as essential for movement between populations. Since the tahr locations clearly indicated high variation in altitude, it was not taken as a criterion for delineating habitat.

Tahr Conservation Units (TCUs) are defined as areas with current population of at least about 100 individuals and habitats large enough to support a viable population giving enough scope for movement between habitat patches. The information from Rice (1984) and Murugan (1997) were considered while delineating Conservation Units. In the absence of information on the minimum viable population size and critical minimum area requirement, the attempt was to ensure as large areas as possible for long-term conservation. Weightage was given to the extent, linkages, habitat quality, poaching pressure and population status. All the identified TCUs represent areas with substantial populations and adequate habitat. But not all TCUs occur in high probability areas for the long-term survival of tahr.

13.4 Results

The tahr population is considered to exist in three landscapes (Easa et al. 2010) as given in Figs. 13.1, 13.2 and 13.3. *The Nilgri landscape*, with an estimated population of about 470 animals, is the northern part of its range and includes the Nilgiris with Silent Valley National Park, Siruvani area and New Amarambalam Reserved Forest (Fig. 13.1). Twenty eight tahr locations are reported in the landscape. The details are given in Table 13.2. These locations are spread over 107 km^2. Of the ten locations in Mukurthi National Park, seven are shared with New Amarambalam of Nilambur South Forest Division and Anginda of Silent Valley National Park. Some of the 14 locations in Kerala are shared with Tamil Nadu. Six locations in Tamil Nadu are in Coimbatore and Nilgiri South Forest Division. Cherumankooban with 0.28 km^2 and Terrace Estate with 0.29 km^2 are the smallest in extent.

The second landscape, *the Anamalais*, has 59 locations spread over Anamalais, Nelliampathis and Anamudis (Fig. 13.2 and Table 13.3). The locations include Grass Hills and Eravikulam. The total extent of tahr habitat is about 310 km^2 with a population of about 1988. Of the 32 locations in the Anamalai Tiger Reserve, five are shared between Tamil Nadu and Kerala. Eighteen locations are identified in Kerala. Four of the locations in Tamil Nadu are within territorial divisions. Eravikulam together with Grass Hills is the largest tahr area in the whole of its range.

The Periyar landscape has the highest number of locations, which are also highly scattered (Fig. 13.3 and Table 13.4). The 60 locations are spread over Kalakad-Mundanthurai Tiger Reserve (KMTR), Srivilliputhur Grizzled Squirrel Wildlife Sanctuary, Neyyar Wildlife Sanctuary, Meghamala Wildlife sanctuary, Periyar Tiger Reserve and Kanyakumari Wildlife Sanctuary. These locations altogether have about 159 km^2 area with about 1900 tahr. The four locations in Kanyakumari WLS have an estimated population of about 290–385. Three of these are shared with KMTR and one with Trivandrum Wildlife Division. KMTR harbours about 415–455 in 11 locations. One of these is contiguous with Trivandrum Wildlife Division. The 2009 estimate in Srivilliputhur indicates about 63 in 13 locations, one of which is shared with Theni. This could be an underestimate if the earlier figures are considered. The 120–150 tahrs estimated in Theni are in four locations in the middle of

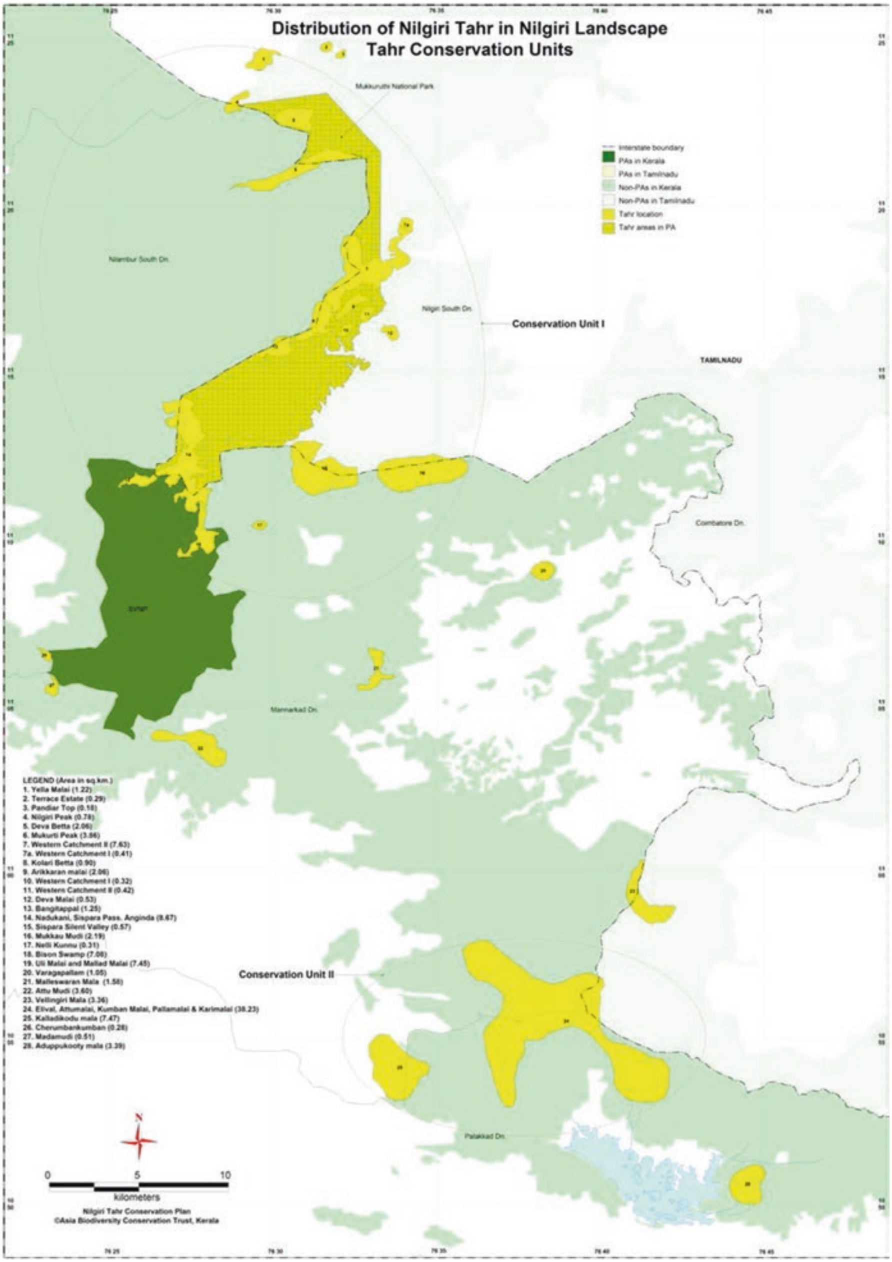

Fig. 13.1 Tahr habitat locations in Nilgiri Landscape and the proposed Conservation Units

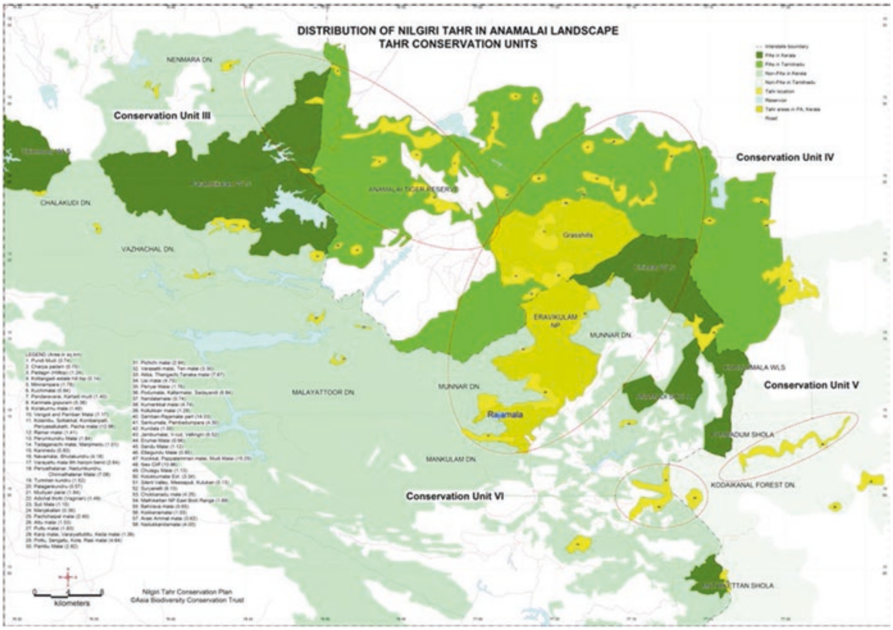

Fig. 13.2 Tahr habitat locations in Anamalai Landscape with the proposed Conservation Units

estates. The estimated tahr population of about 405–505 in Thirunelveli Forest Division is in 27 locations. Trivandrum WL is reported to have about 50–65 animals in two locations. Ponmudi in Trivandrum Forest Division is with 20–25 tahrs. In addition, the Kochu Pamba population and location in Goodrickal are isolated.

13.5 Discussion

Species conservation needs to address the population and genetic issues (Lande 1988). The conservation of a geographically limited species like tahr also has to consider the current knowledge on habitat use, population dynamics, behaviour and population structure. However, though short term, a species is at greater risk in the wake of threats to the population. Fluctuations in the population parameters (natality, mortality, immigration and emigrations rates, population structure) influence vulnerability of a species and are important especially for conservation of small populations (Gilpin and Soule 1986). Lande (1988) considered population parameters as most immediate importance than genetic concerns. The small population size confined to smaller geographical area and existence and distribution in several meta-populations are challenges to ensure the viability of the entire population of Nilgiri tahr.

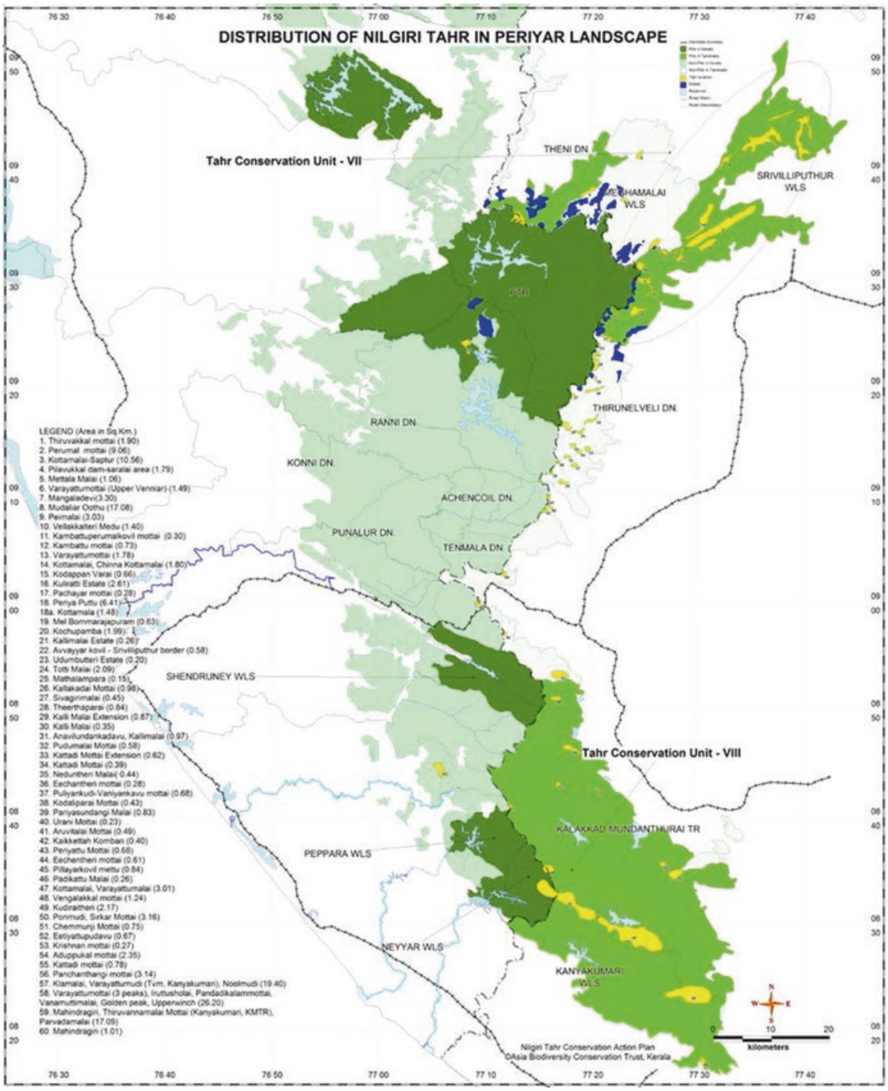

Fig. 13.3 Tahr habitat locations in Periyar Landscape with the proposed Conservation Units

The subpopulations (meta-populations) are presumed to be connected through movement of at least the saddle backs and are considered to be in a state of balance between population extinctions and colonization (Hanski and Gilpin 1991). Nilgiri tahr, as in the case of big horn sheep (Geist 1971), could be considered as slow colonizers as evident from the abandonment of Panchanthangi Mottai in Kalakkad Mundanthurai Tiger Reserve. The meta-populations could be considered to be in non-equilibrium where extinctions occur at a faster rate than colonization (Harrison 1994; Hanski and Simberloff 1997). Such systems are to be managed carefully to

Table 13.2 Details of Nilagiri tahr habitats in Nilgiri landscape

Sl. no	Tahr locations	Extent of tahr habitat (km^2)	Altitude (m)
1.	Yella Malai	1.22	2400
2.	Terrace Estate	0.29	2100–2200
3.	Pandiar Top	0.18	2100–2200
4.	Nilgiri Peak	0.78	2475
5.	Deva Betta	2.06	1900–1950
6.	Mukurti Peak	3.86	2000–2560
7.	Western Catchment II	7.63	2500–2600
7a.	Western Catchment I	0.41	2500
8.	Kolari Betta	0.90	2500
9.	Arikkaran Malai	2.06	2470–2500
10.	Western Catchment I	0.32	2553
11	Western Catchment II	0.42	2500
12.	Deva Malai	0.53	2300
13.	Bangitappal	1.25	2343–2400
14.	Nadukani, Sispara Pass. Anginda	8.67	2070–2470
15.	Sispara Silent Valley	0.57	1900–2100
16.	Mukkau Mudi	2.19	2050–2200
17.	Nelli Kunnu	0.31	1850
18.	Bison Swamp	7.08	2230–2300
19.	Uli Malai and Mallad Malai	7.45	2190–2350
20.	Varagapallam	1.05	792
21.	Malleswaran Mala	1.58	1664
22.	Attu Mudi	3.60	1250–1300
23.	Vellingiri Mala	3.36	1800
24.	Elival, Attumalai, Kumban Malai, Pallamalai and Karimalai	38.23	960–2070
25.	Kalladikodu Mala	7.47	630–1150
26.	Cherumbankumban	0.28	1160
27.	Madamudi	0.51	1160
28.	Aduppukooty Mala	3.39	820–850

avoid extirpation of the smaller groups while promoting colonization of habitat (Gilpin 1991). This calls for actions for reversal of the processes leading to population decline thereby increasing the size of the meta-populations by providing opportunities for movement between the populations.

Inbreeding depression and inability of population to respond to long-term environmental changes are considered to be the aftereffect of loss of genetic variability (Meffe and Carroll 1994; FitzSimmons et al. 1995). The growth rate and resilience of populations could also be adversely affected because of loss of genetic variability (Lacy 1997). The isolation of subpopulations with no connectivity between habitat fragments could also lead to vulnerability to natural fluctuations in the population. The current knowledge about genetic variation within and among the tahr

Table 13.3 Details of tahr locations in the Anamalai landscape

Sl. no	Tahr locations	Extent of tahr habitats (km^2)	Altitude (m)
1.	Pundi Mudi	0.75	1115
2.	Charpa Padam	0.75	850
3.	Padagiri (Hilltop)	1.24	995–1525
4.	Kottangadi Estate Hill Top	0.14	1230
5.	Minnampara	1.78	1585–1635
6.	Kuchimalai	0.84	1100
7.	Pandaravarai, Kartadi Mudi	1.40	1250–1290
8.	Karimala Gopuram	5.36	1150–1450
9.	Korakunnu Mala	1.49	838
10.	Vengoli and Pamban Malai	1.17	1050–1130
11.	Kolambu, Sottakkal, Kombanpalli, Periyasallukatti, Pacha Malai	12.98	615–1400
12.	Ramar Malai	1.41	1490
13.	Perumkundru Malai	1.84	1500–1735
14.	Tadaganachi Malai, Manjimedu	1.01	1050–1400
15.	Karimedu	0.83	890–910
16.	Navamalai, Bhutakundru	4.18	910–1190
17.	Varayattu Mala 9th Hairpin Bend	2.64	1050–1720
18.	Periyathalanar, Nadumkundru, Chinnathalanar Malai	7.08	1150–1510
19.	Tumman Kundru	1.52	1090–1170
20.	Palagankundru	0.60	1173
21.	Mudiyan Parai	1.84	1218
22.	Adichal Thotti (Vagirian)	1.49	450–650
23.	Suli Mala	1.15	1340
24.	Manjakallan	0.36	650
25.	Pachchaipal Malai	2.39	1280–1770
26.	Attu Malai	1.53	1445
27.	Puttu Malai	1.83	1225
28.	Kanji Malai, Varaiyattutittu, Keda Malai	1.38	870–1140
29.	Pottu, Sengallu, Kota, Rasi Malai	4.64	940–1350
30.	Pambu Malai	2.82	1880–2025
31.	Pichchi Malai	2.94	1530–2100
32.	Varasatti Malai, Ten Malai	3.30	1310–1585
33.	Akka, Thangachi, Tanaka Malai	7.67	2190–2515
34.	Usi Malai	4.75	1700–2150
35.	Periyar Malai	1.76	1800–2000
36.	Podumalai, Kallarmalai, Sadayandi	6.84	1140–1285
37.	Nandalamalai	0.74	2000–2370
38.	Kumarikkal Malai	4.74	1545–2525
39.	Kollukkan Malai	1.29	2050–2280
40.	Samban-Rajamalai Part	14.03	1670–2690

(continued)

Table 13.3 (continued)

Sl. no	Tahr locations	Extent of tahr habitats (km^2)	Altitude (m)
41.	Sankumala, Pambadumpara	4.30	2000–2100
42.	Kundala	1.00	2000–2400
43.	Jambumalai, V-cut, Vellingiri	0.00	1840–2400
44.	Erumai Malai	0.96	740–750
45.	Sandu Malai	1.12	950
46.	Ellaigundu Malai	0.85	1250
47.	Mudi Malai	4.46	1830–1905
48.	Kukkal, Pappalamman Malai	1.20	2200
49.	Ibex Cliff	10.86	1950–2520
50.	Chulagu Malai	1.13	1650
51.	Kolukkumalai Ext.	3.34	2000–2280
52.	Silent Valley, Meesapuli, Kulukan	5.13	2400–2650
53.	Suryanelli	6.13	2170–2550
54.	Chokkanadu Mala	4.25	1300–2200
55.	Mathikettan NP East Bodi Range	1.69	1650–1850
56.	Bahirava Malai	0.65	1800–1850
57.	Kokkanamalai	1.03	1980–2215
58.	Arasi Ammal Malai	0.62	1720
59.	Nadukanda Malai	4.00	1985–2000

populations is nil. Destruction of only a fraction of available habitat could drive a meta-population to extinction by disrupting the balance between colonization and extinction rates (May 1991). The evolutionary and ecological process need to be ensured through a near natural geographic distribution (Meffe and Carroll 1994). This could be achieved either by having multiple groups in subpopulations and providing ample opportunities for movement between groups or by population augmentation, reintroduction and captive breeding programmes (Ryman and Laikre 1991; Elliott and Boyce 1992).

13.6 Conservation Challenges

Securing the Habitat Easa et al. (2010) have listed the challenges in conserving the Nilgiri tahr. The Tahr, confined to a narrow belt of higher elevation areas in a restricted geographical region, is considered endangered mostly because of the loss and fragmentation of the habitat. A major part of the historical range of the tahr has been lost to plantations including tea. Parts of the remaining grasslands have been planted with eucalyptus, wattle and pine. Most of the tahr habitat are surrounded or bordered by estates or agricultural land. Some areas like Panchanthangi Mottai in Kalakkad have lost the tahr recently (in the last 15 years). There may also be other areas from where it has been exterminated or the number has been reduced. It is definitely clear that tahr has been pushed to the core of the earlier ranges at least in

Table 13.4 Details of tahr locations in the Periyar landscape

Sl. no	Tahr locations	Extent of tahr habitat (km^2)	Altitude (m)
1.	Thiruvakkal Mottai	1.90	1250–1300
2.	Perumal Mottai	9.06	750–1270
3.	Kottamalai-Saptur	10.56	890–1300
4.	Pilavakkal Dam-Saralai Area	1.79	815–830
5.	Mettala Malai	1.06	1500
6.	Varayattumottai (Upper Venniar)	1.49	1600
7.	Mangaladevi	3.30	1200–1340
8.	Mudaliar Oothu	17.08	730–1650
9.	Peimalai	3.03	1500–1700
10.	Vellakkalteri Medu	1.40	1230
11.	Kambattuperumalkovil Mottai	0.30	1350
12.	Kambattu Mottai	0.73	1350
13.	Varayattumottai	1.78	1700–1750
14.	Kottamalai, Chinna Kottamalai	1.80	1190
15.	Kodappan Varai	0.66	750–900
16.	Kuliratti Estate	2.61	1150
17.	Pachayar Mottai	0.28	1300–1500
18.	Pambamala-Gavi	0.82	1180
19.	Mel Bommarajapuram	0.63	1102–1670
20.	Kochupamba	1.99	1150–1192
21.	Kallimalai Estate	0.26	750
22.	Avvayyar Kovil – Srivilliputhur Border	0.58	675
23.	Udumbutteri Estate	0.20	950
24.	Totti Malai	2.09	1500–1650
25.	Mathalampara	0.15	1100
26.	Kallakadai Mottai	0.98	1000–1300
27.	Sivagirimalai	0.45	1445
28.	Theerthaparai	0.84	1150–1200
29.	Kalli Malai Extension	0.87	1610
30.	Kalli Malai	0.35	1735
31.	Anavilundankadavu, Kallimalai	0.97	1350–1400
32.	Pudumalai Mottai	0.58	1000

(continued)

Table 13.4 (continued)

Sl. no	Tahr locations	Extent of tahr habitat (km^2)	Altitude (m)
33.	Kattadi Mottai Extension	0.62	425
34.	Kattadi Mottai	0.39	710
35.	Neduntheri Malai	0.44	900
36.	Eechantheri Mottai	0.28	1195
37.	Puliyankudi-Vaniyankavu Mottai	0.68	800
38.	Kodaliparai Mottai	0.43	1540
39.	Pariyasundangi Malai	0.83	1200–1300
40.	Urani Mottai	0.23	1700
41.	Aruvitalai Mottai	0.49	1625
42.	Kaikkettah Komban	0.40	1465
43.	Periyattu Mottai	0.68	1100–1150
44.	Eechentheri Mottai	0.61	900–1100
45.	Pillayarkovil Mettu	0.84	600
46.	Padikattu Malai	0.26	850
47.	Kottamalai, Varayattumalai	3.01	1050–1265
48.	Vengalakkal Mottai	1.24	950–1050
49.	Kudiraitheri	2.17	950
50.	Ponmudi, Sirkar Mottai	3.16	1040–1075
51.	Chemmunji Mottai	0.75	1580–1715
52.	Eetiyattupudavu	0.67	1125
53.	Krishnan Mottai	0.27	485
54.	Aduppukal Mottai	2.35	1000–1100
55.	Kattadi Mottai	0.78	760
56.	Panchanthangi Mottai	3.11	1100–1200
57.	Klamalai, Varayattumudi (Tvm, Kanyakumari), Noolmudi	19.40	365–950
58.	Varayattumottai (3 peaks), Iruttusholai, Pandadikalammottai, Vanamuttimalai, Golden peak, Upperwinch	26.20	1580–1780
59.	Mahindragiri, Thiruvannamalai Mottai (Kanyakumari, KMTR), Parvadamalai	17.09	920–1700
60.	Mahindragiri	1.01	450–550

some areas forcing them to limit their area of activity to fragments or smaller areas. The specialized habitat requirements make it more vulnerable to the changes in the habitat and even the recent threat of climate change.

The developmental activities in tahr areas have also been forcing the herds to be within a small area possibly leading to genetic problems due to isolation of subgroups. The cattles grazing in tahr habitat deprived them of the scant resources and pose the potential of spreading disease.

The tahr populations under the administrative control of the Thirunelveli Forest Division are probably the most fragmented with low number of individuals. The populations in these areas are believed to have declined to a stage where there is reduced chance of resilience. Attempts should be made to ensure larger ecosystems minimizing human disturbance and developmental activities for maintaining as many viable populations as possible. Since habitat connectivity is crucial for geographical expansion when the population increase, a list of areas to be secured is to be prepared and prioritized. The areas falling under the government may be managed to maintain habitat connectivity. The owners/corporate of the private areas may be encouraged to manage their land to allow free movement of animals within.

Management of Invasives Exotics have been reported from most of the primary tahr areas, especially Nilgiris (e.g. *Cytisus scoparius* (scotch broom) and *Ulex europaeus* (gorse). The frequent fire and lemon grass (*Cymbopogon flexuosus*) invasion has been reported to be the cause of disappearance of tahr from Panchanthangi Mottai in Kalakkad Mundanthurai Tiger Reserve. In addition, planting of exotics like wattle has reduced suitable habitats in Nilgiris and Palnis, and in some places these intrude the sholas. The mean temperatures in the tropics are expected to increase by at least 1–2 °C over the next few decades (IPCC 1992). General circulation models predict an intensification of the Indian summer monsoon as a consequence of increased temperature (Hulme and Viner 1995). Even with the uncertainty as to the magnitude of climate change, predictions suggest lower incidence of frost and spread of C_3 plants like wattle. This means expansion of montane shola into grasslands and replacement of C_4 grasses with C_3 grasses and herbs (Sukumar et al. 1995; Ravindranath et al. 1997). The management of the habitat needs to consider the impact of climate change on Nilgiri tahr.

Role of Indigenous Communities Majority of the tahr areas are at the higher elevations and are not accessible by road. Traditionally, the natives had been engaged in perambulation of tahr areas. The services of Muduvans in Eravikulam and the Kanis in Kalakkad–Mundanthurai are good examples of protection by the tribal community. This could be followed in most of the tahr areas where there are such communities.

Fire Management This is one of the issues debated in recent times. In most of the tahr ranges, even with stringent protection to prevent fire, at least a part of the habitat invariably gets burnt in summer. Cold burning of grass in blocks in alternate years providing a mosaic of burnt and unburnt areas has been suggested as early as 1940 (Velupillai 1940). There had been suggestions for cold burning to improve the nutritional content of the food species (Rice 1984). The results of the ongoing research on the various burning practices in Eravikulam could be implemented appropriately in the fire management practices.

Outreach Programmes The current awareness programmes in tahr areas are limited to nature camps in protected areas in Kerala. Eravikulam National Park is the only place with a well-planned interpretation centre. Public participation in planning and management would result in public support and help in protection of tahr habitat.

Population Monitoring Easa et al. (2010) have highlighted the problem of lack of information on the population in most of the tahr areas. But for Eravikulam, Mukurthi and Srivilliputhur, there is no reliable information on the population. It is important to periodically monitor the population in all areas, including the fragments using appropriate techniques. It is also important to make a revisit to the bounded count method (Regier and Robson 1967) currently followed in Eravikulam.

Reintroduction Tahr has moved away from some of its distribution areas. Considering that the males move away from the birth range widely, the males could be reintroduced in the abandoned habitats. They will presumably be best acclimatized to the new areas and could be followed by a group of females. In the case of mountain sheep, Geist (1975) proposed introduction of a human-imprinted lamb to a new range and leaving yearlings with the lamb after a year. According to Rice (1990), tahr habitat requirements are not very rigid, and identical habitat is not an absolute requirement for reintroduction. Panchanthangi Mottai in Kalakkad and Varayattumudi above Thannikudy in Periyar Tiger Reserve could be considered for reintroduction.

Genetic Studies Genetics play a minor relatively ill-defined part in the recovery planning process (Moyle et al. 2003). Genetic data are unlikely to be as informative or valuable as demographic data in assessing biological status or determining appropriate management strategies for critically endangered species (Lande 1988; Caughley 1994). Discrepancy between available data for genetics and demography is also noted. Genetic factors are crucial in most of the management programmes, and stress could be given to the isolated populations for understanding the impact of genetic and ecological isolation.

Research and Monitoring Most of the information on Nilgiri tahr have been from earlier studies in Eravikulam and Nilgiris. It is important to update the information from such areas and concentrate on the isolated populations for habitat utilization and suitability for preparing suitable management action plans.

NGOs in Tahr Conservation Programmes Most of the current information on Nilgiri tahr are the contributions of the sportsmen and voluntary organizations active in Nilgiris and High Ranges. Involvement of voluntary organizations could assist in the management of tahr areas, especially in population estimation and monitoring.

The Management Practices In addition to the stress given to scientific management of tahr habitats in protected areas, the plans for other areas could also include tahr-centred conservation activities. It is also important to formulate site-specific strategies for tahr conservation for which the management plans should be revisited and modified accordingly. These could be called tahr conservation plan and implemented appropriately.

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Conservation Threats on Critically Endangered *Gyps* Vultures in the Tamil Nadu Part of the Nilgiri Biosphere Reserve, Southern India

14

A. Samson, B. Ramakrishnan, G. Kannan, A. Veeramani, and S. Ramasubramanian

Abstract

Vultures play an essential role in environmental health by scavenging meat from carcasses and take place end of the ecosystem as decomposer, without which the ecosystem is incomplete. The vultures are under serious threat in all its distribution ranges. In Southern India, there are five species of vultures successfully thriving unlike Northern Indian population. Still, there are many conservation threats such as livestock grazing, bamboo cutting, non-timber forest product collection, honey collection, pilgrims threat, and deliberate poisoning threatening the securement of the population. This paper discusses the conservation threats and its impacts in the southernmost wild viable vulture population.

Keywords

Conservation · Nilgiris · Sigur Plateau · Vultures

A. Samson · B. Ramakrishnan (✉) · A. Veeramani
Department of Zoology and Wildlife Biology, Government Arts College, Udhagamandalam, The Nilgiris, Tamil Nadu, India

G. Kannan
Mudumalai Tiger Reserve, The Nilgiris, India

S. Ramasubramanian
Harur Forest Division, Harur, India

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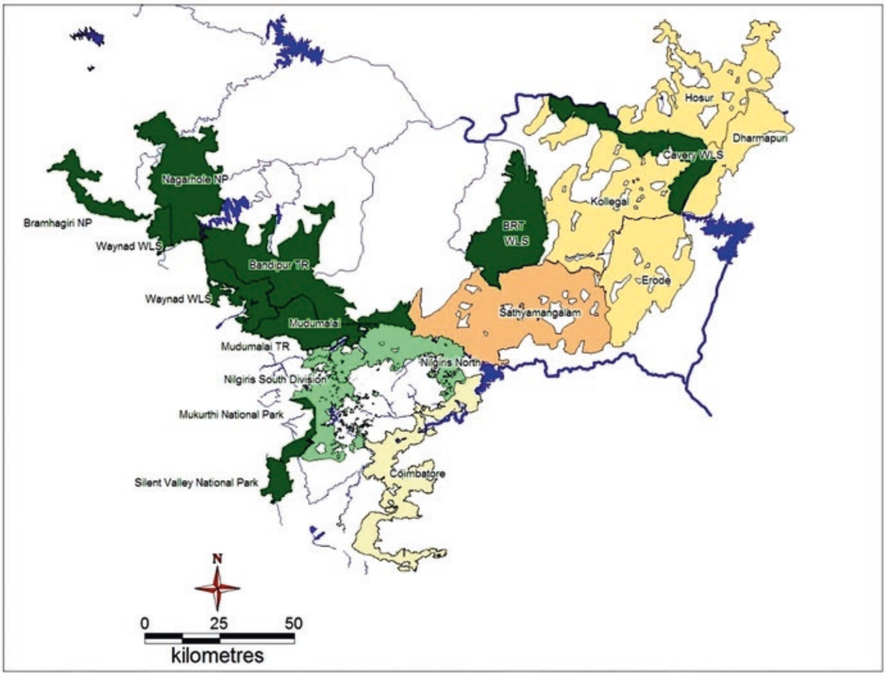
14.1 Introduction

The Indian subcontinent is home for a wide range of flora and fauna owing to its varied range of climatic, topographic, and vegetation structure. Out of 1224 bird species reported from the subcontinent, 79 are threatened and 8 are listed as critical and in immediate danger of extinction. Among the threatened birds, vultures, especially *Gyps* species, are facing radical population crash in India (Prakash 2001). Vultures play an essential role in environmental health by scavenging meat from carcasses. Being a scavenger in habit, the vultures prevent the spread of dangerous diseases such as anthrax and rabies (Prakash et al. 2003), which could cause havoc to the wild animals, livestock, and human. Therefore, it is believed that their absence can lead to a grave crisis in the terrestrial ecosystem (Verner et al. 1986). The vultures are excellent scavengers of dead bodies, and their status is critically tagged with the present situations.

The decline (>95%) of the *Gyps* vultures was first reported in Keoladeo National Park, Rajasthan (Prakash 1999). White-rumped vulture (*Gyps bengalensis*), long-billed vulture (*G. indicus*), and slender-billed vulture (*G. tenuirostris*) have declined by over 99% since the mid-1990s (Prakash et al. 2003; Green et al. 2004) and continue to decline at an alarming rate (Prakash et al. 2007; Green et al. 2007). These vultures are at high risk of global extinction and are listed as critically endangered (IUCN 2004) and are categorized under Schedule I of the Indian Wildlife Protection Act of 1972 as amended in 2002 (GOI 2002). The prime cause for the decline of these three species was identified due to the use of the veterinary nonsteroidal anti-inflammatory drug diclofenac sodium (Oaks et al. 2004; Shultz et al. 2004; Swarup et al. 2007). Despite the ban of this drug in the veterinary sector since 2006, the spillover of human diclofenac multidose formulations into the veterinary sector continues to be the major threat (Shah et al. 2011). Other than diclofenac effect, some of the factors are also reasoned for vulture decline in India; likewise, kite flying is one of the major threats for all avian species particularly with reference to vultures in Gujarat, that is, 47% of death rate was by the kite flying (Roy and Shastri 2013). Malaria was also reported for wild vulture population declining in the country (Poharkar et al. 2009). However habitat destruction, road kills, and other ecological factors also played important roles in the vulture decline (Chhangani and Mohnot 2004; Chhangani 2004, 2005, 2007, 2009).

In Southern India five species of vultures are commonly found, viz., Egyptian vulture (*Neophron percnopterus*), red-headed vulture (*Sarcogyps calvus*), white-rumped vulture (*Gyps bengalensis*), long-billed vulture (*Gyps indicus*), and cinereous vulture (*Aegypius monachus*). The population status of these five vulture species was primarily studied by Davidar (2007) and Davidar and Davidar (2002) and recently by Ramakrishnan et al. (2010, 2012, 2014) in Tamil Nadu, Subramanya and Naveein (2006) in Karnataka, and Sashikumar (2001) in Kerala. In Sigur Plateau, except cinereous vulture (*Aegypius monachus*), other four species are



Map 14.1 Location of Sigur Plateau in the Nilgiris and Eastern Ghats landscape

successfully thriving in the wild. The survival of this small population of vultures gives a glimmer of hope that its entire population may not have been lost in this part of the country. It is quite possible that this isolated population can resist against the effects of agents that have almost decimated the species elsewhere or may not have been exposed to the same. Among the threats, Davidar and Davidar (2002) reported that retaliatory killing of carnivores through poisoning the carcasses was the major reason for declining vulture population in the past. In this paper we made an attempt to consolidate all conservation threats pertaining to critically endangered India's southernmost viable wild vulture population.

14.1.1 Study Area

The Sigur Plateau is situated between the Nilgiri Hills and Eastern Ghats landscape and acts as a crucial habitat corridor for the movement of wild animals (Map 14.1). It covers an area of 778.80 km^2 and an average elevation of 280 m (919 ft). The boundaries of the Sigur Plateau are Bandipur National Park (Karnataka) on the north, Mudumalai Tiger Reserve on the west, and Sathyamangalam Tiger Reserve on the south and east. It harbors a diverse range of wild animals including Asian elephant (*Elephas maximus*), tiger (*Panthera tigris*), leopard (*Panthera pardus*), gaur (*Bos gaurus*), chital (*Axis axis*), sambar (*Cervus unicolor*), and numerous other important mammal and bird species. Five major streams in the Sigur Plateau are the Moyar River, the Sigur River, the Avarahalla River, the Kedarhalla River, and the Gundattihalla River, which crisscrosses the Moyar Valley and drains into the Bhavanisagar reservoir.

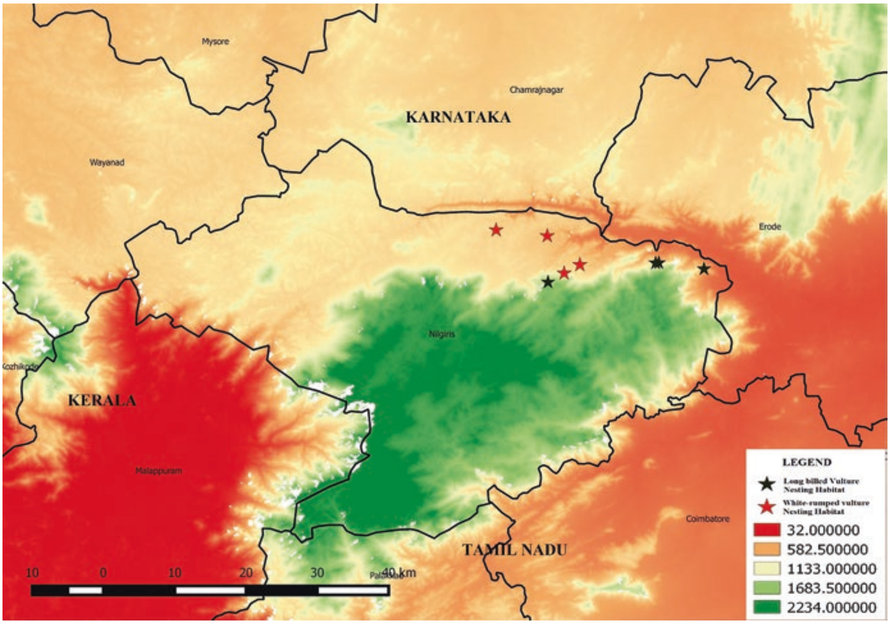
14.2 Methods

This paper is part of the study on ecology of vultures which is underway till 2017. Two types of methods were applied for the documentation of conservation threats. One was questionnaire survey (Ramakrishnan et al. 1997) and the other is direct field observation made on foot survey in the forest areas (Postupalsky 1974). The geo-coordinates of vulture nesting colonies were marked using Global Positioning System (GPS), and the same were depicted on Google Earth as well as Survey of India map applying "Quantum GIS version 1.7.1 (QGIS)" and MapInfo (10) Computer Software.

14.3 Results and Discussion

14.3.1 Nesting Site

A total of four vulture species are found in the Sigur Plateau, namely, white-rumped vulture (*Gyps bengalensis*), long-billed vulture (*Gyps indicus*), red-headed vulture (*Sarcogyps calvus*), and Egyptian vulture (*Neophron percnopterus*), of which, except Egyptian vulture, all are residential, and identification of these nesting areas is under process. We identified nests of white-rumped vulture at Jagulikadavu and Siriyur locations in the Sigur Range of the Nilgiri North Forest Division (Ramakrishnan et al. 2014). It is important to note that both nesting sites were along the river banks of Jagulikadavu and Siriyur rivers, respectively. Jagulikadavu nesting site is located deep inside the forest area of Sigur Range. On the other hand, Siriyur site is located near human settlements of Siriyur tribal village. Our present observation corroborates with some past studies. Galushin (1971) stated that 400 breeding pairs of white-rumped vultures are found near human habitation in Delhi in the mid-1980s; now all of them vanished due to the influence of diclofenac. The nesting of long-billed vulture was identified near the Ebbanad village at the foot hills of Sigur Range, and another nest was recorded at Nilgiri Eastern Slopes Range of Nilgiri North Forest Division. Similarly one more long-billed nest was located at Goolithorai Patti of the Bhavanisagar Range of Sathyamangalam Tiger Reserve.



14.3.2 White-Rumped Vulture Nests and Nesting Characters

The present study observed nests of white-rumped vulture more on large leafy trees, namely, *Terminalia arjuna*, *Spondias mangifera*, *Ficus benghalensis*, *Terminalia bellirica*, *and Manilkara hexandra* tree species. Naoroji (2006) recorded the white-rumped vulture nests on *Azadirachta indica*, *Tamarindus indica*, *Terminalia arjuna*, *Bombax ceiba*, *Dalbergia sissoo* or *D. latifolia*, *Mitragyna parvifolia*, *Balanites aegyptiaca*, *Albizia lebbeck*, *Acacia nilotica*, *A. leucophloea*, *Crateva nurvala*, and *Cocos nucifera* in Northern India. The preference of this tree species for nesting was influenced due to its height and easiness to break the small leafy twigs tugging at it with bill, which assisted vigorous wing flapping to build the nest (Ali and Ripley 1987). The nests in the study area were constructed at about 10–36 m from the ground and inaccessible to humans.

Road (2010) stated that the selection of highest and huge DBH trees by vultures for nest construction was not affected by large mammals such as elephant and gaur. This present study also recorded that the trees selected for nesting by vultures are covered with dense bamboo clumps at the bottom which may be inaccessible for predators and humans. Ramakrishnan et al. (2014) recorded that twigs, dry leaves, grass, thermocol, and sometimes even polythene covers were used as nesting materials by white-rumped vultures in Jagulikadavu and Siriyur areas. On the other hand, the long-billed vulture nests were found at rocky outlet on the mountains and foot hills of Sigur and Nilgiri Eastern Slopes and Bhavanisagar Ranges. The nesting was placed on the outlet of rocky cliffs and suitable areas. The nests were shallow type and twigs were used as nesting material.

14.3.3 Conservation Threats and Problems

The white-rumped vulture nesting colonies are located near the human habitation in Siriyur village. The local people use the vulture nesting area for many purposes such as bathing, cooking, and washing and as an entertainment place. These activities are severely affected on the vultures especially during breeding season. This would influence on incubation before young ones come out and reduce feeding intensity to the young ones after incubation. Vultures generally lay only one egg in one breeding season; if it fails, it would seriously affect its future population.

14.3.4 Livestock Grazing

The livestock grazing under the nesting trees especially during incubation period would cause noise pollution to the breeding pairs. The cattle from Moyar, Semmanatham, Vazhaithottam, and Masinagudi villages bring livestock into the Jagulikadavu vulture habitat for grazing and drinking because of water and forage availability in and around the Jagulikadavu river. The livestock grazers generally make sounds every 10 min to avoid encountering with elephants. This noise pollution creates severe disturbance to the vultures when they are in incubation and feeding their young ones. Thus this results in breeding failure of white-rumped vulture.

14.3.5 Non-timber Forest Product (NTFP) Collection

Although the NTFP collection is not permitted in the protected areas such as sanctuaries and national parks, it is permitted in the reserve forest areas. The NTFP collection generally takes place between January and May and peaks in February for the collection of *Phoenix* leaves for broom stick manufacturing. Other than *Phoenix*, *Sapindus emarginatus*, *Phyllanthus emblica*, *Bombax ceiba*, *Terminalia chebula*, *Tamarindus indica*, and Marapaasam (tree algae) are being collected during this period. Although the NTFP collection does not affect the nesting trees physically or directly, the indirect causes such as noise pollution and people's movement under nesting trees seriously affect the white-rumped vulture population when they are feeding their young ones. The feeding intensity is being drastically reduced due to NTFP collection, which resulted in weak young ones, starvation, and sometimes even mortality to young ones in the nests itself.

14.3.6 Bamboo Cutting

Bamboos are closely related to the tribal life in the Sigur Plateau. The bamboo is mostly used by tribal people as small timber for the construction of house, bathroom, kitchen, compound wall, livestock penning, and temporary tent for temple festival and house festival times. The local people cut bamboo even under nesting trees. The white-rumped vultures generally select the nesting trees that are densely covered by bamboo at the bottom in order to avoid damage from wild animals such as elephant and gaur. The local people cut bamboo even under white-rumped vulture nesting as the need increases. Generally the local people do constructions, festivals, and other house functions during summer, when there will be no rain and they may not have cropping in their agricultural farms and even they may not go as coolies also. During the time the people cut bamboo and other important small timber materials for renovation and new constructions of house, bathroom, kitchen, compound wall, livestock penning, etc. using bamboo sticks. This would affect the present breeding (the breeding takes place from January to May), and sometimes influence on the breeding pair may not prefer the same tree for the next breeding season.

14.3.7 Pilgrims Threat

There are series of temple festivals occurring during summer (January–May) in the Sigur Plateau. The most important and relevant to vulture conservation threat temple festival is Siriyur Mariamman Temple festival which is located at Siriyur tribal village. This temple festival is celebrated in the month of February or March every year for 3–5 days. About 10,000 to 20,000 people from various tribal settlements and also from many villages visit the temple. The white-rumped vulture nesting colony is located at Siriyur River near Siriyur tribal village. During festival time the pilgrims offer free food for the devotees by cooking along the Siriyur riverbed. This activity brings big gatherings along the Siriyur riverbed under white-rumped vulture nesting trees which would havoc serious threat on breeding season by noise pollution and people's movement. We had recorded that one of the nesting trees was burnt by the pilgrims while cooking food along the Siriyur River. Thus it resulted in the reduction of nest construction on the tree from five nests to two or one.

14.3.8 Honey Collection

Honey collection is also one of the threats for vulture conservation in the Sigur Plateau. The honey collection occurs between months of August and October. The nest construction by white-rumped vulture takes place between months of September and October. The nest construction is directly affected by fire while the people do honey collection. Our observation reveals that there is a direct influence of honey collection with vulture nest construction. Thus it resulted in the change of nesting trees by vultures for nest construction. If there is no such preferable trees in the given point of time, that might lead to breeding failure.

14.3.9 Deliberate Poisoning

Poisoning is the one of the deadliest weapons people used against wildlife. The loss of livestock by wild carnivore's depredation usually occurs in the people and wild animals' coexisting environment. The intolerance of wild animal's depredation on livestock creates the mindset of local people to do deliberate poisoning on the livestock carcasses to kill the carnivores. Unfortunately this activity kills the nontargeted animals such as wild boars, hyenas, as well as vultures.

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The Bat Fauna of Meghalaya, Northeast India: Diversity and Conservation

15

Uttam Saikia, Adora Thabah, Oana Mirela Chachula, and Manuel Ruedi

Abstract

Because of past and present geo-climatic condition and unique biogeographic history, the state of Meghalaya harbours a rich bat fauna. An inventory of the bat fauna of the state consisting of 65 species in eight families with distributional information on each species is presented. Four species namely *Megaerops niphanae, Pipistrellus ceylonicus, Tylonycteris malayana* and *Miniopterus pusillus* find first mention from the state. This account is primarily based on reliable published information and online collection database of museums and is supplemented by the chiropteran collection in Zoological Survey of India, Shillong, and recent field observations. Despite the rich diversity, bat fauna of the state is facing multiple existential threats especially from mining and associated activities. These threats and other conservation issues are also being discussed briefly.

Keywords

Meghalaya · Northeast India · Chiroptera · Threats · Conservation

U. Saikia (✉)
Zoological Survey of India, North Eastern Regional Centre, Shillong, Meghalaya, India

A. Thabah
Solar View Cottage, Upper Mawprem, Shillong, Meghalaya, India

O. M. Chachula
National Museum of Romanian History, Bucharest, Romania

M. Ruedi
Department of Mammalogy and Ornithology, Natural History Museum of Geneva, Geneva, Switzerland
e-mail: manuel.ruedi@ville-ge.ch

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Abbreviations

AMNH	American Museum of Natural History
EGH	East Garo Hills
EJH	East Jaintia Hills District
EKH	East Khasi Hills District
HNHM	Hungarian Natural History Museum
RB	Ri-Bhoi District
SGH	South Garo Hills District
UMMZ	Museum of Zoology, University of Michigan
FMNH	Field Museum of Natural History, Chicago
WGH	West Garo Hills District
WJH	West Jaintia Hills District
WKH	West Khasi Hills District
ZSIS	Zoological Survey of India, Shillong

15.1 Introduction

The northeastern part of India is a biological treasure trove and the state of Meghalaya is no exception. Being a part of Indo-Burma biodiversity hotspot (Mittermeier et al. 2004), the state exhibits exceptional diversity and endemism of life forms including over 60 species of bats which comprises about 50% of the 125 bat species known from India (Talmale and Pradhan 2009; Ruedi et al. 2012a, b; Senacha and Dookia 2013; Saikia et al. 2017; Thong et al. 2018).

The extraordinary opulence of life forms in Northeast India as a whole can be attributed to a complex variety of factors like geologic age, past and present climatic conditions, geographic location at the confluence of different biogeographic realms, unique zoogeographic history, etc. (Pawar et al. 2007). Meghalaya harbours numerous caves and caverns of which 925 are scientifically explored and mapped (Arbenz 2013).Caves serve as a major roosting place for a large variety of bats since it offers relatively stable microclimate, insulate them from environmental stochasticity and release predatory pressure. Availability of suitable roost is a critical factor that largely determines diversity and distribution of bats (Arita 1993; Kunz 1982). Thus, the state with abundant caves and caverns especially in the limestone belt offers unlimited roosting opportunity for a large variety of bats.

The zoogeographic chronicle of Northeast India as a whole is very fascinating. Situated at the confluence of Indo-Malayan and Indo-Chinese subregions and also juxtaposed to the Palearctic realm (Rao 1994), the faunal composition of northeastern India is complex and composed of elements from the above regions. Northeast India is hypothesized as a gateway for faunal influx from the neighbouring region to mainland India especially the Indo-Malayan and Indo-Chinese fauna (Kurup 1968). Likewise, many of the Palearctic and Indian animal species were supposedly extended to the Southeast Asian region through the northeast Indian corridor (Kurup 1974). This region possibly served as a refugium for flora and fauna during Cretaceous isolation of Indian subcontinent leading to evolution of endemic taxa (Kamei et al. 2012). The Meghalaya subtropical forests ecoregion (IMO126) covering Meghalaya and the adjacent areas of Assam is recognized as one of the most species diverse regions for plants, birds and mammals (Wikramanayake et al. 2002). Unfortunately, this unparalleled biodiversity of the region is facing serious anthropogenic threats especially mining and deforestation which are magnified in recent times.

Compared to other states of Northeast India, the bat fauna of Meghalaya is relatively better known. This is primarily because of the fact that the provincial British administration was based at Shillong, the headquarters of erstwhile Assam Province and naturalists under the patronage of the British government conducted extensive faunal surveys in the Khasi and Jaintia Hills area. Edward Blyth, a British zoologist and curator of the museum of Asiatic Society of Bengal, first reported a collection of birds, mammals and reptiles from Cherrapunji in East Khasi Hills District. His report including the description of *Nycticejus ornatus* (=*Scotomanes ornatus*) possibly represents the first scientific record of bats from Meghalaya (Blyth 1851). British geologist and surveyor H. H. Godwin Austen surveyed Khasi and Jaintia Hills in the early 1870s and collected mammalian specimens later to be deposited in the Indian Museum, Calcutta. Subsequently, based on Austen's and other's collection in the museum, Edward Dobson, a British army surgeon and a mammalogist par excellence, provided scientific description of *Rhinolophus garoensis* (= *R. subbadius*), *Phyllorhina leptophylla* (= *Hipposideros larvatus*), *Vesperugo* (*Vesperus*) *pachyotis* (= *Eptesicus pachyotis*) and *Pipistrellus austenianus* (= *Hypsugo savii*) and also published a list of bats inhabiting Khasi Hills (Dobson 1871, 1872, 1874). During 1922, Stanley Kemp and his associates of Zoological Survey of India conducted extensive faunal exploration in Siju cave in South Garo Hills. They recorded *Cynopterus sphinx*, *R. subbadius* and *Hipposideros lankadiva* from the cave (Kemp 1924). As a result of the Mammal Survey organized by Bombay Natural History Society (1911–1923), extensive mammalian collection were made from parts of Khasi, Jaintia and Garo Hills by collectors like H. W. Wells, and the results were published in the *Society*'s journal. The report included some bat species from Meghalaya like *R. affinis*, *R. lepidus*, *R. luctus*, *R. pearsonii*, *Scotophilus kuhlii*, *Leuconoe* sp. (*Myotis* sp.), *Scotomanes ornatus imbrensis*, etc. (Thomas 1921; Hinton and Lindsay 1926). In the early 1950s, Walter Koeltz, an American zoologist and collector affiliated to the University of Michigan, made extensive mammal collection from Khasi Hills (Cherrapunji, Mawphlang, Mawryngkneng). His collections including many bat specimens are now mostly housed in the Field Museum of Natural History, Chicago, and the Museum of Zoology, University of Michigan. After a significant lull, Gyorgy Topal from the Hungarian Natural History Museum conducted bat surveys around Cherrapunji and reported the presence of *Ia io* and *Myotis laniger* in Meghalaya (Topal 1970, 1974).Consequently, Lal (1977) reported *Rhinolophus macrotis* from Cherrapunji area. Thereafter, Y. P. Sinha of Zoological Survey of India reported the occurrence of *Eonycteris spelaea*, *Myotis longipes*, *Pipistrellus dormeri* (=*Scotozous dormeri*) and *Miniopterus schreibersii s.l.* from Meghalaya (Sinha 1990, 1994, 1995, 1999a). Bates and Harrison (1997) in their comprehensive account included 50 species of bats from Meghalaya with a few species records now considered redundant. Sinha (1999a) documented the presence of nine species of bats from Siju cave, South Garo Hills. Thabah and Bates (2002) reported *Otomops wroughtoni* from a cave in East Khasi Hills District, Meghalaya, filling a major disjunction in distribution range of this species. Thabah (2006) conducted a study on the bat diversity of Meghalaya with special reference to caves in East Khasi Hills District. Of late, as an offshoot of an ongoing cave exploration project in Meghalaya, scientists have described two new species of bats, namely, *Murina jaintiana* and *M. pluvialis*, and also reported a few additions to the bat fauna of the state (Ruedi et al. 2012a, b). In addition, new roosting colonies of rare *Otomops wroughtoni* have also been reported very recently from the state (Ruedi et al. 2014). Our own ongoing field surveys further revealed the presence of several other species including some poorly known taxa in the state. In view of remarkable species diversity, scattered nature of information especially on distributional aspects and also the existential threat faced by these animals, the present communication aims to collate the available authentic information on diversity and distribution of bat fauna in the state.

15.1.1 Study Area

The state of Meghalaya is spread between $25^{0}02'$ and $26^{0}07'$ N latitude and $89^{0}49'$ and $92^{0}50'$ E longitude and encompass an area of 22,429 sq. km (Anonymous 2005). It is bordered by Assam state in the North, East and north-west and by Bangladesh in the South and south-west. Geologically, Meghalaya mostly consists of a stable structural block called the Shillong Plateau, hills of which rise to a maximum height of 1950 m. A sedimentary sequence called Jaintia Group which is a mixture of limestone, sandstone and coal lies South to Shillong Plateau (Tringham 2012). The state receives high annual precipitation with an average of 2689 mm in western Meghalaya and 7196 mm in the central and western Meghalaya (Haridarshan and Rao 1985). Due to high rainfall, the acidic rainwater absorbed in the ground react with the limestone and dissolves them. Ultimately, it creates an extensive network of underground drainage system, including caves, some of which run into several kilometres. Caves are developed intermittently along the whole limestone belt of the state and also in sandstone and quartzites areas of southern Meghalaya (Tringham 2012).The state has a recorded forest cover of 78.74% of the total geographic area of which 45.20% consists of very dense and moderately dense forest (FSI 2013). The vegetation in the state can be grouped into tropical forest, tropical evergreen forest, tropical semi-evergreen forest, tropical moist and dry deciduous forest, grasslands and savannas, subtropical pine forest and temperate forest (Haridarshan and Rao 1985).

15.2 Methods

The present account is a review of the published information on bat fauna of the state. Besides the published results, online collection database of museums abroad especially that of Field Museum of Natural History, Chicago, which houses a considerable collection of bat specimens from Meghalaya is also utilized for retrieving distributional information. This is supplemented by recent field surveys in Meghalaya state (2011–2018) and examination of voucher collections deposited at Zoological Survey of India, Shillong (ZSIS). A total of 511 specimens belonging to 31 species of bats from Meghalaya at ZSIS were examined and data incorporated in the present report. Recent bat surveys in the states were mostly conducted in the cave systems of Jaintia Hills area. Specimens were captured using mist nets and two bank harp traps. For most species where their identity could definitely be established in the field, individuals were released after morphological measurements and photographic documentation (mentioned here as *pers. obs.*). In case of doubtful species identification, few vouchers were taken and preserved in alcohol for further taxonomic studies.

15.3 Results and Discussion

15.3.1 Bat Diversity of Meghalaya

The latest account on the bat fauna of Meghalaya comprises 60 species belonging to seven families (Ruedi et al. 2012b). Some of the species in the inventory like *Murina jaintiana* and *M. pluvialis* have recently been described (Ruedi et al. 2012a), while a few others like *Rhinolophus siamensis*, *Miniopterus magnater* and *Kerivoula kachinensis* were newly reported from the state. This clearly underlines the scope for a much enhanced inventory with intensive field studies and robust analysis. Sinha (1995) reported *Pipistrellus* (=*Scotozous*) *dormeri* from Meghalaya following which it has been included in Ruedi et al. 2012b. This record was based on a partly damaged male specimen collected from Shillong (ZSIS Regn.No.V/M/ERS/270). However, examination of teeth (e.g. two upper bicuspidate incisors, myotodont lower molars) and external characters (e.g. relatively large and angular ears with elongated tragus, forearm 33.6 mm) of this specimen on which Sinha's record was based revealed that it does not belong to *S. dormeri* but most probably represents another poorly known species, *Hypsugo cadornae*. *Scotozous dormeri* has therefore been excluded from the present report. Likewise, the doubtful record of *Hipposideros ater* from Cherrapunji in Kurup (1968) has also been omitted from the current inventory. Based on differences in echolocation call frequency and genetic divergence, Thabah et al. (2006) reported the existence of two cryptic taxa in the *Hipposideros larvatus* species complex in Meghalaya. They referred them as *H. khasiana* and *H. grandis*, respectively, but in the absence of designated type material, the former must be considered as a *nomen nudum* while the taxonomic position of the second is still debated. Before these two species are formally recognized, they are omitted in the present account and are included in the *H. larvatus* species complex. In view of recent taxonomic revisions and delineation of species boundaries, two species from earlier accounts, namely, *Plecotus auritus* (confined to Europe, Spizenberger et al. 2006) and *Barbastella leucomelas* (distributed in Western Asia, Benda et al. 2008), have been substituted with *P. homochrous* and *B. darjelingensis*, respectively. Similarly, all records of *Miniopterus schreibersii* from the Oriental region are based on a previous taxonomic concept considering that this species is polytypic and widespread across the Old World (Simmons 2005). As *schreibersii* is now clearly restricted to the Western Palaearctic region, populations of large *Miniopterus* from India should either be assigned to *M. magnater* or to *M. fuliginosus* (see, e.g. Appleton et al. 2004; Kruskop et al. 2012). For instance, based on measurements of specimens in ZSIS (e.g. mean forearm length 50.4 mm and mean skull length 16.6 mm), all reported specimens from Siju cave (Sinha 1999a) indeed represent *Miniopterus magnater*. Our own field observations also confirmed the widespread occurrence of *M. magnater* in the caves of Jaintia and Khasi Hills. The slightly smaller *M. fuliginosus* is also likely to be present in the region, although yet to be formally identified. During field surveys conducted in February 2015, we recorded the presence of another, much smaller species of *Miniopterus* at Umlyngsha village in Jaintia hills. Owing to its distinctly small forearm (43.0 mm) and delicate dentition, we assign this adult female specimen to *M. pusillus* and are thus reported here for the first time from the state. A few interesting pipistrelles were also captured in the same area including the uncommon *Pipistrellus ceylonicus* (adult female, forearm length 34.9 mm) and *P.* cf. *paterculus* (five individuals, mean forearm length 33.26 mm) which represent first mention of these species in Meghalaya state.

Our ongoing field surveys further revealed the presence of the greater bamboo bat *Tylonycteris robustula* in small bamboo groves near the village of Kharkhana in East Jaintia Hills. This species represents another addition to the chiropteran fauna of the state. Formerly, *T. robustula* was restricted to the eastern most parts of the Indian subcontinent (Bates and Harrison 1997). A recent taxonomic revision of genus *Tylonycteris* further shows that *T. robustula* is a species complex and the continental representative (including northeastern India) are referrable to the species *T. malayana* (Tu et al. 2017). A few significant recent bat records from the state include a very poorly known vespertilionid, the Joffre's Pipistrelle *Hypsugo joffrei*. Previously known only by a few specimens from Myanmar and Vietnam, it has been found to occur in Shillong, and thus represents an addition to the bat fauna of India (Saikia et al. 2017). Besides this, the Szechwan Myotis *Myotis altarium* previously known from southeastern China and northern Taniland has also been reported from Cave Khung in East Jaintia Hills and Cave Arwah in East Khasi Hills districts of Meghalaya which also constitutes the newest addition to the bat fauna of India (Thong et al. 2018).

Recent winter surveys of bats in the Jaintia Hills further evidenced the presence of two uncommon species of Pteropodidae, *Megaerops niphanae* and *Macroglossus sobrinus* in Meghalaya. The former is being reported for the first time in Meghalaya, whereas the latter was known so far by only a single record from Umkiang, East Jaintia Hills (Das et al. 1995). Both of these species were recorded during the February 2011, 2013 and 2014 surveys in secondary forests with banana plantations near the villages of Kharkhana, Tangsen, Khahnar in East Jaintia Hills. Bats of the genus *Cynopterus* were also common in these secondary forest habitats, but their taxonomy in northeastern India is still uncertain (Chattopadhya et al. 2016). Besides the common *C. sphinx* and the rarer *C. brachyotis*, a further unnamed lineage may exist in Meghalaya. We indeed observed several individuals with morphological character combination that are not typical of either of these species, i.e. a large body size, ears without any pale borders, but further genetic comparisons are necessary before this new lineage can be reported on the species list. Thus, the following account (Table 15.1; Plate 15.1) provides an updated list of 65 species of bats in eight families known from Meghalaya along with distributional information.

Table 15.1 List of bat species authentically recorded from Meghalaya with distributional localities in the state

Sl. no.	Family	Species	Locality records	IUCN status 2014
1	Pteropodidae	*Pteropus giganteus* (Brunnich, 1782) (Indian flying fox)	Shillong, Mawphlang, Mawryngkneng EKH; Nongpoh, RB; Tura, WGH (AMNH M27627; FMNH 85045 and 75,886; *pers. obs.*)	LC
2		*Cynopterus brachyotis* (Muller, 1883) Lesser short-nosed fruit bat	Umlyngsha, EJH; No exact locality, WGH (Sinha, 1999b, *pers. obs.*)	LC
3		*Cynopterus sphinx* (Vahl, 1797) Greater short-nosed fruit bat	Kherapara, Sibbari, Tura, WGH; Williamnagar, Darugiri, Rongrengiri, Songsak, EGH; Baghmara, Siju cave, SGH; Umkiang, Umlyngsha, Khahnar, Kharkhana, Lama, EJH; Majai, Cherrapunji, Mawryngkneng, EKH; Amarsang, WKH (Das et al. 1995; Thabah, 2006; FMNH 75904; ZSIS 202–216, 447, 9422–9426; *pers. obs.*)	LC
4		*Eonycteris spelaea* (Dobson, 1871) Dawn bat	Siju cave, SGH; Lailad Forest, Cherrapunji, EKH and around Lakadong, Umkiang, Kharkhana, Lama, EJH (Das et al. 1995; Thabah, 2006; FMNH 75889–75,898; Ruedi et al. 2014; ZSIS 9252, 9253, 9582–9513, 9599–9618)	LC
5		*Rousettus leschenaultii* (Desmarest, 1820) Leschenaults' rousette	Darugiri, Songsak, Williamnagar, Mahesh Khola, EGH; Siju cave, SGH; Lailad, Sumer, Pahamshken, RB and Umkiang, Kharkhana, EJH (Das et al., 1995; Thabah, 2006; ZSIS 1–83, 9619–9651, 9702–9709; *pers. obs.*)	LC
6		*Macroglossus sobrinus* (Andersen, 1911) Greater long-tongued fruit bat	Phlang Karu Cave, EKH; Tangsen, Kharkhana, Umkiang, Shnongrim, EJH (ZSIS395; Das et al., 1995; *pers. obs.*)	LC
7		*Megaerops niphanae* Yenbutra & Felten, 1983 Northern tailless fruit bat	Kyrshai, WKH; Khahnar, Kharkhana, EJH (ZSIS455; *pers. obs.*)	LC

(continued)

Table 15.1 (continued)

Sl. no.	Family	Species	Locality records	IUCN status 2014
8	Rhinolophidae	*Rhinolophus affinis* (Horsfield, 1851) Intermediate horseshoe bat	Krem Arwah in Sohra, Krem Mawsyrwait, Mawphlang, Mawsmai cave, Cherrapunji, Laitkynsew, Umnuih Tamar, EKH; Khongsnong, Shangpung, WJH; Krem Bylliat, Krem Labit Kseh, Krem Umlawan, EJH (Ruedi et al., 2012b; Thabah, 2006; Das et al., 1995; Sinha, 1999b; ZSIS 320, 321, 322, 356, 364)	LC
9		*Rhinolophus lepidus* Blyth, 1844 Blyth's horseshoe bat	Krem Arwah, EKH; Khandong dam site, Shnongpdeng, WJH; Syndai, Khonshnong, Shangpung, Krem Khung, EJH; "South Garo Hills"; Amarsang, WKH (Das et al. 1995; Ruedi et al., 2012b; Hinton and Lindsay, 1926; ZSIS 9589, 375, 376, 449)	LC
10		*Rhinolophus luctus* (Temminck, 1835) Great woolly horseshoe bat	Mawphlang, Mawryngkneng, EKH; Nongnah, WKH Khonshnong, WJH; Krem Labit Mynlin, Krem Lymke, Saipung, Pynurkba, Kharkhana, Umlatdoh, Krem Lymbait, Krem Sahiong I, EJH (FMNH 76016,85,046; ZSIS 306; Ruedi et al., 2012b; Thabah, 2006; *pers. obs.*)	LC
11		*Rhinolophus macrotis* (Blyth, 1844) Big-eared horseshoe bat	Krem Arwah, Krem Madury, Mawsmai cave, Shella, Cherrapunji, Laitkynsew, EKH; Phut-jaut, WKH; Kharkhana, Umlyngsha, EJH (ZSIS 294, 295, 374; Lal, 1977; Ruedi et al., 2012a; Thabah, 2006).	LC
12		*Rhinolophus pearsonii* (Horsfield, 1851) Pearson's horseshoe bat	Khonshnong, Shangpung, WJH; Shnongrim, Krem Labit Mynlin, Krem Lumjingtep, Krem Lymke, Krem Khung, Krem Lymbait, Krem Sahiong I, Lakadong, Kharkhana, Tangsen, Umlyngsha, EJH; "Garo Hills", Umtong near Mawkynrew, Mawsmai cave, Cherrapunji, Laitkynsew, Krem Mawsyrwait, Shella; EKH; Krem Pam Skey in Mawlongbna, Krem Tylong Kobah, Krem Puri, Krem Mawphun, Krem Lum Shken, Krem Lew Long, WKH; (ZSIS 296, 332, 357; Ruedi et al., 2012a,b; Thabah, 2006; Das et al., 1995; FMNH 75968, 75969)	LC

(continued)

Table 15.1 (continued)

Sl. no.	Family	Species	Locality records	IUCN status 2014
13		*Rhinolophus pusillus* (Temminck, 1834) Least horseshoe bat	Shillong, Krem Pam Skey near Mawlongbna, EKH; Siju cave, Khulbolmagri, SGH; Cherrapunji, Mawshamok, Sohbar, Majai, EKH and Shangpung, Krem Lymbit, WJH; Krem Shalong, Krem Bylliat, Krem Umadoh in Lumshnong, Khanhar, Krem Poh Lakhar, EJH (Bates and Harrison, 1997; Sinha, 1999a; Breitenbach et al., 2010; Ruedi et al., 2012b; ZSIS 339, 340, 377; *pers. obs.*)	LC
14		*Rhinolophus siamensis* (Gyldenstolpe, 1917) Thai horseshoe bat	Krem Labit Kseh, Krem Bylliat, Krem Dieng Jem, Krem Khung, EJH (Ruedi et al. 2012b)	LC
15		*Rhinolophus sinicus* (Anderson, 1905) Chinese horseshoe bat	Cherrapunji, Mawphlang, Shella, EKH; Krem Khleishnong in Lumshnong, EJH (FMNH 76021–76,026; Ruedi et al., 2012b, ZSIS 341)	LC
16		*Rhinolophus subbadius* (Blyth, 1844) Little Nepalese horseshoe bat	"Garo Hills"; Siju cave, SGH; Cherrapunji, Mawphlang, EKH (Bates and Harrison, 1997; Dobson, 1872 as *R. garoensis*; Sinha, 1999a; Thabah, 2006; FMNH 76017,76,018*)*	LC
17	Hipposideridae	*Coelops frithii* (Blyth, 1848) Tailless leaf-nosed bat	Cherrapunji, EKH and Nongnah, WKH (Hinton and Lindsay, 1926; Thabah, 2006)	LC
18		*Hipposideros armiger* (Hodgson, 1835) Great Himalayan leaf-nosed bat	Lawbah, WKH; Cherrapunji, Sohbar, Shella, Shillong, EKH; Khulbolmagri, Siju cave, Durabanda, SGH; Khonshnong, Shangpung, WJH; Khaddum cave, Krem Labit Kseh, Vatesuandung Bakhur (near Saipung), Krem Pedenglapiang, Krem Lakhon, Piel Klieng Pouk, EJH (Das et al., 1995; Ruedi et al., 2012b; Thabah, 2006; FMNH 75941; ZSIS 2562, 369; *pers. obs.*)	LC

(continued)

Table 15.1 (continued)

Sl. no.	Family	Species	Locality records	IUCN status 2014
19		*Hipposideros cineraceus* (Blyth, 1853)	Cherrapunji, EKH; Shangpung, WJH; Krem Labit Lumshnong, Krem Bylliat, Kharkhana, EJH; Stage III dam site, RB (FMNH 75976; Das et al., 1995; Ruedi et al., 2012b; Bates and Harrison, 1997; ZSIS 342,361)	LC
20		*Hipposideros lankadiva* (Kelaart, 1850) Indian leaf-nosed bat	Cherrapunji, Laitkynsew, Shella, Shella, Sohbar, Nongthymmai, Prahng Karuh cave, EKH; Nongpoh, Stage III dam site, RB; Krem Labit Kseh, Krem Dieng Jem, Krem Khleishnong in Lumshnong, Krem Lakhon, Piel Klieng Pouk, Shnongrim, Khaddum, EJH; Siju cave, Chokpot, Rongmachok, SGH; (Das et al., 1995; Bates and Harrison, 1997; Molur et al., 2002; Ruedi et al., 2012a; Thabah, 2006; ZSIS 9481, 104–151, 217–224, 358,359,360; *pers. obs.*)	LC
21		*Hipposideros larvatus s.l.* (Horsfield, 1823) Horsfield's leaf-nosed bat	Tura, WGH; Cherrapunji, Laitkynsew, Shella, Nongtrai, Sohbar EKH, Lawbah, WKH; Umlatdoh, Thangsah, Krem Labit Mynlim, Krem Pdiem Dharei, Krem Dieng Jem, Shnongrim, EJH (Das et al., 1995; Ruedi et al., 2012b, Ruedi et al. 2014; FMNH 75910, 75,913 and ZSIS 297,305)	LC
22		*Hipposideros pomona* (K. Anderson, 1918) Anderson's leaf-nosed bat	Shillong, Cherrapunji, Laitkynsew, Mawryngkneng, EKH; Stage III dam site, RB; Krem Umadoh, Krem Labit, Krem Hartali, Lama, Lumshnong, Kharkhana, Umlyngsha, EJH and Durabanda, SGH (FMNH 75944–75,953,75,971–75,995 as *H. fulvus*; ZSIS 343–348, 355, 362,363,372,373; Hinton and Lindsay, 1926; Das et al., 1995)	LC
23	Megadermatidae	*Megaderma lyra* (E.Geoffroy, 1810) Greater false vampire	Kherapara,WGH; Nongpoh, RB; Sohbar, EKH; Krem Hartali, Kharkhana, EJH (DAS et al., 1995; Ruedi et al., 2012b; *pers. obs.*)	LC
24		*Megaderma spasma* (Linnaeus, 1758) Lesser false vampire	Nongkhyllem wildlife sanctuary, RB; no exact locality, EKH (ZSIS 366, 367; Ruedi et al., 2012b)	LC

(continued)

Table 15.1 (continued)

Sl. no.	Family	Species	Locality records	IUCN status 2014
25	Emballonuridae	*Saccolaimus saccolaimus* (Temminck, 1838) Bare-rumped sheathtail bat	Phulbari, WGH (FMNH 76058)	LC
26		*Taphozous melanopogon* Temminck Black-bearded tomb bat	Krem Rongdangngai Mondil, WKH (Gebauer, 2011; Specimen in Bonn Museum, Alexander Konig *pers. comm.*)	
27	Molossidae	*Otomops wroughtoni* (Thomas, 1913) Wroughton's free-tail bat	Pynurkba, Umlatdoh, Thangsah, EJH and Nongtrai village, EKH (Thabah and Bates, 2002; Ruedi et al., 2014)	DD
28		*Chaerephon plicatus* (Buchanan, 1800) Wrinkle-lipped bat	Tura, WGH; Cherrapunji, EKH (FMNH 76059; Blyth, 1852)	LC
29	Vespertilionidae	*Arielulus circumdatus* (Temminck, 1840) Black-gilded pipistrelle	Shillong, EKH (Das et al., 1995; ZSIS 9562)	LC
30		*Eptesicus pachyotis* (Dobson, 1871) Thick-eared bat	"Khasi Hills" (*Vesperugo pachyotis* in Donson, 1871)	LC
31		*Scotomanes ornatus* (Blyth, 1851) Harlequin bat	Jowai, Khonshnong, WJH; Darugiri, EGH and Cherrapunji, EKH (Blyth, 1851; Hinton and Lindsay, 1926; Bates and Harrison, 1997)	LC
32		*Scotophilus heathii* (Horsfield, 1831) Asiatic greater yellow house bat	Tura, WGH; no exact locality, Sohbar, EKH (Das et al. 1995; Ruedi et al., 2012b; *pers. obs.*)	LC
33		*Scotophilus kuhlii* (Leach, 1821) Lesser Asiatic yellow house bat	"Garo Hills" (Hinton and Lindsay,1926)	LC

(continued)

Table 15.1 (continued)

Sl. no.	Family	Species	Locality records	IUCN status 2014
34		*Pipistrellus coromandra* (Gray, 1838) Coromandel pipistrelle	Sonapur, Kharkhana, Khahnar village, EJH; Khonshnong, WJH; Cherrapunji, EKH; Nongpoh, RB and "Garo Hills" (Hinton and Lindsay, 1926; Sinha, 1999b; FMNH 76095,76,097; ZSIS 333–336, 9579)	LC
35		*Pipistrellus javanicus* (Gray, 1838) Javan pipistrelle	"Khasi Hills" (Sinha, 1999b as *Pipistrellus babu*)	LC
36		*Pipistrellus kuhlii* (Kuhl, 1817) Kuhl's pipistrelle	Cherrapunji, EKH (Kurup, 1968)	LC
37		*Pipistrellus mimus* Wroughton, 1899 Least Pipistrelle	Laitkynsew, EKH; Phulbari, WGH (Hinton and Lindsay, 1926; Das et al., 1995; ZSIS 9560)	LC
38		*Pipistrellus ceylonicus* (Kelaart, 1852) Kelaart's pipistrelle	Umlyngsha, EJH (ZSIS 350)	LC
39		*Pipistrellus* cf. *paterculus* Thomas, 1915 Mount Popa pipistrelle	Umlyngsha, EJH (*pers. obs.*)	LC
40		*Hypsugo joffrei* (Thomas, 1915) Joffre's pipistrelle	Shillong, EKH (Saikia et al. 2017; ZSIS 292)	DD
41		*Hypsugo savii* (Bonaparte, 1837) Savi's pipistrelle	Cherrapunji, EKH (Dobson, 1871 as *Pipistrellus austenianus*)	LC
42		*Barbastella darjelingensis* Hodgson, 1855 Eastern barbastelle	Shillong, EKH; "Khasi Hills"; "Jaintia Hills" (Dobson, 1876, Hinton and Lindsay, 1926; ZSIS 293)	LC

(continued)

Table 15.1 (continued)

Sl. no.	Family	Species	Locality records	IUCN status 2014
43		*Plecotus homochrous* Hodgson, 1747 Common name not designated	"Khasi Hills" (Dobson, 1876)	LC
44		*Ia io* (Thomas, 1902) Great evening bat	Cherrapunji, Phrang Karuh cave, Krem Ramong, Syllang village, Krem Mawphun EKH; Krem Rongdangngai Mondil, WKH; Krem Labit Mynlin, Krem Khleishnong, Krem Shalong, EJH (Topal, 1970; Gebauer, 2011; Ruedi et al., 2012b, Thabah, 2006; *pers. obs.*)	LC
45		*Tylonycteris fulvida* (Blyth, 1859) Club-footed bat	Kherapara, WGH; Cherrapunji, EKH (Das et al., 1995; FMNH 76085)	LC
46		*Tylonycteris malayana* Chasen, 1940 Greater bamboo bat	Kharkhana, EJH (*pers. obs.*)	LC
47		*Myotis formosus* (Hodgson, 1835) Hodgson's bat	Mawphlang, Cherrapunji, EKH (Dobson, 1876; FMNH 85057)	LC
48		*Myotis horsfieldii* (Temminck, 1840) Horsfield's Myotis	Khonshnong, WJH (Das et al., 1995)	LC
49		*Myotis laniger* (Peters, 1871) Chinese water myotis	Mamosmai cave, (possibly Mawsmai), EKH (Topal, 1974; specimen in HNHM, G. Csorba *pers.comm.*)	LC
50		*Myotis longipes* (Dobson, 1873) Kashmir cave bat	Siju cave, SGH; Krem Shallong, Krem Labit Kseh, Krem Bylliat, Umkyrpong, EJH; Mawsmai cave, EKH; Lawbah, WKH (Sinha, 1994, 1999a; Ruedi et al., 2012a, b; ZSIS 263–269, 370, 371)	LC
51		*Myotis pilosus* (Peters, 1869) Rickett's big-footed myotis	Phrang Karuh cave, EKH (*Myotis ricketti* in Ruedi et al., 2012b; Thabah, 2006; ZSIS 354)	NT

(continued)

Table 15.1 (continued)

Sl. no.	Family	Species	Locality records	IUCN status 2014
52		*Myotis muricola* (Gray, 1846) Nepalese whiskered bat	Khonshnong, WJH; Krem Lum Shken, EKH (Kurup, 1968 as *M. mystacinus caliginosus*; Ruedi et al., 2012b)	LC
53		*Myotis siligorensis* (Horsfield, 1855) Himalayan whiskered bat	Krem Hartali, EJH; Khonshnong, WJH; Malki Forest, Shillong, EKH; Amarsang, WKH (Hinton and Lindsay, 1926; ZSIS 380, 397, 436, 437; *pers. obs.)*	LC
54		*Myotis altarium* Thomas, 1911 Szechwan Myotis	Krem Arwah, EKH; Krem Khung, EJH (Thong et al, 2018; ZSIS401)	LC
55		*Miniopterus magnater* Sanborn, 1931 Western bent-winged bat	Siju cave, SGH; Krem Labit Shnongrim; Krem Labit Kseh, Krem Lymbait, Syndai, Umlyngsha, EJH; Phrang Karuh cave in Shella EKH; Lawbah, WKH; Stage IV dam site, RB. (Sinha, 1999a as *M. schreibersii*; Ruedi et al., 2012b; ZSIS 298–304; 351,352; *pers. obs.*)	LC
56		*Miniopterus pusillus* Dobson, 1876 Lesser bent-winged bat	Umlyngsha, EJH (*pers. obs.*)	LC
57		*Harpiocephalus harpia* (Temminck, 1840) Lesser hairy-winged bat	Cherrapunji, Mawphlang, EKH (FMNH 76042–76,051; Das et al., 1995 as *H. mordax*)	LC
58		*Murina aurata* (Milne-Edwards, 1872) Little tube-nosed bat	Mawphlang, EKH (Bates and Harrison, 1997; UMMZ 112549)	LC
59		*Murina cyclotis* (Dobson, 1872) Round-eared tube-nosed bat	Khonshnong, WJH, Forest near Krem Labit Kseh, Krem Hartali, Khahnar, EJH; Cherrapunji, Mawphlang, Mawryngkneng, Shillong, EKH (Hinton and Lindsay, 1926; FMNH 76080, 76,085; Bates and Harrison, 1997; Das et al., 1995; Thabah, 2006; Ruedi et al., 2012b; ZSIS444)	LC

(continued)

Table 15.1 (continued)

Sl. no.	Family	Species	Locality records	IUCN status 2014
60		*Murina huttoni* (Peters, 1872) Hutton's tube-nosed bat	Shillong, EKH; Khahnar Village, EJH (Sinha, 1999b; *pers. obs.*)	LC
61		*Murina tubinaris* (Scully, 1881) Scully's tube-nosed bat	Mawphlang, Mawryngkneng, EKH; Shangpung, WJH (Hinton and Lindsay, 1926; Bates and Harrison, 1997; FMNH 76054)	LC
62		*Murina jaintiana* Ruedi et al. 2012 Jaintia tube-nosed bat	Forest near Krem Bylliat, EJH; Laitkynsew, EKH (Ruedi et al., 2012a, b)	NA
63		*Murina pluvialis* Ruedi et al. 2012 Rainy forest tube-nosed bat	Laitkynsew, Mawphlang, Mawryngkneng, Shillong, EKH; Tangsen near Krem Lanshat, EJH (FMNH 76062–76,079; ZSIS 323, 353; Ruedi et al., 2012a, b)	NA
64		*Kerivoula hardwickii* (Horsfield, 1824) Common woolly bat	Siju cave, SGH; Khonshnong, Shangpung, WJH (Das et al., 1995; FMNH 82777,82,778)	LC
65		*Kerivoula kachinensis* Bates et al. 2004 Kachin woolly bat	Laitkynsew, EKH; Sakwa, EJH (Ruedi et al., 2012a; ZSIS454)	LC

Online database of respective museums abroad have been the source of specimen numbers mentioned in the list

The scientific names follow Talmale and Pradhan 2009; Benda et al. 2008; Benda and Mlikovsky 2008; and Spitzenberger et al. 2006, and the common names are derived from IUCN red list of species. Krem indicate cave in local dialect

15.3.2 Threats to the Bat Fauna of Meghalaya

The state of Meghalaya has huge reserves of mineral resources including an estimated 15,100 million tons of limestone and 576 million tons of coal (DMR 2015). While planned utilization of these resources can usher in economic prosperity for the state, unrestrained exploitation of the same for long periods has left indelible environmental footprint. The areas with extensive cave systems (which also support large populations of bats and other cavernicoles) harbour most of these mineral deposits and thus bring two sets of competing interest into close proximity and the

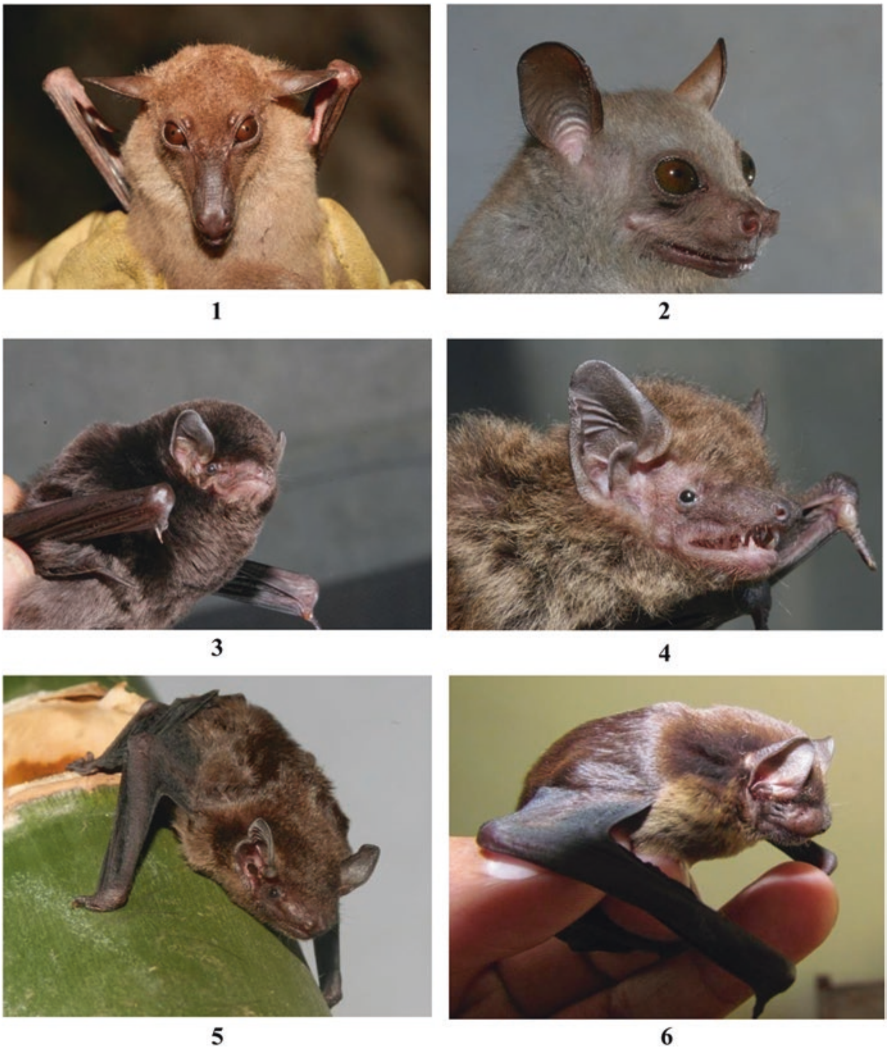

Plate 15.1 Portraits of rare or newly recorded bat species from Meghalaya. *1 Macroglossus sobrinus*, *2 Megaerops niphanae*, *3 Miniopterus pusillus*, *4 Pipistrellus ceylonicus*, *5 Tylonycteris malayana*, *6 Hypsugo joffrei*

resultant conflict. Mining in the state is often done using primitive sub-surface mining method without any environmental safeguards and post-mining treatment of mined areas which render the fragile ecosystems more vulnerable to environmental degradation (Tiwari 1996). To make the matters worse, the state government does not have much control over the land and resources of sixth scheduled areas, and mining in the unorganized sector is largely unregulated (Anonymous 2005).This is especially evident in Jaintia Hills region where unregulated coal mining has caused extensive deforestation and pollution of terrestrial and aquatic habitat and destruction of cave environment (Swer and Singh 2003). The Krem Lait Prah-Um-Im Labit cave system in Jaintia Hills recognized as the longest cave system in India is being threatened by indiscriminate coal mining in the nearby areas (Nayak and Bhattacharyya 2008). Also, there is high possibility of tectonic activities accentuated by surface mining resulting caving in of cave roof and annihilating the entire cavernicolous biodiversity. It is likely that cave Mawmluh in Cherrapunji will be destroyed in the near future because of longtime limestone mining by the adjacent cement factory (Biswas 2009; Daly 2013). There have been newspaper reports that illegal mining in the nearby areas is threatening the rich biodiversity of Siju cave in South Garo Hills, one of the most well-known bat caves in India. The biodiversity of Garo Hills region which is one of the last remaining strongholds of tropical forests of the Indo-Myanmar biodiversity hotspot is in great danger especially from conversion of forest land for road construction, farming, mining, etc. (Bera et al. 2006; Kunte et al. 2012). Undoubtedly, the bat fauna of the region especially the forest-dependent species are facing serious threat to their survival.

Widespread consumption of bat as bush meat poses another grave risk for the survival of bat populations of the state. While use of bat meat for purported medicinal value is prevalent among many communities in the North-East India (Hilaluddin and Ghose 2005), this practice is found to be particularly common in many rural areas of Meghalaya where bat meat is also consumed by the village people as a supplementary source of protein (Ruedi et al. 2012b; *pers. obs.*). During visits to Shnongrim, Piel Klieng Pouk and adjacent areas of East Jaintia Hills District, the authors could observe regular bat trappings by locally improvised techniques in many of the accessible caves. Enquiry with the hunters revealed that a skilled person can easily catch 50–60 bats in one night and the numbers sometimes going over 100 per night. Because of comparatively low rate of fecundity in bats, such overharvesting is certainly not sustainable. Larger species like *Hipposideros lankadiva*, *H. armiger*, etc. are preferred catch although smaller and even smelly species like *Miniopterus magnater* are also consumed. While most of these harvesting are for personal consumption, bat meat reportedly fetch over Rs. 500 per kg in the local market. Knowledgeable sources reported overharvesting and noticeable decline in bat population over the years especially in the well-known bat caves like Krem Labit at Shnongrim in East Jaintia Hills. Bat colonies have reportedly retreated to inaccessible cliffs and caverns in recent times which can be attributed to the severe hunting pressure.

15.3.3 Karst System of Meghalaya as a Priority Area for Bat Conservation

The Shillong Plateau is one of the most tectonically active and wet regions of the world and hosts the richest type of karst phenomena in India (Prokop 2014). Because of high elevation and heavy precipitation, these karstic regions exhibit extensive underground network of caves and drainage channels. They provide unlimited roosting opportunities for a large number of bat species. In karstic regions, most species of bats rely completely on caves as roosting sites (Rodriguez-Duran 1998). Bats are known from most of the caves in Meghalaya (Harris et al. 2008), and some caves harbour dense bat colonies containing thousands of individuals and also a number of poorly known species (Ruedi et al. 2012b, 2014). A majority of bat species in Meghalaya are known to roost in caves and therefore are dependent on caves for survival (Table 15.2). Although locally abundant, a few of these cave-dwelling species like *Otomops wroughtoni*, *Ia io*, etc. are rare or unknown in other parts of the Indian subcontinent (Bates and Harrison 1997) and deserve priority conservation attention. Disturbance and destruction of day roost sites is a major factor in bat population declines (Kunz 1982). Thus, protection of these underground roosting sites constitutes a key conservation strategy for bat fauna of the state. Unfortunately, most of the known caves and their resources in Meghalaya are in peril by unregulated mining activities and other forms of human pressure. In the absence of any legal framework for protection of bats and also their habitat, conservation of the bat fauna presents considerable challenges. The priority lies in detailed documentation of the bat caves and assessment of various forms of pressure on them. Based on these inputs, a scientific cave management plan involving the local communities can be evolved. Sustained efforts on the part of conservation organizations and the scientific communities can make a significant difference. It is high time for everybody to appreciate the gravity of the situation and do whatever it takes to protect this priceless natural heritage.

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Table 15.2 Cave roosting bat species of Meghalaya

Sl. no	Name of the species
1	*Eonycteris spelaea* (Dobson, 1871)[a]
2	*Rousettus leschenaultii* (Desmarest, 1820)[a]
3	*Rhinolophus affinis* (Horsfield, 1851)[a]
4	*Rhinolophus lepidus* (Blyth, 1844)[a]
5	*Rhinolophus luctus* (Temminck, 1835)[a]
6	*Rhinolophus macrotis* (Blyth, 1844)[a]
7	*Rhinolophus pearsonii* (Horsfield, 1851)[a]
8	*Rhinolophus pusillus* (Temminck, 1834)[a]
9	*Rhinolophus siamensis* (Gyldenstolpe, 1917)[a]
10	*Rhinolophus sinicus* (Anderson, 1905)[a]
11	*Rhinolophus subbadius* (Blyth, 1844)[a]
12	*Coelops frithii* (Blyth, 1848)[a]
13	*Hipposideros armiger* (Hodgson, 1835)[a]
14	*Hipposideros cineraceus* (Blyth, 1853)[a]
15	*Hipposideros lankadiva* (Kelaart, 1850)[a]
16	*Hipposideros larvatus* (Horsfield, 1823)[a]
17	*Hipposideros pomona* (K.Anderson, 1918)[a]
18	*Megaderma lyra* (E.Geoffroy, 1810)
19	*Megaderma spasma* (Linnaeus, 1758)
20	*Taphozous melanopogon* Temminck
21	*Otomops wroughtoni* (Thomas, 1913)[a]
22	*Chaerephon plicatus* (Buchanan, 1800)
23	*Ia io* (Thomas, 1902)[a]
24	*Scotomanes ornatus* (Blyth, 1851)
25	*Barbastella darjelingensis* (Hodgson, 1855)
26	*Plecotus homochrous* Hodgson, 1847
27	*Myotis formosus* (Hodgson, 1835)
28	*Myotis horsfieldii* (Temminck, 1840)
29	*Myotis laniger* (Peters, 1871)[a]
30	*Myotis longipes* (Dobson, 1873)[a]
31	*Myotis muricola* (Gray, 1846)
32	*Myotis siligorensis* (Horsfield, 1855)
33	*Myotis altarium* Thomas, 1911[a]
34	*Scotophilus kuhlii* (Leach, 1821)
35	*Miniopterus magnater* Sanborn, 1931[a]

The names with [a] indicate primarily cave roosting bat species. Species list is based on published data from the state as well as available habitat information on the species from elsewhere

Annexure: Geographic Gazetteer of the Localities Mentioned in the Text

Locality	Co-ordinates
Baghmara	25.1935N, 90.6346E
Chokpot	25.3187N, 90.4408E
Cherrapunji	25.2717N, 91.7308E
Darugiri	c25.6333N, 90.75E
Durabanda	25.4752N, 90.3244E
Jowai	25.4509N, 92.2089E
Khahnar	25.2200N, 92.3706E
Kharkhana	25.1588N, 91.1919E
Kherapara	c25.4666N, 92.2166E
Khulbolmagri	Not located
Krem Arwah	25.2717N, 91.7308E
Krem Pamskei in Lawbah	25.2359N, 91.5577E
Krem Mawsyrwait	25.2544N, 91.6558E
Krem Bylliat	25.4283N, 92.6016E
Krem Ramong	25.1228N, 91.3010E
Krem Tylong Kobah	25.1518N, 91.3524E
Krem Puri	25.15N, 91.33E
Krem Mawphun	25.1535N, 91.3357E
Krem Piel Klieng Pouk	25.1025N, 92.2650N
Krem Madury	25.1632N, 91.3324E
Krem Lum Shken	25.1616N, 91.3115E
Krem Lymke	25.22′28N. 92.34′47E
Krem Khung	25.2321N, 92.3448E
Krem Poh Lakhar	25.2304N, 92.3710E
Krem Sahiong I	25.2349N, 92.3723E
Krem Dieng Jem	c.25.4088N, 92.5572E
Krem Labit Shnongrim	25.3508N, 92.5035E
Krem Labit Lumshnong	25.1828N, 92.3768E
Krem Labit Kseh	25.4313N, 92.6016E
Krem Umlawan	25.1688N, 92.3825E
Krem Umadoh	25.1913N, 92.3733E
Krem Umshor	25.1038N, 92.2230E
Krem Khleishnong	25.1808N, 92.3941E
Krem Lymbait	25.1908N, 92.2686E
Krem Lumjingtep	25.2008N, 92.2719E
Krem Pedenglapiang	25.1805N, 92.2013E
Krem Pdiem Dharei	25.1572N, 92.2008E
Krem Hartali	25.1941N, 92.1880E
Krem Labit Mynlin	25.4197N, 92.5877E
Krem Shalong	25.4083N, 92.6113E
Krem Rongdangngai Mondil	25.1236N, 90.0037E
Khongsnong	25.5238N, 92.5016E

(continued)

Locality	Co-ordinates
Khandong dam site	c.25.5030N, 92.6102E
Khaddum cave	25.1708N, 92.5061E
Kyrshai	25.24691N, 92.68384E
Lailad	25.8963N, 91.7684E
Lama	c.25.1591N, 92.2591E
Lakadong	25.5307N, 92.5310E
Laitkynsew	25.2202N, 91.6672E
Lawbah	25.2359N, 91.5577E
Mahesh Khola	c.25.1823N, 90.7925E
Majai	25.1594N, 91.7452E
Mawsmai cave	25.2988N, 91.7086E
Mawphlang	25.4666N, 91.7666E
Mawshamok	25.2271N, 91.7014E
Mawryngkneng	25.5566N, 92.0641E
Nongtrai village	25.2207N, 91.6116E
Nongnah	25.2675N, 91.3240E
Nongpoh	25.8699N, 91.8337E
Pahamshken	25.9301N, 91.9535E
Phrang Karuh cave	25.1874N, 92.3768E
Phulbari	c.25.9N, 90.0333E
Phut-Jaut	25.1928N, 91.3114E
Pynurkba	25.25N, 92.2833E
Rongrengiri	25.8166N, 90.3666E
Rongmachok	c.25.8161N, 90.0997E
Saipung	25.35N, 92.5333E
Sakwa	25.20611N, 92.46191E
Shillong	25.5666N, 91.8833E
Shnongrim	25.3505N, 92.5167E
Siju cave	c.25.3577N, 90.6613E
Sibbari	25.1987N, 90.5547E
Songsak	25.6512N, 90.6074E
Sumer	25.6791N, 91.9069E
Shangpung	25.4813N, 92.3493E
Shnongpdeng	25.2072N, 92.0096E
Syndai	25.1879N, 92.1427E
Stage III dam site	25.7313N, 91.7944E
Stage IV dam site	25.7947N, 91.7783E
Shella	25.1734N, 91.6519E
Shobar	25.1784N, 91.7323E
Sonapur	25.6059N, 92.4348E
Tangsen	25.3316N, 92.5138E
Thangsah	25.1833N, 92.2E
Thlu Shrieh cave	25.1217N, 92.2235E
Tura	25.5166N, 91.2166E
Tangsen near Krem Lanshat	25.3316N, 92.5138E
Umkiang	25.0587N, 92.3826E

(continued)

Locality	Co-ordinates
Umlyngsha	25.2077N, 92.2619E
Umlatdoh	25.2N, 92.2666E
Umkyrpong	25.4284N, 92.5782E
Umnuih Tamar	25.1956N, 91.8310E
Vatesuandung Bakhur	c.25.3047N, 92.7013E
Williamnagar	c.25.5314N, 90.5920E

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Conservation Status of Large Mammals in Chinnar Wildlife Sanctuary, Western Ghats, India

16

Ramoorthy Sasi and Honnavalli N. Kumara

Abstract

We studied large mammals in Chinnar Wildlife Sanctuary of Kerala. Twenty-seven species of large mammals were recorded during the study. As a rain shadow region in Kerala, the vegetation includes dry forest types with good riparian forests and little evergreen forest in upper reaches. This variation in vegetation types supports a wide variety of large mammals; however, the river system and riparian forests are crucial for the persistence of some of the mammal species in the sanctuary including grizzled giant squirrel. Anthropogenic pressure like habitat fragmentation and disturbance is the limiting factor for their abundance. Limiting the anthropogenic pressure with a focus on a different taxonomic group of mammals is recommended as more active conservation.

Keywords

Chinnar · Density · Distribution · Diversity · Mammals

16.1 Introduction

The Western Ghats is a series of hill ranges with a length of about 1600 km from north to south and with an east to west width of 30–80 km, which run parallel to the western coast of southwestern India. The hill system has been classified comprising ecological zones, viz. wet evergreen forests, dry evergreen climax forests and deciduous climax forests (Ramesh 2001). In brief, the forests also can be considered as

R. Sasi
Department of Anthropology, University of Madras, Chennai, Tamil Nadu, India

H. N. Kumara (✉)
Sálim Ali Centre for Ornithology and Natural History, Coimbatore, Tamil Nadu, India
e-mail: honnavallik@sacon.in

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tropical evergreen forests at the western slopes and the ridges and deciduous and scrub forests in rain shadow areas on the eastern slopes of the hills. Western slopes of the Ghats receive high rain fall up to 6000 mm in some of the ridges, where the rainfall drastically decreases from ridge of the Western Ghats to eastern slopes and plains. However, due to high variation in the rain fall across the Ghats, the vegetation also varies from grass hills with mountain shola forest at high elevation zones to dry open scrub at eastern foot hills of the Ghats. High variation in forest type for every few kilometre distance across the Ghats resulted in the high biodiversity. Thus the Western Ghats has been recognized as one of the biodiversity hotspots of the World (Myers et al. 2000); further Western Ghats stands eighth position among the biodiversity hotspots of the world. However, Western Ghats also hold high human density than the other hotspots (Cincotta et al. 2000). Nevertheless, many parts of the Western Ghats retain high biodiversity in spite of high anthropogenic pressure. Large mammals are always been more vulnerable (Madhusudan and Karanth 2002) than many smaller taxon due to their body size. Usually the local hunting is one of the major driving forces for the decline of the large bodied animals apart from many developmental activities and habitat loss due various anthropogenic reasons. Thus the abundance of large mammals can be considered as an indicator of degree of anthropogenic activities. We have carried out a survey of mammals (excluding small rodents and chiropterans) to understand the distribution pattern, selection of forest type and abundance in Chinnar Wildlife Sanctuary that we have discussed in the present paper.

16.2 Study Site

Chinnar Wildlife Sanctuary is located in the rain shadow region of the Western Ghats between 10° 15′ to 10° 22′ N latitude and 77° 05′ to 77° 17′ E longitude and comprising an area of 90.44 km^2 in Devikulam Taluk of Idukki district, Kerala State (Fig. 16.1). The east-flowing Pambar River and its tributaries drain the area. The River Pambar joins Chinnar River at the border of Tamil Nadu and Kerala states. River Pambar and its main tributaries are less seasonal as they originate from the evergreen shola forests at the higher elevation ranges of the Ghats in the southern and western sides of the sanctuary. The sanctuary experiences prolonged hot season and much less rainy days, and the annual rainfall ranges from 500 to 800 mm with a minimum and maximum temperature of 12 °C and 36 °C, respectively. The maximum rainfall occurs only in the upper reaches of the Ghats from where the Pambar River and its major tributaries originate, making them perennial even during the dry season. The vegetation of the sanctuary is highly disturbed due to anthropogenic pressures and is dry, deciduous scrub with xerophytic species dominating with interspersed grasslands (Chandrasekharan 1962 a, b, c; Champion and Seth 1968). The large part of the sanctuary is with scrub forest, which is highly disturbed and also most of the human enclaves are also found in this forest. The north-eastern part of the sanctuary is covered with deciduous forests, where on western part at higher elevation is having smaller grasslands with interspersed evergreen forest. The height

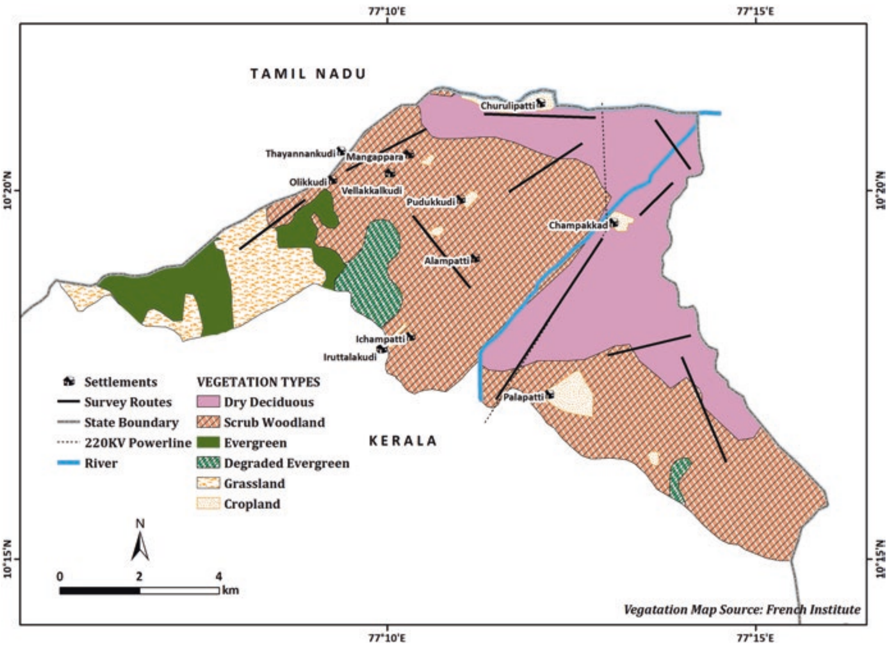

Fig. 16.1 Transect line on vegetation map of the Chinnar Wildlife Sanctuary. (Adapted from Ramesh et al. 1997)

of the scrub forest was between 5.0 and 8.0 m, where the deciduous forest was between 10.0 and 20.0 m. The tall trees (> 20 m up to 30 m) were highly restricted to riparian forest along Chinnar and Pambar Rivers. The riparian forest varied in width from 50 to 80 m.

16.3 Methods

We laid ten transect lines representing all the vegetation types of the sanctuary. The transect length varied between 7.0 and 13.0 km, and a total of 213 km and 144 km of the walk was made during day and night, respectively. The kilometre walked was measured using odometer of the handheld GPS 60. The day walks were made between 06.00 AM and 10.00 AM and 15.00 PM and 18.30 PM. The night walks were made between 20.00 PM and 01.00 AM, at an average speed of 1.5 km/hr. Each transect was walked a minimum of three times and maximum of four times. During the walk, all the sighted animals were recorded with a species name, number of individuals encountered, geo-coordinates and habitat type. During the night, walks were made by flashing the light using handheld three batteries Maglight. Animals were detected based on the reflection of their eyes. Species were differentiated based on the colour of reflection of the light, distance between the eyes and size of the eyes; if some of the species could not be identified, then the animals are approached very close and the species was identified using binocular and flashlight. The data was pooled for each transect from the temporal replication and treated as one sample. Since the total number of detections was less, the encounter rate was calculated as animals detected per kilometre, and the encounter rate of each species was compared between them using SPSS. In the entire sanctuary the major rivers flowing are Chinnar and Pambar, and the forest along the river are the only forest patches with the trees more than 20 m. The geo-coordinates of all detected animals were plotted on the vegetation map of the sanctuary, and the distance to water source or riparian forest was measured to see the influence of the riparian forest on different species of mammals. All the animals sighted during the entire study period during the transect walks and random movement in the forest were recorded, and further local people and forest department personnel were interacted to collect the occurrence information on elusive species. We also noted the secondary signs like footprint, animal's remains and claw mark on the bark, wherever it was identified to the species level.

16.4 Results

16.4.1 Occurrence of Mammals

We sighted 22 species of mammals in the sanctuary of 30 species expected in the sanctuary based on the nominal distribution excluding small rodents and chiropterans (Table 16.1). Some of the species like small cats, nocturnal small carnivores and burrowing animals are difficult to sight during the conventional methods like transect walk; however, the interview with local people confirms the presence of some such species in the sanctuary, e.g. Nilgiri marten, jungle cat, pangolin.

16.4.2 Abundance of Mammals

Among all the species, arboreal mammals were sighted more than the terrestrial mammals (Table 16.2). The mean sighting of Hanuman langur (0.07 ± 0.02) and grizzled giant squirrel (0.07 ± 0.03) was higher than all the species. Among ungulates, the mean sighting of chital (0.04 ± 0.02) was more than other species. During the night walk, leopard, slender loris and giant flying squirrel was sighted. The mean sighting of slender loris and giant flying squirrel was 0.13(±0.05) and 0.01(±0.03), respectively.

16.4.3 Distribution Pattern of Mammals

We plotted sightings of all the species on vegetation map of the sanctuary which provided better understanding of the habitat selection or distribution pattern of the species (Figs. 16.2, 16.3 and 16.4). We suspected that the riverine forest in the

Table 16.1 Occurrence of mammals in Chinnar Wildlife Sanctuary[a]

Common and species name	IUCN status	IWPA	Species occurrence
Hanuman langur *Semnopithecus priam*	LC	S2	P(1)
Bonnet macaque *Macaca radiata*	LC	S2	P(1)
Slender loris *Loris lydekkerianus lydekkerianus*	LC	S1	P(1)
Tiger *Panthera tigris*	EN	S1	P(2,4)
Leopard *P. pardus*	NT	S1	P(1)
Jungle cat *Felis chaus*	LC	S2	P(4)
Leopard cat *Prionailurus bengalensis*	LC	S1	N
Rusty spotted cat *Prionailurus rubiginosus*	VU	S1	P(1)
Dhole *Cuon alpinus*	EN	S2	P(2,4)
Golden jackal *Canis aureus*	LC	S2	P(1)
Small Indian civet *Viverricula indica*	LC	S2	P(1)
Asian palm civet *Paradoxurus hermaphroditus*	LC	S2	P(1)
Stripe-necked mongoose *Herpestes vitticollis*	LC	S4	P(4)
Common mongoose *Herpestes edwardsii*	LC	S4	P(1)
Ruddy mongoose *Herpestes smithii*	LC	S4	N
Nilgiri marten *Martes gwatkinsii*	VU	S2	P(4)
Indian giant squirrel *Ratufa indica*	NT	S2	P(1)
Grizzled giant squirrel *R. macroura*	EN	S1	P(1)
Common giant flying squirrel *Petaurista petaurista*	LC	S2	P(1)
Southern red muntjac *Muntiacus muntjak*	LC	S3	P(1)
White spotted chevrotain *Tragulus meminna*	LC	S1	P(1)
Indian wild pig *Sus scrofa*	LC	S3	P(1)
Chital *Axis axis*	LC	S3	P(1)
Sambar *Cervus unicolor*	VU	S3	P(1)
Gaur *Bos gaurus*	VU	S1	P(1)
Elephant *Elephas maximus*	EN	S1	P(1)
Nilgiri tahr *Hemitragus hylocrius*	EN	S1	P(1)
Indian crested porcupine *Hystrix indica*	LC	S2	P(3,4)
Thick-tailed pangolin *Manis crassicaudata*	NT	S1	P(4)
Sloth bear *Melursus ursinus*	VU	S2	P(2,4)
Black-naped hare *Lepus nigricollis*	LC	S4	P(1)
Common otter *Lutra lutra*	LC	S2	P(1)

P present, *N* no information, *1* sighted, *2* faecal deposit, *3* body parts, *4* local information, *EN* endangered, *VU* vulnerable, *NT* near threatened, *LC* least concerned, *S1* schedule1, *S2* schedule2, *S3* schedule3, *S4* schedule4 (IUCN 2011 and IWPA 1972)
[a]Excluding chiropterans and small rodents

sanctuary plays an important role in the habitat selection by a species; the distance of each sighting of all the species was measured on GIS platform and is provided in Table 16.3. The mean distance of sighting of each species from riverine forest varied significantly ($F_{8,\,59} = 4.21$, $p < 0.000$). Though the ungulates were found in all the forest types, the maximum sightings were in the dry deciduous forest than in the other forest types (Fig. 16.2), and the relative mean distance from riverine forest was higher (gaur, 1.26 ± 0.88; sambar, 0.35 ± 0.56; chital, 1.66 ± 1.38) than the

Table 16.2 Abundance of large mammals in Chinnar Wildlife Sanctuary

Common name	No. of sightings	Mean sightings (SE)	No. of individuals	Mean no. of individuals
Day transect sightings				
Bonnet macaque	4	0.02 (±0.01)	65	16.25
Hanuman langur	15	0.07 (±0.02)	295	19.66
Grizzled giant squirrel	15	0.07 (±0.03)	27	1.80
Indian giant squirrel	1	–	1	1.00
Gaur	4	0.02 (±0.01)	46	11.50
Sambar	4	0.02 (±0.00)	11	2.75
Chital	8	0.04 (±0.02)	102	12.75
Muntjac	1	–	2	2.00
Night transect sightings				
Slender loris	15	0.13(±0.05)	15	
Common giant flying squirrel	2	0.01(±0.03)	2	

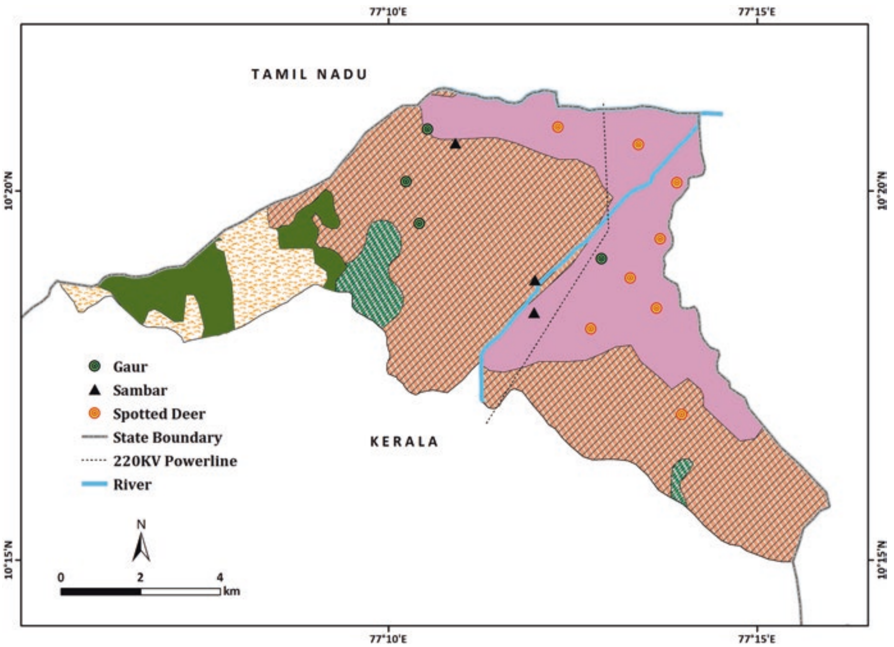

Fig. 16.2 Sightings of ungulate species in Chinnar Wildlife Sanctuary

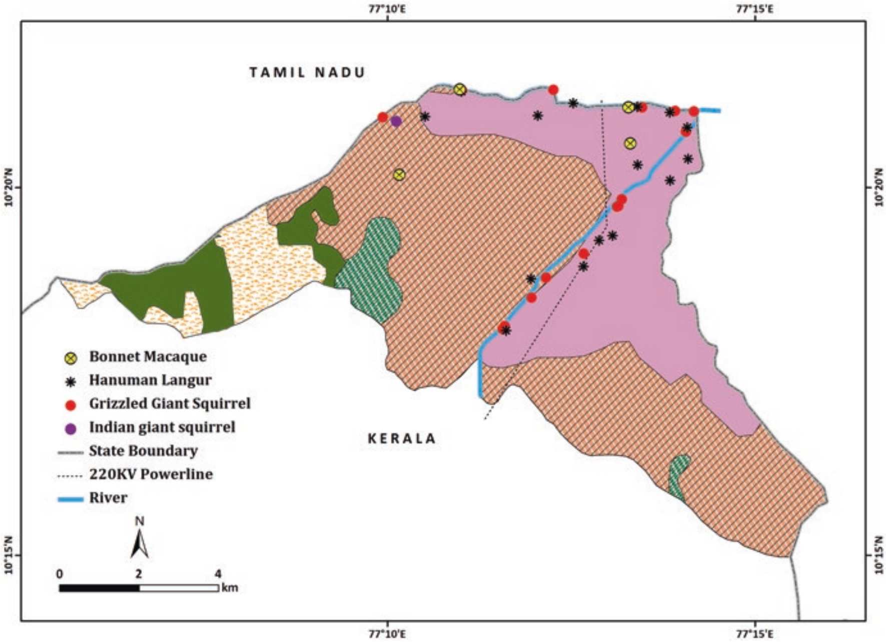

Fig. 16.3 Sightings of diurnal arboreal mammals in Chinnar Wildlife Sanctuary

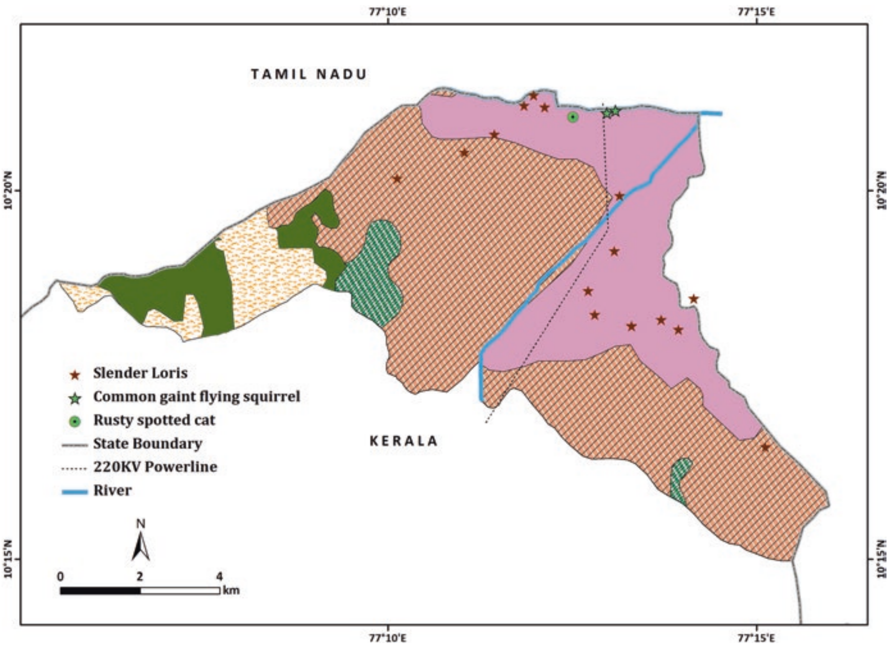

Fig. 16.4 Sightings of nocturnal mammal species during the night walk in Chinnar Wildlife Sanctuary

Table 16.3 Mean distance of sightings of each species from riverine forest

Common name	Mean distance (SD)
Bonnet macaque	0.55(±0.65)
Common langur	0.23(±0.23)
Flying squirrel	0
Gaur	1.26(±0.88)
Grizzled giant squirrel	0.02(±0.08)
Slender loris	1.76(±1.81)
Sambar	0.35(±0.56)
Spotted deer	1.66(±1.38)

Table 16.4 Sightings of each species in different forests

Common name	Total	Dry deciduous (%)	Riverine (%)	Scrub woodland (%)
Bonnet macaque	4	1(25)	2(50)	1(25)
Common langur	15	8(53.3)	7(46.7)	0(0)
Grizzled giant squirrel	15	1(6.7)	14(93.3)	0(0)
Flying squirrel	2	0(0)	2(100)	0(0)
Slender loris	15	9(60)	2(13.3)	4(26.7)
Gaur	4	2(50)	0(0)	2(50)
Sambar	4	1(25)	2(50)	1(25)
Spotted deer	8	7(87.5)	0(0)	1(12.5)

squirrels (giant flying squirrel, 0; grizzled giant squirrel, 0.23 ± 0.23) (Table 16.4). Conversely Hanuman langur and bonnet macaque were found both in riverine and dry deciduous forests (Fig. 16.3). Slender loris was found in all the forest types of the sanctuary nevertheless they were more in the dry deciduous and scrub forest than the riverine forest (Tables 16.3 and 16.4, Fig.16.4).

16.5 Discussion

Chinnar Wildlife Sanctuary is a small protected area along the eastern slopes of the Western Ghats. The sanctuary holds many endangered and endemic species of mammals that makes the importance of the sanctuary in mammal conservation in Western Ghats. The sanctuary is known for having the second largest population of most endangered grizzled giant squirrel in its entire distribution range (Ramachandran 1993; Kumar et al. 2007). Other large population is in Srivilliputhur Grizzled Giant Squirrel Sanctuary (Joshua and Johnsingh 1994) in southern Tamil Nadu. The sanctuary has faced a continuous change in the forest structure due to slash burning cultivation by tribal people till middle of the last century, thus the forest has got transformed drastically and has got dry open scrub forest by losing its intact canopy.

The sanctuary is a part of large protected area complex, north of the sanctuary is Anamalai Tiger Reserve and Eravikulam National Park on the south-west. The dry forests of the sanctuary are contiguous with the Anamalai Tiger Reserve and Palani Hills, thus it forms a large reserve for some of the species. Except the grizzled giant squirrel, population of all other species is contiguous with the neighbouring protected areas especially of Anamalai and Palani hills. As our findings depict, the two major rivers in the sanctuary 'Pambar and Chinnar' play a very important role in harbouring especially the arboreal mammals like grizzled giant squirrel and act important water source for many other species during the dry season. The tall forest with varying width of 20–80 m is a major dwelling place for many species. Thus maintaining the canopy continuity is very crucial for the conservation of grizzled giant squirrel.

Among all the mammals, the most encountered species are grizzled giant squirrel and slender loris. There are two subspecies of slender loris, viz. Malabar slender loris (*Loris lydekkerianus malabaricus*) and Mysore slender loris (*Loris lydekkerianus lydekkerianus*). Malabar slender loris is known to be found in forests of Western Ghats where the Mysore loris is from drier forests of the Eastern Ghats and southern plains. The confusion of subspecies found along the rain shadow areas at eastern slopes of the Western Ghats was confirmed as Mysore slender loris. We confirm that the subspecies found in Chinnar Wildlife Sanctuary is Mysore slender loris. They are known to occur in a variety of habitats with varying height class; however, they are commonly seen in drier forests especially dry deciduous and scrub forests. Present study reflects the importance of dry forests of the sanctuary in conservation of the species.

Rusty-spotted cat is one of the smallest of the wild cats in the World and is endemic to India and Sri Lanka. It was thought that the species is very rare in the wild, but the eventual sightings from different parts of the country show that the species is widely distributed. However the abundance data is not available from most of the region, thus concluding on the population size will be difficult. The present sighting from the sanctuary adds to the list and importance to the park.

Ungulates, being terrestrial herbivores, are known to feed on grass and leaves. They were widely distributed in the sanctuary; however, more sightings are from the eastern side which show the selection of less disturbed region than the western side with high human density and cropland. Conversely, primates being arboreal mammals prefer safe canopy. However, Hanuman langur and bonnet macaques have also adapted to survive in human-dominated landscape. Especially bonnet macaques are known to spend and utilize the food around the human habitations, even in the sanctuary, very few groups were found in such areas. The sightings of some of the rare animals and habitat association of the grizzled giant squirrel to riverine forest and high abundance of slender loris and their occurrence in dry deciduous forest and scrub forest indeed emphasize the importance of conservation of the entire sanctuary with its dry biotope.

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17 Conservation Status and Guidelines for the Maintenance of Endangered Grizzled Giant Squirrel *Ratufa macroura* in Srivilliputhur Wildlife Sanctuary

Juliet Vanitharani

Abstract

India is a home to diverse and rich wildlife resources which includes over 52 critically endangered and 51 endangered species. According to IUCN red list of threatened species (Version 2014.3), the grizzled giant squirrel *Ratufa macroura* is one of the giant arboreal squirrels that inhabited the riverine forest of Srivilliputhur and shares eastern watershed of the Western Ghats located between 9° 21′ to 9° 48’N and 77° 21′ to 77° 46′E. The decline of this species is due to habitat fragmentation due to urban development and the unscrupulous poaching of the squirrels for their fur. Remaining populations in India appear to be significantly more threatened. Great deal of efforts has been made in the last 60 years to preserve the natural habitats. In 1989 the habitat is declared as ‘Srivilliputhur Grizzled Squirrel Wildlife Sanctuary’ in order to protect this inhabitant. The nesting and feeding behaviour observations infer the survival of this giant squirrel which mainly depends on certain group of trees in the dry deciduous and riverine forests of this sanctuary. These squirrels are diurnal and actively forage during early and late hours of the day. In this chapter presented the ecological study and management action plan for the afforestation in the affected and fragmented forest area of *R. macroura*’s habitat to conserve the threatened giant squirrel.

Keywords

Afforestation · Diurnal · Riverine forest · Sanctuary · Threatened

J. Vanitharani (✉)
Zoology Department and Research Centre, Sarah Tucker College (Autonomous), Tirunelveli, Tamil Nadu, India

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17.1 Introduction

Srivilliputhur grizzled giant squirrel sanctuary is home to the threatened, *Ratufa macroura*. This sanctuary is situated at the eastern slopes of the Western Ghats of south India between 9°21′ to 9°48’N and 77°21′ to 77°46′E which were declared as a sanctuary in December 1989 (Tamil Nadu Forest Department 2007). The home range of *R. macroura* is restricted to riverine forests occurring at an elevation below 800 m MSL. Alagar kovil valley area of this sanctuary enjoys more than 50% of their population. The present study mainly concerns about the interaction of the grizzled giant squirrel with the available forest types that prevail in their home range. The report presents the data about the ecological interaction of the squirrel like feeding and nesting site selection in this sanctuary. Despite the fact that very little is known about its population status, density, distribution and ecology, only a few studies have been carried out on this species in India (Davidar 1989; Ramachandran 1992, 1993; Borges 1992; Joshua 1992; Sharma 1992; Joshua and Johnsingh 1994; Paulraj et al. 1992; Senthilkumar et al. 2007; Baskaran et al. 2011).

17.1.1 *Ratufa macroura*

This species is endemic to southern India (Kerala and Tamil Nadu) and Sri Lanka (Molur et al. 2005; Herlekar 2010) and classified under the order Rodentia of family Sciuridae. The common name grizzled giant squirrel came from the grey to brown colouration highlighted with white at the top of the tail, giving it a grizzled appearance (Prater 1971). This greyish-brown squirrel weighs around 2 kg and in the size of a small cat. It measures about 735 mm from the snout to the tail with just the tail being 360–400 mm long, longer than the body length. They are most active in the morning and early evening. Midday is a time of rest, and these squirrels are often observed sleeping on a branch (Prater 1971). The giant squirrel differs from other tree squirrels in that they do not sit upright when feeding. Instead, they balance on their hind feet with their body on one side of the branch and the tail acting as a counterbalance on the other side of the branch. Both their hands and feet are equipped with large powerful claws, making them agile climbers (Nowak 1991). These squirrels have a very distinct voice and can be very vocal. Like many primates, *R. macroura* react to the sighting of predators by provoking a general alarm, a series of calls and barks that alert the other community members to the nearness of the predator. Each individual has a home range that extends between 0.197 and 0.611 ha. (Joshua 1992). Males have range overlap with one or more females especially during the breeding season. There is very little data available on their reproductive cycle. It has a generation time of 7–8 years. The gestation period is believed to last about 28 days. During the breeding season, they construct drays at forked branches where the crowns of neighbouring trees meet. A large nest, similar in appearance to an eagle’s nest, is constructed. Parturition occurs within the nest, and the young remain there for about 2–3 months. Each litter consists of one or two young, and the female nurses them with her three pairs of mammary glands. It has been speculated that *R. macroura* may raise several litters each year (Kanoje 2008). *R. macroura* show limited social behaviour. They are mostly solitary, sometimes live in pairs and show high territoriality. They have been observed to camouflage with the tree branches by flattening themselves against the branches and remaining motionless when frightened. Overall, *Ratufa macroura* are very wary and keep them well hidden in the dense vegetation. *R. macroura* enjoy a diverse kind of diet that includes fruits, tender leaves, seeds, insects, bird eggs and even the bark of some trees. Plate 17.1 describes the digital documentation of feeding, resting and nesting behaviour of *R. macroura* from Srivilliputhur grizzled giant squirrel sanctuary.

17.1.2 Present Status of *R. macroura*

According to IUCN (2010), India has only an estimated population of less than 500 mature *R. macroura*. Habitat loss and degradation due to agro-industry farming, small-scale logging, selective logging, increase in human settlements, forest fire, interspecific competition, competition from alien species, hunting for local consumption purposes and presence of domestic predators have been observed to be the major threats for this species (Joshua and Johnsingh 1992, 1994; Molur et al. 2005; Joshua et al. 2008; Vanitharani et al. 2011). According to the IUCN red list of threatened species (Version 2014.2), the grizzled giant squirrel is facing a high risk of extinction in the wild. Information on the exact population size and density of grizzled giant squirrels in India is lacking.

17.1.3 Habitat the Determinant of Species Survival

Spatial and temporal changes of a forest are an important factor that determines the availability of the habitat for any species (Wilcox and Murphy 1984; McGarigal and McComb 1995). Many aspects of the behavioural ecology of animals in nature like dispersal, home range sizes, territoriality, dietary patterns and time-activity budgets are fundamentally linked to the amount of space used in a habitat and movements within it (Koprowski 2005; Verbeylen et al. 2009). The extensive canopy connectivity facilitates the movement and dispersal of arboreal mammals (Datta and Goyal 2008; Nandini and Parthasarathy 2008).

Grizzled giant squirrel being an arboreal mammal depends on forests and also possesses many other co-evolutionary relationships with the forest plants for the survival. The habitat of *R. macroura* requires the specific tree composition for their survival. They are critically dependent on mature forests that provide tree tissues and seeds as food, stems and canopies as launch sites and cavities and canopies as nest sites. Arboreal mammals are dependent on the spatial structure of the forest for nesting (Umapathy and Kumar 2000). These squirrels are known to prefer areas with good food availability and canopy connectivity to live and build their nests (Ransome and Sullivan 1997; Kumar et al. 2002; Kumara and Singh 2006; Srinivas et al. 2008). Individuals will have a better chance to thrive when they were more

Plate 17.1 Different activities of grizzled giant squirrel

successful at finding food, mating and avoiding predators. Presence of nests in an area reflects the quality of the habitat around it and also indicates the degree of usage of the area by the species (Getty 1981; Datta and Pal 1993). Choosing a nest site is among the important choices made by an animal as it protects it from predation, provides thermoregulation and is also important in the breeding ecology of the animal. The giant squirrel constructs globular nests or drays using leaves and twigs, multiple in numbers within their home range (Srinivas et al. 2008).

Squirrels usually prefer trees significantly larger in all characteristics with large girth at breast height (gbh) and taller height with number of branches for nest building. The nesting trees were significantly larger in all characteristics than the non-nesting ones sampled in the population. According to Ramachandran (1992) such biased selection towards matured trees with greater canopy continuity could facilitate easy movement to and from the nest in all the directions, a major advantage to escape from predators and to move to other parts of the home range for foraging and other activities.

17.1.4 Threats for Survival

Fragmentation of the canopy and associated disturbances can bring about changes in the behaviour of arboreal mammals (Umapathy and Kumar 2000) with consequences for their survival and reproduction. Owing to the increasing human pressure, the habitats of grizzled giant squirrel are threatened by fragmentation through deforestation (Tikader 1983; Joshua 1992; Joshua and Johnsing 1994; Verbeylen et al. 2009).

The study has come out with few suggestions by saying that by increasing the Giant squirrel interactive tree species canopy in the affected/fragmented forest cover of the sanctuary will conserve the endangered squirrel as well as other dependent biodiversity of sanctuary.

17.2 Methods

Field survey was carried out to determine the plant-squirrel interaction in the Srivilliputhur grizzled giant squirrel sanctuary using the line transect method (Cox 1990). Each transect had a length of 2.0 km within the quadrates (5 km^2). Grizzled giant squirrel interactive tree species vegetation sampling was done by using quadrate method in all the forest habitats of grizzled giant squirrel. In this study, mostly the riparian areas of the sanctuary are considered potentially suitable for the conservation of the grizzled giant squirrel, and hence the surrounding matrix habitat was ignored. The grizzled giant squirrel interacting tree species are identified as 'focal plant' species. A small sample of plant twig from the focal plant species was collected, and a herbarium is maintained in the Zoology Department Research Centre of Sarah Tucker College. The vernacular names of the tree species were recorded, and their scientific names were ascertained by Dr. Chelladurai, (Retd.) Botanist, Government Siddha Medical College, Palayamkottai, and Dr. Gopalan, (Retd.) Scientist, Botanical Survey of India, Coimbatore. Grizzled giant squirrel's interaction with the focal tree species were directly observed during the active forage time and during breeding seasons. The observations were recorded from a spot about 10.0–20.0 m away from the focal plant using a pair of binoculars. Extended watches (a minimum of 1.0 h) were done near the focal plant. During the extended watch, feeding and nest building activities with the focal plants were documented.

17.3 Result and Discussion

Being an arboreal, diurnal giant squirrel inhabits tall larger trees of the sanctuary for food, shelter and movement. Understanding the species distribution and its resource requirements is essential for its long-term conservation plans. *R. macroura* interact predominantly with 35 tree species that prevail in the sanctuary, mainly for their survival. It is apparent that the composition of tree species and structural attributes of the forests play a major role in the use of the habitat by the giant squirrel (Ramachandran 1992; Paulraj and Kasinathan 1993; Paulraj et al. 1992; Molur et al. 2005; Vanitharani et al. 2011). Nesting and foraging interactive focal trees species of the grizzled giant squirrel at Srivilliputhur Wildlife Sanctuary were documented in Table 17.1.

17.3.1 Foraging Interactions

The grizzled giant squirrel (*Ratufa macroura)* plays an important role as a seed disperser to their foraging trees via dropping seeds as they cruise over the canopy; the key tree species dependent are *Artocarpus heterophyllus*, *Artocarpus hirsuta*, *Ficus benghalensis*, *Ficus religiosa*, *Ficus racemosa*, *Tamarindus indica*, *Mangifera indica*, *Lannea coromandelica*, *Morinda tinctoria*, *Syzygium cumini, Eriodendrum pentandrum*, *Polyalthia suberosa*, *Aglaia elaeagnoidea*, *Chassalia curviflora* and *Sapindus emarginatus* distributed in the dry deciduous forests of Srivilliputhur Wildlife Sanctuary. During the extended watch near some of these key tree species, the squirrels were observed to eat tender leaves of *Tamarindus indica*. Joshua (1992) and Ellerman (1961) also reported similar feeding habits of the squirrel. Ripe fruit pulp of *M. indica* and *Artocarpus* spp., fig fruits and teak flowers are also the most significant contributor of the diet of these squirrels. Overall, the present study has recorded that the squirrel feeds on a total of 35 tree species. Among their interacting trees, 37% (15 species) are used for both nesting and foraging trees. During the non-fruiting season or during the scarcity of the fruits, grizzled giant squirrel devours the bark and leaves of some key tree species. Becker et al. (1985) and Borges (1992, 2007) suggest these squirrels prefer fruits and seeds, when they are available. Squirrels usually avoid consuming fresh seeds of *S. cuminii* since fresh tissues (bark, fruit pulp, seeds) of these trees are known to be hypoglycaemic (Rafiullah et al. 2006; Villasenor and Lamadrid 2006).

Table 17.1 Nesting and foraging trees of grizzled giant squirrel *Ratufa macroura* in Srivilliputhur Wildlife Sanctuary

Sl. No	Botanical name	Family name	Nesting	Feeding
1	*Lannea coromendelica*	Anacardiaceae	√	
2	*Mangifera indica*	Anacardiaceae	√	√
3	*Stereospermum chelonoides*	Bignoniaceae	√	
4	*Cullenia exarillata*	Bombaceae	√	√
5	*Eriodendron pentandrum*	Bombaceae	√	√
6	*Cordia obliqua*	Boraginaceae		√
7	*Tamarindus indica*	Caesalpiniaceae	√	√
8	*Terminalia arjuna)*	Combretaceae	√	√
9	*Terminalia bellirica*	Combretaceae	√	√
10	*Terminalia chebula*	Combretaceae	√	√
11	*Terminalia tomentosa*	Combretaceae	√	
12	*Mallotus philippensis*	Euphorbiaceae		√
13	*Azadirachta indica*	Meliaceae	√	
14	*Melia azadirachta*	Meliaceae	√	
15	*Acacia cassia*	Mimosaceae		√
16	*Acacia latronum*	Mimosaceae		√
17	*Acacia planiformis*	Mimosaceae		√
18	*Albizia amara*	Mimosaceae	√	√
19	*Albizia lebbeck*	Mimosaceae	√	√
20	*Artocarpus heterophyllus*	Moraceae		√
21	*Artocarpus hirsuta*	Moraceae		√
22	*Ficus benghalensis*	Moraceae	√	√
23	*Ficus racemosa*	Moraceae	√	√
24	*Ficus religiosa*	Moraceae	√	√
25	*Syzygium cumini*	Myrtaceae	√	√
26	*Butea monosperma*	Papilionaceae		√
27	*Dalbergia latifolia*	Papilionaceae	√	
28	*Pterocarpus marsupium*	Papilionaceae	√	
29	*Chassalia curviflora*	Rubiaceae		√
30	*Sapindus emarigandus*	Sapindaceae	√	
31	*Schleichera oleosa*	Sapindaceae	√	√
34	*Grewia tiliaefolia*	Tiliaceae	√	√
32	*Gmelina arborea*	Verbenaceae	√	
33	*Tectona grandis*	Verbenaceae	√	
35	*Vitex altissima*	Verbenaceae		√

17.3.2 Nest Selection Interaction

Grizzled giant squirrel being a canopy dweller largely depends on the tree canopy contiguity for their movement, nesting and breeding (Joshua 1992; Thorington and Cifelli 1989). Giant squirrels are known to build nests in several trees, sometimes even within a small area (Prater 1971). Of the 35 squirrel interacting key tree species within the sanctuary, the squirrels preferred only 25 of them for nest building. It is noteworthy that the tree species *Pterocarpus marsupium*, *Stereospermum chelonoides*, *Schleichera oleosa*, *Tamarindus indica*, *T. arjuna* and *Maesa indica* are seen with multiple nests. *S. oleosa* was the most preferred tree species for nesting followed by *M. indica*. These trees are mostly distributed along the rivers and streams. The dense canopy cover and higher canopy height of these trees provide contiguity that could offer better protection and way to escape from the predators. Nagarajan et al. (2011) suggested that many arboreal dwellers prefer this type of habitat.

According to Kanoje (2008) in the Sitanadi Wildlife Sanctuary, the giant squirrel's most common nesting trees were *Terminalia tomentosa* and *S. oleosa*. The other major species of nesting trees were *S. cuminii*, *T. indica* and *Terminalia* spp. Kanoje also recorded 207 nesting trees and observed approximately 77.68% of the nests were found on deciduous trees (25 species), while only 5 species of nesting trees were located in the evergreen forest.

17.3.3 Threats for Survival

Human interference through various means within the sanctuary threatens the well-being of the habitat used by the giant squirrels. Threats arise as poaching, loss of habitat due to illegal cutting of trees, overgrazing by livestock, frequent forest fires in the summer season and overexploitation of non-timber forest produce (Joshua and Johnsingh 1994). Forest fragmentation is considered to be the biggest threat to global biodiversity (Wilcox and Murphy 1984). The ability of a species to persist at sites after disturbance depends on its ability to modify its behaviour, foraging and dietary patterns to withstand the changes in forest structure and composition. The observations suggest the grizzled giant squirrel really find it hard to cope with the changing habitat. Keeping this in mind, the present study has suggested the plantation of the 35 grizzled giant squirrel interacting tree species in the fragmented forest area to conserve the grizzled giant squirrel.

17.3.4 Management Recommendations

Grizzled giant squirrel shows restricted distribution mostly in riverine habitats. But the riverine habitats along the sanctuary are generally patchy in forest coverage. Restoration of the habitat in the gap and maintenance of canopy continuity through afforestation by the preferred tree species like *T. indica*, *S. oleosa* and *M. indica* can enhance the population size of the grizzled giant squirrel as well as the other faunal diversity.

In addition reducing commercial exploitation of *T. indica* fruits in large scale by the local people and government sectors can lessen the anthropogenic pressure. Strict legislation and management actions against grazing pressure along the riverine habitats will also help to achieve neutral restoration of the forest cover in the sanctuary and will also enhance the long-term survival of grizzled giant squirrel species. Still these threatened species lacks an updated comprehensive database about the distribution and population status across its habitat. Being a threatened species, it definitely deserves the attention of conservationists. Paulraj (1991) suggested that unless the species receives immediate attention for its protection and conservation, it will be a difficult task to save it from extinction.

17.4 Conclusion

Accurately forecasted impacts of disturbance on the native flora and fauna indicates, it is essential to conserve the forest habitats of the sanctuary to conserve biodiversity and the threatened *Ratufa macroura*, grizzled giant squirrel. The present study has identified 35 native and giant squirrel interactive tree species. At the same time, this interaction also reviews the complement and reward gained by the squirrels from the plants for their rendered propagation services. If these squirrels preferred key tree species are planted in the fragmented and degraded forest areas that will enhance natural forest restoration and also habitat for the native threatened and endangered animals.

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18 Crop Damage by Wild Animals in Thrissur District, Kerala, India

Suresh K. Govind and E. A. Jayson

Abstract

Human-wildlife conflict (HWC) is a contentious issue, and crop damage by wild animals is a major problem in Kerala, India. A study on crop damage by wild animals was carried out in Thrissur District, Kerala, India, from April 2009 to March 2012, to assess the crop damage by wild animals and the economic loss incurred to the farmers due to wild animals. For assessing the crop damage, quadrats of 10 m x 10 m were taken randomly in the fringe areas of eight Forest Ranges. Incidences of crop damage were recorded from the quadrat in each month (n = 36), and the species of crops damaged was quantified. Economic loss was estimated by multiplying the quantity of crops damaged within the quadrat, with the market value of crops which was collected from the Farm Information Bureau, Kerala. Ten species of wild animals damaged 11 species of crops in the District. Asian elephant (*Elephas maximus*) did the highest damage, and the economic loss was estimated as Rs.17,35,625/- per annum, followed by wild pig (*Sus scrofa*) (Rs. 3736/- per ha/annum) and Indian crested porcupine (*Hystrix indica*) (Rs. 615.47/- per ha/annum). Feeding on tender coconuts (*Cocos nucifera*) by Indian giant squirrel (*Ratufa indica*) was reported for the first time, and this feeding behaviour was reported from three Forest Ranges adjacent to the wildlife sanctuaries. Mean loss was Rs. 2247/- per annum. Indian peafowl (*Pavo cristatus*) and other birds contributed to high economic loss in the paddy fields (*Oryza sativa*) near Chulanur Peafowl Sanctuary, Kerala, and the loss was Rs. 16,615.45/- per ha. The study indicated that crop damage by animals is causing severe economic loss to farmers in the District, and mitigation measures, namely, solar electric fence, chilli-rope fence, yellow-coloured plastic sheet fence and fishnet fence, are suggested.

S. K. Govind · E. A. Jayson (✉)
Wildlife Department, Kerala Forest Research Institute, Thrissur, Kerala, India
e-mail: jayson@kfri.org

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Crop damage · Human-wildlife conflict · Kerala · Thrissur · India

18.1 Introduction

Human-wildlife conflict (HWC) is an interdisciplinary or multidisciplinary area of research, which deals with the dimensions of both human and wildlife (Heberlein 2004). It results in crop damage by wild animals, cattle lifting, human casualties and household damage (Conover 2002), and in that, crop damage by wild animals is the major problem faced all over the world (Dublin and Hoare 2004). Besides the scientific understanding of conflict, perception of farmers towards crop raiders is crucial for managing the conflict (Hill 2004; Manfredo et al. 1998; Marker et al. 2003; Naughton-Treves et al. 2003). Quantification of damage and giving ex gratia to the victims will minimise its severity (Nyhus et al. 2003). Inadequate disbursement of ex gratia and delay on its processing are the major complications faced today (Ogra and Badola 2008). Crop damage by wild animals and poor payment of ex gratia to the farmers are the serious problems in the fringe areas of forest in Kerala. Previous studies reported that the Kerala Forest and Wildlife Department disbursed only 8.2% of the total ex gratia claimed (Veeramani and Jayson 1995). It negatively affected the attitude of farmers towards wildlife. This problem can be resolved by estimating the actual economic loss due to wild animals and providing sufficient amount of ex gratia to them. Improvement in the distribution of ex gratia is a significant factor for increasing the co-existence between humans and wildlife (Madden 2004). So far, no study has been carried in Kerala to estimate the economic loss incurred by farmers due to wild animals. In this paper, an attempt was made to assess the crop damage by wild animals in Thrissur District (10° 46′–10° 7′ N and 75° 57′–76° 55′ E), Kerala, India, with special reference to the economic loss incurred by the marginal farmers due to wild animals.

18.1.1 Study Area

Thrissur District (10° 46′–10° 7’ N and 75° 57′–76° 55′ E) lies in the central part of Kerala, India, spanning an area of 3032 km^2. The District has a tropical humid climate and plentiful seasonal rainfall. Different varieties of soil, namely, laterite, sandy loam, alluvial, clayey and black, are found. The District is comprised of 11 Forest Ranges and 2 wildlife sanctuaries (210 km^2) and 1 Peafowl Sanctuary (3.44 km^2). Asian elephant (*Elephas maximus*), wild pig (*Sus scrofa*), Indian crested porcupine (*Hystrix indica*), sambar (*Rusa unicolor*), leopard (*Panthera pardus*), wild dog (*Cuon alpines*) and Indian giant squirrel (*Ratufa indica*) are the major animals found in the forests. Main vegetation types are moist deciduous, evergreen and semi-evergreen forests, grasslands and monoculture plantations. Agriculture is the main source of livelihood. Coconut (*Cocos nucifera*), rubber (*Hevea *brasiliensis*), paddy (*Oryza sativa*) and plantain (*Musa paradisiaca*) are the major cash crops cultivated by the farmers in the fringe areas of the forest.

18.2 Methods

For assessing the crop damage, permanent quadrats of 10 m × 10 m were laid in the crop fields near the boundary of forest (Jayson 1999). From each Forest Range, two locations were selected randomly and the permanent quadrats were laid in their farms (Fig. 18.1). Four quadrats (sample plots) in the mixed crop field (more than two crops were cultivated in the farms) and two quadrats (control plots) in the Reserve Forest near the sample plots were taken from each location (Fig. 18.2). Two more quadrats were also laid in a mixed crop field of each Forest Range, which were blocked or fenced to prevent the entry of wild animals. These quadrats were laid for quantifying the yield of major crops raided, namely, coconut, areca nut, rubber and plantain. Each plot was demarcated and marked using ribbon.

Crop damage incidences were recorded from the quadrats in each month ($n = 36$) from April 2009 to March 2012, and the species of crops damaged was quantified. Enquires were also made among the farmers to confirm the crop-raiding animals. In order to quantify the consumption of tubers, estimates were calculated after discussing with the farmers of respective farms. Indirect evidences left by the wild animals such as scats, droppings, diggings, feeding signs and scratching marks were also recorded in each visit. Percentage occurrence of wild animals in the crop field was

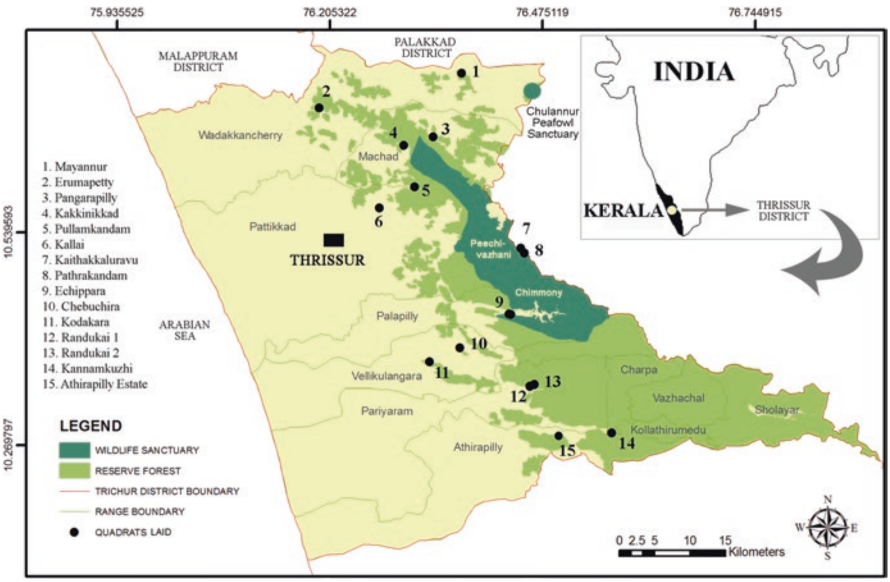


Fig. 18.1 Locations of permanent quadrats laid in different Forest Ranges in Thrissur District, Kerala

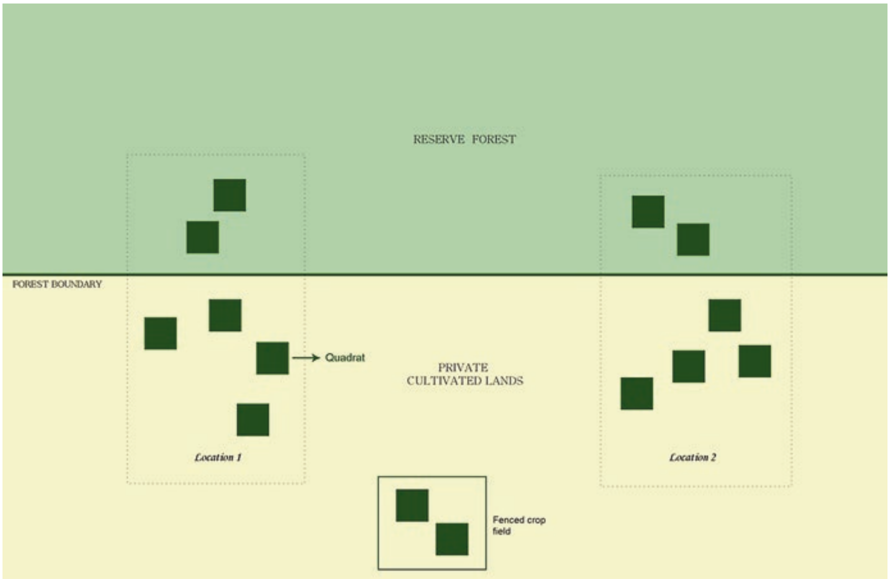


Fig. 18.2 Pictorial representation of permanent quadrats laid in a Forest Range

calculated by dividing the number of occurrence of these species in the quadrats in each month by total months observed ($n = 36$) and multiplying this by 100. From the quadrats, following data were collected:

1. Number of trees or plants damaged and undamaged
2. Number of fallen coconuts damaged per tree in each month
3. Indirect evidences of wild animals in the quadrat

A total of 118 permanent quadrats were taken from the Forest Ranges, namely, Wadakkancherry, Machad, Pattikkad, Peechi, Palapilly, Vellikulangara, Pariyaram, Charpa and Athirappilly. The Forest Ranges with negligible cultivation of crops, namely, Vazhachal, Kollathirumedu and Sholayar, were not sampled. Quadrats from Athirappilly Forest Range were discontinued after 9 months of observation, as no wild animals were recorded in the sample plots and in the nearby areas. Case studies were carried out for Asian elephants (*Elephas maximus*), as they were not recorded from the permanent quadrats. In such cases, quadrats of 10m × 10m were laid in an area where the crop damage occurred ($n = 238$), and the number of crop plants damaged was quantified. These running quadrats were laid after getting information from the farmers during field visits and newspaper reports on crop damage by elephants.

The consumption of coconut by Indian giant squirrel (IGS) was quantified by taking quadrats of 10m × 10m systematically in the fringe areas of the three Forest Ranges, where this behaviour was observed. Six quadrats with 20 coconut trees were marked in Machad Forest Range, 3 quadrats with 6 coconut trees in Palapilly

Forest Range and 6 quadrats with 20 coconut trees observed in Peechi Forest Range of Peechi-Vazhani Wildlife Sanctuary. The number of coconuts consumed per tree was quantified in each month (n = 36) from the quadrats. Analysis of variance (ANOVA) test was used for comparing the variance between the consumption of coconut by IGS in different Forest Ranges. Spearman's rank correlation (r_s) was used to find out the relationship between coconuts consumed/tree by Indian giant squirrel in Machad Forest Range and the price of coconut during the study period.

Consumption of paddy by Indian peafowl and other birds was assessed by an enclosure experiment (Wilson et al. 2009), which was conducted in the paddy field adjacent to Chulanur Peafowl Sanctuary, Kerala, India. Plots of paddy field were protected with metallic frames and nets (10m × 10m) to prevent the damage of paddy by peafowls. They functioned as control plots of the study. Paddy consumption was quantified by comparing the yield of paddy from the control plots and open plots. Two control plots and two open plots (10m × 10m) were monitored in four trials (December 2009, September 2010, December 2010 and September 2011) at different locations near the Sanctuary. The mean distance from the forest boundary to the area of experiment was 112.5 ± 47.87 m. Independent sample t-test was used to compare the yield from control plots and open plots.

Economic loss was estimated by multiplying the quantity of crops damaged within the quadrats, with the market value of crops which was collected from the Farm Information Bureau, Kerala. For estimating the potential loss of perennial crops, its economic life period was classified into immature phase and productive phase. The economic value of immature phase was considered as the market value of a new plant or a seed, and the productive phase was estimated by multiplying the mean market value of the yield during the study period, with the overall yield during its economic life period. The perennial crops in the forest fringes are susceptible to damage during all the ages due to Asian elephants. In order to quantify the loss, the productive phase was further classified into two age classes, i.e. primary stage (the period from initial stage of bearing to the middle age of its productive phase) and secondary stage (the period from the middle age of productive phase to the end of its economic life period). In the primary stage, the overall potential value of the perennial crop was considered, and half portion of the overall potential value was used for the secondary stage. Mean yield per annum of the perennial crop was collected from Rubber Board, Kottayam, Kerala, Central Plantation Crops Research Institute (CPCRI), Kasaragod, Kerala, and Kerala Agricultural University, Thrissur, Kerala. The economic value of the plantain was estimated by multiplying the mean weight of the bunch of banana with its economic value.

18.3 Results

Ten species of wild animals, namely, Asian elephant (*Elephas maximus*), wild pig (*Sus scrofa*), Indian crested porcupine (*Hystrix indica*), Indian giant squirrel (*Ratufa indica*), Indian peafowl (*Pavo cristatus*), bonnet macaque (*Macaca radiata*), sambar (*Rusa unicolor*), Indian giant flying squirrel (*Petaurista philippensis*),

Table 18.1 Price of damaged crops in the study area during April 2009 to March 2013 (Farm Information Bureau, Kerala)

Sl. No.	Crops	Economic value (Rs.) (Mean ± SD)
1	Coconut	6.31 ± 3.15 per nut
2	Areca nut	88.3 ± 31.5 per kg
3	Rubber	170.72 ± 46.13 per kg
4	Banana (Nendra)	24.38 ± 4.63 per kg
5	Banana (Palayamthodan)	12.5 ± 2.85 per kg
6	Paddy	11.33 ± 3.03 per kg
7	Colocasia	20.5 ± 5.82 per kg
8	Tapioca	11.2 ± 2.74 per kg
9	Elephant yam	18.29 ± 2.71 per kg
10	Plantain (Nendra)	243.8 per plant
11	Plantain (Palayamthodan)	125 per plant

Table 18.2 Economic loss due to wild animals in different Forest Ranges (April 2009 to March 2012)

Sl. No.	Forest Ranges	Economic loss for 3 years (Rs.)	Economic loss (Rs.)/ annum	Loss (%)
1	Pattikkad	15,55,404.68	5,18,468.23	29.72
2	Charpa	15,45,374.66	5,15,124.89	29.53
3	Pariyaram	14,34,194.94	4,78,064.98	27.40
4	Palapilly	6,37,668.35	2,12,556.12	12.18
5	Peechi	25,415.39	8,471.80	0.49
6	Athirappilly	23,662.50	7,887.50	0.45
7	Machad	10,445.17	3,481.72	0.20
8	Wadakkancherry	960.85	320.28	0.02
9	Vellikulangara	574.21	191.40	0.01
	Total	**52,33,700.75**	**17,44,566.92**	**100**

rose-ringed parakeet (*Psittacula krameri*) and spotted dove (*Streptopelia chinensis*), were damaging the crops in the study area. The species of crops damaged were coconut (*Cocos nucifera*), areca nut (*Areca catechu*), rubber (*Hevea brasiliensis*), oil palm (*Elaeis guineensis*), plantain (*Musa paradisiaca*), nutmeg (*Myristica fragrans*), cocoa (*Theobroma cacao*), elephant yam (*Amorphophallus paeoniifolius*), colocasia (*Colocasia esculenta*), tapioca (*Manihot esculenta*) and paddy (*Oryza sativa*). For estimating the crop damage, the price of nine species of crops was collected by the Farm Information Bureau, Kerala (Table 18.1).

Crops are damaged by wild animals in nine Forest Ranges of the District. Highest economic loss was recorded in Pattikkad Forest Range (Rs. 15,55,404.68/-), followed by Charpa (Rs. 15,45,374.66/-) and Pariyaram (Rs. 14,34,194.94/-) (Table 18.2). Actual loss was estimated as Rs. 17,44,566.92/- per annum.

Asian elephants were involved in 31 incidents of crop damage during the study period. They fed on plantain (74.11%) (Nendra (65.73%) and Palayamthodan (8.39%), both are commercial cultivated varieties in Kerala), followed by areca nut

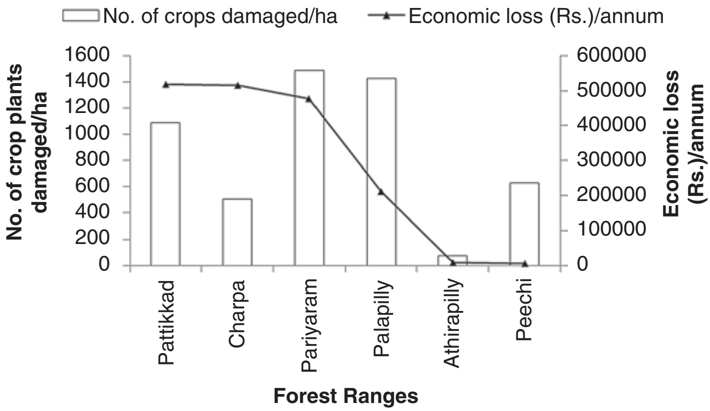


Fig. 18.3 Number of crop plants damaged by Asian elephants and the economic loss reported from different Forest Ranges (Thrissur District, Kerala)

palm (11.38%) and coconut palm (3.37%). Rubber (10.44%), nutmeg (0.14%), oil palm (0.18%) and cocoa (0.37%) were also destroyed, as they were planted as an intercrop in the farms. The pseudostem of the plantain was preferred as staple food, but the unripen fruits were not fed. Forty nine per cent of areca nut trees were trampled during the immature phase, and elephants consumed the tender leaves. The remaining trees were damaged during the productive phase. Most of the coconut trees were also uprooted during the productive phase (76.09%), and the fresh leaves including the central rachis were consumed. Number of crop plants damaged/ha was recorded highest in Pariyaram Forest Range (Fig. 18.3). Three species of perennial crop were considered for the estimation of potential loss, and their potential value is given in Table 18.3. Highest damage was recorded in Pattikkad Forest Range, followed by Charpa, Pariyaram, Palapilly, Athirappilly and Peechi (Fig. 18.3). The mean loss was estimated as Rs. 17,35,625/- per annum. Among Grama Panchayaths, Athirappilly (51%) recorded the highest damage, followed by Kodassery (18%), Panacherry (12%), Varandarappilly (11%) and Puthur (8%).

Wild pig is distributed in all Forest Ranges in the District (Fig. 18.4). They consumed fallen coconuts (26.03%) followed by tubers (11.6%) (elephant yam, colocasia and tapioca) and plantains – ‘Palayamthodan’ (52.27%) and ‘Nendra’ (10.2%). Number of fallen coconuts consumed was 0.12 ± 0.15 coconut/tree/month ($n = 296$). Mode of consumption was by removing the mesocarp (coconut husk) and endocarp and feeding the endosperm. The removed mesocarp had irregular shape and size. While grubbing soil for feeding earthworms, partial damage to young rubber plants was reported from all Forest Ranges ($n = 58$). Highest crop damage was recorded in Pattikkad Forest Range (Fig. 18.4) and among Grama Panchayaths in Panacherry (41%), followed by Thekkumkara (12%), Chelakkara (11%) and Madakkathara (9%). The mean economic loss was estimated as Rs. 3736/- per ha/annum.

Indian crested porcupine is found in the fringe areas of all Forest Ranges, except Charpa Forest Range (Fig. 18.5). They fed on fallen coconuts (80.1%) and tapioca

Table 18.3 Potential value of perennial crops damaged by Asian elephants

Sl. no	Species	Economic life period (years)	Average yield per annum	Categorisation		Age class (years)	Potential value (Rs.)
1	Rubber tree	32	5.5 kg of dried rubber	Immature phase		0–6	80.00
				Productive phase	Primary stage	7–19	23,730.08
					Secondary stage	20–32	11,865.04
2	Coconut palm	60	75 coconuts	Immature phase		0–9	15.00
				Productive phase	Primary stage	10–34	23,662.50
					Secondary stage	35–60	11,831.25
3	Areca nut palm	20	15 kg of nut	Immature phase		0–5	10.00
				Productive phase	Primary stage	6–13	19,867.50
					Secondary stage	14–20	9,933.75

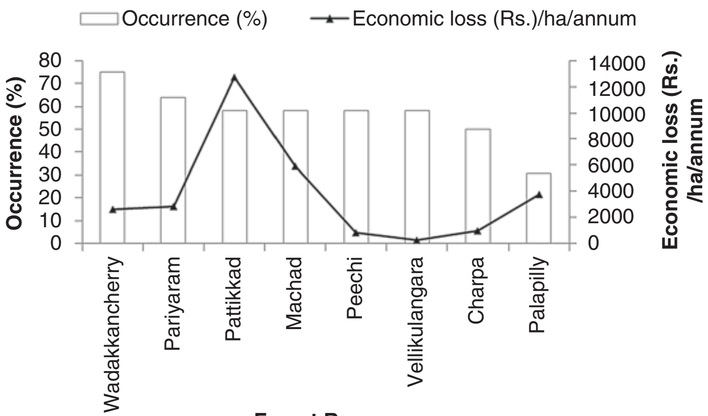


Fig. 18.4 Percentage occurrence and the economic loss reported by wild pig in the fringe areas of different Forest Ranges (Thrissur District, Kerala)

(19.9%). The number of fallen coconuts consumed was 0.06 ± 0.09 coconut/tree/month (n = 150). Like wild pig, mode of consumption of coconut was by removing the mesocarp and endocarp and feeding the endosperm. But the removed mesocarp had sharp edges with uniform size. Debarking the basal portion of coconut trees was reported from Vellikulangara (n = 4), Pariyaram (n = 3) and Peechi (n = 2) Forest Ranges. Highest damage was recorded in Vellikulangara Forest Range (Rs. 2129.63/- per ha/annum), and the mean economic loss was estimated as Rs. 615.47/- per ha/annum (Fig. 18.5). As this species belonged to the order Rodentia, they could cut the fishnet fence with their sharp teeth and enter into crop field in Machad Forest

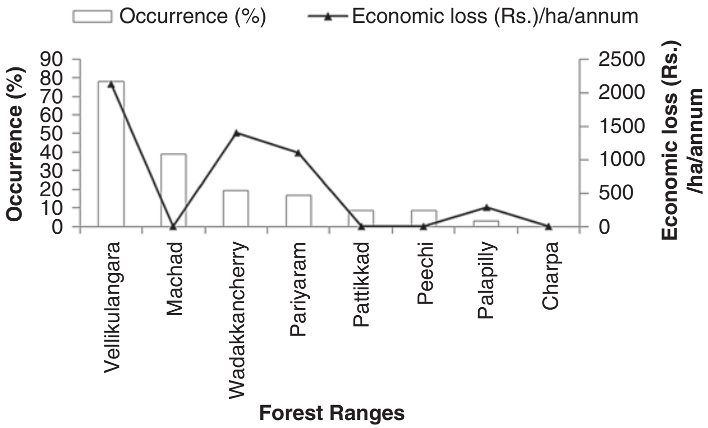


Fig. 18.5 Percentage occurrence and the economic loss reported by Indian crested porcupine in the fringe areas of different Forest Ranges (Thrissur District, Kerala)

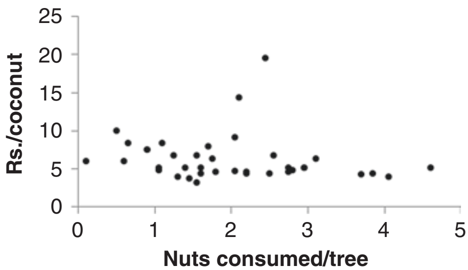
Range (two incidents). Among Grama Panchayaths, the highest damage was in Mattathur (34%), followed by Kondazhy (23%), Erumapetty (21%), Kodassery (17%) and Varandarappilly (4.57%).

Indian giant squirrel feeding on tender coconuts was recorded in the fringe areas of Forest Ranges, namely, Peechi, Machad and Palapilly. The coconuts were consumed by making a hole (circumference was 19.1 ± 4.2 cm, n = 200) into endocarp after removing mesocarp and fed endosperm (Plate 18.1). The same mode of attack was made by Indian giant flying squirrel (*Petaurista philippensis*), but the opening had only a circumference of 13 ± 2.4 cm (n = 25). Negligible amount of loss was reported by Indian giant flying squirrel. Feeding of coconuts by Indian giant squirrel was highest in Peechi Forest Range (4.6 ± 2.2 nuts/tree/month), followed by Machad (1.99 ± 1.04 nuts/tree/month) and Palapilly (0.45 ± 0.453 nuts/tree/month) (ANOVA, $F = 74.977$; $p < 0.001$). Approximately 2.11 ± 1.1 coconuts were consumed/tree/month in the immediate fringe areas of the forest. Due to the presence of human habitation near the quadrats which was laid 200 m away from the forest boundary, consumption of coconut was less in Palapilly Forest Range. Sixty eight per cent of the total yields of trees were being consumed in Peechi Forest Range, followed by Machad (33%) and Palapilly (9%). Highest economic loss was recorded in Peechi Forest Range (Rs. 3528/- per annum), followed by Machad (Rs. 3009/- per annum) and Palapilly (Rs. 205/- per annum), and the mean economic loss was estimated as Rs. 2247/- per annum. Puthur Grama Panchayath (36%) reported the highest damage followed by Chelakkara (31%), Thekkumkara (31%) and Varandarappilly (2%).

No significant relationship was observed between the market price of coconut and coconuts consumed/tree by the species in Peechi (Spearman's rank correlation, $r_s = 0.18$, $n = 36$, $p > 0.1$) and Palapilly ($r_s = 0.09$, $n = 36$, $p > 0.1$) Forest Ranges. In Machad Forest Range, a slight negative correlation was obtained (Fig. 18.6). The farmers frequently monitored the coconut plantations in Machad Forest Range and controlled the intrusion of IGS by throwing stones and producing sound with

Plate 18.1 Mode of attack on coconuts by Indian giant squirrel and Indian giant flying squirrel

Fig. 18.6 Relationship between the nuts consumed/tree in Machad Forest Range and the price of coconut (Spearman's rank correlation, $r_s = -0.301$, n = 36, $p < 0.1$)



metallic objects, when the price of coconut increased (three incidents). In Peechi and Palapilly Forest Ranges, farmers did not adopt any control measures, though their attitude was antagonistic towards the species.

Indian peafowl and other birds, namely, rose-ringed parakeet and spotted dove consumed paddy, were reported in the fields adjacent to Chulanur Peafowl Sanctuary, Kerala, India. During dusk (16.00–19.00 h) and dawn (06.00–09.00 h), peafowls were active in the fields (total time of observation was 95 h). Mode of consumption was by peeling off paddy from the plant with its beak. Rose-ringed parakeet and spotted dove were active in the fields during the noon hours (11.00–14.00 h) (total time of observation was 90 h). In the enclosure experiment, the yield of paddy from the control plots and open plots were 32.09 ± 3.26 kg/100 m^2 and 17.42 ± 5.46 kg/100 m^2, respectively ($t = 11.86$, $p < 0.05$) (Fig. 18.7). On an average, 47% of paddy was being consumed in the immediate fringe areas of the forest, and the mean loss of paddy was 1466.5 ± 247.31 kg per ha. Economic loss was

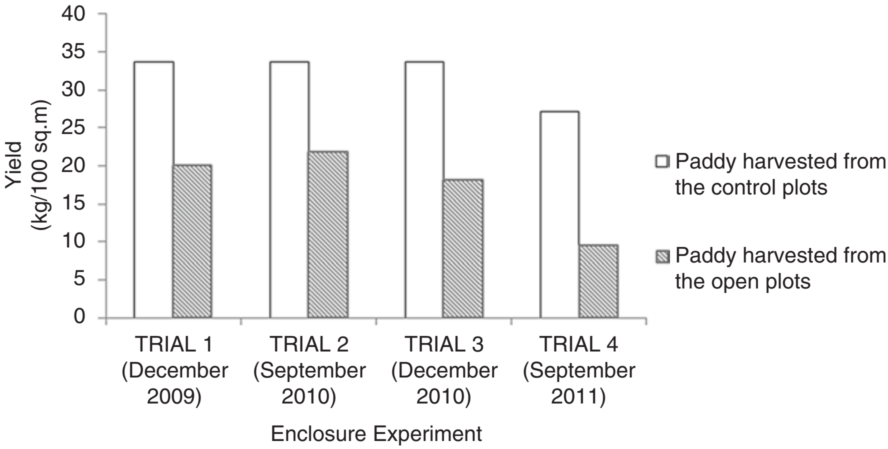


Fig. 18.7 Consumption of paddy by Indian peafowl and other birds near Chulanur Peafowl Sanctuary, Kerala

calculated by multiplying the quantity of paddy damaged, with its market price @ Rs. 11.33 ± 3.03/- per kg, which was estimated as Rs. 16,615.45/- per ha.

Bonnet macaque (*Macaca radiata*) found in all Forest Ranges. The menace from this species was reported from the Forest Ranges, namely, Palapilly, Wadakkancherry and Machad. They consumed banana, followed by jack fruit and mango. Damage to households was the main problem faced by the farmers in these Forest Ranges. Three troops were recorded from Wadakkancherry Forest Range (troop strength = 10.33 ± 2.08). Presence of sambar (*Rusa unicolor*) was recorded in the crop fields of the Forest Ranges, namely, Peechi (14%), Pattikkad (3%), Palapilly (3%), Vellikulangara (3%), Pariyaram (8%) and Charpa (3%). They entered the rubber plantations and stripped off the bark of young rubber plants (n = 34). Negligible amount of damage was reported by bonnet macaque and sambar.

18.4 Discussion

Asian elephant was recorded from all Forest Ranges, except Wadakkancherry and Machad. This species mainly consumed plantain in the immediate fringe areas of the forest. Mode of consumption of the crops was already reported by Jayson (1999). Elephants did an extensive damage in Pariyaram Forest Range (1485.71 plants/ha), followed by Palapilly (1427.91 plants/ha) and Pattikkad (1088.89 plants/ha). As more perennial crops were damaged in Pattikkad Forest Range, the economic loss was reported highest in this Range. Sukumar (1985) reported that several crop species were damaged in South India, and the loss was estimated as Rs.1,89,600/-. According to him, higher palatability and nutritive value are the causes for preferring the cash crops. In Buxa Tiger Reserve, India, paddy loss due to elephants was amounted to Rs.8,70,00,000/- for 4 years (Roy and Sah 2012).

Solar electric fence is a good mitigative measure for elephants and other wild animals, if it is properly maintained (Webb et al. 2009). Chilli-rope fence is a good short-term control measure for deterring elephants, which was proved successful in the tropical areas (Chelliah et al. 2010; Govind and Jayson 2013).

Wild pig was recorded in the fringe areas of all Forest Ranges and distributed in all types of forest in India (Prater 1965). Veeramani and Jayson (1995) reported that wild pig preferred tubers all over Kerala. *Oryza sativa*, *Ipomoea batatas* and *Eleusine coracana* were the selective species for consumption in North India (Chauhan et al. 2009), which were also targeted in Giant Panda Reserve, China (Cai et al. 2008). In Bhutan, wild pigs fed on paddy, maize, wheat and grain (Wang et al. 2006). Schley and Roper (2003) postulated that as the vegetables have high energy-rich content, these are more selective than the normal diet. Indian crested porcupine is a frequent crop raider which mainly damaged sugarcane in North India (Srivastava 2000) and coconuts (Ali et al. 2003) and nontraditional crops in Pakistan (Hafeez et al. 2012). They damaged fruit orchards and fed on vegetables (Alkon and Saltz 1985). In the study area, this species mainly fed on fallen coconuts, and it was also reported by Thyagaraj et al. (2006) in South India. Chakravarthy et al. (2006) state that degradation and fragmentation of the forest habitat compelled Indian crested porcupines to human habitations and to damage the cash crops. All these assumptions regarding the cause of damage by wild pig and Indian crested porcupine may not be valid in Kerala. The conservative attitude of the local people due to the stringency of wildlife laws led to the increase in the menace of these species in the crop field. Yellow-coloured plastic sheet fence is a good control measure to prevent their encounters in crop fields. Fishnet fence is widely practised in the study area for reducing the crop damage by wild pig.

Consumption of coconuts by Indian giant squirrel was recorded from the crop fields adjacent to Peechi-Vazhani and Chimmony Wildlife Sanctuaries. Planting of coconut trees in the immediate fringe areas of the forest lured this species to human habitation. Due to the low price of coconut (less than Rs.5/- per kg), farmers were not paying much attention to protect this cash crop. As the control measures applied by the farmers became weak, the squirrels expanded their activity into the undisturbed coconut plantations. Watch and ward is a good remedy to prevent the entry of this species into the coconut farms. As it is an arboreal mammal, another successful solution is to remove the branches of the trees near the boundary.

When the price of coconut was highest, poaching of Indian giant squirrel was recorded in Machad Forest Range. Increase in the price of coconut adversely affected the conservation of this species, and it is reflected in the attitude of farmers towards this species. In Peechi Forest Range of Peechi-Vazhani Wildlife Sanctuary and Palapilly Forest Range near Chimmony Wildlife Sanctuary, farmers did not respond to the damage of coconuts. Their approach towards this species was neutral, due to the stringent wildlife protection laws and awareness programmes conducted by the Kerala Forest and Wildlife Department. Sillero-Zubiri et al. (2007) reported that tolerance for the loss due to wild animals is highly influenced by the socio-economic factors.

Damage to paddy by peafowl and other birds was a serious problem to the farmers near Chulanur Peafowl Sanctuary, Kerala. Indian peafowl is the main bird species involved in the consumption of paddy than rose-ringed parakeet and spotted dove. Watch and ward is the only control measure executed to deter them. Due to Indian peafowls, huge financial loss was reported to the farmers in the buffer areas of Kitam Bird Sanctuary, Sikkim (Pradhan et al. 2012) and Kanha National Park, Madhya Pradesh (Karanth et al. 2012). Sambar did partial damage to rubber plants, which were cultivated in the periphery of forest. Browsing, stripping and fraying of barks are the typical mode of damage made by the species of deer family (Gill 1992), and the similar mode of damage was observed in rubber plantations in the study area.

18.5 Conclusion

Ten species of wild animals were damaging the crops in Thrissur District, Kerala, India, and they are Asian elephant, wild pig, Indian crested porcupine, Indian giant squirrel, Indian peafowl, sambar, bonnet macaque, Indian giant flying squirrel, rose-ringed parakeet and spotted dove. Species of crops damaged by wild animals are coconut, areca nut, rubber, oil palm, plantain, nutmeg, cocoa, elephant yam, colocasia, tapioca and paddy. Highest damage was reported from Pattikkad Forest Range (Rs. 5,18.468.23/- per annum). Asian elephant did the highest crop damage (Rs. 17,35,625/- per annum), followed by wild pig (Rs. 3736/- per ha/annum) and Indian crested porcupine (Rs. 615.47/- per ha/annum). Feeding of Indian giant squirrel on tender coconuts is reported for the first time, and the damage was estimated as Rs.2247/- per annum. Indian peafowl and other birds consumed paddy near Chulanur Peafowl Sanctuary, Kerala, and the extent of damage was Rs.16,615.45/- per ha. The study indicated that crop damage by wild animals is causing severe economic loss to the farmers in the District. For mitigating the conflict, control measures, namely, chilli-rope fence, yellow-coloured plastic fence and fishnet fence, are suggested.

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People Participation in Biodiversity Conservation

19

S. M. Vairavel, Amit Malick, and Sanjayankumar

Abstract

Social systems and ecosystems are strongly interlinked, forming social-ecological systems. With its long and intense history of human occupation and the present strong pressures from urbanization, tourism and agriculture, the tropical ecosystem especially the Western Ghats is the compelling example. These human-induced pressures are altering all components of biodiversity and ecosystems in the region they live, including their functional trait composition. Functional traits (i.e. the physiological, structural, behavioural or phenological characteristics of the organisms that form an ecosystem) have been shown to play important roles in the provision of many ecosystem services. Periyar Tiger Reserve (PTR) is one of the best managed tiger reserves in the country. The area falls under the Periyar landscape that consists of more than 4000 km^2 of forested areas mainly of rain forests both in Kerala and Tamil Nadu states of South India. The objective of the management is to ensure viable source population of tigers, co-predators and prey animals and to support agricultural, livelihood, developmental and other interests of the people living in the buffer and fringe areas of the Reserve. The PTR took many initiatives to improve livelihood and empower the people lives in its fringes. The initiative includes the release of tribal community from their debt trap, the transformation of the tribal community to become real owner of their agricultural produce, the assurance of regular income and food security, their involvement in biodiversity conservation, etc. One example is the pepper cultivation which has become the traditional agricultural practice and major source of livelihood income of the indigenous tribal communities, the Mannans and Paliyans. As these indigenous were not educated in the past and at that time the money lenders manipulated their loan account and made entry it into many fold increase. So, the people suffered always with loan amount for which they were not actually liable. The borrowing of money was being accumulated with wrong

S. M. Vairavel (✉) · A. Malick · Sanjayankumar
PTCF, Periyar Tiger Reserve, Thekkady, Kerala, India

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entry and continued till harvest season begins. During the harvest season, all money lenders reach tribal hamlets with untold and untruth loan register and force the people to repay, and the negotiation finally ends up with mortgaging their land and pepper yield. The money lenders harvest and take away all the pepper. This was the practice of "a debt trap" that continued for many decades. The initiative through the India Eco-Development Project (IEDP) intervened in this immoral debt trap. The Forest Department conducted a series of awareness programme for these indigenous tribal communities regarding their trap, and eco-development committees (EDCs) were formed. Then the initiative called up all money lenders for fact finding, and their accounts were scrupulously verified, and the anomalies were removed. The amount lent by the lender was negotiated and paid by the initiative, and the initiative conclusively pushed out all money lenders and their miscreant activities from the indigenous tribal community.

The indigenous tribal community people came to know the value and actual revenue of their pepper product. The communities organized under the village EDCs are managing themselves the cultivation, harvest, collection, product value addition, and marketing. The Forest Department initiatives were extended to help them to acquire *Organic Pepper Certification* which helped to export opportunity. This greater increase in their livelihood income through the initiatives did not necessitate the community to go for forest produce collection which helped to prevent forest degradation and destruction. The present paper describes all the initiatives from PTR towards conservation with people participation.

Keywords

Biodiversity · Conservation · Ecotourism · Kerala · Periyar Tiger Reserve

19.1 Introduction

Social systems and ecosystems are strongly interlinked, forming social-ecological systems. With its long and intense history of human occupation and the present strong pressures from urbanization, tourism and agriculture, the tropical ecosystem especially the Western Ghats is the compelling example. These human-induced pressures are altering all components of biodiversity and ecosystems in the region they live, including their functional trait composition. Functional traits (i.e. the physiological, structural, behavioural or phenological characteristics of the organisms that form an ecosystem) have been shown to play important roles in the provision of many ecosystem services. The ecosystem services provided by the Periyar landscape are very important to the five districts of Tamil Nadu state for their livelihood and agriculture farming. The landscape provide ecosystem services in terms of water, electricity energy etc. to the community including those who living away from reserve and the human population cross across many millions.

Periyar Tiger Reserve (PTR) is one of the best managed tiger reserves in the country. The area falls under the Periyar landscape that consists of more than

4000 km^2 of forested areas mainly of rain forests both in Kerala and Tamil Nadu states of South India. PTR is spread over 925 km^2 of the forested area in which 881 km^2 is core zone (free from human activities except protection) and the remaining 44 km^2 is buffer zone. The objective of the management is to ensure viable source population of tigers, co-predators and prey animals and to support agricultural, livelihood, developmental and other interests of the people living in the buffer and fringe areas of the Reserve. The park was facing challenges like poaching, smuggling of timber, ganja cultivation, uncontrolled collection of non-wood forest produce, tourism management, pilgrim management, etc. In the past these challenges were managed by policing.

It is also found that natural resources of the park are not only utilized by fringe area village people but also exploited by faraway urban people. The urban people were used by the local people to exploit park resources, and the urban people also exploited the innocence and poor education of local people. The local people were used as labourer. Ultimately, local people were victimized with poor livelihood opportunities, and other people were enjoying the benefit of natural resources. During the late 1990s, the park management realized that people participation in conservation is inevitable, and eco-development committees (EDCs) were formed for the people who are depending on the park. The people participation model is implemented with the objectives: to ensure viable population of tigers, co-predators and prey animals and to support agricultural, food security, livelihood, developmental and other interests of the people living in the buffer and fringe areas of the Reserve. This paper reveals and explicates various innovative initiatives taken by the park management and the ways of implication.

19.1.1 Past History

Forests of PTR had been rampantly used unscientifically and often misused by the people living around the park. As the terrain of the park is highly undulating and has very poor road network, many areas are difficult to access, and also having 90 km length of interstate border leads to frequent poaching and rampant smuggling of sandal wood and *Cinnamomum* bark. The famous Hindu religious temple, Sabarimala, is located inside the park. A large pilgrimage through the forest of PTR in Sabarimala created chaos, forest degradation and sidelining of local people by outsiders. Littering of plastics and other wastes; pollution of soil, air and water; massive clearing of forests for erecting temporary sheds; umpteen number of shops; large-scale collection of firewood and thatching materials; felling of trees; smuggling of valuable timber; poaching; illicit brewing; and extensive forest fire were prevalent. Demand for firewood and thatching grass was on the rise, and forest degradation was the result. Very importantly the local people were victimized, exploited, cheated and misused by other people using their ignorance and uneducation.

19.1.2 Approach

In due course it was realized that policing alone will not suffice in conserving forest and inclusion of local people in conserving forest in which they depend on is very much important and inevitable. So the park required change in its approach, and paradigm shift in the approach was made during 1996 with the help of India Eco-Development Project (IEDP).

The major objectives of the IEDP were to improve the capacity of protected area (PA) management, to conserve biodiversity and to minimize negative impacts of people on PA and vice versa by increasing collaboration of local people in the conservation effort. The major components of IEDP were improved PA management, village eco-development, nature education and training, research and monitoring. At the end of the project period, 78 EDCs were formed encompassing almost 40,000 people from the forest fringe areas. In order to sustain the process of participatory management beyond the project period, Periyar Foundation, a government-owned trust (under Trust Act), was established with the aim of sustaining the park management and fostering the eco-development initiatives in the park.

19.2 Results

During the year 1996, major paradigm shift was made with the implementation of IEDP project. Through consultations, consensus developed, and 78 EDCs were formed and grouped into 4 types based on their traditional skill, knowledge and profession. Negative dependency of these people on forest was almost reduced, poaching and wildlife crime rate was at its lowest, and sandal smuggling and forest fires were controlled through people's participatory management regimes. Formation of EDCs like Ex-Vayana (*Cinnamomum*) Bark Collectors' EDC (EVBC-EDC) comprising of ex-smugglers and Vidiyal EDC comprising of ex-poachers, etc. made an opportunity of operating community-based eco-tourism (CBET) programmes in PTR thereby getting a substantial livelihood means for these people. From a dark side of life, their activities came to that of protectors of forest and social status got upgraded. More than 150 families got food security, job security and regular monthly wages.

19.2.1 Release of Local Community from Debt Trap

Background Mannans and Paliyans are the two prominent tribal groups in Periyar. They were living inside the forest at places like Ummikuppan, Mlappara, Thannikudy, etc., and the main occupation was cardamom cultivation and fishing. In the 1940s, they were relocated to the fringe area of Periyar. Hence after relocation, in technical terms, they were inside the forest itself, but for all practical purposes, they were in the mainstream with mainstream people.

Fig. 19.1 Pepper plantation

Fig. 19.2 Harvesting of pepper

Kumily, the local township, had all services available. When all utilities were near an arm's distance, these tribal people were inclined to enjoy all these facilities. The place they were now living was fertile and much suitable for pepper (Fig. 19.1), internationally known as 'black gold'. As the pepper was of much demand and valuable, local money lenders had taken the innocence of the tribal for their greedy marketing techniques.

Whenever these people were in need of money, the money lenders were ready to give any amount of money as loan, and in return they persuaded the poor tribal to give all the pepper under their possession. During harvest (Fig. 19.2), the money lenders would weigh the yield and calculate the price. The tribes were being cheated in terms of weight and also in terms of price. Every time the calculation was in such a way that the debt was increasing year after year.

Fig. 19.3 Harvesting under EDC leadership

They also asked the tribes to do more tending operations to get more yield, so that their debt will become lesser. Since the tribes were not having enough money to do these tending works, the money lenders promised to do those works for them, with a cost. The work was being done with the tribes themselves, and hence the owners of the land became the labourers.

Intervention Periyar was selected as one of the seven sites to implement eco-development activities under India Eco-Development Project in 1996. As part of trust building with local communities, interactions were made with these tribes also. While collecting financial background of households, it was found that every household in the tribal hamlet was having huge debt to those money lenders numbering 20. Assessment of the volume of debt has given a figure of about 7 lakhs of rupees for the total number of 350 families. The money lenders were contacted by the forest officials and collected the figure from their part. Their figure was 21 lakhs.

In order to come to a realistic figure, the officials collected a list prepared by the leaders of the eco-development committee. A similar list was asked from the money lenders also, and they also presented a list. A triangulation was made with selected persons, and they were sticking on their figures. The money lenders said that the tribes have not calculated the interest portion. In the end the officials made a calculation by adding reasonable interest part, and the amount thus calculated came to 11 lakhs of rupees. It was made clear to the money lenders that they are not going to get a rupee more. At this point they came with a new proposal of forfeiting all the loans if they were allowed to harvest that year's yield. This offer was made as the yield was unprecedented that year and also the market price. The officials were stern on their stand that there is no place for the debt-makers inside the sanctuary any more. Publicly proclaiming that the Department believes the tribes and not the money lenders, arrangements were made to pay off the entire calculated money to the lenders. The money was made available by the then Principal Chief Conservator of Forests from a separate Head of Account under 'World Food Programme'.

Harvesting was done under the leadership of EDC (Fig. 19.3), and arrangements were made for the judicious marketing. Token advance money was given to every

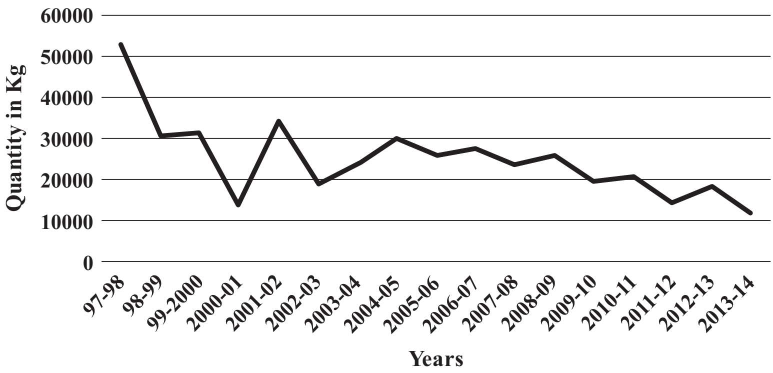

Fig. 19.4 Overall pepper collection trend – Mannakudy

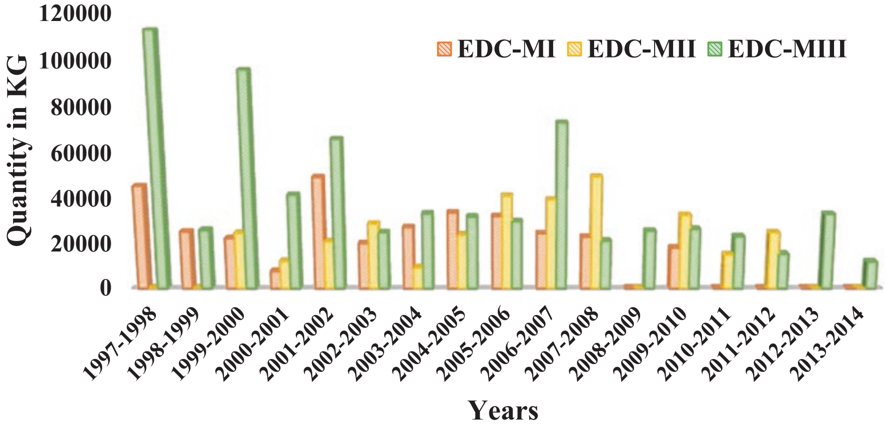

Fig. 19.5 Pepper collection across the three EDCs at Mannakudy over the years

household. At the end of the harvesting season, the yield was for 52 lakhs of rupees. Savings bank accounts were opened jointly in the name of the male and female heads of each family, and their share of money was deposited. The debt of every household was eliminated, and a bank balance was there in every house. For the first time in scores of years, they realized that they are the real owners of their land. A comparison of pepper production in Mannakudy is given in Figs. 19.4 and 19.5. It shows reduction in productivity over the years, and this is because the pepper vines are becoming not only old, and also they do not use any chemical manure. The community uses their own wild strain of pepper, regenerating the wild strain, and never goes for hybrid and chemical fertilizers for yield. The organic cultivation improves their livelihood although they have low productivity but high income due to their sustainable and ecologically organized farming pattern. Figure 19.6 reveals the income generation over the years in comparison with market price. As these people do only organic farming, their price is always higher.

Fig. 19.6 Market price comparison – certified pepper and conventional pepper


स्पाइसेस बोर्ड
SPICES BOARD
वाणिज्य एवं उद्योग मन्त्रालय, भारत सरकार
Ministry of Commerce & Industry, Government of India

निर्यातक के रूप में पंजीकरण प्रमाणपत्र
CERTIFICATE OF REGISTRATION AS EXPORTER

प्रमाणपत्र सं.
Certificate No. ML/REG/P780/2008

प्रपत्र - क FORM - A
अनन्तरणीय (Not transferable)
(स्पाइसेस बोर्ड अधिनियम, 1986 की धारा 11) (Section 11 of Spices Board Act, 1986)

मेसर्स M/s. PERIYAR FOUNDATION
OLD D.F.O QUARTERS, (W) NO.IX(H)NO.211, THEKKADY, KUMILY, KERALA-685 536

is/are hereby authorised to do business as Merchant / ~~Manufacturer~~ Exporter of Spices from India subject to the conditions specified in the Spices Board (Registration of Exporters) Regulations, 1989 and instructions issued by the Spices Board. The certificate is valid up to the 31st day of August 2011.

स्थान:
Place: Cochin - 25
तारीख:
Date: 01/09/2008

मोहर
Seal

बोर्ड द्वारा प्राधिकृत अधिकारी
Officer Authorised by the Board
O.T.S. NAMBIAR
Joint Director (Mktg.)

Fig. 19.7 Certificate of registration as exporter

Community Achievement The real owners, the Mannans and the Paliyans, realized their ownership and started the act of actual cultivation, and they began to do the tending operations in time which made advancement in yield. The way the cultivation based on organic with traditional practice proved to get certify (Fig. 19.7) international export, and the benefits were directly imbibed to local community by Periyar Foundation, Kerala Forest Department.

19.2.2 Sabarimala Pilgrims and Conservation of Natural Resources

Background Sabarimala is a holy place in Kerala, well known in the whole of South India. Lord Ayyappa is the deity here, and the temple is located well inside Periyar Tiger Reserve. Large number of devotees used to come to his holy place every year, and the peak season is just 2 months, which is from 15 November to 15 January. The activities of the temple are managed by Travancore Devaswom Board, which is a state-owned board. Every year the number of pilgrims to this shrine is increasing, and most of them are from Andhra Pradesh and Tamil Nadu. About 2 crore pilgrims visit every year and 95% of them during the peak season of 2 months (Travancore Devaswom Board's claim is 6–7 crores). About 10% of the pilgrims take a traditional walking route through the dense forest. This stretch from a place called Azhuthakkadavu to the temple is about 23 km, which is undulating and tiresome. But due to devotional and traditional aspects, many prefer this route.

In the Past Hundreds of shops and resting places are being established to cater the needs of the pilgrims in this route. The vendors used to cut poles and saplings for establishment of shops, and trees were ruthlessly cut to be used as firewood.

They were also squeezing the devotees by charging exorbitant rates for food items and also for the space for taking rest or sleeping. A mafia group was managing this route and collecting rent at their whims and fancies under the guise of some religious organization, even though they never had any connection with that organization. The Forest Department was just an onlooker in this affair as religious spirit was involved. The locals were not happy in this state of affairs, but there was no alternative, and this mafia group controlling the business was much stronger.

Death of animals was frequent, and the post-mortem examination revealed the presence of plastic substances inside the intestines. This was due to usage of large quantity of food materials packed in polythene covers, which were being thrown into the forest by the pilgrims.

Intervention Periyar was selected as one of the seven sites to implement eco-development activities under India Eco-Development Project, which started during 1996. While interacting with the fringe area people, it was revealed that the vendors during Sabarimala pilgrimage season, numbering around 1200, contained mainly from people from faraway places, and the number of locals was very few, and they were used as labourers only. All the profit made by the vendors was being taken to faraway places. There was no commitment from the part of these vendors after the season, and year after year, the density of the forests became severely affected.

The Department proposed an alternative to end this bad state of affairs, and the locals who were involved in the business were ready to co-operate with the Department, and an Eco-Development Committee (EDC) was formed. The name given to this EDC was SAPP EDC, which meant Swami Ayappa Poomkavana Punarudharana EDC. The first step for forming the EDC was eliminating persons who came from faraway places but were reluctant to leave the business. But they were not allowed to be involved in this initiative through mere force and by the will of the Department. The final number was just above 600. The dependency of the vendors in the past was analysed and found that every year, thousands of saplings and trees were being cut. Moreover the leftover of all the business residue and debris was instrumental in heavy forest fires. The micro-plan prepared for this EDC included commitment from the part of the vendors that they will not cut even a sapling and LPG or firewood from outside the forests would be used for cooking. Arrangements were also made for proper auditing of accounts and to have a judicious distribution of profits. Materials were brought from outside for erecting shops, and LPG and rubber wood were brought from outside. The EDC was made operational in the year 1998, and the officials had a constant and strict watch so that proper adherence of the provisions of the micro-plan is complied with.

Achievement Soon after the pilgrim season, results of the initiatives were analysed, and a study revealed that 4 lakhs of trees were saved in that season. This was calculated by studies conducted by the Ecology wing of Periyar Foundation on the basis of number of shops and the materials required for its erection and also the quantity of firewood requirement. Moreover all the debris was removed from the route, and plastic wastes were fully removed out of forest. Persons involved in the business could get a substantial profit, and through which, a number of families could get financial support. People were ready to perambulate the entire forests during fire season, and proper forest protection was ensured throughout the year. Incidence of forest fire became an old story. The prestigious Indira Priyadarshini Vriksha Mitra Puraskar Award for 1999 was bagged by this EDC. It was a rare chance of getting an award for *not doing something* rather than *doing something*.

19.2.3 Livelihood Income Through CBET Programmes

The various community-based eco-tourism programmes (CBET) by EDC members such as bamboo rafting, border hiking, bamboo grove, jungle camp, pugmark trail, tiger trail, jungle scout, jungle inn, nature walk, etc. were designed in such a way that they provide protection for the park and regular income for the people (Table 19.1 and Plate 19.1). The programmes are allocated to the identified EDCs based on their skill, experience and area of knowledge. Various CBET programmes, the EDCs involved and number of families benefiting are given in Table 19.2. Later it was found that the revenues of various CBET programmes are unequal, and the Park Welfare Fund (PWF) was put forth to resolve the inequality. Presently, all the income from the CBET programmes (which are conducted by the local community) are pooled in to the Park Welfare Fund (PWF) and disbursed as wages to the local community on monthly basis (Table 19.3).

Table 19.1 Yearly income generated through various CBET programmes

CBET programme	Yearly income in Indian rupees 2004–2005	2005–2006	2006–2007	2007–2008	2008–2009	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015 (upto 15th December)
Bamboo Rafting	2,360,000	2,507,000	3,642,000	1,900,000	2,283,000	2,024,000	2,698,000	4,749,000	5,233,050	4,925,000	3,130,000
Bamboo Rafting (Half day)	–	–	–	–	–	–	–	–	1,834,800	2,799,000	2,389,500
Border Hiking	387,750	663,750	1,046,250	826,250	704,250	634,750	848,250	1,166,000	1,422,000	1,626,000	1,029,000
Bamboo Grove	351,200	652,515	1,294,000	1,119,700	1,286,650	1,133,475	645,850	471,275	1,499,350	1,951,250	1,733,180
Jungle Camp	–	16,000	240,000	207,500	62,500	90,000	70,000	5000	852,800	910,500	912,000
Windy Walk	–	–	–	19,500	13,500	9000	–	–	–	–	–
Pugmark Trail	–	–	–	–	–	–	–	–	51,480	96,560	60,200
Tribal Dance	–	–	–	–	–	–	–	64,800	904,200	906,600	510,600
Tiger Trail	948,500	1,133,000	1,253,500	1,226,000	1,506,000	1,267,500	1,021,000	1,955,000	2,562,000	2,923,000	1,368,000
Jungle Scout	874,500	1,259,500	1,486,500	1,240,000	1,347,000	1,269,500	738,750	1,450,500	2,159,250	2,434,500	1,646,000
Jungle Inn	64,000	107,000	153,000	59,000	68,500	70,000	72,000	16,000	22,000	–	–
Nature Walk	1,115,000	1,291,000	1,594,900	1,448,800	1,197,000	1,387,700	2,169,900	2,699,000	2,716,200	3,372,100	1,844,400
Tribal Heritage Museum	104,300	124,900	143,400	56,400	70,350	60,150	34,800	31,850	–	–	–

(continued)

Table 19.1 (continued)

CBET programme	Yearly income in Indian rupees										
	2004–2005	2005–2006	2006–2007	2007–2008	2008–2009	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015 (upto 15th December)
Green Walk	–	–	–	396,800	569,400	888,900	1,168,400	1,726,200	1,974,800	2,219,700	1,334,400
Bullock Cart Discoveries	159,000	338,750	474,500	475,500	337,500	403,500	461,000	301,000	25,000	–	–
Range Scan	–	–	–	–	235,500	334,500	106,500	–	–	–	–
Clouds Walk	–	–	–	168,700	528,800	408,200	383,900	193,200	–	–	–
Total	**6,364,250**	**8,093,415**	**11,328,050**	**9,144,150**	**10,209,950**	**9,981,175**	**10,418,350**	**14,828,825**	**21,256,930**	**24,164,210**	**15,957,280**

Plate 19.1 Signboards of various community-based eco-tourism (CBET) programmes

Table 19.2 CBET programmes, the EDCs involved and number of families benefiting

Name of EDCs	Number of families benefiting	Name of CBET programme
PETS	64	Bamboo grove
		Jungle camp
		Jungle scout
		Jungle inn
Tribal trackers	20	Nature walk
Tribal heritage	20	Bamboo rafting
		Border hiking
		Tribal dance and heritage museum
		Green walk
Ex-Vayana	13	Bamboo rafting
		Tiger trail
Vidiyal	18	Border hiking
		Bullock car discoveries
		Range scan

19.3 Conclusion

The PTR made successful biodiversity conservation through People Participatory Conservation during the IEDP project period. The major objectives of the IEDP were to improve the capacity of protected area (PA) management, to conserve biodiversity and to minimize negative impacts of people on PA and vice versa by increasing collaboration of local people in the conservation effort. The major components of IEDP were improved: PA management, village eco-development, nature education and training, research and monitoring. At the end of the project period, 78 EDCs were formed encompassing almost 40,000 people from the forest fringe areas. Negative dependency of these people on forest was almost reduced, poaching and wildlife crime rate was at its lowest, and sandal smuggling and forest fires were controlled through people's participatory management regimes. In order to sustain the process of participatory management beyond the project period, *Periyar Foundation* took birth on 27 July 2004. *Periyar Foundation*, a government-owned trust (under Trust Act) established with the aim of sustaining the park management and fostering the eco-development initiatives in the park, became *a role model* in the country and for establishing the Tiger Conservation Foundation in all tiger reserves through amendments. As per the amendment to Wildlife (Protection) Act under Section 38x, it was directed to constitute Tiger Conservation Foundation in all tiger reserves, and hence the Periyar Foundation was dissolved, and *Periyar Tiger Conservation Foundation (PTCF)* took birth as per G.O.(Ms) No.73/2012/F&WLD, dated 4 July 2012.

Table 19.3 Wages paid to local communities (EDCs) as livelihood income against their man-days

Type of EDCs	2004–2005	2005–2006	2006–2007	2007–2008	2008–2009	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015 (upto Dec, 2015)
WAGES PAID (Indian Rupees)											
PETS EDC	1,017,590	1,259,800	1,155,213	1,410,637	1,205,357	1,320,806	1,864,788	3,023,422	2,953,336	3,125,211	2,031,901
Tribal Trackers EDC	828,425	792,403	841,797	803,447	941,741	874,653	1,183,426	1,976,811	1,835,262	19,71,336	1,354,391
Tribal Heritage EDC	456,073	545,592	548,931	592,217	979,342	949,801	1,065,215	1,764,652	2,027,829	21,40,015	1,488,713
Ex-Vayana EDC	936,099	872,898	799,819	694,801	658,568	662,603	731,330	920,031	1,201,745	12,58,289	838,588
Vidiyal EDC	142,000	281,849	329,112	377,352	796,363	1,010,673	1,209,593	1,700,312	1,974,135	19,91,769	1,423,515
TOTAL	**3,380,187**	**3,752,542**	**3,674,872**	**3,878,454**	**4,581,371**	**4,818,536**	**6,054,352**	**9,385,228**	**9,992,307**	**10,486,620**	**7,137,108**
MANDAYS											
PETS EDC	7123	8819	8087	8654	7395	6808	7371	8743	8158	8071	5176
Tribal Trackers EDC	5082	4861	5164	4929	5778	4509	4678	5717	5070	5091	3450
Tribal Heritage EDC	2798	3347	3368	3633	6008	4896	4210	5103	5602	5527	3792
Ex-Vayana EDC	5743	5355	4907	4263	4040	3415	2891	2661	3320	3250	2136
Vidiyal EDC	1479	2936	3428	3931	4352	5210	4781	4917	5453	5144	3626
Total	**22,226**	**25,319**	**24,954**	**25,410**	**27,573**	**24,838**	**23,930**	**27,141**	**27,603**	**27,083**	**18,080**

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Colonization of Large Wildlife in Rehabilitated Forests of Lowland in Chitwan National Park's Buffer Zone, Nepal

20

G. S. Solanki, M. K. Chalise, and B. K. Sharma

Abstract

The study was conducted in community-managed Baghmara buffer zone forest of Chitwan National Park, Nepal, to identify the colonization of large wildlife in rehabilitated forest areas within the protected area system. Total count of animals and review of secondary sources were employed for data analysis. The number of wildlife species recorded in the pre-community-managed phase was five, and their number was increased to ten during post-community-managed forest during this study. The total population of wildlife species recorded was 7 individuals in initial phase in the year 1995 that increased to 365 individuals after 20 years. The number of species and the size of population colonized were barking deer ($n = 12$), hog deer ($n = 2$), sambar deer ($n = 23$), spotted deer ($n = 182$), wild boar ($n = 5$), hanuman langur monkey ($n = 1$), rhesus monkey ($n = 76$), mugger crocodile ($n = 35$), tortoise ($n = 25$), tiger ($n = 1$), and rhinoceros ($n = 3$). Density of ungulates increased from 0.5 animal/km^2 to 104.2 animals/km^2 in post-management phase. There is an increased ($P < 0.05$) in prey population (ungulates), marsh mugger, and tortoise population in post-management phase.

Keywords

Community forest · Wildlife population · Rehabilitation · Habitat

G. S. Solanki (✉)
Department of Zoology, Mizoram University, Aizawl, India

M. K. Chalise
Central Department of Zoology, Tribhuvan University, Kathmandu, Nepal

B. K. Sharma
Biodiversity Coordinator - Conservation Development Foundation (CODEFUND), Kathmandu, Nepal

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20.1 Introduction

Wildlife species cannot survive in man-dominated habitats, and some of them are more sensitive to changing habitats than others and begin to decline prior to any noticeable degradation in the plant community to which they are inhabited. Undisturbed habitats are indispensable for such species are to survive in the wild. The complex interdependencies of living being state that conservation efforts should be focused at community and ecosystem level. If there are sufficient opportunities for the survival of large-bodied wildlife, then the other less space-demanding members of their communities would also survive (Shaffer 1978).

Nepal is situated between latitudes 26°22′ and 30°27′ N and longitudes 80°40′ and 88°12′ E on the southern slopes of the central Himalayas and occupies a total area 147,181 km^2. Hills and high mountains cover about 86% of the total land area, and the remaining 14% are the flatlands of the Tarai, which are less than 300 m in elevation. Altitude varies from some 60 m above sea level at Kechanakalan in the eastern Tarai to Mount Everest (Sagarmatha) at 8848 m, the highest point in the world. It has therefore, incorporated different habitats within the short horizontal distance resulting high biological diversity. Nepal's biodiversity (floral and faunal species) is a reflection of its unique geographic position, altitudinal, and climatic variations. It incorporates the Palaearctic and the Indo-Malayan biogeographical regions and the major floristic provinces of Asia (the Sino-Japanese, Indian, western and central Asiatic, southeast Asiatic, and Indian desert) creating a unique and rich terrestrial biodiversity (Chalise 2013; Sharma 2014).

Forests are also inextricably linked to the livelihoods of Nepali people. Thus, forest plays a vital role in reducing the incidence of poverty, bolstering local livelihoods, and supporting other co-benefits like biodiversity conservation and ecosystem services (Giri 1996). Resource degradation has exceeded after the nationalization of private forest in Nepal in 1957 and due to the unstable government and lack of proper institution for conservation. Later the conservation activities were institutionalized in the form of forest law (1956) and protected area law (1973). It was experienced that conservation activities were not so effective outside the protected areas, because it is still considered as common property. Therefore, the law enforcement agency in the protected areas and the local communities in conservation areas worked together and showed the positive impact on resource conservation. By realizing the fact, buffer zone concept arose as a new approach for protected area management was initiated through King Mahendra Trust for Nature Conservation (KMTNC 1998).

In the study area lowland (subtropical) region of Nepal is famous for charismatic and diverse wildlife species. The riverine subtropical forest with floodplain adds its richness in biodiversity. The commercial demand and the local marginalized peoples' needs have exerted pressure that has led to decrease of its densities and their population outside the protected areas. However, the community forestry programs established by government and managed by local people outside the protected areas are the last refuse of biodiversity and especially of large-size fauna including larger mammals.

A systematic wildlife and vegetation study of this area was conducted first time in 1994 (NCRTC 1995), and thereafter it was monitored on regular basis. After more than 20 years of conservation efforts, a healthy forest area with different habitat types was created, and some endangered flagship species and other common large wildlife species started colonizing (NCRTC 2000). This study is focused on the colonization of large wildlife in rehabilitated areas of BBZCF in Chitwan National Park's Buffer Zone, Nepal. The information on restoration of large mammalian and other wildlife population during these 20 years has compared comprehensively. During the early period, less security added with the open grazing practices and available space was not supportive for the diversity of wild animal and their population. The study will describe the large mammalian species available in BBZCF and increase in their population during 1995 and 2011.

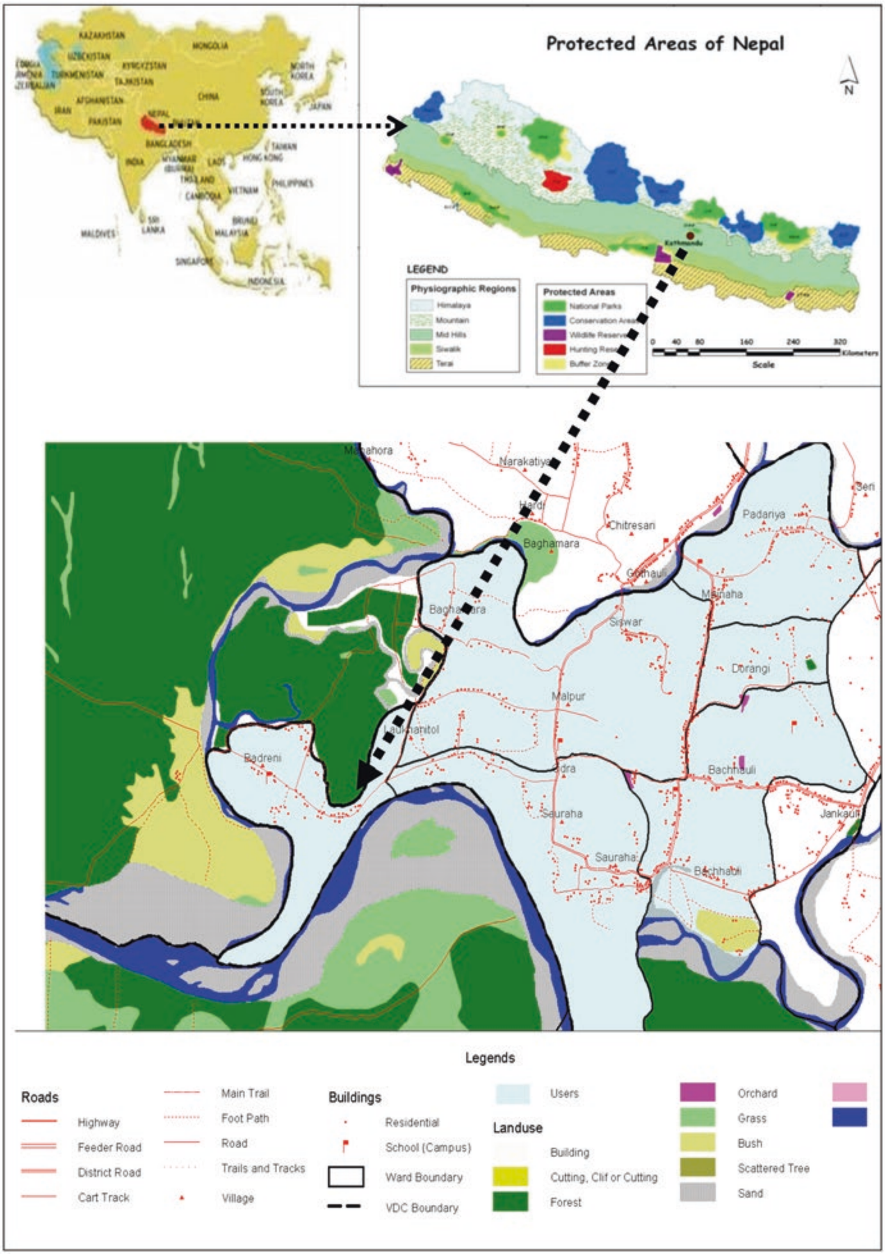
20.1.1 Study Area

Study was carried out in Baghmara Buffer Zone Community Forest (BBZCF), the part of the buffer zone of Chitwan National Park. It is situated in between 27°34.78′–27°35.53′ N latitude and 84°28.43′–84°29.40′ E longitude in subtropical region of central lowland at an elevation of 170–200 m above sea level and covering covers 215 ha area (Tamrakar and Sharma 2002; KMTNC 1997; Pant 2003) (Map 20.1). Community conservation efforts have ameliorated the condition of BBZCF. The institutional engagement in the resource management and involvement of local stakeholders in process of conservation of the community forest, illegal grazing and collection of fuel wood, and fodder and hunting was totally controlled that provided good environment for conservation of community forest including wildlife species inhibited there.

In 1963, the Baghmara forest was favorable habitat for tiger and rhinos and was also a hunting ground. Later due to extensive exploitation of the forest, it was merely an unproductive barren wilder land for animals and plants. In 1988 Baghmara forest area was identified for conservation activities. At that time a few wildlife species existed, but the information about them was scattered in different notes and papers. Although the conservation initiative started in 1989, BBZCF was officially institutionalized in 1994 under the legislation of Department of Forest (BCF 1994). In 2003, this forest was registered according to buffer zone regulation based on the fourth amendment of the National Parks and Wildlife Conservation Act (in 1995).

20.2 Methods

Total count of large animals was conducted once in 2011 with the help of elephant rides by direct visual counting technique (Witmer 2005). To reduce the double counting and missing of some animal in count, the enumerators were placed in such a way that they could see other enumerators in their left and right. The enumerator covered the entire forest by walking along the fixed bearing from one end (baseline)



Map 20.1 Location of the study area

to another end of the forest and counting all the wildlife. In total 18 transects traversing the entire forest were prepared for the census. The size of transects was set in such a way that it can be covered by 18 enumerators, spaced at least a distance of 100 m, within an hour. The animals were stalked and approached with minimum disturbance; count and sex were confirmed by the help of binoculars. Three enumerators were waiting in the tree platform as vantage point at the end of forest to count the escape animal during census.

The area was barbed wire fenced for three sides and fourth side, western part is bordered by river. Therefore, thorough counting of wild animals were conducted early in the morning driving out the animals in such a way that chances of escaping animals from the sight of enumerator minimizes. Considering entire community forest as one census unit, total count was performed to all the large wild animals. Prior to start briefing about the counting techniques and the area to be counted was allotted to all technicians. A starting point was identified, and 23 technicians (including 5 elephant drivers) are setting hand watch to each observer spaced at intervals of 100 m. They were instructed to move quietly through the jungle with compass bearing on hand and record sighted large wildlife. Date, time, species, age, sex, number, and location with reference to the line of travel and direction of movement of the wildlife were recorded whenever animal is seen including their left and right.

Data regarding the yearly systematic wildlife monitoring, from 1994 to 2010, was collected from the official documents (BCF 1994; NCRTC 1995; KMTNC 1997; NCRTC 2000; BBZCF 2003), official records of BBZCF and Biodiversity Conservation Center, Chitwan. The collected information were analyzed by using Microsoft excel and Minitab version 15. Secondary data from other research works were also used for analysis. Paired *t*-test was used to compare population size of wildlife in pre- and post-management period (Johnson and Bhattacharyya 1996). The population increment factor was calculated by dividing the wildlife population of post-management by the wildlife population of pre-management regime.

20.3 Results

The status of population of wildlife categories was evaluated on the basis of more than 20 years of community conservation efforts. The entire period was divided as (a) pre-community-managed period from 1989 to 2000 and (b) post-community-managed period from 2001 to 2011. How the various wildlife species grew and colonized in these phases is reported here.

20.3.1 Colonization of Prey Species

Composition of prey species in BBZCF includes barking deer (*Muntiacus muntjack*), hog deer (*Axis porcinus*), sambar (*Cervus unicolor*), spotted deer (*Axis axis*), and wild boar (*Sus scrofa*). During this study, 12 resident barking deer, 2 hog deer, 23 sambar deer, and 182 individuals of spotted deer were recorded. Only one

Table 20.1 Population with age and sex composition of prey species in BBZCF, 2011

Wildlife species	Age/sex/number								Total number
	AM	AF	SM	YAF	JM	JF	Infant	UN	
Axis axis	43	63	8	5	7	8	13	35	182
Axis porcinus	1	1	–	–	–	–	–	–	2
Cervus unicolor	7	13	–	1	1	–	1	–	23
Muntiacus muntjack	8	2	–	–	–	–	1	1	12
Sus scrofa	–	1	–	–	4	–	–	–	5

***Note*:** *AM* adult male, *AF* adult female, *SM* subadult male, *YAF* young adult female, *JM* juvenile male, *JF* juvenile female, *UN* unidentified

resident wild boar group was recorded in Baghmara Buffer Zone Community Forest (BBZCF). Total population of this species become five with more juvenile male (n = 4) and one adult female. A wild boar group with juveniles indicates presence of adult male which could not be observed (Table 20.1).

20.3.2 Colonization of Flagship Species

Two species under this category, namely, Bengal tiger (*Panthera tigris*) and Asian one-horned rhinoceros (*Rhinoceros unicornis*), were recorded in the study area. Tiger was frequent visitor, a nonresident to the area. Only three rhinoceros were recorded as residential in this forest area with an adult male, an adult female, and a subadult male. However, ten calves of rhinos have been born inside this BBZCF till now (Table 20.3).

20.3.3 Preferences of Other Wildlife

Under this category nonhuman primates from terrestrial habitat and mugger and tortoise from wetland were included. Two species of monkeys were recorded during this study. However, only one resident male hanuman langur (*Semnopithecus entellus*) was observed during the study in this forest. This solitary male comes from nearby other forest frequently at daytime. Rhesus monkeys (*Macaca mulatta*) were frequently seen and distributed throughout forest with 76 individuals in 8 troops and found mostly associated with spotted deer (Table 20.2).

Initially during establishment of BBZCF in 1995, only one marsh mugger (*Crocodylus palustris*) was recorded from the study area (NCRTC 1995). One small wetland (1 ha) was managed in the center of the forest area, and two marsh muggers were released in 1996. Their number increased to 29 individuals in 2000 (KMTNC 2001) and to 35 in 2011, and their resident habitats were found in all wetland areas inside BBZCF. Similarly, the population of water tortoise increased to 25 from only 1 individual in 1995 (Table 20.3).

Table 20.2 Population with age and sex composition of other wildlife species, 2011

Wildlife species	Groups	Age/sex/number								Total number
		AM	AF	SM	YAF	JM	JF	Infant	UN	
Macaca mulatta	8	11	19	9	18	4	11	–	4	76
Semnopithecus entellus	NA	1	–	–	–	–	–	–	–	1
Crocodylus palustris	NA	–	–	–	–	–	–	–	35	35
Kachuga dhongoka	NA	–	–	–	–	–	–	–	25	25

***Note*: *NA* not available, *AM* adult male, *AF* adult female, *SM* subadult male, *YAF* young adult female, *JM* juvenile male, *JF* juvenile female, *UN* unidentified

Table 20.3 Census of wild animals in pre- and post-management regimes (1995–2011)

	Recorded year (1995–2011)																
	Pre-community manage (1995–2000)						Post-community manage (2001–2011)										
Name of wildlife	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11
Barking deer	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12
Hog deer	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Marsh mugger	1	–	3	–	–	–	29	–	–	–	–	–	–	–	–	–	35
Rhesus monkey	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	76
Rhino	3	2	2	2	–	2	1	–	–	–	–	–	–	–	6	3	3
Rhino calves born	–	2	3	–	1	–	–	–	–	–	–	–	–	1	1	1	1
Hanuman langur	–			–		–	–	–	–	–	–	–	–	1	1	1	1
Sambar	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	23
Spotted deer	–	–	–	–	–	–	24	–	–	–	–	–	–	–	–	–	182
Tiger	1	1	1	1	1	1	1	–	–	–	–	–	–	1	1	1	1
Wild boar	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
Water tortoise	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	25

20.4 Discussion

20.4.1 Colonization of Prey Species

During this study nine resident species of large wildlife species were recorded in BBZCF. Most of them were herbivores and found in groups. Tiger was a single visitor individual recorded in all the events. The previous study indicated that this area was quite favorable habitat for large and charismatic wild mammals (NCRTC 1995). Before the 1950s the severe anthropogenic pressure in various forms such as hill migration, agriculture extension, overgrazing, and illegal logging of trees reduced the wildlife population heavily (NCRTC 1990).

We recorded four ungulate species, viz., spotted deer, barking deer, hog deer, and wild boar, in Baghmara forest. There were no earlier reports about their presence in area. Barking deer are solitary animal and observed mostly single along the shady areas of dense forest habitat (Chalise 2001). Any record regarding its presence and absence was lacking in the pre-management regime of this community forest. This area was much disturbed due to heavy grazing by cattle and collection of forest product by the people of surrounding villages and that would have caused the removal of wildlife during the pre-management phase.

Presence of hog deer in the study area indicates the availability of its suitable floodplain grassland habitats that is available in BBZCF (15.3%). The general distribution indicates its solitary nature in alluvial grassland (Mishra 1982). In the pre-management phase, there was not a single record of this species in this area (NCRTC 1995). Current status indicated its availability (n = 2) at the edge of oxbow lake rather than from floodplain. Sambar deer was not reported at the early stage of community management (NCRTC 1995), later one individual of sambar deer was reported in the study area in 1995. Population record of this species was unavailable after a long time from its first record. The conservation of favorable habitats, like forests, grassland, and wetlands, inside the study area leads to increase ($n = 23$) the population of this species in the post-community management period.

The population of spotted deer grew well in post-community regime, whereas no residential spotted deer is recorded during the initial phase of community-managed forest. They may be then frequent visitor from nearby national park forest. Wildlife count in 2000, immediately after flooding, reported 24 spotted deer in the area (KMTNC 2001). This was the first official record of availability of this species from the Baghmara area. Then the systematic count of this species during the current study recorded 182 individual of spotted deer. Proper management of the available spaces (BBZCF 2003), regular patrolling, and permanent water sources in the area (KMTNC 2001) favor the wildlife to recolonize. Density of 5 wild ungulates in the study area was 104.2 individuals/km^2, which is more than 200 times higher than in pre-community-managed period. The increment was mainly due to the remarkable increase the population of spotted deer and sambar deer as the habitat flourished.

There was significant increase in prey species population in post-management than pre-management phase ($T = 2.01$, $p < 0.05$, df = 9). We observed that the population of wild ungulates increased by 11.2 times in community forest management in 20 years. The density of ungulates in the area was 0.5 animals/km^2 in 1995/1996 that increased to 104.2 animals/km^2. Increase in density was due to remarkable change in population of all five ungulates. The frequent patrolling and the users' group members provided safeguard to the wildlife against poaching. Regular patrolling inside the forest helped to reduce the disturbances to the wildlife. These all factors in association with the improvement in quality of habitat favored the increase of the number and density of wild ungulates in the study area.

20.4.2 Colonization of Flagship Species

The area especially used for tiger hunting before the initiation of national conservation efforts in 1957 as it was a prime habitat for those animals. Due to heavy hunting and habitat destruction, Baghmara remained barren land until community conservation effort started in 1989. Human population increased around this area due to mass migration of people by the malaria eradication program. During the initial wildlife study, there was no report of the presence of any tiger in the Baghmara area (NCRTC 1990). Later during 1997 a tiger killed the sambar deer, and in 1998 one problematic tiger entered inside this forest and caused human casualties (KMTNC 2001). After capturing this tiger there was no report of presence of any resident tiger. However, pugmark sign of the tigers were reported during a decade before (NCRTC 2000). After this period the signs of tiger's presence were recorded (n = 1), but not a single resident was seen physically (KMTNC 2001). During this study we observed several signs of a male tiger that showed its presence and frequent movement through the Baghmara forest area. It further indicates that the suitability of habitat to tiger increased because of sufficient number of prey species. Nevertheless tiger could not accommodate in the Baghmara forest, might be due to its small space (215 ha) and large tourist flow (average 266 tourist per day, official record of BBZCF).

Asian one-horned rhinoceros (*Rhinoceros unicornis*) was one of the frequently observed large herbivore in this community-managed forest. They were also recorded elsewhere in the grassland, forest, and wetland areas inside the community forest (Chalise 2008). We recorded a total of three rhinoceros in this forest area with an adult male, an adult female, and a subadult male. The subadult male was nearly 2.5 years old at the weaning stage. During the initial period of community management of this forest, rhino was frequent visitor only (NCRTC 1990). They were visiting from nearby Chitwan National Park, especially during monsoon, when the park floodplain areas would heavily inundated from flood (NCRTC 1995). Immediately after the community conservation initiatives, these big herbivores started to reside in Baghmara forest. The availability of food plants like *Saccharum spontaneum* and *Litsea lancifolia* with fewer disturbances from anthropogenic activities might have attracted this wildlife species to become resident in this forest. Other reasons of rhino residency might be lack of resident large carnivores in the forest. Regular survey since 1995 indicated that the number of resident rhinos in the study area ranged from one to three within 5 years. However, a number of resident rhinos were fluctuating, and the number of resident rhino was reduced to one during 2001 (KMTNC 2001).

During 2000 there was a heavy flood in the Rapti river system, which was one of the prime habitats of rhino. This flood inundated all floodplain areas inside National Park, and some favorable habitats of rhinos were washed away (KMTNC 2001). After that flood, Icharni Island which is one of prime habitat of rhino inside National Park had 22 resident rhinos (NCRTC 1995). Baghmara forest area was also inundated, and there was no movement for about a week (KMTNC 2001); therefore hardly any shelter could be provided to this charismatic wildlife. That flood disaster impact still prevails to rhino residential status. That natural calamities caused the loss of some ungulates in the area.

20.4.3 Colonization of Other Wildlife

During the pre-management phase of this community forest, there was no report about any type of nonhuman primates either common langur (*Semnopithecus entellus*) or rhesus (NCRTC 1995). The availability of food plant seems to be the main cause of their presence in this forest (Chalise 2000). Attraction of those primate species in this community forest and availabilities of larger number indicated that their habitat became suitable, and adequate food plants have been regenerated after the management by the community. After conservation initiation of the area wetland habitat was also being improved. After imposing a ban on illegal fishing by using poison and electric trappings, the increase of marsh mugger crocodile and water tortoise population has been evident. The reduced anthropogenic pressure and due conservation of their favorable habitats for availability of food might have given opportunity for aquatic species (Maskey 1999). Current finding also reflect significant increase in the population of marsh mugger and water tortoise in post-management ($T = 5.49$, $p < 0.05$, df = 2) than the pre-management phase.

20.5 Conclusion

Conservation efforts of local community facilitated the plant succession in degraded land areas. The reoccurrence of forest, grassland, and wetland habitats in the community-conserved area provided required habitat components for wildlife. The available space of the community-managed forest area currently incorporated one mega herbivore, five deer species, two species of wild primates, and two species of reptiles. The population of available prey species is significantly increased than the initial phase of forest conservation.

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