Ulysses Paulino Albuquerque
Rômulo Romeu Nóbrega Alves *Editors*

Introduction to Ethnobiology

Springer

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Editors
Ulysses Paulino Albuquerque
Universidade Federal Rural de Pernambuco
Recife, Brazil

Rômulo Romeu Nóbrega Alves
Universidade Estadual da Paraíba
Campina Grande, Paraíba, Brazil

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Preface

Despite major advances in ethnobiology, there is still a lack of textbooks that can serve as references for its teaching worldwide. There is no doubt that in recent years, many books have appeared to fill gaps in ethnobiology teaching and research. In this sense, this book is aimed at subsidizing initial ethnobiology teaching at the undergraduate and graduate levels. The aim was to produce short chapters that introduce the reader to the major themes that have been or can be addressed in ethnobiological research. Obviously, given the complexity of ethnobiology, it was not possible to present all views on and approaches to this subject. Therefore, this book is a brief introduction to the topic, taking into account the academic and investigative interest biases of its organizers.

This book is divided into five parts, each covering the aspects of ethnobiology that were considered relevant for the ease of reading and learning. In the first part, the aim was to explain most historical and conceptual aspects of ethnobiology. Some chapters address relatively new or little debated approaches, which will interest even the most experienced readers in the field of ethnobiology.

The appropriation of nature, in various forms, may be perceived by mankind in certain ways. Thus, the second part of the book specifically addresses this initial stage of the relationship between humans and nature. Also, the second part, addresses the classic debate and the major theoretical contributions regarding how humanity classifies the nature.

In the third part of the book, one of the most discussed aspects in ethnobiology will be addressed: the use of natural resources.[1] This topic was chosen to address only the resources that are most often studied by ethnobiologists as a very simple and direct introduction to each of these resources. The fourth part is configured as a natural extension of this approach, addressing the consequences of a utilitarian relationship with nature. Thus, this fifth section focused on the extractivism of forest products and plant and animal domestication.

[1] The term "natural resources" is used several times by the authors in this book as a synonym for biota. Thus, it does not necessarily have an economic or utilitarian connotation.

Finally, the fifth part is a synthesis of which variables affect local biological knowledge (LBK). Although not every influencing factor will be addressed, a set of information that undoubtedly serves as an approach to the subject will be offered to the reader.

Thus, we believe that this book will help ethnobiology teachers and students with its relatively benign approach to the subject. The reference list in each chapter and a small dictionary of ethnobiology terms and related areas complement the book, allowing readers to gain a deeper understanding of the covered topics.

Recife, Brazil Ulysses Paulino Albuquerque
Campina Grande, Brazil Rômulo Romeu Nóbrega Alves

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Dr. Ulysses Paulino Albuquerque
Dr. Rômulo Romeu Nobrega Alves

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Part I
History, Approaches and Concepts

What Is Ethnobiology?

Ulysses Paulino Albuquerque and Angelo Giuseppe Chaves Alves

Abstract Ethnobiology has been defined classically as the study of the interactions of people and the environment. It is in fact a complex field of knowledge and action that interfaces with many scientific disciplines. These interfaces result in different approaches and theoretical challenges. Ethnobiology occupies a privileged position because of its potential to integrate local and global knowledge, to connect cultures and academic approaches, and to relate biological and social aspects of the human experience to the environment.

The term "ethnobiology" refers to a union of competences that encompass aspects ranging from cultural to biological, comprising the study of very diverse relationships. It is challenging to define such a complex field, which involves different approaches and theoretical problems. Classically, ethnobiology has been defined as the study of the interactions of people and the environment. This sometimes makes it appear that the term is associated with human ecology and ethnoecology[1]. Darrell Posey (1987a), one of the greats of ethnobiology, sees it as the study of knowledge and concepts developed by any culture on biology.

This chapter is a revised and updated version of the "Introduction" published in the book *Ethnobiology and Biodiversity* (Albuquerque 2005).

[1] In this regard, for further debate, see Begossi (1993, 2004) and Alves and Souto (2010). In another chapter of this book, we introduce a discussion on the relationships between ethnobiology and ethnoecology.

U.P. Albuquerque (✉)
Laboratory of Applied and Theoretical Ethnobiology, Department of Biology, Federal Rural University of Pernambuco, Rua Dom Manoel de Medeiros s/n, Dois Irmãos, 52171-900 Recife, Pernambuco, Brazil
e-mail: upa677@hotmail.com

A.G.C. Alves
Department of Biology, Federal Rural University of Pernambuco, Rua Dom Manoel de Medeiros s/n, Dois Irmãos, 52171-900 Recife, Pernambuco, Brazil
e-mail: agcalves.ufrpe@gmail.com

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Table 1 Some of the different approaches in ethnobiological research

Approach	Definition
Evolutionary ethnobiology	Studies the evolutionary history of the patterns of human behavior and knowledge of the biota, considering historical and contemporary factors that influence these patterns
Historical ethnobiology	Studies the interrelationship between humans and the biota from past evidence preserved in historical documents
Medical ethnobiology	Studies traditional medical systems encompassing the use, management, and knowledge of the biota in these systems
Quantitative ethnobiology	Involves the use of multivariate statistical techniques to explore different aspects of the interrelationships between people and the biota
Predictive ethnobiology	Focuses on developing quantitative models to predict the behavior of systems formed by the interrelationships between people and the biota
Urban ethnobiology	Studies the relationship between people and the biota in urban ecosystems

The presented settings do not necessarily represent consensus among experts

There are two classical approaches in ethnobiology, cognitive and economic, which are neither exclusive nor exhaustive. Table 1 shows other approaches that, over time, have emerged and that can relate directly or indirectly with the first two. For its cognitive approach, ethnobiology is concerned with know how cultures perceive and know the biological world; in its economic focus, it considers how these cultures convert biological resources into useful products. Other related approaches may focus on different aspects, ranging from politics to emotions (Hunn 2007, 2014).

Ethnobiological information has long been collected from studies investigating how human populations use their plant and animal resources (Castetter 1944). Ethnobiology has contributed information for biodiversity conservation and sustainable use, as well as giving greater visibility to the knowledge and rights of so-called traditional or local peoples (see Toledo et al. 2003; Moller et al. 2004; Donovan and Puri 2004). Consequently, it has achieved growing recognition on the part of conservationists, environmentalists, ecologists, biologists, social scientists, and other researchers. In recent years, the number of publications has grown considerably, thus showing the implications of ethnobiological research in the conservation of ecosystems in different parts of the world (see Svanberg et al. 2011; Albuquerque et al. 2013).

One of the goals of ethnobiology has been to associate knowledge of natural sciences with knowledge of human sciences to record the entire breadth of knowledge, classification, and use of natural resources from different cultures (Posey 1987b). One of the fields of ethnobiology that has experienced more concentrated work in Latin America is that of ethnobotany, alongside others that are growing in terms of the number of publications, such as ethnozoology and ethnoecology (see Albuquerque et al. 2013).

Ethnobiologists occupy themselves with understanding so-called traditional knowledge or local knowledge, especially with regard to living beings and their habitats. In the literature, we also find the terms such as "traditional biological knowledge" and "traditional ecological knowledge." We understand traditional knowledge as accumulated experiences and knowledge by a human group in relation to natural resources. This knowledge is dynamic and changeable. The term "traditional" has been much discussed. McClatchey (2005) argues that this term, although used with positive connotations for ethnobiologists, is vague and often used improperly. To situate the reader in the debate, we transcribed some considerations of Santos et al. (2005): "the terms 'local knowledge', 'indigenous knowledge', 'traditional knowledge' or even 'ethnoscience' have appeared frequently in the last decade, aiming to draw attention to the plurality of knowledge production systems in the world and to their importance in the development processes (…)."

The adjective *local*, despite its limitations, has an advantage: it serves to indicate from where some people are speaking and acting. Therefore, it reveals the situation in space and time from which these populations express their knowledge, cultures, and their relationship with the environment. No one is omnipresent. Everyone, whether researcher or member of a traditional population, speaks from a specific viewpoint. On the other hand, the term tradition[2] does not necessarily mean a static condition, as it relates etymologically to transition, indicating its intrinsic potential to incorporate changes, innovations, and experiments performed by humans. If on the one hand we must act with caution and seek a theoretical basis for selecting adjectives to apply to studied people, on the other hand it is valid to devote ourselves also to understanding the expressions with which these same people prefer to refer to themselves[3].

In recent decades, the search for alternatives to contain the devastation of natural resources was intensified, as well as the development of sustainable management systems for the maintenance of biological diversity. Methods for the sustainable management of ecosystems have been proposed over time. Nonetheless, many of them are characterized by the untying of human populations that traditionally live in different ecosystems. A number of studies have been devoted to revealing the knowledge of local population[4], especially indigenous and peasant groups, regarding the environment in which they live (Toledo et al. 2003). The following are some examples.

Donovan and Puri (2004) provide an interesting example of how traditional ecological knowledge can be a guide to autoecology studies with species of economic interest. They compared the knowledge of a group of people in Indonesia who collected products of species of *Aquilaria* (Thymelaeaceae) with scientific records.

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[2] Tradition: from *tradere* "deliver, hand over," from *trans-* "over" (see *trans-*) + *dare* "to give." http://www.etymonline.com/index.php?term=tradition

[3] We have already had the opportunity to discuss the use of traditional and local terms (Alves and Albuquerque 2010), and therefore, we invite the interested reader to consult this material.

[4] We prefer to use here the terms traditional or local population rather than traditional community. In our view, given that ethnobiology is a field that is close to ecology, it is better to regard the terms "community" and "population" in their ecological sense. Thus, a group of people is faced here (ecologically) as a "population."

Species of this type produce an aromatic resin (*gaharu*) of great commercial value. The knowledge of the collectors had many points in common with academic knowledge, particularly regarding physiology, ecology, and species distribution patterns. From this, the authors suggested that traditional knowledge can help fill the gaps in academic knowledge regarding plants.

Local biological knowledge is not restricted to organisms but includes perceptions and explanations of the landscape and the geomorphology and of the relationships between different living beings and the physical environment. By classifying landscapes, for example, people can make use of various criteria. Verlinden and Dayot (2005) found that the Namibian people demonstrate a good knowledge of landscape changes as a result of human interference and different types of management. For them, local knowledge of these changes could be easily translated into academic ecological models of vegetation change.

Knowledge of the soil is another aspect that has been observed in many peasant and indigenous populations. In this sense, Warren et al. (2003) showed, from a ethnopedological survey of a group of farmers in Nigeria, that the local population had a broad view of the damage caused by erosion, unlike the technicians working in that region, who had a rather reductionist view, which seemed to be hardly useful for practical soil conservation purposes.

The knowledge of local people has long been underestimated by most scientists, who seemed to neglect other knowledge systems. The appreciation of local knowledge, specially on the part of ethnobiologists and ethnoecologists, has produced alternatives to current paradigms with beneficial effects for the advancement of scientific or academic knowledge (Posey 1987a). Ethnobotanical studies, for instance, indicate that various forms of anthropogenic manipulation of plant resources can contribute to increases in genetic diversity. In this way, knowledge of biological resources has aroused the interest of the pharmaceutical industry and natural product industry in the search of biodiversity for pharmaceutical, biotechnological, and conservational purposes. In turn, several ethnobiologists have acted politically in association with local peoples and decision makers to define and ensure conditions for the socially appropriate distribution of the benefits of the studies in which these people participate.

Thus, ethnobiology is not just a field of "knowledge" but also involves a concrete role we may have in society. As scientists, we ethnobiologists have responsibilities that go beyond the planning and execution of research. Our work can encompass various types of actions related to education, conservation, public policies, traditional property rights, as well as cultural aspects of development, for example. This implies valuing and deepening the connections between what is formally considered "scientific" and other fields of knowledge and social practice, within and outside the academia.

Finally, ethnobiology occupies a privileged position because of its potential to integrate local and global knowledge, to connect traditional cultures and academic approaches, and to relate biological and social aspects of the human experience to the environment.

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History of Ethnobiology

André Sobral and Ulysses Paulino Albuquerque

Abstract The history of ethnobiology has been addressed by different authors to portray the development of the discipline, its main authors, and its theoretical and methodological approaches, challenges, gaps, and perspectives. At first, ethnobiological studies were characterized by more descriptive approaches and by the documentation of the uses of plants and animals. Currently, it is considered that ethnobiology is in its interdisciplinary stage, where a greater cooperation among researchers from different areas is sought in order to handle more complex problems that can affect biological and cultural diversity. In this chapter, we briefly review the history of ethnobiology starting with the characterization of its stages, its main authors, and prospects for the future.

It is not an easy task to describe the history of a science, especially with regard to a science that is complex in nature and that, throughout its history, has received (and still receives) the influence of different areas of knowledge. The history of ethnobiology has been addressed by different authors, who often rely on the historiography proposed by Clément (1998), who divides its development into preclassical, classic, and postclassical periods. This chapter discusses, as an introduction, the history of ethnobiology, presenting the roles of different authors and highlighting for each period the main events that contributed to the development of this science.

Preclassical Period

Ethnobiology's preclassical period was characterized, in the late nineteenth century, by studies that aimed to understand the knowledge of different peoples and cultures regarding plants and animals. There was a great interest from European

A. Sobral (✉) • U.P. Albuquerque
Laboratory of Applied and Theoretical Ethnobiology (LEA), Department of Biology, Federal Rural University of Pernambuco, Av. Dom Manoel de Medeiros, s/n, Dois Irmãos, 52171-900 Recife, Pernambuco, Brazil
e-mail: sobral.a@gmail.com

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scholars at that time regarding the uses of natural resources of the New World; that is, attention was focused on documentation of the uses of plants and animals, especially those uses that could become profitable for settlers. In this context, it is worth highlighting the work carried out by naturalists and European settlers who, between the fifteenth and nineteenth centuries, wrote descriptive works that contained rich descriptions of the physical environment, the fauna and the flora found in the new continents, and the use of living beings by native peoples (D'Ambrosio 2014; Medeiros and Albuquerque 2014). Additionally, according to D'Ambrosio (2014), this period corresponds to ethnobiology's colonial or preclassical period.

This descriptive approach, though it focused primarily on utilitarian interests for natural resources, was important to prepare the path for future studies, not only regarding the natural environment but also the different cultures of the New World (Clément 1998).

Additionally, in the preclassical period, between the late nineteenth century and the 1940s, the first studies of subdisciplines that can currently be considered as the basis of ethnobiology appeared: ethnobotany and ethnozoology. Studies of the interrelations between biota, especially plants, and human populations began to take shape from Harshberger's work, which presented the first definition for the term ethnobotany in 1896 (Clément 1998). In 1935, Edward Castetter coined the term ethnobiology (D'Ambrosio 2014). Importantly, in the preclassical period, the work of European and American researchers, mostly anthropologists, prevailed (Anderson 2011).

In addition to Clément (1998), Eugene Hunn (2007) also contributed to characterizing the historical evolution of ethnobiology, and he divided it in four phases. To Hunn (2007), the first phase had the same preclassical period characteristics as described by Clément. For both authors, the preclassical ethnobiology phase is marked by a descriptive approach to plants and animals.

Classical Period

The classical period of ethnobiology began in the first half of the twentieth century. For Clément (1998), this period is marked by the pursuit of indigenous knowledge as a means to understand how humans make sense of their environment. In this regard, studies by Harold C. Conklin contributed substantially to the development of ethnobiology and are considered a turning point in the history of ethnobiology (Hunn 2007). The work conducted by Conklin in 1954 on nomenclature and the botanical classification of Hanunóo inaugurated the phase of studies guided in a consciously comparative and theoretical position; that is, the studies shifted from an essentially descriptive approach to another approach considering meticulous documentation and appreciation of emic[1] or indigenous perspectives, with careful

[1] The emic perspective represents the worldview of indigenous/traditional peoples regarding natural resources (e.g., names and descriptions of species and natural phenomena), as opposed to the ethical perspective, which is the researchers' interpretation of these phenomena. To learn more about the emic/ethic distinction, see Batalha (1998).

attention to local language uses (names, descriptive conventions, etc.) (Hunn 2007). This phase is known as cognitive ethnobiology, which in the 1970s saw the contribution of authors such as Brent Berlin, Peter H. Raven, Roy Ellen, Eugene Hunn, and Nancy Turner (D'Ambrosio 2014; Hunn 2007).

In his research, Conklin tried to understand how the process of appropriation of natural resources by human beings occurred. This involves understanding not only how people relate to the biota (plants and animals) but also how the biota relates in full to all physical (soil, water, topography, climate, etc.) and biological factors, as well as the perceptions and uses that different cultures have for these different elements (Toledo and Alarcón-Cháires 2012).

In addition to Conklin, Brent Berlin and William Balée are also considered important contributors to this cognitive phase of ethnobiology, with strong links to cognitive psychology and linguistics (Hunn 2007).

During the 1970s and 1980s, studies with an ecological focus were intensified, forming what Hunn (2007) considered the third phase of ethnobiology. This period is marked by the contributions of the Mexican researcher Victor Toledo. The approach proposed by Toledo and his collaborators was a response to what they considered a gap in the ethnobiology then practiced, i.e., a response to the lack of a more holistic view on the broader ecological context in which interrelations between values and beliefs of traditional peoples' systems, knowledge possessed regarding natural resources, and management practices of these resources occurred (Hunn 2007). To address these interrelations, Toledo developed the model known as *kosmos-corpus-praxis* or the k-c-p matrix (for more on the k-c-p matrix, please see Barrera-Bassols and Toledo 2005).

Postclassical Period

For Clément (1998), the 1990s represented a very important period for ethnobiology known as the postclassical period or phase four of ethnobiology in Hunn's classification (Wolverton et al. 2014b). We can emphasize at this point the contribution from the anthropologist Darrell Posey who, for more than a decade, conducted studies on the ecological knowledge of the Kayapó Indians in northern Brazil, specifically in the fields of ethnoentomology and ethnoecology.

Darrell Posey was a founder of the International Society of Ethnobiology, created in 1988. In the same year, Posey organized the first International Congress of Ethnobiology in Belém, Pará, Brazil. One of the main results of this congress was the preparation of the "Declaration of Belém," a document that recognizes the importance of indigenous and traditional nonindigenous peoples, as well as their knowledge and management practices for the conservation of biological diversity and natural resources, essential for the maintenance of well-being (ISE 2014). Another important contribution of this declaration is the definition of the role of ethnobiologists in the awareness of indigenous peoples regarding their own knowledge and the disclosure or return of the results of their research in native languages (ISE 2014).

As Hunn (2007) highlighted, perhaps equally or more important than Posey's studies was his contribution to making ethnobiology consider the importance of fighting for the preservation of the knowledge of indigenous peoples and the defense of their intellectual property rights regarding traditional knowledge. This attitude, an ethnobiology more observant to the needs of local communities, marked the fourth stage of the development of ethnobiology (Hunn 2007).

In this historical process of the consolidation of ethnobiology, it is important to highlight the role that ethnobotany has played over the past 20 years. This area of study, inserted into the broader scope of ethnobiology dealing with the study of the interrelations between people and plants, today comprises most publications and includes different approaches (Albuquerque et al. 2013). Different approaches vary from a descriptive approach, which aims to record the relationships between people and plants through descriptions regarding their uses, to quantitative approaches that, by including statistical tools commonly used in ecology (Begossi 1996), allow the testing of hypotheses regarding the factors that motivate people to use certain plants and the reasons for their use (Phillips and Gentry 1993). Another aspect we should highlight is the importance of historical ethnobotany, which introduces the study of the relationships between people and plants in the context of changes in historical, social, and cultural dynamics of different cultures over time (Medeiros and Albuquerque 2012; Medeiros 2014).

Currently, ecological and evolutionary approaches have been incorporated into ethnobiological studies with the objective of increasing scientific knowledge regarding the interrelations between people and the biota, considering that these dynamic interactions occur in different ecosystems and, therefore, are established in time and space. Evolutionary ethnobiology considers it necessary to understand which factors shape the current behaviors of cultures and knowledge of plants, animals, and other biological resources (Albuquerque and Medeiros 2013).

The Fifth Phase of Ethnobiology

In addition to the historical periods of ethnobiology described thus far, Wolverton (2013) believes that we are experiencing a contemporary phase of ethnobiology's developmental history, i.e., the fifth phase. He emphasizes the interdisciplinary nature that ethnobiology should have regarding its objects of study and reaffirms the importance of ethnobiological research in the context of complex environmental and cultural changes. In this context, Wolverton et al. (2014a) emphasize that studies of the impact of global climate change and the effects of these changes on humans and their cultures are urgent and important issues for ethnobiologists now and in the future.

One of the striking features of this phase, a challenge to contemporary ethnobiologists, is the need to expand the borders of this area through the incorporation of scholars from other fields of knowledge in addition to anthropology and biology, whence most ethnobiologists come from, through a greater dialogue with other applied research areas such as environmental management, conservation biology, environmental ethics, and others (Hidayati et al. 2015; D'Ambrosio 2014; Wolverton 2013; Wolverton et al. 2014b). Another important aspect is the expansion of ethnobiological research in southern hemisphere countries. In fact, this expansion has been occurring since the 1960s, as shown by the work of Albuquerque et al. (2013) and Hidayati et al. (2015) regarding the increase in publications in Latin America and Asia, respectively. Currently, countries such as Brazil, Mexico, India, and China and Southeast Asian countries have increased their contribution to the diversification of ethnobiology in terms of the range of study subjects and approaches used (theoretical and applied) and in the increase in authors who contribute to the development and consolidation of ethnobiology worldwide (Hidayati et al. 2015; D'Ambrosio 2014) (Table 1).

According to Wolverton (2013), ethnobiology can (and should) be configured as a discipline that provides a more propitious environment to address biocultural conservation, environmental comanagement, environmental ethics, respect for the intellectual property rights of indigenous and local peoples, and other relevant issues, such as climate change, to solve modern local, regional, and global environmental and cultural issues.

Table 1 Number of works by region and country (Latin America and Asia) from the 1960s to the present

Region	Countries	Total number of works	Total works (%)
Latin America	Brazil	289	41
	Mexico	153	22
	Peru	61	9
	Argentina	58	8
	Bolivia	45	6
	Other Latin American[a] countries	97	14
		Total: 703	
Asia	Indonesia	93	25
	Thailand	68	19
	Malaysia	58	16
	Philippines	42	12
	Vietnam	31	9
	Laos	29	8
	Other Southeast Asian[b] countries	44	12
		Total: 365	

[a]Chile, Colombia, Costa Rica, Cuba, El Salvador, Ecuador, Guatemala, Haiti, Honduras, Nicaragua, Panama, Paraguay, Venezuela
[b]Brunei, Cambodia, East Timor, Myanmar, Singapore

Source: adapted from Albuquerque et al. (2013) and Hidayati et al. (2015)

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Ethnobiology or Ethnoecology?

Angelo Giuseppe Chaves Alves and Ulysses Paulino Albuquerque

Abstract Ethnobiology and ethnoecology form a hybrid knowledge field, which is marked by interfaces involving the natural and social sciences. In addition, it is directly related to local cultural knowledge and practices and efforts for nature conservation. Thus, a quite complex and rich epistemological scenario is present. In this context of porous boundaries between disciplines, it is not correct to state that ethnobiology is part of ethnoecology, or vice versa. These areas are connected and are not related by inclusion or opposition, but by complementarity.

Ethnobiology is intrinsically a hybrid knowledge field. Therefore, it is characterized by disciplinary intersections, both internally (within the ethnobiology field) and externally (with other knowledge areas). It is a science that is being consolidated, mainly from the 1990s, in a different historical context from that which led to the emergence of classical disciplines, such as biology, physics, chemistry, history, and philosophy. In this context, over the past two or three decades, it has been difficult to create or even define any discipline in the highly rigid terms of ancient, or classical, disciplines. Ethnobiology hybrid characteristics are also present in fields that are similar or associated, such as ethnobotany, ethnozoology, and ethnoecology.

Therefore, it is of particular interest to consider the differences and relationships between ethnoecology and ethnobiology, especially when trying to define which of these approaches would have a broader scope to cover the other within itself. The question is: is ethnoecology part of ethnobiology or vice versa? Or are there other nonhierarchical, less rigid, and perhaps more useful ways to look at the relationships between them?

A.G.C. Alves (✉)
Department of Biology, Federal Rural University of Pernambuco, Rua Dom Manoel de Medeiros s/n, Dois Irmãos, 52171-900 Recife, Pernambuco, Brazil
e-mail: agcalves.ufrpe@gmail.com

U.P. Albuquerque
Laboratory of Applied and Theoretical Ethnobiology, Department of Biology, Universidade Federal Rural de Pernambuco, Rua Dom Manoel de Medeiros, s/n, Dois Irmãos, 52171-900, Recife, Pernambuco, Brazil
e-mail: upa677@hotmail.com

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In an attempt to hierarchically represent the ethnoscientific field, the ethnobotanist Gary Martin (1995) found that the term ethnoecology covers all studies that describe the interactions of local people with the environment, including some "subdisciplines," such as ethnobiology, ethnobotany, ethnoentomology, and ethnozoology. However, this does not appear to be feasible because these are currently very dynamic areas. Thus, it becomes impossible to establish a rigid hierarchical relationship via inclusion and contrast where a knowledge area is inserted as a simple branch or another subarea.

On the other hand, including ethnoecology as a branch or subarea of ethnobiology is not justifiable for the same reasons mentioned above but also because there are many studies that address local and traditional knowledge of environmental non-biotic elements, such as soil, rocks, climate, and stellar constellations (e.g., Orlove et al. 2010; Campos 2006). Studies of abiotic factors can hardly be classified as ethnobiological and are more likely to be characterized as ethnoecological research. The point is that there are many points of view regarding these interactions, as well as regarding the main purposes of these disciplines. According to Hurrell and Albuquerque (2012), both ethnobiology and ethnoecology are disciplines that address human relationships between living beings and other components of nature, which strongly approaches ecology. In turn, Alves et al. (2010), more specifically referring to ethnoecology, followed this same direction but also stressing that linking ethnoecology to ecology adds complexity to the situation, especially when taking into consideration the idea that ecology is, according to Odum (1977), a bridge between natural and social sciences.

In a historical, nonhierarchical approach, Eugene Hunn (2007) proposed to represent the development of ethnobiology into four phases, of which the third (occurring mainly in the 1980s and 1990s) would correspond to the emergence of ethnoecology. In this case, ethnoecology would not be inserted (statically) in ethnobiology but would represent one of the stages of its development. On one hand, this would not be a coherent representation of historical facts, since the term ethnoecology emerged decades earlier in the work done by Harold Conklin (1954a). On the other hand, the fact that Conklin had published his paper in the mid-1950s as a statement of his thesis (Conklin 1954b), which was about "the relation of Hanunóo with the plant world," clearly shows the existence of a strong interface among ethnoecology, ethnobotany, and tropical agriculture.

Still, regarding hierarchical representations, Clément (1998) noted that ethnobotany and ethnozoology, at their beginnings (in the nineteenth century), represented subdivisions of ethnology. The author also commented that, up to the late twentieth century, the term "ethnobotany", created by biologist J.W. Harshberger, remained the most stable and most widespread designation among those used to name activity fields within ethnology. Indeed, ethnobiology and the so-called ethnosciences have, in general, an undeniable historical link with social sciences. On the other hand, recent development in some areas, such as ethnobotany and ethnozoology, has been associated with increasing use of theories and methods from ecology and biology.

The ideal of a fully symmetrical or equidistant interdisciplinary science, based on the equivalent contributions of several existing disciplines, is virtually impossible to be implemented in practice. If that happened, the result would be a super-science, supposedly neutral and universal. What is tangibly observed in scientific practice, including ethnobiology and ethnoecology, are negotiations (Fourez 2001), in which some trends become prevalent, at least temporarily, to the detriment of others.

The apparent trend is that ethnobiology and ethnoecology will continue to develop themselves, but not as parallel lines. They may develop as similar areas that complement each other. Thus, in many research groups, numerous researchers carry out and publish ethnobiology and ethnoecology studies, sometimes simultaneously, sometimes alternately. This indicates that the disciplinary division between the ethnobiology and ethnoecology fields is usually approximate and inaccurate and that the relationship between these two areas should not be represented as a binary opposition. In other words, ethnobiology and ethnoecology are not synonymous terms, but any differences that may exist between them are not sufficient to set them as mutually exclusive fields. Neither ethnobiology nor ethnoecology has developed enough separately to characterize a situation like the one that Latour (1987) called a "Copernican revolution", based on a metaphor previously used by the philosopher Immanuel Kant. As we take a look at the discussion on applications (Barrera-Bassols and Toledo 2005; Albuquerque and Hanazaki 2009) and implications (Albuquerque et al. 2009; Toledo and Alarcón-Chaires 2012) of the ethnoscientific research, we see that many important aspects are still at stake during the recent historical development of these fields.

On the one hand, these fuzzy connections between different knowledge bases can generate misunderstandings, especially for the beginners. However, on the other hand, it is a fairly realistic representation of knowledge interfaces that currently take place, both in academia and in many other sectors of society. An exemplary case, in this regard, is that of the American entomologist and anthropologist Darrell A. Posey, who worked since the 1970s among the Kayapó, in the Brazilian Amazon. Discussing the intellectual property rights of traditional peoples, Posey (2000) referred to "ethnobiology and ethnoecology (sic) in the context of national laws and international agreements, which affect indigenous and local knowledge, traditional resources and intellectual property rights". Simultaneous use of the two terms (ethnobiology and ethnoecology) as the title of a relevant publication is a demonstration that they are considered different approaches, although very close and ultimately complementary. A similar example is observed in the writings of Ghillean Prance (1995), who referred to an ethnobotany method manual (Martin 1995) that would, in his view, be of interest to ethnobiologists and ethnoecologists. Such examples indicate that using the word "and" could be often more appropriate than using "or" when referring to related fields in this interdisciplinary context.

Currently, ethnobiology is being developed in Brazil and in other Latin American countries, which is evidenced by the growing number of publications on the subject (Albuquerque et al. 2013). Brazil has proved to be a fertile ground for both areas. The first Brazilian author to create a unique theoretical framework for ethnoecology was Marques (1995, 2001). In his comprehensive ethnoecology, he proposed the study of basic connections through which humans relate to other components of ecosystems: human-mineral, human-plant, human-animal, human-human, and human-supernatural. Another feature of this approach is the attempt to balance or articulate the emic and etic dimensions.

It is concluded that in regard to representing the disciplinary divisions in the ethnoscience fields, it is more productive to connect several knowledge sectors than to separate them in an exclusive way.

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Historical Ethnobiology

Maria Franco Trindade Medeiros

Abstract In this chapter, the reader will become familiar with the concept of historical ethnobiology. To that end, the manner in which research in this field is conducted will be considered a point of conceptual reflection. Preserved testimonies and written and iconographic sources (e.g., a manuscript document, a book, a painting, or a photography) will be considered key elements in the production of documents. It will be emphasized that the documents chosen by the researcher constitute elements that reveal traces of social memory in the present and that are taken to be corroborating documents of an interrelationship established between human beings and biota in a given time and space. Finally, this reflexive path will lead to the conclusion that the conceptual model of documentary analysis by which memory works is what allows the construction of ethnobiological information. In this way, it will be considered that the information that will compose the scientific discourse is based on a subject/object relation, which involves three dimensions: psychological action (subject), social action, and environment, all producing the material to memory (object).

Ethnobiology in its historical approach, thus designated *historical ethnobiology*, is defined as the study of the interrelationship between human beings and biota, taking past evidence preserved in historical documents as a basis for the development of these investigations (Medeiros 2010, 2014; see also the term definition in the dictionary's chapter, in this book). This approach, then, focuses on the "repertoires" of the relationships between people and the elements that comprise nature, which are fixed in time and space. From this historical perspective, we discuss the constitution of ethnobiological information based on a reflection through documentary analysis.

The use of historical documents is of utmost importance, and as a way to evidence the essential importance of the documentary analysis to ethnobiology

M.F.T. Medeiros (✉)
Unidade Acadêmica de Biologia e Qímica, Centro de Educação e Saúde,
Universidade Federal de Campina Grande, Campus Cuité, Sítio Olho D'Água da Bica, s.n.,
Cuité, Paraíba, Brazil, CEP: 58.175-000
e-mail: mariaftm@hotmail.com

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researches, Silva et al. (2014) realized a review article about this subject. As these authors analyzed and discussed the content of some publications that belong to one of the approaches concerning *historical ethnobiology*, the one called *historical ethnobotany*, they viewed a scenario for this field. The overview made by them pointed that the majority of the studies analyzed were based on written records (98 %) and also that 66 % of the studies involved a species or species group as an object of study. So we can say that the history, the social presence of a biological resource during a period of time in a civilization, has been the subject of most interest by the researches.

This reveals to us that information that are discovered or obtained by documentary analysis in manuscripts and books, as to say not only in these sources but also in iconography or in other sources of information, promote a chronological view that tells us about human beings and its interrelationship with the biota.

One of the goals of these chronological data analysis and interpretation is to clarify some matters that involve different aspects of human life, through looking into the decisions that were made in the past by a person or by a human group, a civilization, that contributed consistently to our reality nowadays.

In this sense, the studies in the field of *historical ethnobiology* can allow us to better understand our present reality in many ways. For example, we can better comprehend our current conception of disease, the forms of cultivation and domestication, and the sources that provided nutrients for the past human communities (Raghavan and Baruah 1958; Negbi 1992; Barbera et al. 1992; Prohens et al. 1996; Pardo-de-Santayana et al. 2006; Zepeda and White 2008; Bussmann and Sharon 2009; Alencar et al. 2010; Medeiros and Albuquerque 2014); the economic importance of some resources and to reveal possible temporal changes in its use (Goor 1965; Porterfield 2008; Ferreira Júnior et al. 2012); and also to have a profound knowledge and comprehension of plant-derived discoveries (Giorgetti and Rodrigues 2007; Burns 2008; Alves and Ming 2015), and still to verify changes in vegetation cover (Oudijk and Jansen 2000; Smith et al. 2003).

However, who wants to work in this field of *historical ethnobiology*, with this kind of historical sources, and that wants to collect, analyze, and interpret the information contained on them has to have in mind that it is necessary to have a know-how in diverse areas of knowledge, in its theoretical and methodological aspects. We can say that the most important areas are social memory, history, anthropology, and biology.

Introduction to the Transcendental Past of Knowledge and Practices

Considering social memory to work with information on the knowledge and practices of the past means basing our interest in collectively constructed representational forms. The focus is on verifying the perception of expressive forms, starting from visible and invisible material objects, and referencing the various narrative forms and understandings of statements that they communicate in their process of realization. The objects and images are surrounded by the social frameworks of memory and point to the existence of a relationship between our individual memories and the collective, social memory.

In this search for the knowing-doing of the past, which transcends era, we confront the fact that attempting to identify memory does not provide us the certainty of what we have in our hands. What we find and have in hand are institutions (sites of memory), and in these, we find "things" or testimonies—books, documents, and objects. Potentially, these supports refer us to something. They find meaning if placed in relation by an intellectual process with a universe of constructed data. The things/testimonies are, first, what create the access road to these institutions, and they then fill this path with nodes of the network that are, in short, possibilities of interpretation. Between things/testimonies and social memory exist distances to be covered without the existence of the paths needed to achieve this unity, given that social memory is not naturally available to whatever concept is being argued.

To that end, below, we continue by establishing some understandings through which the trails of things/testimonies can be followed to construct a narrative that dates back to history and to social memory based on the ethnobiological perspective.

The Understanding of Historical Ethnobiology Through the Pathway of Document Analysis

Historical ethnobiology heeds the principle of complexity, not logical simplification. No simplification of a drive exists to be commented on, as in historical ethnobiology, we do the examination of the techniques of different disciplinary fields to choose the ones we will apply to obtain our results. As described by Foucault, the certainty of methodological problems is more fertile than facing a defined path. We advance this thought because we believe that the specificities of each study are what require researchers to engage in the exercise of considering the cohort that is proposed in their research. Nevertheless, we can establish parameters for the understanding of historical ethnobiology through a common procedure that we should take as fundamental in our investigative actions (for a deeper study in a methodological parameter, see Medeiros 2014). Thus, we now expand upon the conceptualization of this approach through commentaries on its key elements, providing them for reflection in the form of this brief outline:

1. The constitution of a coherent and homogenous *corpus* of documents is composed of a study material that reflects the expression of authors/actors occupied with the cohort perspective centered on the research.
2. The establishment of a principle of choice is the definition of the sampling that will determine the survey of the documentary mass, selecting the most representative elements. It constitutes the selection of informative nuclei that are representative of aspects of the universe that is being researched.

3. In the definition of the levels of analysis and of the elements that are pertinent to the studied material, explicit or implicit references, events, institutions, practices, and words used can be emphasized alongside their rules of use and the semantic fields that they outline or even by the formal structure of the propositions and the types of linkages that bind them.

   The point of departure, or the informative content analysis, operates in the universe of the analysis of theoretical discourse (plane of ideas) (Kobashi 1989), which covers three segments: the situational analysis of discourse, characterized by the production of the text in direct relation to the contextual action, considering the age of the document; theoretical discourse, which results from an effort of abstraction and an independence of the situation from a particular articulation; and the narrative, which establishes an origin through which the narrated events are subsequently organized.
4. The specification of a method of analysis refers to the quantitative treatment of data, decomposition according to a certain number of remarkable traits whose correlations are analyzed, frequency analysis, and distribution analysis.

   The analysis process becomes a classificatory process that aims to provide conceptual comparison, bringing to this universe the specific differences in the attributes of the document under analysis. The relationship between these conceptual attributes leads to the categorization of concepts on scales of complexity and specificity (qualitative data treatment).
5. The delimitation of the sets and subsets that articulate the analyzed material will consider the geographic positioning [regions], time [periods], social actors, and botanical, zoological, and mineral groups involved in the textual proposition.

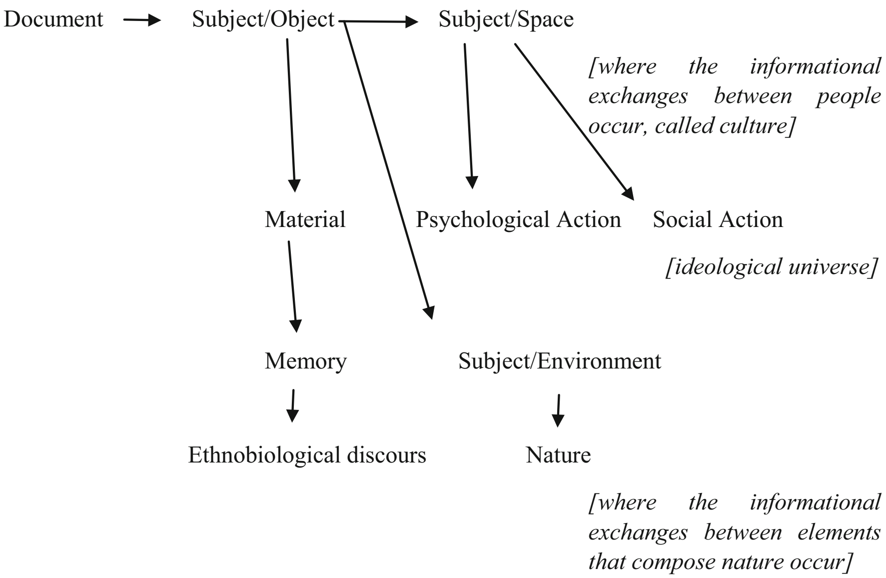
   On this point, it is interesting to establish a qualitative analysis of the insertion of activities [aspects in question] into a broader theoretical framework, clearly leading the researcher to the examination of their genesis in cohorts that identify the conceptual continuities and ruptures.
6. In the determination of the relationship that allows for the characterization of documents or propositions, themes, or analyzed species, one can attempt to establish logical, causal, or semiotic relationships between the productions under consideration.

   The analysis of the informational attributes of documents is based on the identification of essential attributes, the identification of the relationship between informational attributes of the documents, and the informational conditions of the subject and of space-time.

   Therefore, by relating the attributes, it is necessary to include them in a higher order of events, which involves reading the document itself, considering the necessities of peripheral information for the formation of its very identity from the unit of memory that is being accessed, including even the spatial conditions for the maintenance of memory (whether the intentionality is implicit or explicit in the constitution and maintenance of the document) and the influences of thought of the temporal dimension at the moment of production and throughout time (the latter when it is also the established principle of analysis [level and method of analysis]—being a past-present relationship).

Conceptual Model

We now summarize the premises assumed in historical ethnobiology through a model of the dynamics of the process of information transference from the document (multiple preserved evidence) to the ethnobiological discourse. We use the representational model of the information cycle produced through the subject/object interrelationship, considering here the dimensions of space and of the environment in the constitution of a social memory that makes up the ethnobiological discourse. In summary, we believe that the process of documentary analysis in ethnobiology assumes the following relationship:



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Paleoethnobiology

Steve Wolverton, Andrew Barker, and Jonathan Dombrosky

Abstract Ethnobiology is broadly defined as the study of human-environmental interactions in various times and places, covering such topics as traditional and local ecological knowledge, cognition and language, plant and animal taxonomy, and medicinal uses of plant and animal tissues, but also topics that relate to environmental archaeology. It is these types of topics, such as studies of past subsistence systems, material culture made from plant and animal products, as well as interactions of people with ancient environments, that are the subject matter of paleoethnobiology. In this chapter, we summarize various types of paleoethnobiology from zooarchaeology to archaeobotany to archaeological residue chemistry, and we discuss issues of data quality, taphonomy, and related research problems in the field.

Introduction

Paleoethnobiology is the study of human-biota interactions through analysis of faunal and floral remains from archaeological and paleobiological contexts. Paleoethnobiological research plays the important role of adding an empirical record of time depth to ethnobiology, which examines human-environment relationships within cultures and compares these interactions cross-culturally. The framework of paleoethnobiological research centers on two primary research questions: (1) what types of plants and animals were incorporated into past diets through foraging, pastoralism, or gardening? And (2) what were paleoenvironments like that people interacted with in the past? The two questions are interwoven,

S. Wolverton (✉)
Department of Geography and the Environment, University of North Texas,
Denton, TX 76203, USA
e-mail: wolverton@unt.edu

A. Barker
Department of Biological Sciences, University of North Texas, Denton, TX 76203, USA
e-mail: andrewbarker@my.unt.edu

J. Dombrosky
Department of Anthropology, University of New Mexico, Albuquerque, NM 87131, USA
e-mail: JDombrosky@unm.edu

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Fig. 1 Avian bone whistles from Ponsipa'akeri (LA 297), an Ancient Pueblo village in New Mexico, that illustrate the confluence of subsistence behaviors and the past environment from which these specimens were foraged. The whistles are manufactured from limb bones of a large bird, probably turkey (*Meleagris gallopavo*), which may have been hunted from wild populations or raised in captivity. Turkeys were hunted or raised for food but have also provided feathers. Bone whistles might have been used as turkey calls

as archaeobotanical and zooarchaeological remains (whether macroscopic, microscopic, or molecular) represent past human subsistence behaviors and the paleoenvironments from which biota was foraged or produced (Fig. 1). The subfields of paleoethnobiology generally overlap with those of environmental archaeology, historical ecology, and paleobiology. An important distinction is that paleoethnobiologists focus on human-biota interactions across space and time, whereas mainstream archaeological research emphasizes past human behaviors and paleobiological research does not focus on human interactions.

Types of Paleoethnobiology

In this chapter, we organize paleoethnobiology into three different subfields: paleoethnobotany, zooarchaeology, and archaeological chemistry (Table 1). Floral, faunal, and biomolecular-residue remains are identified and analyzed in a variety of ways because

Table 1 Types of paleoethnobiological remains and residues

Zooarchaeology	Paleoethnobotany	Archaeological chemistry
Bone	*Macrobotanical*	Ancient DNA
Teeth	Wood and charcoal	Fatty acids and lipids
Horn	Seeds	Alkaloids
Antler	Nuts	Proteins
Shell	Fibers	Stable isotopes
Rock art	Rock art	
	Microbotanical	
	Pollen	
	Phytoliths	
	Starches	

each type of animal remain, plant remain, or molecular residue preserves and is recovered in distinctive ways. In this brief summary, we do not describe the different approaches for each type of analysis; rather, we focus on general challenges that are shared across them. For recent summaries of the fundamentals of paleoethnobotany, see research by Adams and Smith (2011) and Pearsall and Hastorf (2011); for brief primers on zooarchaeology, see Lyman (2005) and Stahl (2011). For a compilation of important ecological papers in zooarchaeology, see Broughton and Cannon (2010). There are several useful volumes that introduce archaeological chemistry of biomolecular residues; a recent one is by Brown and Brown (2011). See Barbarena (2014) for a clear introduction to stable isotope analysis in environmental archaeology. Although research approaches vary within the types of paleoethnobiology, there are shared concerns of data quality, taphonomy, and quantification. In addition, all three areas of paleoethnobiology are increasingly important in applied ecological research, from conservation biology to ecological restoration.

Data Quality

All paleoethnobiological analyses relate closely to particular research questions. The "target population" represents what the researcher seeks to understand about past human-environment interactions (Lyman 2008). For example, if one wants to understand differences in local vegetation and animal paleobiogeography to assess past landscape change, then in many cases flora or fauna may need to be identified to species, which can be difficult with paleoethnobiological remains that may or may not be well preserved. Different species with similar morphology may prefer distinctive habitats; thus, the reliability of conclusions depends on the confidence with which the analyst can make identifications. The paleoethnobiologist, however, does not work directly with target populations and instead works with samples recovered from archaeological or paleobiological contexts. These assemblages of remains are not randomly designed samples of past biological populations, ecological communities, or human behaviors. Instead, they are fortuitous samples recovered during field surveys and excavation. Thus, the validity of paleoethnobiological analysis depends on answering two important questions: (1) how confident is the

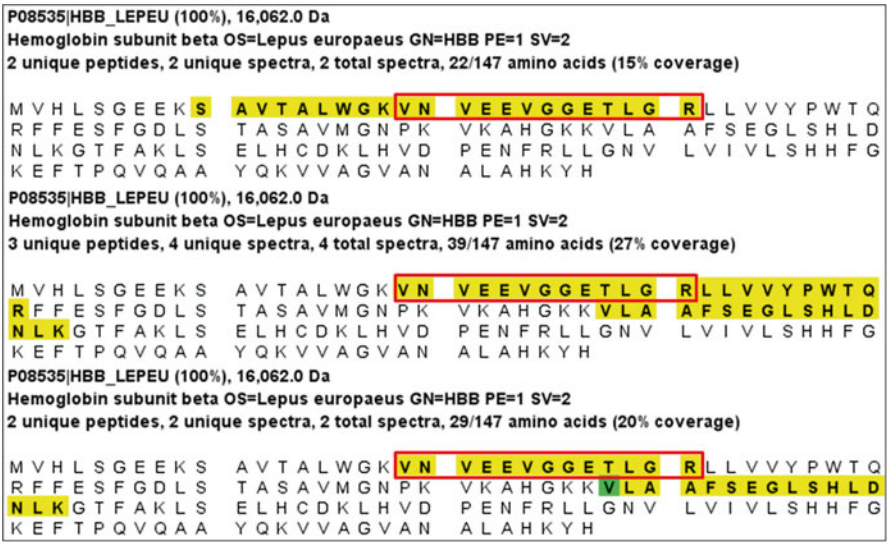

Fig. 2 We analyzed proteins in ca. 800-year-old archaeological long bones from the Goodman Point complex in Southwestern Colorado, USA, using liquid chromatography-mass spectrometry (Barker et al. 2015). Three lagomorph samples (*above*) yielded hemoglobin, a blood protein that was identified as originating from the European hare, *Lepus europaeus*. The amino acid sequence of hemoglobin is listed for each of three samples, with identified peptides highlighted in *yellow*. Taxonomic confusion was generated by species homology and a lack of reference species (e.g., *Lepus californicus*) in commonly available databases. One peptide (VNVEEVGGETLGR) was recovered in all three samples and thus may be an ideal candidate for more sensitive, targeted methods. The *green-highlighted* valine (V) in the third sample was chemically modified (acetylation), presumably via long-term weathering and/or extraction and processing techniques in the lab, making identification more difficult. These data illustrate several of the current challenges in archaeological protein analysis

analyst in the taxonomic identifications? (2) How representative of past populations, communities, and behaviors do remains appear to be given preservation, sample size, and recovery context (returned to below under “Taphonomy”)?

Identification of archaeobotanical, zooarchaeological, and molecular-residue remains follows the same basic principles. State-of-the-art identification procedures in each of the three areas require a reference collection or database of known contemporary or historically documented specimens. For example, the paleoethnobotanist will have large reference collections of wood samples, pollen, seeds, nuts, phytoliths, and other types of plant tissues for species that are common in their region of study. The zooarchaeologist will assemble a reference collection of skeletons of species in her/his region of study. Many paleoethnobiologists rely on large natural history collections at universities and museums. Similarly, the archaeological chemist relies on large databases that record molecular structures of known examples of compounds that derive from plant and animal tissues, whether these are fatty acids, proteins (Fig. 2), or other types of residues. A constant challenge in laboratory analysis is the degree to which molecular structure or tissue morphology is conserved in terms of evolutionary biology (homology) across similar species. Thus, an important area for growth in paleoethnobiology is not only the construction and maintenance of reference collections but also the probabilistic assessment of molecular and morphological characters for determining whether or not closely related species or genera can be identified (Wolverton 2013).

Taphonomy

Taphonomy is the study of the transition of organic matter from the biosphere (the living world) to the lithosphere (the geological world). Taphonomic research within paleoethnobiology has been developed most within zooarchaeology, in which studies have been done to determine processes and agents that modify skeletal remains in various settings over time (Lyman 1994). Taphonomic processes that influence bone include weathering, carnivore gnawing, processing of bone for within-bone nutrients by people, soil chemistry, and other factors that modify or destroy bone. Most taphonomic research within zooarchaeology has focused on vertebrate remains, and there has been limited work on invertebrate remains (Wolverton et al. 2010). Taphonomic research in paleoethnobotany is considerably less synthetic (compared to Lyman's 1994 volume) and tends to focus on attempting to find ways to improve analysis for purposes of reconstructing paleoenvironments and past cultures, though studies also focus on preservation, identifiability, and sampling (see a recent review by Collinson 2011). For a recent compilation of paleobotanical taphonomic studies, see the special issue in *Palaios* by Ferguson (2012). Much of taphonomic research in zooarchaeology and paleontology concerns recording the taphonomic history of remains from a particular context to address whether or not those remains can serve as an adequate sample for addressing specific research questions. For example, one might wish to determine if butchery patterns of Great Plains bison (*Bison bison*) changed over time; in order to interpret any observed changes in frequencies of skeletal parts as indicative of human butchering behavior, the analyst must first determine that differential preservation from other nonhuman processes did not influence the tallies (see examples in Lyman 1994). Very limited research has been done on the taphonomy of molecular residues in archaeological chemistry, which remains an important avenue for future research (e.g., the effects of weathering, cooking, digestion, or other processes on bioresidue preservation). In summary, there are at least two perspectives on the role of taphonomy in paleoethnobiological research: (1) that taphonomic research can aid the researcher in removing biases from samples or (2) that taphonomic effects should be considered as working hypotheses to explain observed patterns in paleoethnobiological data. Given the contingencies of paleoethnobiological sampling (e.g., paleoethnobiologists do not directly or randomly sample target populations of plants and animals by design), the second perspective may prove the most fruitful for future research.

Quantification

The quantitative revolution in archaeology embedded in the new archaeology of the 1960s and 1970s led to increased application of statistical approaches (e.g., Binford 1964; Clarke 1968). However, regarding zooarchaeological remains, Grayson (1979, 1984) illustrated that quantitative data of taxonomic and skeletal part abundance (tallies of bone, shell, antler, or horn specimens) are at best ordinal scale (see a detailed summary by Lyman 2008). Grayson's logic extends to paleoethnobotanical remains, and what he meant is that differences in abundance of, say, pollen grains in a stratum of a core between one taxon of plant and another may suggest that one type of plant was *more* or *less* abundant than another. However, the magnitude of difference in abundance is unknown. Despite twice as much pollen from one taxon compared to another, it should not be concluded that the former was twice as abundant as the latter on the past landscape. This logic extends to many types of paleoethnobiological quantitative data (e.g., tallies of zooarchaeological, archaeobotanical, and paleobotanical remains as well as biomolecular residues), and it stems from a fundamental problem with paleoethnobiological sampling. Inferential statistical approaches are designed to be applied when sampling error is known to be randomly generated, which can be controlled through sampling design when drawing specimens directly from the target population of interest (e.g., an animal or plant population). However, paleoethnobiological populations are never sampled directly or randomly and are subject to diverse taphonomic histories. Thus, statistical approaches should be adopted with caution, making as few assumptions as possible. A conservative approach is to use only descriptive statistical approaches; a more liberal approach is to use robust, resistant, inferential tests, such as nonparametric statistics. The most liberal approach is to use powerful parametric tests, which, if Grayson's recommendation is heeded, should be avoided (Wolverton et al. 2014).

Applied Paleoethnobiology

Within the last two decades, paleoethnobiologists have contributed to scholarship in conservation biology and restoration ecology. Formal research contributions have been made in both applied zooarchaeology (e.g., Wolverton and Lyman 2012) and applied paleoethnobiology (e.g., Lepofsky et al. 2003), and the potential for conservation research through analysis of biomolecular residues in archaeological chemistry is recognized (Barker 2011). Paleoethnobiology contributes a perspective of disclosure to conservation research (see Borgmann 2000); such a perspective is one that shifts the scale of understanding. For example, conservation science aims to support a mission of sustainability, which entails use of natural resources today at a rate that ensures future generations of people the same opportunity. Sustainability explicitly concerns a temporal consideration of human-environment interactions. However, contemporary people live their daily lives at much shorter time scales through economic, social, and political activities. Paleoethnobiology provides an empirical data source with which to study human-environment interactions over deep time.

Conclusion

Paleoethnobiologists are in a unique position to address issues of sustainability and improve understanding of human impacts on the environment at broad, temporal, and biological scales. Such a perspective is increasingly important as human impacts on the environment reach unprecedented levels. Not only can we more fully understand the past with paleoethnobiological data, but with the continued attention to issues regarding data quality, taphonomy, and quantification, we can better anticipate future challenges that may result from the behaviors of modern societies.

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Urban Ethnobiology

Ana Haydeé Ladio and Ulysses Paulino Albuquerque

Abstract People can be the causative agents of introducing new animal or plant species, which may demonstrate invasive behaviors and produce significant changes in the dynamics of the urban ecosystem. Therefore, landscape humanization processes in cities are a significant event but have been little studied from an ethnobiological perspective. Urban ethnobiology proposes thus a study of the interrelations (whether symbolic, affective, emotional, or material) between city dwellers and natural resources.

One of the most intriguing topics in ethnobiology is the use of biological resources in urban cultural systems. Cities, as a representation of these systems, are agglomerations organized for collective life, in which a significant portion of the population performs nonagricultural activities (Derruau 1964). These cultural concentrations may have different densities, from 2000 inhabitants to tens of millions of inhabitants. Usually, these people live in tall collective buildings and have ways of life that are fundamentally linked to activities of the secondary and tertiary sectors (industry, trade, and services). Despite this scenario, which appears to distance humans from nature, in cities there is still a relationship of interdependence, forming an ecosystem of high environmental variability in which the natural and the artificial articulate and intertwine with each other (Duarte Almada 2010).

Although the logic of globalization and the capitalist market is very present and may have a homogenizing effect in cultural terms regarding the relationship between

A.H. Ladio (✉)
Ethnobiology Group, INIBIOMA—Instituto de Investigaciones en Biodiversidad y Medio Ambiente (Biodiversity and Environmental Research Institute), CONICET-Universidad Nacional del Comahue, Centro Regional Universitario Bariloche, Quintral, 1250-8400 San Carlos de Bariloche, Río Negro, Argentina
e-mail: ahladio@gmail.com

U.P. Albuquerque
Laboratory of Applied and Theoretical Ethnobiology, Biology Department, Universidade Federal Rural de Pernambuco, Rua Dom Manoel de Medeiros, s/n, Dois Irmãos, Recife, Pernambuco CEP 52171-900, Brazil
e-mail: upa677@hotmail.com

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humans and biological resources, in big cities worldwide, multiethnicity is presented as a peculiar characteristic, which implies different degrees of heterogeneity (Quave et al. 2012). Due to internal migrations, from rural communities, or due to international migrations, from other countries, there are different social groups and collectivities with shared sociocultural backgrounds, which, in most cases, have usage patterns for the environment and/or biological resources (natural, cultivated, and marketed) that are very distinct from each other (Duarte Almada 2010; Ceuterick et al. 2008, 2011).

In the process of reproducing particular ways of life, according to the specific human group, there is a certain cultural inertia with regard to the use of traditional resources, while due to market pressure for the diffusion of other elements, asymmetries of power and prestige are also generated. This determines, to varying degrees, the maintenance, abandonment, and/or innovation of certain practices related to the use of plants and animals (Medeiros et al. 2012).

A Definition of Urban Ethnobiology

We can define, generally, urban ethnobiology as the study of the interrelations (whether symbolic, affective, emotional, or material) that are established, individually and/or collectively, between city dwellers and natural resources (animals and/or plants) to which they have access. In this interrelationship, it is possible to highlight tangible (biological resources) and intangible (values, norms, and rules prevailing in each particular worldview) components, which determine the flow of these interrelationships in the lives of individuals and groups, i.e., their entry, exit, exclusion, and subordination. The determination of the forces that explain this flow of interrelations is one of the biggest challenges of urban ethnobiology.

Components and Contexts

The tangible and intangible components that are articulated in the relationship between urban society and biological resources may be considered traditional or nontraditional, although this distinction is complex and often transient. Traditional resources are those that maintain long-standing ways of life, putting into practice worldviews from local or immigrant societies, thus strengthening their cultural identity. In turn, nontraditional components are vegetable or animal features that are not typical of a culture or environment; they differ from those considered traditional because their relationship with the members of a culture is scarce or of short duration. In general, it is known that their use was not generated locally or emerged through cultural transmission from generation to generation or through shared practices.

These resources reach people through the intentional or non-intentional introduction of other cultures or cultural trends or through the appropriation of ecological and environmental changes in landscapes of anthropogenic origin or non-anthropogenic origin (Ladio and Molares 2014). Therefore, biological resources may be native or exotic, reaching people through with wildlife contact (Ladio and Rapoport 1999), through cultivation or animal breeding (Hurrell et al. 2011), through formal or informal commercialization (Alves and Lucena Rosa 2012; Medeiros et al. 2012), or through other forms of social exchange, such as barter (Balick et al. 2000; Ceuterick et al. 2008; Richeri et al. 2010).

Until now, different studies conducted by urban ethnobiologists can be illustratively separated into two groups according to their context. On one hand, we have relationships that manifest mainly within the residence, referring to studies related to diet, household medicine, and horticulture, beautification of homes with plants and animals that depend on family and/or individual decisions inside the house. On the other hand, we have relationships that emerge between people and natural resources of the external environment (outside the household, nonresidential), which depend not only on family and/or individual decisions but also on other stakeholders, such as employees of urban planning and/or urban reserves and formal and informal traders, among others. This artificial cut does not imply that both study universes do not interact with each other, as what happens within the household is closely linked to its surroundings and vice versa.

Urban Locations

Both ethnozoological (Alves et al. 2010) and ethnobotanical (Medeiros et al. 2012; Wayland and Walker 2014) studies have shown that cities can be relics of traditions in terms of the use of plants and animals (from immigrant cultures or otherwise) living in the context of cosmopolitan resources of widespread use. Among the most studied biological resources in urban ethnobiology are medicinal and edible plants (Ceuterick et al. 2008; Ladio and Rapoport 1999), urban horticulture (Hurrell et al. 2011), and ornamental plants and animals (Alves et al. 2010; Larredo 2008). All of these uses appear to be linked with a growing trend for urban inhabitants to adhere to naturist and/or new age philosophies, implying a greater presence of naturally occurring resources in people's lives. In addition, many poor sectors of cities have no alternative but to resort to the use of such resources for economic reasons.

The Urban Landscape

It is a remarkable fact that cities, with urban growth, suffer successive transformations both in terms of vegetation cover and wildlife (Van Herzele and Wiedemann 2003; Ladio and Damascos 2000). In particular, the vegetation in cities plays a structural role, representing the sustaining base of processes and ecological services (Larredo 2008; Ladio and Damascos 2000). However, based on the degree of urbanization, spaces such as vacant lots, very steep slopes, and gardens with few interventions, for example, appear as remnants of the native landscape in fragmented habitats of different sizes, offering a source of propagules for local vegetation and sites of refuge and host for animals (Ladio and Damascos 2000). These spaces also serve as biological resource supply sites to meet the material, symbolic, and spiritual needs of the inhabitants (Alves et al. 2010; Ladio and Rapoport 1999).

Landscape humanization processes in cities are a significant event but have been little studied. Citizens, both wittingly and unwittingly, may be the causative agents of the insertion of animal or plant species, which may exhibit invasive behaviors and produce significant changes in the dynamics of the socio-environmental system (Nuñez et al. 2005). In general, we see a clear preference on the part of urban dwellers (observed in squares, gardens, hedges, and public groves) for the ornamental use of plants that are introduced by replacing native species over time (Larredo 2008; López-Moreno 1991; Rovere et al. 2013).

Another notable aspect of this theme are outdoor fairs (Alves and Lucena Rosa 2012; Albuquerque et al. 2007) and the sale of animals and plants in more formal places, such as herbalists and pet shops (Alves et al. 2010; Pochettino et al. 2008). To understand and study these marketing sectors is fundamental to comprehend urban modes of access to biological resources, thereby exercising a significant role in conservation programs. Overall, in cities that are growing, we see a trend toward the generation of an increasingly wide demand for organic products that are usually derived from natural or wild areas (Cunningham 2001).

In cities, people's access to resources from remote natural environments, beyond the limits of civility, is often favored by ties maintained with rural and wilderness areas. Many urban dwellers, for example, also have a rural residence. Thus, the use of plants and animals no longer just depends on urban conditions. This situation of transcommunity implies an expansion of social spaces in which people act, favored mainly by increased mobility due to better access to transport and communication means (Ladio and Molares 2014). Thus, rural and urban segments link up continuously and bi-directionally, resulting in the incorporation of features in a new context.

Conclusions: The Process of Hybridization in Urban Ethnobiology

According to Garcia Canclini (2001), cities are hybrid enclaves. From an ethnobiological point of view, hybridization processes may be defined as the adjustment of practices and traditional biological resources in view of modernity and vice versa. The hybridization process concept implies a cultural conversion that is expressed in different areas, in particular in terms of the material, economic, and symbolic.

Hybridization, as a process involving intersection and transactions, involves logic underlying the upgrade to new circumstances, which, according to some studies (Richeri et al. 2010; Medeiros et al. 2012), appears to be inherent in traditional ecological knowledge systems. If this upgrading capacity is maintained in cities, they may be resistant sites of knowledge and practices while maintaining the traditional knowledge of their own innovations that promote the market or its entry into the supply chain. According to Vandebroek and Balick (2012), this is aligned with a possible change in viewpoint regarding the current paradigm that wrongly links globalization to cultural erosion as a general standard. The orthodox idea that modernity necessarily implies the disappearance of premodern traditions should be taken with caution for each subject studied in cities.

Given that the most significant feature of ethnobiological studies is their strong pattern of temporal change, especially in dynamic systems such as a city, the solution to the issues mentioned consists of making comparative studies in the same city but at different times, so that we can view and document entries, reconversions, and/or outputs of the uses of biological resources in urban life. Although these are studies that require time and effort, they constitute the means to explore the intricate ethnobiological world within cities.

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Diaspora Ethnobiology

Robert A. Voeks

Abstract Ethnobiological research often focuses on the relationship between culturally significant species and relatively stable human populations. This follows from the assumption that learning the properties of nature is space and time contingent. However, migration is a major feature of human existence, and although mobility in the past was often of a seasonal nature, many other movements represented permanent relocations to distant landscapes. Resultant diaspora communities often found themselves confronted with unfamiliar cultures and alien biotas, conditions that presented barriers to continuity in maintaining traditional ethnobiological relations. Nevertheless, diaspora communities around the globe crafted novel relations with wild and domesticated nature by introducing useful biota, by substituting local species for those left in their homelands, and by assimilating knowledge of the useful biota in their chosen homes. This chapter examines these three ethnobiological processes with reference to prehistoric human migrations, colonial European migration, the plight of enslaved Africans, and recent human migrations.

Species Introductions

The most direct means for migrating people to maintain traditional relations with plants and animals is to travel with them. The earliest joint migrations were likely by hunting and gathering peoples and their domesticated dogs, which have protected and hunted with humans for 50,000 years or more. Although there is little physical evidence to determine how and when these human-canine migrations occurred, the widespread co-occurrence of people and their dogs throughout much of their prehistoric range suggests that dogs were crucial to successful human migrations. Hunting and gathering people also carried the seeds of their most important wild plant species with them, particularly short-lived annuals with wide ecological tolerance. In central Asia, for example, evidence suggests that cannabis seeds (*Cannabis* spp.) were carried over long distances by preagricultural societies. Cannabis served as food, fiber, and psychoactive resin for early people and was

R.A. Voeks (✉)
Geography Department, California State University, Fullerton, CA 92831, USA
e-mail: rvoeks@fullerton.edu

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easy to scatter and cultivate prior to serious efforts at domestication (Clarke and Merlin 2013).

There is ample evidence that prehistoric cultivators actively transported their domesticated biota, particularly as the cultivation of staple grains and roots dramatically increased human carrying capacity. As Alfred Crosby notes, "Calories can make as much history as cannons—more in the long run" (Crosby 1994, p. 148). The great Polynesian voyages of discovery and settlement of the Pacific Islands provide a useful example. Roughly 60 "canoe plants" were carried by Polynesians in their double-hulled canoes beginning 7000 years ago, from Samoa and Tonga in the west to Hawaii and Easter Island thousands of kilometers to the east. Polynesian peoples carried plants for food, clothing, medicine, construction, crafts, dyes, poisons, and other uses. These mostly tropical islands were biologically rich, but they sustained relatively few native foods. Thus, the most important introductions would have been subsistence crops, including taro (*Colocasia esculenta*), breadfruit (*Artocarpus altilis*), bananas/plantains (*Musa* spp.), and sweet potatoes (*Ipomea batatas*). Polynesians also introduced their most important domesticated animals, including chickens, pigs, and dogs, not to mention the accidental introduction of rats (Whistler 2009). Although the latter are considered vermin almost everywhere they occur, it is difficult to discuss human migration without mentioning the globalizing influence of rats. Where people wander, rats are sure to follow.

The arrival of Christopher Columbus in the Americas initiated a global exchange of animals and plants that was unprecedented in Earth's history. Whether for profit, nostalgia, or altruism, Europeans carried their familiar plants and animals, intentionally and by accident, wherever they traveled. Indeed, within two centuries, the most important grains, roots, and fruit trees had been thoroughly dispersed throughout the world (Crosby 1994). By the mid-1500s, American peanuts (*Arachis hypogaea*) and maize (*Zea mays*) were being cultivated in China. Cinnamon (*Cinnamomum verum*) from Sri Lanka was being cultivated in Brazil, as was black pepper (*Piper nigrum*) from India, and ginger (*Zingiber officinale*) from China. By 1609, Dominican priest João dos Santos observed from present day Mozambique that "There are lots of pineapples (*Ananas comosus*), excellent as the ones in Brazil" (Voeks 2013).

Many newly arrived esculents revolutionized the course of history among indigenous peoples—cassava (*Manihot esculenta*) in Africa, potatoes (*Solanum tuberosum*) in Europe, and horses (*Equus caballus*) in the Americas. Others enabled Europeans to create neo-Europes wherever they journeyed and settled. In Latin America, the importation of cattle and horses allowed Spanish immigrants to recreate their Iberian "cattle culture," including views on land use and tenure and a craving for beef that persists to this day. Numerous Old World grasses were introduced to North and South America during this period, further facilitating the spread of European open range cattle culture (Butzer 1988). But the spread of crops and people was even more impressive. In the early years of colonization, for example, the Portuguese were intent on replicating their Iberian agrosystems in South America, however impractical. By the 1550s, Padre Nóbrega could boast that several species of fruit from Portugal were acclimatizing well in Brazil, including grapes, citron, oranges, lemons, and figs, and that there were already plenty of cattle, sheep, and chickens. Vicente de Salvador in the 1560s could speak of the abundance of European food in Brazil, including wheat, rice, and yams. By the end of the sixteenth century, the abundance of naturalized Iberian cultivars moved Fernão Cardim to proclaim: "This Brazil is already another Portugal" (Voeks 2004). Wherever European colonists settled, they could expect to encounter a wealth of familiar domesticated plants and animals.

The colonial era was also marked by the largest forced immigration in Earth history—the African slave trade. From the sixteenth to the nineteenth century, nearly 11 million sub-Saharan Africans were transported to North, Middle, and South America. Brazil alone witnessed the arrival of nearly five million enslaved people between 1538 and 1851. The vast majority of slaves, probably over 90 %, were forcibly removed from one tropical landscape—rainforest, seasonal forest, and savannas—and deposited in another, mostly in Latin America. Thus, the slave trade was largely a tropical enterprise, and for better or worse, arriving Africans found considerable that was familiar in the New World in terms of climate, soils, and vegetation structure. By the time of the peak of slave arrivals, beginning in the eighteenth century, newly arrived Africans would have encountered a wide variety of their traditional edible plants already cultivated in South America, such as sesame (*Sesamum indicum*), okra (*Abelmoschus esculentus*), coconuts (*Cocos nucifera*), bananas, and many others. This trans-Atlantic ebb and flow of useful species encouraged and facilitated cultural continuity and reformulation of foodways and ethnobotanical traditions among America's black diaspora. Among the direct transfers was dendê (African oil palm, *Elaeis guineensis*), introduced by the Portuguese to colonial Brazil early for commercial purposes. Captain William Dampier recorded its presence in Bahia in 1699 and noted that it had retained its Yoruba name, "Palm-Berries (called here Dendees) grow plentifully about Bahia…These are the same kind of nuts or berries as they make the palm-oyl with on the coast of Guinea, where they abound." Today *dendê* is an iconic element in Afro-Brazilian culture and cuisine (Voeks 1997; Watkins 2015). Another was African rice (*Oryza glaberrima*). Domesticated by the West Africans, African rice arrived in North and South America early in the slave trade, likely introduced surreptitiously by enslaved Africans (Carney and Rosomoff 2009). Although extinct throughout most of the Americas today, African rice was recently discovered being cultivated in the interior of Suriname by the descendants of escaped African slaves (Andel 2010).

The complexity of these biotic transfers in terms of maintaining traditional relations with nature is well illustrated by the American peanut. Native to South America, peanuts were transplanted and naturalized by the Portuguese in West Africa by 1660. They spread rapidly from farmer to farmer, perhaps because of their similarity to the native Bambara groundnut (*Vigna subterranea*), a domesticated but less productive African groundnut. Over time, peanuts became both an important food crop and a significant ethnomedical component. Later, as a common provision on slave ships, peanuts were transferred to African-American gardens along America's Atlantic coast. The Virginia variety, which had earlier journeyed to West Africa via Mexico and the Antilles, was thus (re)introduced in the seventeenth century to the West Indies and North America. As a result, having journeyed to and from West Africa, peanuts over time came to be identified as an iconic food for Africans and their American descendants, one that from their perspective was native to both coasts of the Atlantic (Voeks 2009).

Most introduced plants and animals remained dependent on their human importers and cultivators, but others either escaped cultivation or arrived by chance. Some of these escapees become invasive species, threatening agricultural production as well as ecological function. However, in many cases, the negative impacts of weeds or otherwise invasive species were offset by their positive cultural values (Pfeiffer and Voeks 2008). As a result, when immigrants traveled from their homelands to their new homes, they discovered not only a host of familiar domesticated crops but also many culturally significant wild and invasive plants and animals that had preceded their arrival. In this way, diaspora communities were able to sustain traditional ethnobiological relations with nature far from their homelands. An early example was the colonial dispersal of domesticated goats (*Capra hircus*) to tropical and subtropical islands. Goats quickly became feral and invasive while at the same time providing a ready and familiar source of food for mariners in the coming centuries (Chynoweth et al. 2013). Numerous useful weeds also preceded the arrival of migrants. One was the castor bean (*Ricinus communis*), known to colonial Europeans as the Hand of Christ. A readily identifiable shrub both cultivated and spontaneous, this plant has been known and used medicinally since ancient times as a purgative and to eliminate lice (Carney 2013). Enslaved Africans arriving in the Caribbean and South America rediscovered the castor bean and quickly re-assimilated it into their evolving New World ethnoflora (Voeks 2013).

Species Substitution

Where species introduction was either impractical due to climate limitations or impossible due to political constraints, immigrants identified similar taxa that could replace elements of their lost ethnoflora. During the course of the African slave trade, for example, forced immigrants discovered considerable taxonomic similarity between Africa and South America at the family and genus rank. Some of the most ubiquitous families in Brazil's Atlantic forests are common components of West Africa's flora—Myrtaceae, Sapotaceae, Euphorbiaceae, Lauraceae, Melastomataceae, and Moraceae—and the list of genera common to both continents is even more impressive. An example of direct substitution is provided by the genus *Bauhinia*, a small leguminous tree. In Nigeria, Yoruba priests employed abafé (*Bauhinia thonningii*) in their magical baths. In Bahia, lacking the same species, African immigrants substituted the morphologically similar *Bauhinia ovata*, which is known to this day by its Yoruba name abafé in Brazil and which is similarly employed in healing baths (Voeks 1997). Similarly, in the famous Haitian "zombie" formulas, several Caribbean species were substituted for their distant African counterparts (Davis 1988). This process has also been reported among Austrian immigrants who migrated to South America in the mid-nineteenth century. Lacking numerous species in the Peruvian tropics, Austrian immigrants gradually replaced most of their traditional healing flora with Peruvian plants (Pirker et al. 2012).

Species Assimilation

Immigrants seek to reestablish elements of their traditional relations with nature in their adopted homes, but by necessity they develop novel relationships with newly encountered domesticated plants and animals. In the colonial Americas, European immigrants adopted indigenous crops—manioc, maize, potatoes, cacao (*Theobroma cacao*), and chilies (*Capsicum* spp.). Turkeys (*Meleagris* sp.) became an iconic food for Anglo-Americans, but other domesticated animals, such as Andean guinea pigs (*Cavia porcellus*) and Mesoamerican xolo dogs (*Canis lupus familiaris*), failed to enter into the cuisine of immigrant Spanish. Tobacco (*Nicotiana tabacum*), which was long employed for healing and relaxation by Native Americans, was readily adopted by Europeans and Africans throughout the Americas.

The adoption of unfamiliar and sometimes toxic wild plants is more complex than domesticated animals and crops and provides insights into the ethnobiological assimilation process. One feature that stands out among migrant people is the frequency with which novel magical plants are adopted. Unlike medicinal species, magical plants are less often ingested and therefore less likely to cause toxic reactions. In Suriname, for example, the descendants of maroons assimilated an impressive array of New World magical plants. During their wars with the Dutch, escaped slaves cultivated a cosmopolitan herb (*Canna indica*) for its spherical, rock-hard seeds known as *weglopershagel* or “runaway hail.” These tiny seeds were coated in poisonous substances and blasted like shotgun pellets at the enemy. Today the seeds are used in herbal baths as magical protection against bullets and general violence (Andel et al. 2013). Similarly in Brazil, the descendants of enslaved Africans adopted a wide range of native species for use in magical and spiritual baths known as abô (Voeks 1997). Likewise in Italy, a comparison of the ethnofloras of native Italians and immigrant Albanians demonstrated that Italians employed many more species for healing, whereas Albanians employed the local flora more often to treat illness of magical origin, such as evil eye (Pieroni and Quave 2005).

During the previous century, many millions of people immigrated to large metropolitan areas. For these recent arrivals, home gardens have played a particularly important role in the ethnobiological replication and adoption process. Migrants often develop hybrid ethnofloras in home gardens, both continuing the uses of foods, medicines, and ornamentals from their homelands, while at the same time learning the properties of new species from friends, neighbors, and increasingly social media. The Kickapoo Indians, for example, emigrated from the Northern United States in the mid-nineteenth century to Mexico. There, they developed a hybrid ethnoflora, consisting of elements of the useful plants of their homeland but supplemented by foods and medicines learned from their Mexican neighbors.

These included new foods, crafts, construction materials, medicinals, ornamentals, and spiritual species (Dolores and Latorre 1977). Similarly among Tyrolean immigrants in Brazil and Peru, some traditional species continued to be used, others were abandoned, while other newly encountered species were adopted (Pirker et al. 2012). Hmong immigrants to California after the Vietnam War continued to cultivate many of their traditional foods and medicines in home gardens. But over time they also learned to grow an array of new crops from their neighbors, such as zucchini (*Cucurbita pepo*) and bell peppers (*Capsicum annuum*) (Corlett et al. 2003).

The establishment of new ethnobiological relations with plants among immigrants is frequently necessitated by the existence of new illnesses in the adopted country (Medeiros et al. 2012). In urban environments, lifestyle diseases such as high cholesterol, hypertension, and diabetes, often related to new food consumption patterns, plague recent arrivals. To combat these maladies in New York City, new species and uses have been adopted, such as cucumber (*Cucumis sativus*) and celery (*Apium graveolens* var. *dulce*) to treat hypertension and *Bixa orellana* for diabetes, labor pain, and vaginal infections. Indeed, one of the primary insights derived from research with urban immigrants is the increasing importance of foods, new and traditional, in their pharmacopoeias. Lacking access to wild vegetation and even home gardens, many urban immigrants learn the healing properties of locally grown or imported fruits and vegetables to treat what ails them (Vandebroek and Balick 2014).

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Ethnophycology

Patricia Marta Arenas

Abstract Ethnophycology studies the interrelationships between man and aquatic autotrophs. Our approach is urban ethnophycology, where the algae become consumers at different stages of presentation (dehydrated, fragmented, ground, packaged, and sold in bulk) and often have lost the aspect that occurs in nature. These reasons, coupled with the lack of tradition in the consumption of seaweed, the preference of other foods, its high prices, the restricted to certain socioeconomic levels, the association unpleasant smells and textures, and the emerging legislation, determine fragmentary and partial knowledge, in which misconceptions with other successful are also combined.

Marine ethnobiology is defined as the study of the uses, practices, knowledge, beliefs, and language that a given culture has on the marine biodiversity. More broadly, this discipline looks at the interaction between culture and marine biota (its marine environment alive). The variety of environments that covers could give rise to fields of study more specialized, such as the ethnophycology, ethnomalacology, ethnoornitology, and ethnoherpetology, among others (Thaman 1994).

Particularly, the ethnophycology examines the interrelationships of people with the aquatic autotroph organisms, including algae and aquatic vascular plants (García-Quijano and Pitchon 2010). The fact of not adhering strictly to the algae corresponds to an emic perspective, according to which various organisms such as the aquatic plants are included in the same category.

For a part of the population that lives away from aquatic environment, the natural habitat of the algae, both marine and freshwater, often go unnoticed.

The academic background information concerning ethnophycological studies are virtually scarce; the few found are ethnobotanical research showing the use of certain algae or the study of the uses for peoples such as those of the Pacific (Turner and Bell 1971a, b) or of the British Columbia in Canada (Turner 1995, 2003) in relation to the impact that those cause on the human group; traditional way of

P.M. Arenas (✉)
Laboratorio de Etnobotánica y Botánica Aplicada, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata—CONICET, La Plata, Argentina
e-mail: parenas@fcnym.unlp.edu.ar

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preparing edible seaweed (Abbott and Williamson 1974); seaweed as food (Abbott 1978); food, industrial,, and potential uses of seaweed (Abbott 1996); the harvesting of *Arthrospira platensis* and the preparation of an food named *dihé* (Abdulqader et al. 2000); phytonyms (Lovric et al. 2002); improvements in harvesting practices to increase the nutritional benefits of algae and obtain new contemporary cultural uses (Hart et al. 2014); management of seascape to enhance resilience using algae farming, fishing, and sea grasses (Torre-Castro and Ronnback 2004); research on the taxonomy, harvesting, marketing, socioeconomic role in the society studied (South 1993), and application of traditional practices (Friedlander et al. 2000); ethnophycology from an ethnohistorical perspective (Godínez and Ortega 2001); and sustainable cultivation of *Caulerpa* (Morris et al. 2014). Some publications dealt with the study of algae as a resource of economic value and its impact on local groups of fishermen but do not apply ethnobotanical methodology (Vásquez et al. 2012; Periyasamy et al. 2014).

The academic background about ethnophycological studies carried out in urban areas, with the local population current, is an emerging topic which deals with the study of dietary supplements containing algae used as slimming in urban areas (Arenas 2007); case studies in rural and urban environments (Arenas 2009); reallocation of resource use in the algae (Arenas 2010); consumption and trade of food algae (Arenas and Losada 2004); possible causes about the low scientific production of ethnobotanist nature of some groups cryptogams such as algae (Arenas and Fajardo 2014); lack of tradition in the consumption of seaweed, unified all in the term algae (Pochettino et al. 2008); ethnobotanical approach of used products against obesity and how they are perceived by sellers of health food stores (Arenas et al. 2013); algae and plants present in the commercial circuit used as slimming (Arenas et al. 2014a); and quantitative approach to urban ethnobotany (Molares et al. 2012). These investigations are framed within the Ethnobotany Urban, a line that the Laboratory of Applied Botany and Ethnobotany (LEBA) has been developing for more than 15 years in Argentina (Arenas 2006). Some background information about this discipline is the record of plants used as adaptogens by different ethnic groups in Argentina (Cristina and Arenas 2010), papers about the traditional uses of adaptogens and the modification of the uses originally assigned to them (Arenas et al. 2011), Andean plants of Bolivian inmigrants (Puentes et al. 2011), urban botanical knowledge of Bolivian and Asian inmigrants (Hurrell et al. 2011, 2013b), urban ethnobotany conducted in a market of Bolivian immigrants (Pochettino et al. 2012), a study on plants with adaptogenic and cognitive enhancing properties (Arenas et al. 2014b), micrographic analysis (Cristina and Arenas 2014), theoretical reflections and innovative methodological tools in urban ethnobotany (Hurrell and Pochettino 2014). Similarly, and within the same theoretical framework, LEBA has also been a pioneer in ethnophycological investigations.

On the other hand, studies are carried out in the framework of the micrographical method by which it is possible to determine a successful species, through the search and identification of the diagnostic characters of the algae (Arenas and Cortella 1996; Arenas et al. 1997; Arenas 2003). Table 1 presents the most relevant topics addressed with the ethnophycological approach.

Table 1 Aspects addressed in urban ethnophycology

Topics covered	Contents
Commercial products	Algae as food, medicinal, dietary supplements
Use category	Slimming, food, medicinal uses
Micrographical method	Qualitative and quantitative analytic microscopy, taxonomic identification of algae in different state of presentation
Quality control	Adulteration, substitution
Botanical knowledge	Urban phycological knowledge (UPK)
Regulatory framework	Legislation; government agencies of comptroller (Agrifood National Health Service, SENASA)
Uses	Therapeutic and nutritional properties recognized and attributed

Urban Phycological Knowledge

Urban phycological knowledge (UPK) is defined as the body of knowledge possessed by the retailers of the health food store (called “dietéticas” in Argentina) about the algae which are marketed in urban contexts. The alga known as nori (*Pyropia* spp.), widely distributed in the Western world in the last 15 years (Levine 1998), is presented in the commercial circuit in the form of flakes or sheets for the preparation of the sushi. Some marketers believe that this form is given from the preparation of a dough, and they do not know their appearance in the nature of rosette shaped. Also they awarded elongated shape as worms and exemplified the trichomes of *Spirulina* (trade name that is known as *Arthrospira*), which illustrates the label of a product. The latter is also described by interviewees as a unicellular alga, when in fact it is a multicellular trichome. Similar to what happens with the nori, the retailers believe that the natural form of algae is an imperceptible powder. There is a marked tendency to assimilate the commercial aspect to the actual shape of organisms’ trend. Also, often they confuse *Spirulina* with other algae posing aspect of sticks and normally served in restaurants from Asian food. Regarding the form of *Fucus*, which usually occurs fragmented trade, aerocysts are described as droplets. It is also referred to as a root, which could be sea or ground. It is likely that this confusion comes from the plant belonging to the genus *Ficus*.

Regarding the composition of algae, some shop assistant ensures that *Spirulina* is marine, contains iodine, and therefore is not suitable to be consumed by hyperthyroid, which in no way is, as it is a freshwater alga. Another alga, wakame (*Undaria pinnatifida*), is believed to be in Argentina, when in fact it is of Asian origin.

It is a fairly widespread belief among sellers of health food stores to consider the agar-agar as an alga or as a substance that is extracted by making incisions in some trees, as if it were a rubber or resin, when in fact it is a phycocolloid present in the walls and in the intercellular spaces of some Rhodophyta.

In relation to the centers of sale, the dealer states that the knowledge of all products involves time and interest and that it is generated as it is working. It considers that whoever serves is as a shopkeeper: if a consumer orders a product, the seller

Table 2 Issues that affect the ethnophycologic approach in urban areas

Subject	Possible reasons
Investigation	Vacancy area
Habitats in urban areas	Lack of tradition in consumption; preponderance of other foods; restricted to certain areas; high costs
Geographic	Remoteness from aquatic environments
Food security	Absent regulatory framework or outdated
Aesthetic	Negative perception; unpleasant association

expressly brings it. It also rejects the concept that has a part of the public about the ecological and natural character that has that kind of trade, health food shop. For its part, the consumer is who installed between people the benefits and disadvantages of consuming a product or another.

While retailers often adhere to concepts such as that all algae serve to slimming, all are marine, or all tend to be flat, it is important to note that not all the knowledge they hold is wrong. So they know that *Spirulina* is a freshwater microalgae and even when they do not know their shape, they imagine it is multicellular. They also know about the marine origin of nori, wakame (*Undaria pinnatifida*), kombu (*Saccharina latissima*), *Fucus*, and *Gigartina*. The common name wakame is associated with gender *Undaria* and some sellers report that in Peru the alga known as mococho is removed from the sea, washed, and eaten fresh. Retailers also express that the people of the Falkland Islands are referred to as kelpers because they consume kelp.

The knowledge possessed by retailers comes from what they hear, what consumers transmit them, reading brochures, and watching television cooking shows. Sometimes, some of them received some of formal university education (chemical) or technical (technical agronomist).

Some products promoted as slimming, which also have plants in their composition, are often also considered algae. For example, *Garcinia*, an Indian fruit used as an appetite suppressant (Hurrell et al. 2013a).

This new line of research in various aspects, little addressed so far, could be affected by different variables. A brief summary is presented in Table 2.

In urban areas, with complex patterns of production and consumption, the majority of consumers of plant products, especially algae, rarely know its shape, its size, its habitat, and its origin, given that there is no direct relationship between the actors and their natural environment. This scenario results in obtaining a fragmentary and partial knowledge, in which misconceptions with other successful are also combined.

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Gastronomic Ethnobiology

Andrea Pieroni, Lukas Pawera, and Ghulam Mujtaba Shah

Abstract The inextricable link between biodiversity and cultural customs related to the holistic domain of food (gastronomy) represents the very foundation of the human experience and contributes in a variety of ways to the well-being of humans and their *oikos*. The study of the complex interactions between human societies, food, and their environment—what we define here as gastronomic ethnobiology—is nowadays considered "the" crucial pillar for fostering food security and especially food sovereignty. This research area emerged from a broad range of studies encompassing, for example, those concerning folk categorization and uses of wild food plants and mushrooms, uses and management of neglected crops and local landraces, local bio-fermentative processing of food, as well as folk perceptions, uses, and management of animals/ethnoveterinary, nutritional transitions among migrant and diasporic groups, and bio-cultural interactions between *foodscapes* and terroirs.

On the Importance of Documenting Local Foods

Food Biodiversity, Folk/Traditional Knowledge Systems, and Bio-Cultural Refugia

Food biodiversity and *foodscapes* constitute the very foundations of the human experience and contribute in a variety of ways to the holistic well-being of humans. However, biodiversity as such is in a state of decline worldwide and the key factors

A. Pieroni (✉)
University of Gastronomic Sciences, Pollenzo/Bra (Cuneo), Italy
e-mail: a.pieroni@unisg.it

L. Pawera
Department of Crop Sciences and Agroforestry, Faculty of Tropical AgriSciences, Czech University of Life Sciences, Prague, Czech Republic
e-mail: paweralukas@gmail.com

G.M. Shah
Department of Botany, Hazara University, Mansehra, Pakistan
e-mail: gmujtabashah72@yahoo.com

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contributing to this loss include industrialization trends, unsustainable farming, fishing and forest practices, and a tremendous hyper-consumption of land.

Moreover, global climate change threatens biodiversity by altering environments and modifying the equilibria of different biota and their *oikos*, while the narrow spectrum of products manufactured from industrial agriculture make ecosystems increasingly vulnerable. In this changing landscape, the dynamic conservation of biodiversity, i.e., the enhancement of the resilience of socio-ecological systems (Berkes and Turner 2006), should become a clear worldwide priority.

In the ethnobiological approach linked to food, in order to consider the entire dimension of socio-ecological systems, the focus must be not only on “natural” environments, but also on place-related history, culture, and philosophy, as well as the spiritual aspect, which occur behind this diversity. Simply, the *holistic* nature of food socio-ecological systems (Berkes et al. 2003) shape what we nowadays call *gastronomy*, referring to the 1825 definition of the French scholar Jean Anthelme Brillat Savarin (Brillat Savarin 1960; Petrini 2007).

Moreover, this “dynamic” conservation strategy of food heritage allows the continuous process of evolution and coadaptation through appropriate and sound management practices.

On the other hand, folk/traditional knowledge systems are reemerging as a priority concern at the global level, as they are increasingly being recognized as constituting not only the tangible but especially the intangible heritage (UNESCO 2003), and what we may describe as *invisible fingerprints* of local communities.

Local communities are experiencing a loss of folk/traditional knowledge and values, which goes hand in hand with a decline in cultural diversity and the dilution of a true sense of community. This process of impoverishment of the social dimension of diversity and social cohesion is reflected in the present global food system which, hinging on the idea that local, small-scale agriculture must also serve the global market, transforms food into a mere commodity and compels people to conform to a single way of producing and consuming it.

In this scenario, cultural, social, and environmental costs are extremely high, and in order to counteract such phenomena, it is fundamental to foster research trajectories aimed at documenting and promoting folk/traditional tangible and intangible food heritage, which can in turn empower local communities in their dynamic understanding and “use” of this heritage.

Moreover, Barthel et al. (2013) introduced the concept of *bio-cultural refugia*, i.e., places retaining specific, dense, social memories related to food security and stewardship of biodiversity.

These hotspots of food bio-cultural heritage have shaped specific landscapes, which have been maintained through a mosaic of management practices that have coevolved in relation to local environmental fluctuation.

Genotypes, specific practices of gathering, harvesting, breeding plants/animals, folk culinary processes and recipes, *sociabilities* attached to traditional consumption frameworks, artifacts, written and oral accounts, as well as embodied rituals, art, and self-organized systems of rules constitute a portfolio of knowledge, practices, and beliefs (what we call traditional environmental knowledge, TEK) that results in specific genetic and social reservoirs related to food and for which survival inclusive platforms between scientists, farmers, gatherers, shepherds, fishermen, environmentalists, consumers, and the society at large are needed, in order to orient food production towards ecologically and socially sound practices.

Foodscouting ***for Sustaining Food Sovereignty***

As we have describe above, an important part of current ethnobiological research on biodiversity and TEK focuses on food.

A major role in food ethnobiological research is played by *foodscouting*—the ethnography-based documentation of folk/traditional perceptions, uses, and management of threatened or neglected plant, animal, and microbial food ingredients used within a given cultural setting/community as well as the folk customs attached to them that developed within a certain area as the result of a long socio-ecological coevolution.

On the other hand, food sovereignty (Forum for Food Sovereignty 2007), i.e., the right of local communities to shape their *foodscapes* and to take care of their food bio-cultural diversity and heritage (Nolan and Pieroni 2014), is seen by many international stakeholders as the cornerstone for sustaining safe, good, clean, and fair local foods across the globe (Petrini 2007).

At the heart of the food sovereignty concept lies the idea of the urgent need to truly foster environmental sustainability and social justice in food production and consumption and to promote short food chains based on local foods and conviviality (Biglino et al. 2011). In achieving this goal, *foodscouting* represents a crucial step in obtaining baseline data regarding the food heritage of communities/places.

And this is also why gastronomic ethnobiology is the core of many pursuits well beyond ethnobiology and that from it departs: food rights, public health/nutritional policies, and political ecology as well (Anderson 2010).

Domains of Gastronomic Ethnobiology

Gastronomic ethnobiology deals with a variety of research topics and subjects; however, in the last few decades, the following have emerged as the most crucial ones in the worldwide arena:

- Folk categorization and uses of wild food plants/food ethnobotany (see example below).
- Uses and management of neglected crops and specific local landraces of cultivated plants (plant genetic resources) (see example below).
- Folk perceptions and uses of natural resources during times of famine and war (i.e., Redžić 2010; Redžić and Ferrier 2015).
- Folk perceptions and uses of mushrooms/food ethnomycology (i.e., Alonso-Aguilar et al. 2014; Tibuhwa 2012; Volpato et al. 2013).

- Local bio-fermentative processing of food/food ethnozymology (see example below).
- Folk categorization, perceptions, uses, and "management" of wild animals/food ethnozoology (i.e., Chowdhury et al. 2014; Souza and Alves 2014; Silvano and Begossi 2005).
- Folk management of local animal breeds, veterinary use of curative and fodder plants, and attached traditional animal-based food products/ethnoveterinary medicine (see example below).
- Nutritional transition among migrant or diasporic groups/food ethnobotany of migrants (see example below).
- Bio-cultural interactions in foodscapes and terroirs/food ethnoecology (i.e., Nishida et al. 2006; Orr and Hallmark 2014; Reyes-García et al. 2014).

In the following paragraphs, we will briefly illustrate, for a few of the aforementioned domains, examples of gastronomic ethnobiology—with a focus on Europe and the Middle East.

Wild Food Plant Consumption in Mediterranean Diets

Some rural communities in Mediterranean and Southeast European countries still practice the gathering of wild vegetables, which was and partially continues to be the core of their daily diet for several months each year (generally from November/December up until May/June: Fig. 1) and what nutritionists have described for a few decades as the "Mediterranean diet." Despite the extensive literature on the subject of the nutritional benefits and epidemiology of the Mediterranean diet and populations, very little is still known about this important "hidden" part of the Mediterranean folk daily food (Conforti et al. 2012; Fragopoulou et al. 2012; Local Food-Nutraceuticals Consortium 2005; Marrelli et al. 2014).

A few recent studies have not only confirmed the vast richness and complexity of this food biodiversity but also proposed gastronomic and educational frameworks for re-instilling traditional knowledge on wild food plants as well as sustaining small-scale (famers') markets, through which neglected wild vegetables of Mediterranean cuisines (such as *Sonchus oleraceus*, *Apium nodiflorum*, *Ruscus aculeatus*, *Reichardia picroides*, *Scolymus hispanicus*, *Silene vulgaris*, *Tamus communis*, *Montia fontana*, and others) can continue to be sustainably gathered and traded (Dogan 2012; Parada et al. 2011; Menendez-Baceta et al. 2012).

Old Landraces in Rural Czech and Slovak Folk Diets

Whereas "old fashioned" concepts of bio-conservation mainly have ex-situ conservation strategies (conservation of biodiversity in its three dimensions: genetic, species, and ecosystem based) as their cornerstone, i.e., in gene banks, botanical

Fig. 1 Woman processing gathered wild vegetables in inland Southern Italy

gardens, eco-museums, and natural parks, nowadays bio-cultural diversity conservation trajectories (i.e., in situ, on-farm conservation projects) are instead seen as fundamental for taking into account the human/social component of food biodiversity.

For example, the White Carpathians, a unique biologically and culturally rich mountain range along the south-east border between the Czech Republic and Slovakia is home to a vast richness of fruit tree landraces (apples, pears and plums). Inventories conducted in the last decade documented 220 old fruit varieties and landraces on the Czech side and nearly 300 fruit varieties on the Slovak side, comprising several hundred folk names. In this mountainous area, fruit landraces are embedded in the local culture; locals have experienced over centuries which varieties are appropriate for direct consumption, food preparation, winter storage, drying, and processing into jams, preserves, juices, alcoholic liqueurs, or distillates. In addition, the second author of this contribution documented a remarkable medicinal importance of wild apples and old pear/apple landraces and the local raw consumption of wild and cultivated varieties of *Cornus mas* and *Sorbus domestica*, as well as their use in preserves and as distillates in high-quality spirits. In the same area, oil was made in the past by pressing plum seeds; moreover, plums along with wild mushrooms and sour cream are the main ingredients of a local Christmas soup ("*Vánoční kyselica*").

Considering the nutritional and health properties of old crop landraces, intra-specific diversity of these aspects has rarely been studied; however, interestingly, Rop et al. (2009) found significantly higher antioxidant activity and nutrient content of local White Carpathian plum cultivars in comparison to modern varieties. As emphasized by Heywood (2011), there is enormous potential for ethnopharmacology and ethnobiology focusing on plants from local agro-ecological systems and agrobiodiversity, as traditional crop varieties and landraces have been an essential part of local and possibly "healthy" food cultures for many centuries, and they have shaped cultural heritages and local identities. If we continue to lose this diversity, we will not only lose invaluable genetic resources, but also traditional knowledge systems associated with this, as well as tasty and healthy foods.

Ethnozymology in the Balkan Mountains

Ethnobiological knowledge of often neglected fermented food products and processes serves in many areas of the world as an important tool for sustaining local traditional foods and implementing food sovereignty, as these products belong to local bio-cultural heritage, which has evolved through centuries of interactions between local societies and their environment (Nabhan 2010). In other words, the adaptive nature of the fermentation process within a given territory, which arose from long-lasting human relationships with microbial niches in the environment, suggests that the process and products of fermentation are part of a complex socio-ecological system consisting of living and nonliving components and of their interactions (Scott and Sullivan 2008). In this sense, they ultimately contribute to the building of local populations' identities and their gastronomic "sense of place" as well (Evans et al. 2015; Redzepi 2010).

For example, among the Slavic Gorani inhabiting the mountains at the borders of Kosovo, Albania, and Macedonia (Quave and Pieroni 2014), the fruits or roots of a number of local wild plants (i.e., *Cornus mas*, *Rosa canina*, *Prunus cerasifera*, *Gentiana lutea*, *Juniperus communis*) are fermented to produce various nonalcoholic, gassy beverages, all of which are consumed for their refreshing quality and perceived "health" benefits.

The bitter liquid resulting from fermentation of the roots of *Gentiana* in water is used in the treatment of stomachache and as a panacea. Likewise, the fermentation of *Juniperus* galbuli results in the production of a very sour product, which is used in the treatment of kidney problems and as a cold remedy, as in other South-Slavic areas.

The ease of their preparation makes them a common household staple as a source of nutritious, potable beverages (Fig. 2). Moreover, these nonalcoholic or slightly alcoholic beverages are culturally appropriate for the Gorani as the use of alcoholic beverages is not permissible in the Islamic faith.

Fig. 2 Lacto-fermented gentian beverage from Northeast Albania

Folk Veterinary Plants in Lesser Himalayan Pastoralism

Pakistan is the home of different types of pastoralist and nomadic groups, which inhabit the mountains and the desert lands of the country. In the Lesser Himalayan range, ethnoveterinary remedies represent the health care for livestock used by most shepherds, who cannot afford modern drugs. The third author of this contribution, for example, recorded among pastoralists in this area the use of *Verbascum thapsus* (*gidar tambaku*) and *Foeniculum vulgare* (*saunf*) for treating diarrhea in their herds, while *Zanthoxylum armatum* (*timbar*) is used for treating fever and *Saussurea costus* (*kuth*) for treating stomach disorders in goats. Moreover, the fresh roots of *Salvia moorcroftiana* (*kalijiri*) are ground into a powder and given to buffalos for treating abdominal pains and fever, a macerate obtained from the fresh leaves of *Cissampelos pareira* (*ghorasum*) is given to sheep as a tonic, and *Grewia optiva* (*dhmarn*) bark is peeled off branches and given to cattle as a galactagogue.

This immense pastoralist traditional knowledge on remedies used for improving the overall health of animals has a substantial impact on both the well-being of the animals and the quality of their dairy products—and ultimately the quality of the resulting *foodscape*. However, aged shepherds retain more traditional knowledge compared to younger ones, as intergenerational transmission of these crucial practices is in jeopardy.

Food Ethnobotany of Migrants

Dietary habits change rapidly among migrant communities in Western countries, and these changes can cause major concerns for public-health policymakers because they frequently lead to increases in diet-related diseases like diabetes. Such is the case in most South Asian communities in Northern England, where several food plants are perceived as having high medicinal value and thus widely used within households in the host country, with a predominant role of *karela* (*Momordica charantia*) to treat diabetes (Pieroni et al. 2007). Similar trends have also been found among Caribbean people living in New York (Vandebroek and Balick 2012) and Polish diaspora in South America (Kujawska and Pieroni 2015).

In another, unpublished, study on Albanian migrants in Italy, we found that the majority of community members daily use *plant cultural markers*, which are considered distinctive signs of *Albanianness* and identity, i.e., the use of *caj mali* (*Origanum vulgare* and *Sideritis* spp.) in teas.

However, original plant uses often "change" in the new context, as plants are substituted with similar ones and original dishes may be rearranged, and the consumption of traditional plant-based dishes is inextricably embedded in cultural heritage, fluctuant representations of identity (Pieroni and Gray 2008), and health-seeking strategies among migrants. All this should inform, in our opinion, the way institutional stakeholders shape culturally appropriate management of public health/nutritional policies devoted to newcomers.

Relevance of Gastronomic Ethnobiological Research

From the aforementioned examples, we can easily identify the areas in which gastronomic ethnobiological research may be most relevant today; there are in fact diverse trajectories, which make this field of ethnobiology research of great interest to various stakeholders:

- Niche and specialty food (and farmers') markets
- Artisanal entrepreneurships based on traditional food products
- Local food-based and avant-garde restaurants/cuisines
- Sustainable, rural development
- Ecotourism
- Community-based bio-conservation strategies (i.e., natural protected areas)
- Educational frameworks on sustainable gastronomy
- Bio-cultural heritage, cultural landscapes, and eco-museums
- Food security and sovereignty-driven policies
- Public health/nutrition policies
- Culturally sensitive approaches devoted to migrant groups

The next few years, and decades, will surely demonstrate the importance of these horizons for promoting the holistic well-being of both the environment and local communities.

We strongly believe that food lens will become more and more central in all future discourses related to the interaction between natural resources and human societies, not only because “we are what we eat” (as the philosopher Lukas Andreas Feuerbach wrote in 1863), but especially because food represents in every community, in every corner of the globe, a central pillar of the *ethnoecological web*, as its essence is ultimately experiential and relational.

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Ethnoprimatology

Marilian Boachá Sampaio, Antonio Souto, and Nicola Schiel

Abstract The relationship between humans and primates around the world is present at various levels. While in some places primates are considered pests, in others they may be considered sacred animals and may even serve as tourist attraction. Humans and primates share remarkable similarities from the physiological to the ecological and behavioral level. However, people's perception of primates may vary according to how they relate to each other. Understanding the conflicts between humans and primates involves studies aiming to understand the needs of these two groups. This resulted in the arising of ethnoprimatology, which is the discipline studying the dynamic of the interactions between humans and primates.

In the search for understanding human behavior, there are many researches aiming to study animal behavior (Snowdon 1999; Riley 2006; Rapchan 2010; Jones-Engel et al. 2011). Among animals related to humans, nonhuman primates (in this chapter referred to simply as "primates") are by far those maintaining a greater physical, behavioral, and social resemblance (Jones-Engel et al. 2011).

Primate population size and the distribution patterns are directly related to the structure of the forests they inhabit and to the allocation of resources in these areas (Loudon et al. 2006). Therefore, anthropogenic landscape alteration may directly influence the use and preference of forest resources by primates, as well as exert great pressure on the population of this animal group, increasing the overlap of

M.B. Sampaio
Programa de Pós-Graduação em Etnobiologia e Conservação da Natureza, Universidade Federal Rural de Pernambuco Dois Irmãos, Recife, Pernambuco 52171-900, Brazil
e-mail: marilian_boacha@yahoo.com.br

A. Souto
Departamento de Zoologia, Universidade Federal de Pernambuco
Cidade Universitária, Recife, Pernambuco 50670-901, Brazil
e-mail: asouto.labet@gmail.com

N. Schiel (✉)
Departamento de Biologia, Universidade Federal Rural de Pernambuco
Dois Irmãos, Recife, Pernambuco 52171-900, Brazil
e-mail: nschiel@yahoo.com

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areas occupied by both groups (Fuentes and Hockings 2010). Thus, the interfaces between humans and primates ultimately resulted in a complex network of ecological, epidemiological, and economic relationships (Riley 2006; Fuentes 2006). However, the main conflicts arise from the use and occupation of the same geographical space which generates competition for resources (Estrada 2006; Hill and Webber 2010).

The current scientific fields, primatology and anthropology, in our opinion would present difficulties to understand more precisely the relationships between humans and other primates. These difficulties seem to be due to limitations of both fields: while primatology focuses on the study of nonhuman primates (Strier 2011), anthropology focuses on the study of humans (Lévi-Strauss 2014). Thus, there is the need for a field allowing a research approach which specifically addresses the relationships between humans and primates. Ethnoprimatology arises in this framework and, therefore, it is a multidisciplinary field of studies. This field involves tools of both anthropology and primatology with the aim of understanding the relationships between humans and primates in their various aspects (Sponsel 1997; Jones-Engel et al. 2011).

The complexity of the themes that can be addressed by ethnoprimatology should be assessed on a case-by-case basis since it does not allow us to restrict or exhaust all the applicable methods. Depending on the study, both the methods used by primatology, which derives from ethology and ecology (for a better understanding, please see Lehner 1996; Jones-Engel et al. 2011; Strier 2011) such as those assessing primate behavior and ecology, and the methods widely used in ethnobiology (Albuquerque et al. 2014) are complementary.

Ethnoprimatology: Fields of Application

Space and Resource Use

The manipulation of environments inhabited by primates affects them directly and indirectly (Loudon et al. 2006). The gradual reduction of natural areas directly contributes to a decrease of resources for primates (Hill and Webber 2010). As a consequence, primate populations are indirectly forced to either seek new areas that meet their food demand (Hill and Webber 2010) or even use food which usually does not belong to their traditional diet (Ludwing et al. 2006). As an example, we can cite agricultural crops installed near small forest fragments and targeted by primates which cannot find enough food in their environment (Lee and Priston 2005; Riley and Priston 2010). According to Hill and Webber (2010), this adaptability of primates may affect the perception of people who suffer from the incursion of these animals in the fields and identify them as pests.

According to Lee (2010), in order to share the space harmoniously with other species, humans should recognize the importance of the existence of each species and the fact that they could have their food demand served. Studies seeking to understand these relationships require a broad view, so that the needs of both humans and nonhuman primates are considered (Fuentes and Wolfe 2003). Ethnoprimatology can fill these gaps in knowledge and provide means for primate conservation by considering behaviors, cultures, and ecological anthropogenic variables (Loudon et al. 2006).

Use of Primates by Traditional Communities

As for the relationships between primates and traditional human communities, hunting for different types of uses is still one of the main causes of primate population decline (Alves et al. 2010). Hence, despite the growing food supply coming from agriculture and livestock, part of the food obtained in some traditional communities still comes from hunting (Papworth et al. 2013). Sponsel (1997), for instance, reported that the Waorani, a community inhabiting the Ecuadorian Amazon, used several primate species as food items in their diet. Accordingly, in a more recent study of the same community, Papworth et al. (2013) described that, although primates are not the main dietary component, six primate species were confirmed to be still part of the Waorani's diet. Parathian and Maldonado (2010) reported that primates are also a traditional component of the diet of local communities inhabiting Amacayacu National Park, Colombia, even though their consumption has decreased due to the implementation of a law which forbids hunting.

Several studies mention the use of primates for medicinal purposes, including critically endangered species (Apaza et al. 2003; Alves and Rosa 2007; Li et al. 2007; Lippold and Thanh 2008). This generally results from the use of body parts of primates which were hunted for other purposes, such as feeding (Alves et al. 2010). Parts like bones can be crushed and used to produce teas, while the fat, blood, and brain can be processed into ointments and used to treat diseases such as rheumatism, inflammation, fever, and impotence, among other purposes (Alves et al. 2010).

In other traditional communities of the Brazilian Amazon, primate parts (leather, teeth, skulls, etc.) constitute the raw material of many objects used by humans, such as hats, necklaces, and various decorations (Alves et al. 2010). Moreover, their meat is used as bait to catch other animals, such as large mammals and fish (Alves et al. 2010). In some traditional communities of countries as Uganda, India, and Indonesia, primates may be treated as mystic or sacred creatures (e.g., Hockings and Souza 2013; Hill and Webber 2010; Riley and Priston 2010). On the other hand, the inhabitants of a small community in Brazil believe that primates could bring bad omen (Melo et al. 2014).

Given the diversity of cultures of peoples around the world and consequently the different uses of primates deriving from their cultural practices, ethnoprimatology becomes a fascinating and essential tool (Fuentes and Wolfe 2003) since it allows bringing out the various ways in which primate species are used by traditional communities.

Epidemiology and Tourism

Primate populations are subject to a natural demographic fluctuation. Nevertheless, the frequent contact between humans and primates may cause the transmission of diseases and alter their population dynamic (Pusey et al. 2008; Boesch 2008). Accordingly, as primates can be the source of several diseases affecting humans, such as rabies (Aguiar et al. 2011), they can also be exposed to diseases of human origin (Pusey et al. 2008). However, healing from these diseases is easier for human populations than for primate populations due to the use of medicaments (Garber 2008). The recurrent contact with local human populations, or even ecotourists and researchers, can act as disease transmission pathway in primates.

Specifically relating to ecotourism, this practice can benefit of the presence of primates, like in the Central African Republic, where groups of free-living gorillas are exploited (*Gorilla gorilla gorilla*) as tourist attraction (Klailova et al. 2010). Practices like these can help people to better understand primates and add value to their conservation. However, direct interactions between tourists and primates should be controlled because of potential conflicts such as aggressions and interferences in the behavior of primate species (Klailova et al. 2010), as well as the risk of disease transmission. Ethnoprimatology would become an essential tool to understand the knowledge and conceptualization of tourists, researchers, and local communities regarding primates.

Primate Conservation

In view of what has been discussed in this chapter, it is clear that a broad understanding of the relationships between humans and primates is crucial for effective conservation measures. Therefore, the importance of considering the needs of both humans and primates and pursuing projects allowing their coexistence in the same space is stressed. Hence, ethnoprimatology serves as a base discipline to understand the interconnections between humans and primates and contributes to the management of primate conservation programs (Fuentes 2006).

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An Ethnobiology of Change

Álvaro Fernández-Llamazares and Victoria Reyes-García

Abstract In contrast with the long-held ethnobiological tradition conceptualizing knowledge systems as static and continuous, in recent decades the discipline has reemerged with a focus on the dynamic character of local environmental knowledge (LEK). This new era in ethnobiology started with studies documenting the erosion and loss of local knowledge systems around the world and is now shifting toward the understanding of the ability of LEK systems to adapt to new social-ecological conditions. Nourishing from resilience theory, new ethnobiological research points toward the adaptive capacity of LEK systems, also addressing the structural constraints of LEK adaptation in the face of ever-encroaching global environmental change. This chapter provides a historical view of the literature addressing change and adaptation of LEK systems and identifies critical tasks for future ethnobiological research, as the discipline keeps expanding into new understandings of the changing human-biota relationships in novel social-ecological scenarios.

The definition of ethnobiology as the scientific study of the dynamic relationships between peoples, biota, and environments (Anderson et al. 2011) highlights the importance of the changing relations between these dimensions; yet, the dynamic nature of knowledge systems was often neglected in ethnobiological research (Reyes-García et al. 2014). Since its consolidation in the 1950s (Conklin 1954) and until the 1990s, modern ethnobiology has been mostly devoted to describe cultural systems of classification of the environment, from an emic perspective

Á. Fernández-Llamazares, PhD (✉)
Institut de Ciència i Tecnologia Ambientals (ICTA), Universitat Autònoma de Barcelona, Barcelona, Spain

Department of Biosciences, Metapopulation Research Centre (MRC), University of Helsinki, Helsinki, Finland
e-mail: alvaro.fernandez-llamazares@helsinki.fi

V. Reyes-García, PhD
Institució Catalana de Recerca i Estudis Avançats (ICREA), Barcelona, Spain

Institut de Ciència i Tecnologia Ambientals (ICTA), Universitat Autònoma de Barcelona, Barcelona, Spain
e-mail: victoria.reyes@uab.es

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(D'Ambrosio 2014). Such research drew from the historical and intergenerational continuity in resource use management and tended to view LEK systems as static and hermetically isolated from other forms of knowledge (Berkes et al. 2000), a view largely in consonance with a tradition in anthropology of conceptualizing local and indigenous peoples as *people without history*.

Yet, the 1990s and the entrance into the new millennium set the foundations of a new era of ethnobiological research (Agrawal 1995; Gragson 1999). Ethnobiology started to shift from a static approach centered on the description of LEK systems as *atemporal* toward the understanding of LEK as a *complex form of adaptation*, resulting from the coevolutionary dynamics of nature and culture (see Berkes et al. 2000; D'Ambrosio 2014). Several researchers started to emphasize that LEK systems should neither be considered static nor in isolation from other knowledge systems (Agrawal 1995). Rather, local knowledge systems should be understood as being in constant change, in a type of process that anthropologists have noted to involve simultaneously *continuity and change* (Reenberg et al. 2008).

This new era in ethnobiological research emerged with the first studies on changes in local knowledge systems (Benz et al. 2000; Kingsbury 2001; Pieroni et al. 2004). Much of this body of research was centered in documenting fading local knowledge (Ferguson and Messier 1997), understanding the parallel decrease of biological and cultural diversity (Maffi 2005), or assessing the drivers of change leading to the loss of LEK (Godoy et al. 2005; Brosi et al. 2007). The thread in all this literature has been the analysis of the changes in LEK systems in terms of *loss* of knowledge. Without neglecting the importance of such a process, by focusing only on knowledge losses, the understanding of other processes of change has often been overshadowed, and, consequently, ethnobiological research has tended to downplay the dynamic nature of LEK (McCarter and Gavin 2013).

Some recent works are starting to move the spotlight from the specific bodies of knowledge that are lost and/or eroded to the capacity of local knowledge systems to absorb changes and adapt to new social and environmental conditions (Leonti and Casu 2013; Reyes-García et al. 2014). For example, in a study among the Tsimane hunter-horticulturalists of Bolivian Amazonia, Reyes-García et al. (2013a) found that while particular domains of knowledge less frequently used (e.g., wild edibles) are decreasing, there are other domains of knowledge (e.g., house building) that seem to be increasing due to new social contexts (e.g., increasing sedentarization and the need to make more permanent houses). Some of these studies also highlight the process of the hybridization of local knowledge with other forms of knowledge (Dove et al. 2007; Reyes-García et al. 2013b; Tengö et al. 2014). For example, in a study in Oaxaca, Mexico, Giovannini et al. (2011) found that individual knowledge of pharmaceuticals does not necessarily displace knowledge of medicinal plants but that the two knowledge systems coexist in a complementary way.

Nourishing from resilience theory, this original and innovative body of research points toward the adaptive capacity of LEK systems and their ability to generate, transmit, and discard knowledge according to the particular needs of a society. Without denying the rapid loss of knowledge, such approach does not necessarily perceive all changes in LEK as a loss, but rather as part of the general self-organizing process of the knowledge systems (Reyes-García et al. 2014). Such dynamic nature of LEK is valuable for adapting to changing social conditions (Berkes et al. 2000) and providing strategies for adaptive management in the face of global environmental change (hereinafter GEC; Turnhout et al. 2012; Noble et al. 2014). In this context, LEK is argued to be *adaptive* because it reacts to the ever-changing nature of social and environmental conditions (Gómez-Baggethun and Reyes-García 2013). Such potential of LEK systems to absorb change can contribute to the long-term resilience of social-ecological systems (Gómez-Baggethun et al. 2013).

In the same line, ethnobiologists have also started to explore the structural constraints of LEK adaptation in the context of GEC (e.g., Gómez-Baggethun et al. 2013; Fernández-Llamazares et al. 2015). The increase in the pace at which GEC takes place has raised skepticism regarding LEK persistence and/or effectiveness (Cox 2000; Kameda and Nakanishi 2002). For instance, with regard to climate change, the Intergovernmental Panel on Climate Change (IPCC) notes that LEK may not always be sufficient to meet the rapid changes in climate, because changing climatic conditions are beyond the knowledge range of the cultural repertoire (Adger et al. 2014). In other terms, because rapid ecosystem changes deriving from GEC are often abrupt and unprecedented, they might be hard to anticipate through LEK systems (Turner and Clifton 2009; Valdivia et al. 2010). Furthermore, in many cases, these changes are not only faster but also nonlinear, generating feedback and forward loops along with new thresholds of irreversible change, all phenomena possibly leading to a novel or *no-analog future* (*sensu* Ruhl 2010, i.e., completely dissimilar to past and/or present conditions). In such context, LEK could potentially become outdated and/or inefficient (Macchi et al. 2008; McNeeley and Shulski 2011), thereby undermining local adaptive capacity (West et al. 2007; Newsham and Thomas 2011).

In such changing social-ecological scenarios, several ethnobiologists have emphasized the need for LEK to adjust and evolve in parallel with GEC (Gómez-Baggethun et al. 2013; Aswani and Lauer 2014). The failure of LEK systems to detect, interpret, and respond to change undermine resilience and exacerbates vulnerability to GEC (Mercer et al. 2010; Simelton et al. 2013). Some works have raised concerns about the mismatch between the temporal rates of environmental change and the pace of potential changes in LEK systems to adapt to such change (Berkes 2009; Fernández-Llamazares et al. 2015). This literature supports the argument that the temporal dimensions inherent in the biophysical phenomena of GEC are not always well suited to the timescales of local knowledge systems (Armitage and Plummer 2010; Pahl et al. 2014). It is important to note that this argument does not necessarily imply that LEK systems do not have capacity to adapt to changing environments, but rather that the timescales needed for environmental changes to be captured in social memory may be longer than the time frames at which GEC currently operates (Held 2001; Weatherhead et al. 2010).

In such context, a critical task for the research agenda in ethnobiology is to identify and understand the factors underlying the capacity of communities with historical continuity in the use of their resources to keep their capacity to adapt and regenerate LEK (see Gómez-Baggethun and Reyes-García 2013). While LEK systems have shown through history great resilience and adaptability, some traditional responses to absorb change (i.e., through flexibility in traditional practices or close social networks) have already been compromised by sociopolitical and environmental changes (Kesavan and Swaminatahan 2006; Homann et al. 2008). For example, in some communities in the Arctic, current social, economic, and cultural trends toward adopting Western lifestyles have eroded the cycle of traditional knowledge transfer upon which adaptive capacity is built (e.g., Ford et al. 2006, 2010). In such contexts, the ability of local and indigenous peoples to cope with substantial changes in the future cannot be considered as unlimited, unless their knowledge systems adapt to these changes and/or people keep the ability to continue experimenting with local knowledge. In other terms, bodies of LEK remaining in indigenous, peasant, and other types of semi-autarkic societies are bound to either change and adapt (e.g., through hybridization) or disappear (Gómez-Baggethun and Reyes-García 2013). Ethnobiological research is thus urgently needed to identify the limits of the adaptive capacity of LEK in rapidly changing social-environmental conditions and the factors facilitating the flexibility of knowledge systems in the face of new global scenarios.

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Political Ecology and Ethnobiology

Steve Wolverton, Justin M. Nolan, and Matthew Fry

Abstract Political ecology concerns the interconnections among political, economic, and culture processes centering on environmental issues. Ethnobiologists pursue research in cross-cultural contexts relating to human-environmental interactions and hold ecological understanding about environmental heritage in societies in which they live and do research. In this chapter, we summarize three case studies that explore the political ecological dimensions of ethnobiological research.

Introduction

How an ethnobiologist interfaces between ethnobiology and political ecology is determined by how she/he defines either term. Ethnobiology flowed historically from ethnoscience, first concerned with taxonomy and cognition, later with local ecology (D'Ambrosio 2014; Hunn 2007). Contemporary ethnobiology overlaps with ecological anthropology as the study of interactions between humans and biota in multiple temporal, spatial, and cultural contexts. Ethnobiologists work with people (or paleoethnobiological remains deposited by people) regarding biological and ecological topics—concerning local subtle ecologies consisting of "slow relations [between people and place] that rely on diffuse causalities and micro-effects related to invisible or fleeting action" (Wyndham 2009:272). Understanding people's ecological knowledge requires intimate conversations because human-environment relations are nuanced.

Subtle ecologies play an important role in biological conservation, biocultural conservation, and environmental justice, which fall within political ecology. Paul Robbins (2012:20) provides a description of political ecology that covers many

S. Wolverton, Ph.D. (✉) • M. Fry, Ph.D.
Department of Geography and the Environment, University of North Texas, Denton, TX 76203, USA
e-mail: wolverton@unt.edu; mfry@unt.edu

J.M. Nolan, Ph.D.
Department of Anthropology, University of Arkansas, Old Main 330, Fayetteville, AR 72701, USA
e-mail: ozarksanthro@msn.com

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definitions; the field concerns "condition and change of social/environmental systems, with explicit consideration of the relations of power" with the purpose of designing less exploitative and more sustainable ways to live in the world (Davidson-Hunt et al. 2012). Ethnobiologists find themselves in conversations with peoples ranging from the exploited to the exploiter, from those with sustainable lifeways to those without. Given this intimate contact, what can ethnobiologists bring to political ecology?

Ethnobiology went through a period of ethical self-examination related to biopiracy and cross-cultural advocacy, which are important themes within political ecology. Ethnobiologists also recognize that ethics are central to cross-cultural interactions (Anderson et al. 2011; Figueroa and Waitt 2010). It is in these fleeting, constant interactions that ethnobiologists record, respect, and convey the diversity of ecological understanding among people structurally immersed in differential power relationships (Wolverton et al. 2014).

In this chapter, we share three case studies highlighting how ethnobiologists encounter ecological understanding. Our case studies include Cherokee traditional ecological knowledge (TEK), Andean puestero pastoralism and culture change in western Argentina, and archaeological biomolecular human remains in the American Southwest. The first study considers preservation of TEK and language, the second concerns the political ecological implications of loss of local ecological knowledge (LEK), and the third addresses cultural heritage and archaeology. Three themes that emerge are as follows: collaborative work with indigenous groups supports greater appreciation for cultural heritage; diverse external influences affect traditional lifeways, which leads to appreciation for LEK; and ethnobiologists must be increasingly cognizant of the power dynamics embedded in research.

Cherokee Ethnobotany

Collaborative research began between Cherokee Nation and the University of Arkansas in northeast Oklahoma when tribal educators engaged the second author. Language documentation was the cornerstone of the program, but the purpose was to generate models of cultural persistence where Cherokee is still spoken (Schmid 2001:24). The language thrives only in remote corners of the 14-county region. We examined rural residents' classification of wild edible and medicinal plants as the project took shape. Our team was warmly received by the Cherokee; we attended weekly community "wild plant" workshops over the 3-year project.

Conversations with elders evolved into friendships, facilitated by rapport established by the educators. Interchanges illuminated the relevance of safeguarding gathering areas for wild food plants—possum grapes (*Vitis cinerea*), hickory nuts (*Carya texana*), watercress (*Nasturtium officinale*), blackberries and raspberries (*Rubus* spp.), huckleberries (*Gaylussacia* spp.), kochani or green-headed coneflower (*Rudbeckia* spp.), wild onions (*Allium stellatum*), and others. Rural Cherokees associate intimately with seasonal gathering of traditional plant foods (Fritz et al. 2001).

Fig. 1 Cherokee Nation educator and artist Roger Cain harvesting bloodroot (*Sanguinaria canadensis*) with Justin Nolan, Adair County, Oklahoma, Spring 2006. Bloodroot is one of dozens of wild plant dyes gathered and used by Oklahoma Cherokees in the construction of traditional river cane basketry

They also identify deeply with related customary skills including weaving with river cane (*Arundinaria gigantea*) (Perdue 1998:22). Weaving river cane baskets is an intricate, time-consuming endeavor, requiring knowledge of canebreak locations; it entails learning proper techniques for harvesting, splitting, drying, and dyeing cane strips prior to use (Fig. 1). Traditional weavers are skilled in creating elaborate double-walled baskets from cane dyed with bloodroot (*Sanguinaria canadensis*), black walnut (*Juglans nigra*), sumac (*Rhus* spp.), and elderberry (*Sambucus canadensis*) (Power 2007).

As the project evolved, our team discovered that the few remaining canebreaks in the region occur in riparian pockets across the wooded, rugged corners of Cherokee Nation where the language is still thriving among the older generations. While we have yet to describe this overlap in detail, it signals the rural Cherokee community's cognizance of culturally valuable habitats, including TEK of conserving them. However, accessing river canebreaks is difficult nowadays for rural Cherokees committed to perpetuating historic plant gathering and use traditions. Most canebreaks have been lost to livestock, agriculture, and clear-cutting of bottomlands adjacent to streams, where they once existed contiguously prior to Cherokee resettlement in Oklahoma following the Trail of Tears in 1838–1839.

Efforts to restore river canebreaks gained Tribal support following the language documentation study. These efforts serve to maintain cultural identity and resist homogenization, preserving subtle ecologies through celebration of native heritage (Tuleja 1997). The Cherokee River Cane Initiative is a proactive, organic effort to protect tribal lands with importance to the well-being of local people. Flexible partnerships promoted the growth of this project, which has evolved into a program that helps ensure the conservation of canebreaks and other tribally designated foraging grounds along with related TEK. Listening carefully to the goals and priorities articulated by grassroots communities—that is, cognizance of the political ecological implications of the research—has been crucial.

Puestero Political Ecology

Puesteros are pastoralists of European, indigenous, or mixed descent who live along the Andean escarpment in western Argentina and other parts of the South American Andes. Many puestero families migrate between high and low elevation camps to ranch goats (*Capra hircus*), sheep (*Ovis aries*), cattle (*Bos taurus*), and horses (*Equus caballus*). Other puesteros are sedentary. All puesteros hold LEK concerning how to practice sustainable livelihoods in arid environments, including herding livestock, living on wild plant and animal resources, and managing water resources. As with pastoralists worldwide (Nori and Davies 2007), their livelihood is changing in response to global environmental and cultural change. Ethnobiologists are able to recognize and articulate loss of puestero LEK in the context of political ecology.

Households have become more mobile and herds less mobile during the last three to four decades. Herd mobility fluctuates between transhumance and range pasturing depending on physiography (Cabrera 1976). In western Argentina, most sedentary puestos are located in the monte and Patagonia ecosystems where herds forage on open ranges. Transhumant puesteros move between the Patagonia and Andean alpine ecozones. Grazing in alpine valleys during summer allows winter pastures to recuperate and takes advantage of high productivity of upland river bottom meadows (Baied 1989). Although each region has distinct floral assemblages and differential access to water, all puestero herding techniques rely on open ranges and mobile foraging that limits overgrazing and allows herds to access new fodder.

Herd mobility is an adaptive strategy that allows puesteros to persist in arid environments; reduced mobility detrimentally affects their ability to subsist. Increasingly, fencing and land grabbing constrain puestero ranging capabilities, while greater access to markets, schools, and employment increases household members' mobility away from puestos. Like other regions of Latin America, the territorial expansion of private protected areas or "green grabbing" is occurring in western and southern Argentina (Fairhead et al. 2012). As a result, many puesteros contend with a process of land consolidation by wealthy citizens who acquire land titles and fence areas for "landscape reserves" that affect herd movements and subsistence hunting practices.

Long-term drought in western Argentina (Leiva et al. 2007) has detrimentally impacted herd sizes; projected climate change impacts will likely compound precipitation and foraging uncertainties for pastoralists throughout the Andes (Rangecroft et al. 2013). More rain, equals more pasture, equals more animals; to make up for diminished pastures, puesteros convert household garden plots from fruits and vegetables to alfalfa for animal fodder, which leads to reliance on urban markets for food. As a result, puestero diets are becoming dependent on market access as much

Fig. 2 Ethnobiologists and puesteros visiting in the piedmont of the Andes in Western Argentina. The pickup truck to the right in the photo belongs to the puestero

as local ecology. As well, diets are changing in response to new conservation laws that inhibit hunting. Wild game are important supplements in puestero diets. National Law 22.421 (Argentina 1981), a response to intense sport harvesting throughout Argentina, protects all terrestrial fauna. Fearing legal consequences, puesteros limit their hunting, which includes organized communal hunts for the flightless rhea (*Rhea* sp.), and instead purchase beef from urban butchers. In addition, hunting restrictions seem to impact puestero herding practices due to a perceived boom in puma (*Puma concolor*) populations, which threaten their goat herds.

Although greater access to metropolitan areas provides puestero households access to education and income opportunities, new lifestyle desires and out-migration by youths slowly lead to loss of LEK. Multi-localized households are characterized by older parents living in rural homesteads and children studying and working in cities (Reardon et al. 2001). Pickup trucks are symbolic of puestero multi-localization. They provide transport to social events, medical facilities, and schools and an ability to purchase market goods and sell animals. Increasingly pickup trucks (Fig. 2) also bring purchased feed back to puestos, especially during times of drought.

Puesteros confront external structural and environmental factors that affect their traditional livelihoods. Ethnobiologists recognize the global costs of LEK loss; in this case, puesteros hold important knowledge about how to live sustainably in arid environments. Given the cultural, political, and environmental changes facing puesteros, ethnobiological and political ecological perspectives become critical for identifying household and local-environmental impacts and for preserving LEK.

Paleoethnobiology in the American Southwest

Within subfields of ethnobiology that focus on archaeological residue chemistry, issues that relate to political ecology can be unclear. However, research into paleoethnobiology influences living peoples who may not hold the same cultural heritage of ethnobiologists. For example, the lead author received National Science Foundation support to improve analysis of biomolecular residues of food proteins from cooking pottery. Much of this research has been done with residues from laboratory cooking experiments (Barker et al. 2012). However, with refinement, it has become important to apply the methodology to archaeological pottery.

In order to validate the approach for study of ancient proteins, pottery was obtained from many parts of the world. Liquid chromatography-mass spectrometry was used to scan extracts for protein residues. The first series of results were negative, as there were residue preservation issues and challenges of instrument sensitivity. However, there was a single identification of a human intestinal protein from an archaeological potsherd dating to the late Ancestral Puebloan occupation of the Mesa Verde region of Colorado, United States. This was a false identification, likely from contamination. However, the potential to encounter human remains as paleoethnobiological residues became clear and led to concerns about environmental heritage. Contemporary Pueblo peoples do not support extensive excavation of Ancestral Puebloan villages, and they never support disturbance of human remains. Typically, such remains are skeletal. The team of researchers had unintentionally unearthed a different type of human remain, at a different analytical scale.

Crow Canyon Archaeological Center in Colorado excavated the site where the potsherd was recovered. The center has a long-term, formal relationship with Pueblo peoples, and part of the center's mission is to embrace dialogue in order to address issues of cultural heritage. As a result, Crow Canyon has a forward-thinking human remains policy stating that the Native American Advisory Group (a council of individuals from across North America, including members from pueblos) must be informed when human remains are encountered. The group aids in determining a course of action. The result of the residue research was brought to the Native American Advisory Group, and all laboratory research was stopped. Several lessons emerged. First, multiple Pueblo, group members were concerned about the potential to recover biomolecular human remains from archaeological contexts. To paraphrase, one pueblo man in the advisory group stated: "once a person is laid to rest, it is forever… we do not have a ceremony to deal with the disturbance and reburial of these remains." Our paleoethnobiological research was of concern because of cultural heritage. That these remains were not skeletal caught everyone off guard.

The research group was encouraged to validate the identification, and the results were not replicated. Importantly, the research group, Crow Canyon archaeologists, and members of the Native American Advisory Group worked together to revise the human remains policy to include biomolecular remains. Paleoethnobiologists often ask pure research questions about the past under the umbrella of science. In terms of political ecology, there is an important concern that became clear: research is often designed without the input of local peoples who may have environmental and cultural heritage related to a project. This is often unintended, as exemplified by the potsherd residue example. However, at times archaeologists "do not ask so that we cannot be told 'no'," which is of great concern in political ecology because scientists often have more economic and social power than local people who might be impacted by the research.

Conclusion

Ethnobiologists are intermediaries of "ecological understanding" within and between societies (Hunn 2014). Turner and Berkes (2006:496–499) argue that conservation ethics can arise in response to periods of unsustainable land use practices, which may correlate to environmental and social injustices for local peoples. Potential disparities in power relations may extend into issues of environmental heritage, the purview of paleoethnobiology. Turner and Berkes (2006:498), however, also demonstrate that intimacy and direct encounter with the "environment" increases ecological knowledge, which can lead to conservation ethics and political ecological interactions that are preemptive and not crisis driven. Such increases in cross-cultural and ecological understanding are what ethnobiologists mediate best. The Western ethnobiologist scholar, for example, may be granted the gift of ecological understanding through fieldwork and direct encounter with LEK and its assemblage of subtle ecologies (Hunn 2002; Wolverton 2013). Bringing their own social context to the fore in their texts, teaching, and presentations allows them to emphasize the political ecological value of their research. However, as is clear from each of these case studies, as collaborations proceed, ethnobiologists' roles often shift from participatory to one that facilitates the needs, concerns, and priorities of the actors involved. Understanding and navigating local politics requires ethical vigilance and respect for the perspectives of elders, rural residents, and community members who are vested in environmental policy and cultural resources.

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Ethnobiology, Ethics, and Traditional Knowledge Protection

Gustavo Taboada Soldati and Ulysses Paulino Albuquerque

Abstract Darell Posey was one of the first ethnobiologists to express interest in and advocacy for indigenous communities, leaving a legacy that has influenced a whole generation of scientists. This chapter briefly discusses the ethical and legal aspects of ethnobiology research, considering the rights of peoples and traditional communities. Brazil will be used as a case study, considering that it was one of the first countries to elaborate upon traditional knowledge access and protective legal mechanisms.

A recurring question today refers to the ethical and legal aspects of ethnobiology research and knowledge protection. This theme has been part of the discussion agenda for a long time, especially among ethnobiologists, as their activity involves two basic components (see Albuquerque et al. 2013):

1. "Access to natural or agricultural biodiversity, which includes collecting samples of animals, plants or other organisms"
2. "Access to traditional knowledge associated with that biodiversity at all levels (i.e., from genetic diversity up to the landscape level, using sampling tools such as interviews, for example)"

This has raised concerns at different levels, not only with regard to traditional knowledge intellectual property associated with biodiversity but also with regard to the return to research communities involved in ethnobiology studies. As for the latter, there has been no consensus, even though several researchers have already adopted

G.T. Soldati, Ph.D. (✉)
Federal University of Juiz de Fora,
Rua José Lourenço Kelmer, s/n, Bairro São Pedro, Juiz de Fora,
Minas Gerais 36036-900, Brazil
e-mail: gtsoldati@gmail.com

U.P. Albuquerque, Ph.D.
Laboratory of Applied and Theoretical Ethnobiology (LEA), Department of Biology,
Federal Rural University of Pernambuco Av. Dom Manoel de Medeiros, s/n Dois Irmãos,
Recife, Pernambuco 52171-900, Brazil
e-mail: upa677@hotmail.com

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certain procedures during their research, especially for the dissemination of their research results (see Albuquerque et al. 2014a). Therefore, it is important to ethnobiologists to have a minimum knowledge of the rights of peoples and traditional communities,[1] which were implemented through several national and international documents, in order to build an ethically referenced professional practice.

International Legal Instruments for the Protection of Peoples and Traditional Communities

The current recognition of the rights of peoples and traditional communities is the result of a long process that can be understood by analyzing the history of many international legal instruments, such as covenants, agendas, codes, agreements, and declarations. At this discussion level, the main social actor is the United Nations (UN) and its agencies.

Without a doubt, the first international step toward this scenario occurred in 1948, with the publication of the "Universal Declaration of Human Rights" (UN 1948), which determined that "everyone has the right to life, liberty and security of person," also stating that "everyone has the right to the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he is the author." It was only in 1957, through Convention 107 of the International Labor Organization (ILO), signed in Geneva, that a specific international instrument for indigenous peoples was created. However, in 1989, this document was revised and replaced by Convention 169, which is one of the most important documents for this international scenario. The Convention includes some criteria that recognize groups to be protected as "traditional life styles, with different culture and way of life from the other segments of the national population, with their own social organization and traditional customs and laws" (ILO 1989).

It is worth noting that, for indigenous peoples, the aspect of "living in historical continuity in a certain area, or before others invaded or came to the area" (ILO 1989) is still considered. This last element was later used by some countries, such as Brazil, to build their national protection policies, not only for the people themselves but also for their traditional territories. The 44 articles in ILO Convention 169 revolve around certain general principles, such as consultation and participation, which requires "that indigenous and tribal peoples are consulted on issues that affect them" (ILO 1989).

Another international instrument is the Convention on Biological Diversity (CBD), signed in 1982 in Rio de Janeiro, Brazil, which consolidates discussions on people and the environment that started in 1972 during the Stockholm Conference in Sweden. The three main objectives of this convention, "[1] the conservation of biological diversity, [2] the sustainable use of its components and the fair and [3]

[1] There are several terms used to define peoples and traditional communities, especially when considering multiple national and international legal instruments. In this sense, this study will use the term "traditional peoples and communities" to refer to the idea of "indigenous and tribal people," which is present in Convention 169 of the International Labor Organization (ILO 1989).

equitable sharing of the benefits arising out of the utilization of genetic resources (…)" (CBD 1992), emphasize the importance of traditional groups as generators and maintainers of this biological diversity, opening the door to more instruments for their protection. The eighth article, (j), explains this perspective by stating: "respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities that embody traditional lifestyles that are relevant for the conservation and sustainable use of biological diversity. Promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices, and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices" (CBD 1992).

In order to ensure implementation of the third CBD objective, the Nagoya Protocol was adopted after 6 years of negotiation and addresses genetic resource access and the fair and equitable sharing of benefits deriving from their use. In its text, it is explicit that "there is interrelationship between genetic resources and traditional knowledge, and they are of inseparable nature for indigenous and local communities. There is also interrelationship between biological diversity conservation traditional knowledge importance and the sustainable use of its components for the sustainable livelihoods of these communities" (CBD 2011). In addition, article 17 specifically discusses access to traditional knowledge and genetic resources, requiring this to be a mutually agreed on and previously consented process. The United Nations, from its Human Rights Council discussions, approved the United Nations Declaration on the Rights of Indigenous Peoples in its General Assembly in 2007; this document emphasizes that "indigenous peoples are equal to all other peoples, while recognizing the right of all peoples to be different, to consider themselves different, and to be respected to such" (UN 2007). This statement also recognizes that "respect for indigenous knowledge, cultures and traditional practices contributes to sustainable and equitable development and proper management of the environment" (UN 2007).

The discussed legal instruments elevate peoples and traditional communities and their knowledge systems to a special historic level. However, activities conducted with these groups, particularly scientific research, are recognized as sources of concern, due to the possible negative impacts on their cultural and intellectual property (CBD 2010). Given this concern, the Conference of the Parties (COP), in 2010, prepared and adopted the Tkarihwaié:ri Ethical Conduct Code, aimed to be a milestone for "collaboration, ensuring indigenous and local communities effective participation and prior informed consent or approval in activities, including research proposals on their knowledge, territories and associated resources" (CBD 2010). This code presents ten general ethical principles designed to promote respect for traditional peoples and communities, such as respect for intellectual property, nondiscrimination, transparency in information disclosure, intercultural respect, and fair and equitable benefit sharing.

In addition to the discussed instruments, the following documents are also highlighted: the Universal Declaration on Cultural Diversity of the United Nations Educational, Scientific and Cultural Organization (UNESCO), 2001; Second International Decade of the World's Indigenous People, 2005; and Convention on the Protection and Promotion of the Diversity of Cultural Expressions, UNESCO, 2005. Although diverse and issuing from different agencies, all of these instruments must be understood in communion.

Chart 1: National Legal Protection Instruments for Traditional People and Communities, Brazil

Brazil, as a member country of the United Nations, aims to reference its national legal instruments in international discussions. Given the previous discussion and, above all, hosting of the "People's Summit," the first Brazilian legislative proposals in the biodiversity and traditional knowledge field associated with biodiversity were introduced in 1995. However, Provisional Measure 2.186-16 was only approved in 2001, which provides for "access to genetic resources, protection and associated traditional knowledge, benefit sharing and technology access and transfer for their conservation and use" (Brasil 2001). This Provisional Measure, as its name indicates, is not definitive but had legal life for more than a decade. To coordinate policy implementation for genetic heritage management, the Provisional Measure created the Council for Genetic Heritage Management (CGEN) (Brasil 2001, Albuquerque et al. 2014a).

Other presidential measures were important to facilitate the Brazilian scenario today, especially those that were the result of social movement actions. In 2004, the National Commission on Traditional Communities Sustainable Development was created, and it was modified in 2006, changing its name to National Committee Commission on the Sustainable Development of Traditional Peoples and Communities (CNPCT) (Brasil 2006). It is composed of diverse social movements, Amerindians, "quilombolas," family farmers, and other traditional identity representatives and the Federal Government. This commission, in addition to legally representing these groups, had the National Policy for the Sustainable Development of Traditional Peoples and Communities development and implementation as its main function, which was consolidated in 2007 by Decree 6.040/2007. Its aim is "to promote traditional people and communities sustainable development, with emphasis on the recognition, strengthening and guaranteeing of their territorial, social, environmental, economic and cultural rights, with respect and appreciation to their identity, organization forms and institutions" (Brasil 2007).

Provisional Measure 2.186-16, over its 14-year period, received several criticisms. Scientists said the rules red-taped research to the point of paralyzing it. As a result, for some years, some investigations conducted in the country were illegal. The Provisional Measure also received criticism from the business sector, as these same rules crippled native flora and fauna bioprospecting in a megabiodiverse country. Under strong pressure, in 2014, the Federal Government prepared a document to consider these criticisms, sending it for approval by the Federal Congress. However, this process excluded the main social actors in question, namely, traditional peoples and communities. Therefore, it infringed upon many international agreements signed by Brazil, especially Convention 169 of International Labor Organization, the Convention on Biological Diversity, and the International Treaty on Plant Genetic Resources for Food and Agriculture (TIRFAA) (see MPF 2014). As the result of not being consulted,

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the National Commission on Sustainable Development of Traditional Peoples and Communities sent a letter to the Federal Government requesting the withdrawal of voting on the project from the agenda. However, despite strong pressure from social movements, on May 20, 2015, President Dilma Rousseff sanctioned Law 13.123, known as "Marco da Biodiversidade" (Biodiversity Milestone) (Brasil 2015). Although approval of this law has lowered scientific research bureaucracy, this law was a retreat from historically achieved rights according to various entities, organizations, associations, and scientific societies that are close to traditional people and community concerns.

Ethnobiology Research Ethics and Legal Aspects

Previous international discussions influenced and were influenced by the actions of ethnobiologists. Darrell Posey's great political activism in favor of traditional peoples and communities through his experience in Brazil, for example, is noteworthy, especially among the Kayapó (see Posey 1996; Posey and Dutfield 1996). Posey opened the discussion on traditional rights in the ethnobiology field. In 1988, his speech gained strength with the creation of the International Society of Ethnobiology (ISE)[2] and its first international congress in the city of Belém, Pará, in northern Brazil. Articulated by Posey, "Carta de Belém" (Belém's Letter) was published as a historically significant document that explains ethical aspects for scientists who research local knowledge, as well as their responsibilities in relation to traditional peoples and communities. This letter recognizes unbridled sociobiodiversity loss and strengthens, among other things, "mechanisms to be established by which indigenous specialists are recognized as proper authorities and are consulted in all programs affecting them, such as their resources, and their environments" and "procedures to be developed to compensate native peoples for their knowledge and their biological resources utilization." It was the first time that an international scientific society became politically positioned on the subject.

Belém's Letter was so important that it became the embryo of the International Ethnobiology Society Code of Ethics, published in 2006, which presents a set of ethical positions that can contribute to ethnobiology research decision-making and related activities. This code comprises seventeen principles, such as "Active Participation," which "recognizes the crucial importance of Indigenous peoples, traditional societies and local communities in actively participating in all phases of research and related activities, from inception to completion, as well as in research results application."

The Latin American Society of Ethnobiology (SOLAE), which is concerned with the ethical and legal aspects of ethnobiology research and all its consequences,

[2] All information in the text related to the International Society of Ethnobiology was collected from the institution site: http://www.ethnobiology.net.

began a process to build its own ethics code in 2012 (Contreras et al. 2014). Since then, some drafts have been produced and discussed in several forums, always with the representative participation of traditional peoples and communities. To design their code, SOLAE assumes that "legislative and policy milestones on indigenous peoples and traditional community rights must be respected, along with their territory autonomy and ancestral knowledge, which are central elements to be considered by scientific research" (Contreras et al. 2014). It also considers that "development processes to be performed in the communities must have respect, consultation, collaboration and dialogue among peoples [and traditional communities], academics and Ethnobiology professionals…" (Contreras et al. 2014). Additionally, the Latin American ethics code presents ethical principles, such as "care must be taken at all times, so that ethnobiological investigation does not show any access, protection, usufruct, property or conservation risk; and if that is the case, the tangible and intangible territory in which the group with whom it is being worked developed" (Contreras et al. 2014).

Conclusion

Traditional peoples and communities hold several international and national legal instruments that protect them as autonomous and political beings who are able to manage their own resources, wield their territories, and make their choices. As these different groups are the primary subjects of ethnobiologist actions, it is important that professionals have a minimum knowledge of these documents such that their practice as a researcher, teacher, or extensionist (see Albuquerque et al. 2014b) is in harmony with historically built ethical values.

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Part II
Biota Perception and Classification

What Is Environmental Perception?

Taline Cristina Silva, Leonardo da Silva Chaves, and Ulysses Paulino Albuquerque

Abstract Over time, human groups have established cognitive, perceptual, and behavioral ties to the natural environment. Accessing perception is a challenge, as it involves having to address physiological, psychological, and cultural aspects that are involved in how one accesses the world outside. In this chapter, we introduce some conceptual issues on this theme and propose the adoption of the term environmental representation in reference to perception studies within ethnobiology.

The perception phenomenon is driven by a set of internal factors and has a fundamental importance for human survival because the act of perception allows us to feel what exists around us (Gendlin 1997). Academic approaches to our perception of the environment are somewhat complex, as they involve different conceptual, disciplinary, and methodological aspects.

According to the "Oxford Advanced Learner's Dictionary" (Stevenson 2010), perception means "the ability to see, hear, or become aware of something through the senses." This definition is related to the physiological aspects of the perceptual process as it relates to the senses involved in the act of perceiving. However, beyond this, there are numerous definitions (Table 1) and developments of the term perception, particularly in regard to "environmental perception," which relates to our perceptions of the natural environment, a subject of interest to ethnobiologists.

Concepts that consider cultural and biological aspects as factors that influence the way we perceive the environment (Bell 2001; Okamoto 2002) are more appropriate in ethnobiological research because they have a connection with the research object of this field: the interrelation between people and biota.

Not everything in the external environment is accessed through our senses, given that we only access a small representation of reality as perceived by the individual (Tuan 1974). This is because the real perception of the individual in relation to the environment goes through biological and cultural filters, and the individual

T.C. Silva, Ph.D. (✉) • L.S. Chaves • U.P. Albuquerque
Laboratory of Applied and Theoretical Ethnobiology, Department of Biology, Federal Rural University of Pernambuco, Rua Dom Manoel de Medeiros s/n, Dois Irmãos, 52171-900 Recife, Pernambuco, Brazil
e-mail: talinecs@hotmail.com; lsxaves@gmail.com; upa677@hotmail.com

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Table 1 Some concepts of environmental perception

Author/year	Concept of environmental perception
Tuan (1974)	"Is both the response of the sense to external stimuli and purposeful activity in which certain phenomena are clearly registered while other recede in the shade or are blocked out." According to the author, much of what is perceived has a value to the individual and its biological survival, and it provides some satisfaction that is rooted in the culture
Zube (1999)	"Has commonly been defined as awareness of, or feelings about, the environment, and as the act of apprehending the environment by the senses"
Bell (2001)	"Apprehension of the external world through the senses, guided by physical and psychological elements"
Okamoto (2002)	Perceptions of the environment influenced by cultural factors
Fernandes et al. (2006)	It is the "vision" that every person has of the environment that surrounds it. It is the first step toward the process of knowledge and an environmental awareness exercise

externalizes a representation of reality. Thus, as we access only what is externalized (represented), the term "representation" appears more appropriate than "perception" if we want to refer to what was perceived. Importantly, the term representation, which we address here, is not related to the term "social representation," because, as Höijer (2011) highlighted, studies utilizing this approach try to understand collective symbols that produce societies with common bonds.

The term "environmental representation" is most appropriate when conducting an investigation into what people report about environmental elements (See Silva et al. 2014).

Filters in Perceptual Phenomena

To explain the role of these filters in perceptual processes and their externalization, we can mention daltonism[1] (as a kind of physiological filter). People may have physiological limitations that cause them to have perceptions that are different from the common sense. Another example of how physiological filters interfere at the perceptions and consequently at the use of resources is the capacity, based on a specific genetic predisposition, that some people have to recognize different organoleptic properties, such as smell and taste, better than others (Bartoshuk 2000). The implications of this in the context of resource use can be reflected in the form of selection and use of food and medicinal plants by certain people (Johns 1990).

Perceptual processes are not purely physiological. Sociocultural aspects also influence the way we perceive the outside world (Garling and Golledge 1989). A member of a cultural group presenting a next-generation handset to another cultural

[1] Disturbance of visual perception, in which the individual finds it difficult to distinguish between green and red.

group living in isolation constitutes an example of a cultural filter. It is likely that this object will be perceived (by touch, vision, etc.) without having any immediate cultural significance for these people. Goldstein (2010) goes further when discussing the role of cultural filters in environmental perceptions, arguing that if an element is perceived in a particular culture but has no meaning, it can receive special attention from this cultural group, who attempt to assign meanings, values, and uses for this element.

To illustrate the role of cultural filters in our perceptions, despite the fact that several ornithologists consider Tanzania and Kenya to be countries that constitute the "epicenter" of African traditional medicine, very few records of bird species are used for this purpose across East Africa (Williams et al. 2014). To some extent, such behavior appears to be attributable to the presence of a cultural filter, given that in this region it is common for people to associate the use of certain birds with witchcraft practices, illustrating how perception affects the way people appropriate a resource (see Williams et al. 2014).

Another example is a specific food, which, for certain cultural groups, is extremely tasty, while for others causes disgust. However, accessing this type of perception is somewhat difficult because chemical perceptions such as smell and taste include two simultaneous processes: one biological and one cultural, related to the interpretation and evaluation of information.

Thus, perceptions of reality are difficult to access because they are abstract and influenced by factors such as age, gender, income, and biological and evolutionary factors. Therefore, the representation that an individual externalizes through speech, writing, and/or illustrations is the only way we can access worldviews, feelings, values, and opinions of people regarding the environment.

Importance of Environmental Representation Studies

Importantly, research on environmental representation can be useful to verify changes in the landscape and their possible causes, understand the criteria involved in the selection and use of natural resources, elaborate on conservation strategies, conduct environmental diagnostics, and develop projects that take into account the views of the environment that different social actors have, among other implications.

A representation study can be a tool for the rapid assessment of long-term impacts on biodiversity, as it accesses the perceptions of people directly involved with an issue. However, it is noted that, in this case, for the recognition of changes in the environment in addition to good knowledge regarding the quantity or quality of the conditions or resources, a good reference for the "natural" state (without interference) of the environment is required. In this case, failure in communication between people of different age groups within the same community can cause a phenomenon known as *shifting baseline.* Knowledge of the initial conditions of the area under study is not transmitted from one generation to the next. Young people, based on their personal experiences, take on a more recent and therefore different reference from that assumed by older people. The idea of a *shifting baseline* has been revised by Fernández-Llamazares et al. (2015). The authors suggest that to identify such a phenomenon, the existence of three criteria is necessary: (1) the studied environment should be characterized by a noticeable change, (2) age-related differences of perception of such a change must be verified, and (3) scant communication between people of different generations must be characterized.

By investigating changes over time in terms of the abundance of fish in an Angler's extractive reserve, Bender et al. (2014) characterized the occurrence of *shifting baseline* based on the differences in responses related to experience in fishing activity. In this study, more experienced fishermen could perceive a further reduction in the abundance of fish species exploited by fishery activities. A good example of how people's perceptions may interfere with actions aimed at conservation is a case in which there is a clear relationship between the aesthetic perception that people have of wildlife and their willingness to preserve it. Pinho et al. (2014) consider that animals perceived as "beautiful" or "charismatic" have received more attention than other animals in conservation campaigns both by the general public and public managers. These authors found that, for some people, animals perceived as physically attractive and those identified as a priority for conservation coincide. In contrast, animals that have an "ugly" perception are mentioned by some interviewees as justification for a possible hostile attitude toward them.

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Biota Perception and Use

Taline Cristina da Silva, Letícia Zenóbia de Oliveira Campos, Josivan Soares da Silva, Rosemary da Silva Sousa, and Ulysses Paulino Albuquerque

Abstract Perceptual processes are complex and are addressed by several disciplines. These processes are responsible for the ways that humans access the external world. Therefore, they influence the ways in which human beings appropriate environmental resources. Some studies have indicated that differences in intra- and intercultural perception, such as age, individual social role, and religion, may influence perceptions about nature. Thus, how certain factors affect human perception of nature, its use, and environmental resource appropriation will be discussed in this chapter.

The perceptual phenomenon is of fundamental importance for human survival in many types of environments: the act of perceiving allows one to feel what exists around oneself, allowing humans to respond to environmental stimuli (Gendlin 1997). Thus, throughout human evolutionary history, skills and perceptual functions were developed to ensure human survival in multiple environments (Garling and Golledge 1989). Efficiency in detecting predators through the senses and identifying toxic substances through smell and taste were important to different cultures in the selection process of animals and plants for food and medicinal purposes. However, perceptual processes are not purely physiological but also sociocultural, as culturally experienced perceptual events can be stored in the memory (Garling and Golledge 1989). Furthermore, culture can act as giving sense to perception, such as animal species selection for different purposes due to their coloration. Thus, how different factors affect the way humans perceive and appropriate resources will be highlighted in this text.

T.C. da Silva, Ph.D. (✉) • L.Z. de Oliveira Campos, Ph.D. • J.S. da Silva
R. da Silva Sousa, Ph.D. • U.P. Albuquerque, Ph.D.
Laboratory of Applied and Theoretical Ethnobiology (LEA), Department of Biology, Federal Rural University of Pernambuco, Av. Dom Manoel de Medeiros, s/n, Dois Irmãos, 52171-900 Recife, Pernambuco, Brazil
e-mail: talinecs@hotmail.com; leticia.zenobia@hotmail.com; josivan.biologia@gmail.com; meiry.sousa@hotmail.com; upa677@hotmail.com

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Physiological Factors

Perception mediated by smell, taste, and touch can be the result of adaptations to the ecological and cultural environment, which is fundamental for the recognition of the nutritional and toxicological characteristics of natural resources. Johns (1996) notes how taste perception is important in selecting species to be used as food and medicine in a particular cultural domain. Organoleptic characteristics, such as bitter taste and astringency, are related to the selection of species that will be used for the prevention and treatment of certain diseases, and species with a sweet taste are used as edible plants (Johns 1996). Specifically regarding animal resource use, Koster et al. (2010) reported how taste influences human population perceptions, as well as their use forms, which is considered an important feature in the selection of species to be used for food purposes.

Smell is also an important feature in terms of the recognition of chemical aspects of natural resources, mainly for plants. Certain smells are associated with poisonous substances, while plants with a "pleasant odor" are selected for the treatment of specific diseases (see Brett and Heinrich 1998). In addition to taste and smell, sight has a strong influence on the way people use resources. The colors of several plant and animal species play an important role in how such species are perceived and which actions will be carried out with them. Colorful birds are usually selected as pets or ornaments in religious ceremonies in several regions of the world because of their beauty, for example (Alves 2012). However, vibrant colors in other animals can be perceived by people as an indication that such species are dangerous and therefore avoided or less appreciated over others (Prokop and Fancovicova 2013).

Socioeconomic and Cultural Factors

Several studies indicate that intra- and intercultural differences in perception, such as age, individual social role, and residence time, can influence the perception of nature. Silva et al. (2010) investigated children and adolescent perception of Atlantic Forest fragments, verifying that children aged between 10 and 13 years old have positive affective links with the forest, while adolescents between 14 and 18 years old have a more utilitarian relationship with the forest. An explanation for this is likely the fact that, in childhood, children are encouraged to admire and contemplate nature. This fact can also be explained by the idea of biophilia, which represents the natural tendency of a human group to have emotional bonds with different elements of nature (Wilson 1984). However, in the transition from adolescence to adulthood, these perceptions are altered, giving way to a more utilitarian reading of nature and considering what it can offer to enable material survival.

In addition, recent studies have sought to understand generational differences in the perception of available resources from the *Shifting Baselines Syndrome* (SBS) perspective (Hanazaki et al. 2013; Fernández-Llamazares et al. 2015). SSB is related to miscommunication between people of different age groups with regard to the knowledge and perception of changes in environmental resource abundance. That is, knowledge of the initial conditions in a studied area is not passed from one generation to another, and young people, based on their personal experiences, assume a more recent reference, which is different from that known by older people.

Communities that have been settled for longer periods of time in a given area tend to indicate changes to that area in greater detail. On the other hand, communities that have been settled for shorter amount of time tend to not perceive these changes (Silva et al. 2014a, b). However, some studies have shown that landscape modification process perceptions are not always consistent with the reality of the studied environment (Zube et al. 1989; Nazer et al. 2010). Other factors may be associated with variations in perception regarding environmental changes, such as the degree of people's dependence in relation to natural resources. It has been observed that the more people depend on natural resources, the more they notice changes linked to these resources (see Sieber et al. 2010; Campos et al. 2011).

The human nervous system has evolved to the point that multiple filters prevent individuals from being aware of everything that happens around them, which is a mechanism to avoid information overload. Thus, some types of information are ignored. There are many people who are potentially able to indicate changes in the availability of a biological resource that they use (see Silva et al. 2014a, b). Others appear not to have the same ability, even if they maintain the same type of relationship with the environment. However, this is an empirical observation that must be further investigated. Thus, there must be several filters and stimuli in combination with each other to determine ways to perceive and use resources, which, undoubtedly, could be a very interesting research topic.

As for the role of culture, specifically religion, in perceptions and, consequently, the use of natural resources, some examples related to fauna are highlighted. The negative perceptions that people associate with snakes, especially human groups that have a Judeo-Christian influence, are strongly related to the passage of Adam and Eve through the Garden of Eden, where the serpent is opposed to divine advice (Alves et al. 2012). This negative association related to snakes can often result in defensive or preventive reactions resulting in the deaths of these animals. Negative relationships appear to be so strong in some regions of Brazil that these perceptions are also extended to amphisbaenids, which are popularly known as blind snakes because they have a similar body shape to snakes, thus influencing actions taken against individuals in this group (Fita et al. 2010). An interesting case that reinforces this negative perception of people regarding snakes involves the *Salvator merianae* (Duméril and Bibron 1839) lizard, which is popularly known in northeastern Brazil as "tejú" or "teiú." People in a Ceará rural community note that snakes are an item in the diet of this species (Silva et al. 2014a, b) and often associate the lizard's appearance with that of ophidians. Many avoid this animal for food use, even though it is the most popular lizard for food and medicinal purposes within traditional communities in several regions of Brazil (Alves et al. 2012). An opposing example of the assignment of negative perceptions to some animal species is related to the *Fluvicola nengeta* (Linnaeus 1766) bird, which is known in northeastern Brazil as “laundress” or “washerwoman.” The bird is popularly believed to have helped Saint Mary wash the feet of Jesus Christ. The same belief is attributed to the *Motacilla alba* (Linnaeus 1758) bird, also known as “washerwoman” by the people of Galicia, Spain (Farias et al. 2010). Thus, these mythical attributions exert strong influences on human actions in relation to the aforementioned species (Farias et al. 2010). In both cases, culture mediates human relations with these animals, which consequently grants them higher protection, as they are rarely hunted, captured, or killed. Sacred perception, as well as the negative representation of some animal species, has been shown to be common in many cultures, influencing actions taken toward them. In India, the divine assignment attributed to several animal species is quite remarkable (Anthwal et al. 2010).

Different decisions related to food resources of both animal or plant origins are not only strictly mediated by religious factors. A number of motivations are related to mystical or legendary valuations (Farias et al. 2010), gender or age restrictions, and other beliefs that stimulate negative or positive actions toward an animal or plant (Meyer-Rochow 2009). Examples that have been previously shown are associations with utilitarian taboos that are expressed in several ways; these taboos can be defined as social rules, and they are believed to be present in all human societies (Meyer-Rochow 2009).

Restrictions regarding resource collection areas are also possible. So-called “sacred areas” are present in different cultures and occur, for example, in many African regions; these are respected areas with strong cultural meanings that regulate access to and obtainment of the desired resources (Bobo et al. 2014). Thus, these utilitarian taboos are being studied to better understand forms of human/biota interactions and are important for the conservation of some species given that they can provide information about factors that influence the choice of one resource over another. Given the above, it is possible to say that human perceptions associated with natural resource use must be carefully investigated because results from these studies may help us to understand the criteria for the selection of certain natural resources by different cultural groups. Moreover, these factors generally do not act alone and require comprehension of forces that act together and the different forms of interactions between people and the biota.

Chart 1. Case Study: Cultural Keystone Species

Some plant and animal species are culturally perceived to be very relevant, with such pronounced central roles that they are called cultural keystone species, which is analogous to the keystone concept in ecology (see Power et al. 1996). These species are understood as cultural system elements, whose functions are essential for the relationships and adaptations of members of a culture to the environment (Cristancho and Vining 2004) and are also essential for the formation of cultural identity (Garibaldi and Turner 2004).

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However, not all species have such roles in cultures, which is why several authors have proposed indicators as well as the Culturally Defined Influence index to those that do (see Cristancho and Vining 2004; Garibaldi and Turner 2004; Assis et al. 2010). A study conducted in extractive communities in an area of northeastern Brazil, the Araripe region, identified two cultural keystone species: *Caryocar coriaceum* Wittm and *Attalea speciosa* Mart ex Spreng (see Sousa 2014). It was found that these plants are distinguished from other local botanical system species because they have higher Culturally Defined Influence values. It was also found that these species have high economic importance, and there are such close material and immaterial dependency relationships between studied extractive communities and these cultural keystone species that they are already rooted in the local way of life. Thus, it is possible that the cultural practices developed in the community, which in this case constitute plant resource extraction for commercial purposes, may determine *C. coriaceum* and *A. speciosa* keystone function. Knowing that these plants play key roles in the way of life of a studied extractive community, they can be used as emblematic species to incorporate environmental and social dimensions and thus act as key elements in the creation of biocultural conservation strategies related to local sustainable development. Therefore, it is necessary to combine the preservation of local cultural practices and species conservation, contemplating not only the ecological dimension but also cultural sustainability.

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Biological and Evolutionary Bases of Human Perception of the Natural Environment

Washington Soares Ferreira Júnior, Taline Cristina da Silva, and Ulysses Paulino Albuquerque

Abstract Perception is the gateway of the human species to the outside world. However, the concept of human perception may vary in accordance with the perspectives of different authors. For ethnobiology, investigation of the factors that influence perception is important to facilitate our understanding of the attitudes of human beings in their interactions with the environment. Thus, this chapter will focus on the biological and evolutionary bases that can explain the multiple perceptions of our species in terms of different environments and certain natural resources. The perception of organoleptic properties and the perception of landscapes will be used as examples in this discussion. Studies show that the perception of organoleptic properties by human groups is important in the recognition of food and medicinal plants, and perceptions of landscapes are fundamental to human survival in different environments.

Interactions between people and the environment may be mediated by the perceptions that people have about the natural environment. It has been suggested, for example, that the actions and attitudes that people have in relation to the environment are linked to how people perceive this environment (Gelcich et al. 2008; Wandersee et al. 2012). Human perception is a complex phenomenon that involves capturing stimuli and environmental information through the sense organs, generating an internal representation as the result of cognitive mechanisms, and, from that, assessing the represented information to make judgments, decisions, and choices (Garling and Golledge 1989). From this complexity, many factors can interfere with the human perception of the environment, such as sociocultural and biological factors (Parsons 1991; Korpela et al. 2002; Teka and Vogt 2010). Hence, an assessment of the factors that explain environmental perception may be important to understand the actions that people exert on the environment.

Ethnobiology studies have addressed environmental perception, aiming to access how the interactions of human groups with environmental resources, plants, and

W.S. Ferreira Júnior, Ph.D. (✉) • T.C. da Silva, Ph.D. • U.P. Albuquerque, Ph.D.
Laboratory of Applied and Theoretical Ethnobiology, Department of Biology,
Federal Rural University of Pernambuco, Rua Dom Manoel de Medeiros,
s/n, Dois Irmãos, Recife 52171-900, Brazil
e-mail: kba.bio@hotmail.com; talinecs@hotmail.com; upa677@hotmail.com

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animals can be mediated by the perceptions that people have regarding the characteristics of these resources (Johns 1990; Brett and Heinrich 1998), beyond perceptions of the landscape where the resources are located (Silva et al. 2010; Molares and Ladio 2014). By adding an evolutionary perspective to studies, we can understand how our perception of resources and landscapes has been shaped by our evolutionary past (see Parsons 1991), which provides an understanding of how our relationship with the environment has evolved. Accordingly, in this chapter, we present the biological and cultural factors that may mediate the perceptions of people regarding environmental resources. For this, we focus on two sets of investigations that have been important in ethnobiological studies: (1) the selection of medicinal plants based on the perception of organoleptic properties and (2) the human perception of different landscapes.

Biological and Evolutionary Bases of Human Perception Involving the Selection of Environmental Resources

From an ethnobiological perspective, the study of the use of medicinal plants by different cultures has been important for understanding the role of perception in human interaction with environmental resources. A number of studies have shown that the perception of organoleptic properties, such as taste and smell, by human groups is important in the recognition of plants in medicinal use (Johns 1990; Brett and Heinrich 1998; Ankli et al. 1999). For example, Ankli et al. (1999) showed that medicinal plants for Yucatec Maya communities had perceived features of taste and smell, but plants without medical utility did not present these organoleptic characteristics that are perceived by people. Some evidence has shown that human perception of the organoleptic properties of plants, such as taste and smell, and their influence on species selection for medical use have ancient roots in our evolutionary history (Johns 1990). The importance of recognizing organoleptic properties for medicinal use for our species leads us to question how the perception of these properties has evolved. Clues to understand this evolution can be found in studies that discuss the use of plants by other animals, especially nonhuman primates.

The self-medication behavior of chimpanzees for the treatment of parasitic diseases has similarities with the behavior of human beings (Huffman 2001). For example, the use of the plant species *Vernonia amygdalina* Delile for the treatment of parasitic diseases has been documented in both chimpanzees and different human groups (Huffman 1997, 2001). In humans, this behavior may have evolved as a consequence of nervous system improvement in early hominids (Fabrega 1997), allowing our ancestors to achieve a heightened awareness perception of environmental resources to select foods to increase nutritional benefits and avoid the effects of potential toxins (Johns 1990). This is reflected in the perception of taste, as there are innate behaviors associated with our ability to identify specific flavors. For example, from an evolutionary point of view, a sweet taste is associated with the recognition of food with compounds that provide energy, and thus, there is an innate behavior of acceptance of this taste; however, a bitter taste tends to be avoided because it can be associated with potential toxins (Hladik et al. 2003; Wooding et al. 2004; Dinehart et al. 2006).

Notwithstanding, our species also associates bitter taste with the potential medicinal properties of a plant (see Johns 1990). Often, for toxic resources, there were improvements in the processing and use of these plants, such as infusions and decoctions, to minimize adverse effects. Thus, improved knowledge of the use and processing of medicinal plants was passed between generations, resulting in the formation of an increasingly complex pharmacopoeia (Johns 1990). In addition to the processes involved in detoxification, factors such as population growth, change of lifestyle from nomadic to sedentary, and injuries caused by the threat of predators and hunting activities may have contributed to the emergence of new diseases in human groups, in addition to the increase in the incidence of diseases; in consequence, this may have favored the development of a more complex pharmacopoeia (Huffman 2001; Fabrega 1997).

Moreover, we cannot ignore the role of culture in the human perception of environmental resources. In particular, we assume that culture acts to assign meanings to what we perceive through our senses, such that something mentioned as unpleasant by a culture can be pleasant and desired by another. Hence, a culture typically provides context and meaning for the expression of innate human behavior in contact with different tastes and smells (Shepard 2004), acting as a filter for innate responses. For example, plants with a strongly bitter taste are primarily intended for the treatment of gastrointestinal diseases by the Tzeltal Maya, from Mexico, due to their wide acceptance within the culture (Brett 1998).

Furthermore, there are certain foods that are extremely tasty for certain cultural groups, while for others, they cause disgust. For example, fungi are appreciated in certain human groups in Continental Europe, while English-speaking groups have a repulsion for them (Lincoff 2010). This may indicate the role of cultural filters in the sense of taste perception. We have realized that perceptions related to smell and taste include two simultaneous processes, one biological and another cultural, related to the interpretation and evaluation of information.

Evolutionary Pressures and Their Role in the Perception of Landscape

In studies on the perception of landscapes, there is evidence indicating that humans have a preference for open landscapes compared to closed landscapes, such as dense forest environments (Parsons 1991; Korpela et al. 2002). For example, in Australia, American and Australian groups indicate a preference for landscapes with little vegetation cover instead of forest areas (Kaplan and Herbert 1987). Likewise, Nigerian groups tend to prefer savanna landscapes instead of forest landscapes (Falk and Balling 2010).

These findings can be understood with an evolutionary perspective. According to the psychoevolutionary model proposed by Roger Ulrich (see Ulrich et al. 1991), humans drive a rapid and immediate affective response to natural environments containing elements linked to more open landscapes and the presence of water, among other factors. This innate affective response may influence the cognitive assessment of the environment, leading to a preference for open natural landscapes (Ulrich et al. 1991). The work of Korpela et al. (2002) presented evidence that corroborates the idea that human beings have a quick emotional response directed primarily at natural landscapes compared to urban landscapes. This affective response occurs approximately 200 milliseconds after the contact between the person and the environmental figure (Korpela et al. 2002).

One possible explanation for the preference for open natural landscapes suggests that early hominids selectively responded to savanna settings as a relatively safe place where food was available (Parsons 1991; Korpela et al. 2002; Hartmann and Apaolaza-Ibáñez 2010). In Africa, millions of years ago, natural selection acted to maintain the first hominids in savanna areas, which has left them with a preference for more open environments (Falk and Balling 2010). In this case, our ancestors did not have specific skills to live in closed forests, which offer an environment with strong selective pressure due to the presence of potential predators that can be difficult to see. This means that today we innately prefer open natural environments.

Nonetheless, people do not always exhibit a preference for more open landscapes, suggesting that other factors may interfere with this preference, such as sociocultural factors (Van den Berg et al. 1998). By studying the landscape preferences of a human group in Spain, Hartmann and Apaolaza-Ibáñez (2010) found that the savanna environment (open natural landscapes) was not preferred, unlike other landscapes of natural environments that are more familiar to the people, which were most preferred. A study by Van den Berg et al. (1998) showed that different groups of people who visited a rural area in the northern part of the Netherlands (local residents, farmers, and visitors) exhibited differences in their assessments of preference for natural landscapes. These examples suggest that culture may also play an important role in human learning with various types of environments. Thus, the preference for open landscapes is not only an innate issue: cultural experiences are also important in human perceptions and preferences (see Hartmann and Apaolaza-Ibáñez 2010).

Surely, as we consider this discussion, we have realized that our relationship with nature is very complex and cannot be reduced to mere simplistic explanations that disregard our evolutionary and cultural history. Thus, we believe that if the arguments already mentioned regarding our preferences in relation to landscape are correct, there may be an innate human aversion to areas of closed forests, which can somehow justify the current context of environmental degradation in which we live. However, this statement is still speculative and must be scientifically tested.

Regardless of this, as a cultural species, we can overcome the pressures imposed on us by our biological nature. In this case, there are still many questions to be answered related to the evolution of the human mind and its influence on our landscape perceptions. This indicates an instigating research scenario for ethnobiologists because understanding the factors associated with human perception of the environment is important to understand how we appropriate the nature physically, emotionally, and intellectually.

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Risk Perception

Taline Cristina da Silva, Washington Soares Ferreira Júnior, Flávia Rosa Santoro, Thiago Antônio de Sousa Araújo, and Ulysses Paulino Albuquerque

Abstract Human groups, throughout their history, have always been exposed to different types of risk, i.e., to potentially unfavorable circumstances. These risk situations have influenced the relationships of people with the environment and have been instrumental for the development of strategies for the exploitation of natural resources, as well as in other aspects of human survival. Practices and beliefs related to health care, for example, reveal key points in terms of how people perceive the environmental risks to which they are susceptible. In this chapter, we conceptualize risk perception and discuss how this can be important from a theoretical and practical point of view in ethnobiological studies.

Risk can be understood as the exposure of a subject to potentially unfavorable circumstances (Smith et al. 2000). Certain cultural practices, conflicts with other cultures, environmental variations (prolonged droughts, floods), and epidemics can pose challenges in potentially unfavorable situations, i.e., in risk situations. Knowing the future consequences of potential risk events currently taking place or those that may occur in the future is extremely important for the continuation of human populations in their environments (Sjöberg 2000).

Risk perception can be defined as the set of judgments, feelings, attitudes, and beliefs of an individual, or a human group, directed to risk assessment (Pidgeon et al. 1992). The ways in which humans perceive and assess risks can determine the strategies that will be followed for the use of natural resources, as well as other decisions and judgments that may affect quality of life.

T.C. da Silva, Ph.D. (✉) • W.S.F. Júnior, Ph.D. • F.R. Santoro
Thiago Antônio de Sousa Araújo, Ph.D. • U.P. Albuquerque, Ph.D.
Laboratory of Applied and Theoretical Ethnobiology, Department of Biology, Federal Rural University of Pernambuco, Rua Dom Manoel de Medeiros s/n, 52, Dois Irmãos, 171-900 Recife, Pernambuco, Brazil
e-mail: talinecs@hotmail.com; kba.bio@hotmail.com; flaviasantoro@gmail.com; thiagocaruaru@hotmail.com; upa677@hotmail.com

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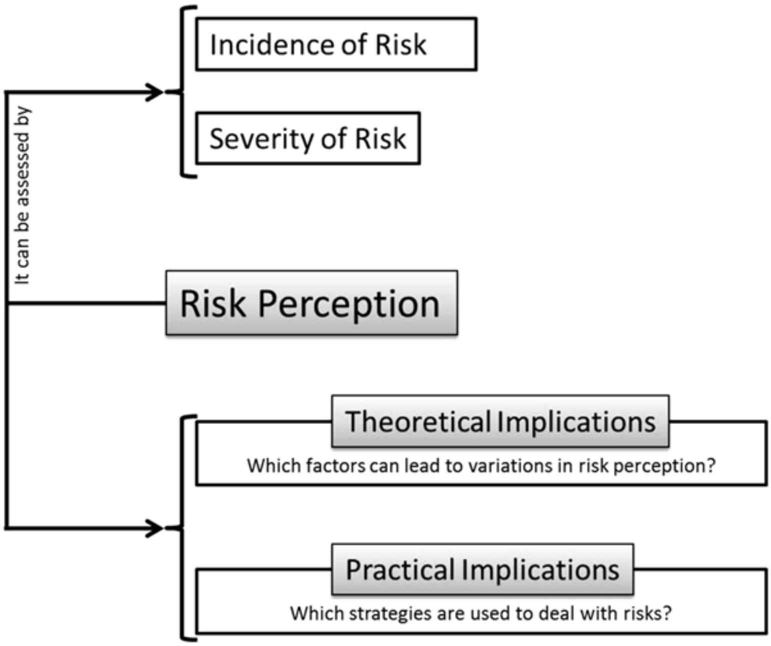

Fig. 1 Conceptual representation aspects of risk perception

The perception of risk may be assessed by the incidence and severity of risks (Smith et al. 2000). Incidence measures the proportion of people in a cultural group that identified a particular source of risk, while severity measures how much this risk is perceived as serious and capable of affecting quality of life (Quinn et al. 2003). A risk may have high incidence but low severity. Though, high incidence and severe risks deserve attention, usually because they can be useful for the implementation of public policies. Thus, the analysis of the incidence and severity of risks allows the construction of risk maps with different themes and social contexts.

After presenting the concepts and methods to assess risk perceptions (Fig. 1), this chapter will briefly deal with how this approach can help us to understand different aspects of the relationships between people and the environment, as well as the theoretical issues surrounding investigations related to risk perception in ethnobiological studies.

Risk Perception and Ethnobiological Studies

We can investigate how social and cultural factors influence the risk perceptions of people toward the environment. This is key information for two main reasons: (1) from the theoretical point of view, it allows a greater understanding of the factors that can lead to variations in the perception of risk involved in interactions between people and the environment, both between individuals of the same group and between different human groups, and (2) from a practical perspective, it is important to understand the actions of people in the face of risk (Peters and Slovic 1996), contributing to the production of strategies and political actions that minimize possible threats existing in the interactions between people and the environment (Oltedal et al. 2004) (Fig. 1).

Practices and beliefs related to health care, for example, reveal key points regarding how people perceive environmental threats to which they are susceptible. However, perceptions about what a healthy condition is and is not depend on the values set by a culture. For example, there is not always a correspondence between diseases identified by biomedicine and health problems recognized by different cultural groups. In this case, several investigations have shown that various human groups have their own concepts built on health and disease, assigning different causes to health problems (Hodes 1997; Levin and Browner 2005). For instance, the causes of local diseases in 50 families of villages in Maharashtra, India, are based on the seasonal variation of the environment, on deviations between behavior and social norms, and also on the imbalance of the five elements (earth, water, fire, sky, and wind), on taboo breaks, and the punishment of evil spirits (Mukherjee 2003). Two indigenous villages in India have also presented diseases linked to evil spirits and deities of various kinds, which are the causes of diseases (Jain and Agrawal 2005). The research of Joshi (2000) found a set of beliefs and magical-religious causes attributed to different diseases in the Jaunsari tribe in the Himalayas. Other studies show interesting examples of different concepts of health and disease in human groups (see Herndon et al. 2009; Reyes-García 2010). This means that risk perceptions involving health problems demonstrate great intercultural variation (see Douglas 1966).

Within the same human group, socioeconomic factors may affect risk perceptions in relation to health. For example, the study of Buster et al. (2012) found that the perception of the risk of contracting skin cancer may be higher among younger people, women, among those with higher education levels, and among those with lower income from the same cultural group. Regarding gender, women in rural communities in Tanzania perceived the risk of certain diseases differently than men. Men, for example, indicated diseases linked to livestock to be those with the greatest increased risk for their quality of life (Quinn et al. 2003). These results may reflect the different social roles played by men and women in these communities. In some human groups, women take care of home and children and hold a greater knowledge of medicinal plants, being responsible for the treatment of diseases in the family. Men, meanwhile, often carry out their activities in the field, through agriculture and livestock management. In this case, it is expected for men to demonstrate a greater risk perception for diseases linked to livestock.

Previous findings have shown that the understanding of risk perception involving diseases encompasses different factors. If this risk perception is an important modulating force to determine which practices individuals and groups will adopt in a given situation, it is very likely that what is recorded today in medical practices of different cultures (such as the use of medicinal plants and animals of the environment) results from a much more complex phenomenon than imagined, which also has consequences for public policies. For example, public health projects become a problem when they are held without considering the perceptions of risk regarding diseases that affect people, as these perceptions may vary, and consequently these variations reflect the search for preventive measures of health care (see Buster et al. 2012). Without dialogue between the parties concerned, it is difficult to identify the sources of risk that may be the target of public policies to improve the quality of life of a population.

Access to risk perceptions may also be important for the conservation of natural resources, as the predispositions that people have to change in some situations are accessed from the moment they start to see the problem and their willingness to solve it emerges (Sudimeier-Rieux et al. 2012).

One must keep in mind that perceptions of risk may also vary intraculturally. As an example, a wide variation was found between the risk perceptions of flooding of two distinct ethnic groups living on the shores of the same lake in Benin, Africa (Teka and Vogt 2010). In this region, the group that fishes as its main economic activity perceived floods in a positive way because, according to the people in this group, such an environmental phenomenon increased the abundance of fish stocks. The other group, which performed intensive agricultural activity, regarded the floods as a major threat. Thus, perceptions of risk may be higher if the consequences of a particular event affect the availability of important resources for a given group, demonstrating the importance of utilitarian aspects in perception.

Finally, approaches aimed at accessing risk perception are valuable for the development of projects that will cause environmental changes (Meng et al. 2013). Usually, these projects are based on technical reports that do not take into account local perceptions (Meng et al. 2013), disregarding the fact that the populations living near these areas can provide more detailed information about the possible social and environmental risks posed by these enterprises. In this case, the formulation of projects that use local demands and perceptions of risk involving the consequences of their implementation can increase the chances of these endeavors being successful (Lykke 2000; Xu et al. 2006).

Chart 1: Case Studies

Rural Nevada and Climate Change: Vulnerability, Beliefs, and Risk Perception

One way to verify the perception of risk is to access how people perceive and adapt to changes. The study of Safi et al. (2012) sought to assess how ranchers and farmers exposed to different levels of vulnerability (measured by availability and local distribution of water, which is directly affected by climate change) perceive risks related to climate change. The study adopts the prediction that the higher the vulnerability, the higher the risk perception. Respondents were encouraged to classify risks on a scale of one to five according to their amplitude, from risks that would affect only the individuals themselves, to the perception of risks that could affect the family, the community as a whole, other nations, plants and animals, and future generations. The main results of the study showed that ranchers and farmers perceive climate change as presenting a low risk to them but realizing that the risks of climate change are high for plants and animals in the future. In addition, the degree of vulnerability in which people are exposed to water shortages did not affect risk perception of climate change.

Attitudes and Risk Perceptions of Stakeholders in a Nuclear Waste Siting Issue

Nuclear plants generate risks to the environment and consequently for people living close to such facilities. People possibly affected by the implementation of a nuclear waste factory were subjected to a study (Sjöberg 2003). Risk perceptions regarding the implementation of nuclear installations were thus accessed through extensive research with people who supported the project and with those who opposed it, totaling 2,548 respondents. The results showed that respondents in favor tended to see its risks as high. However, people who supported the implementation project had extremely opposing perceptions, considering the facility to be of low risk and high benefit. These people were also much more likely to firmly embrace extreme statements about the project they supported and were interested in. The results of this study illustrate that there is a real risk that people in favor of nuclear installations do not represent the public's views well because they are too extreme in the exposition of their ideas and therefore influential in the process of political decision-making.

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How and Why Should People Classify Natural Resources?

Andrêsa Suana Argemiro Alves, Lucilene Lima dos Santos, Washington Soares Ferreira Júnior, and Ulysses Paulino Albuquerque

Abstract Folk classification systems consist of a set of concepts that individuals in a society apply to living beings around them. Much has been investigated regarding what motivates people to classify biota. One of the ideas that seeks to explain these relationships, proposed by Brent Berlin, states that systematization obeys universal cognitive principles that have similarities to scientific classification systems. This chapter provides a brief introduction to the principles of classification proposed by Berlin and their contribution to the understanding of folk classification.

Many scientists are motivated to understand how people classify natural resources, whether they be species or landscapes. This can be observed in several studies (see Peroni et al. 2007; Oba and Kaitira 2006; Roba and Oba 2009). Interest in resource classification processes has guided research lines around the world, and we undoubtedly consider these investigations throughout the history of ethnobiology to be fundamental approaches during certain periods. Scientists willing to investigate these approaches focused their efforts on so-called folk taxonomies or traditional biological classification systems (see Atran and Medin 2008). These systems represent a set of concepts from members of a society regarding living beings. They represent the contact of people with the environment that they live in and directly reflect the level of knowledge that people have of such an environment (Bousquets 1990).

Scientists do not fully agree on the motivations underlying the classification of nature by the human species. Thus, it can be said that the explanatory scenarios are dominated by two schools of thought regarding folk classification systems: the utilitarian and the intellectualist or cognitive. Considering the former, traditional

A.S.A. Alves, M.Sc. (✉) • W.S.F. Júnior, Ph.D. • U.P. Albuquerque, Ph.D.
Laboratory of Applied and Theoretical Ethnobiology, Department of Biology,
Federal Rural University of Pernambuco, Rua Dom Manoel de Medeiros, s/n, Dois Irmãos,
52.171-900 Recife, Pernambuco, Brazil
e-mail: andresa_flora@hotmail.com; kba.bio@hotmail.com; upa677@hotmail.com

L.L. dos Santos, Ph.D.
Federal Institute of Pernambuco, Rua Sebastião Rodrigues da Costa,
55.155-730 Belo Jardim, Pernambuco, Brazil
e-mail: lucilenelima@gmail.com

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classification systems are strongly influenced by the utilitarian character of the various components of the natural world (see Hunn 1992); that is, the resources that are valuable to people are targets of classification. A great advocate of this school of thought is the anthropologist Eugene Hunn, a professor at the University of Washington. In counterpoint to this school of thought is the intellectualist or cognitive theory. It suggests that biological classification systems are governed by intellectual principles through which people classify organisms to satisfy an innate human need to organize the world around them or merely for curiosity reasons. This idea has Brent Berlin as its main advocate. Berlin believes that there are similarities in folk and scientific classification systems. To him, the sense of order developed by humans obeys cognitive principles reflected in hierarchical patterns relating to pre-scientific classifications or framed in scientific classification systems.

Folk Taxonomy Principles According to Brent Berlin

Brent Berlin proposed the principles that govern folk biological classification (Berlin et al. 1973; Berlin 1992). These principles, according to the author, share a classification standard that can be summarized in nine universal principles (Chart 1). These principles, in general, state that humans, regardless of where they are and to which cultural group they belong, classify living beings hierarchically, similar to scientific taxonomy. In this case, classification systems are structured in inclusion levels, in which living things are grouped into categories (taxonomic units) that are hierarchically subordinated to each other. The criteria for naming consist of the use of contextual meanings based on continuities and discontinuities of natural elements (Rosaldo 1972). That is, the classification of organisms is based on behavior and in particular on the characteristics of living things that allow people to recognize, considering differences and similarities, various organisms or other elements of the natural world.

According to Berlin's principles, names given to units in each category are unique, i.e., a unique name is assigned to each category (monomial levels), or categories are named with a first base word followed by a second word that will differentiate individuals included in the immediately previous category (binomial levels). To demonstrate the logic of this ordering, consider a plant popularly known in Brazil as "passion fruit," which will be included in a monomial category. To differentiate the various types of "passion fruits," it is necessary to use a new word that will be included in a new category subordinate to the former, e.g., "yellow passion fruit," "woods passion fruit," and "açu passion fruit." In this example, the proximity assigned by Berlin between folk and scientific classification systems is clear, where a generic *taxon*[1] is added to a specific epithet to distinguish an organism from others that are related to it.

[1] According to the International Code of Botanical Nomenclature, any taxonomic unit of any hierarchy (kingdom, class, order, genus, species, etc.) is understood as *taxon* (sing.) or *taxa* (pl.).

Chart 1: Principles of Folk Classification According to Brent Berlin (Adapted from Berlin et al. (1973) and Berlin (1992))

1. In all societies, natural world organisms can be linguistically distinguished from one another by ordering mechanisms, that is, different degrees of inclusion.
2. *Taxa* involved in folk classification criteria are included in categories defined from linguistic factors, not exceeding more than five categories. Thus, when considering a systematic ordering, folk classification systems are similar to scientific classification systems. Ethnobiological classification categories are unique beginner, life-form, generic, specific, and varietal. In addition to the abovementioned categories, in some cases, the existence of a sixth category, called intermediate, is possible.
3. The categories of folk classification systems follow a hierarchical order in which *taxa* included in each of them are mutually exclusive, with the exception of the unique beginner, which consists of a single member, for example, a plant.
4. In all languages, classification systems follow degrees of inclusion. However, some of the ordinated elements may not be present, thus allocating the category from a lower level to an immediate superior level.
5. *Taxa* belonging to the unique beginner category are not linguistically categorized by a single habitual expression. This category includes names such as plant and animal and is considered the most inclusive taxon and therefore is rarely named.
6. The life-form category includes few *taxa*, whose naming consists of linguistic expressions derived from primary lexemes; the *taxa* consist of a single word, e.g., tree, grass, fish, and insect.
7. The generic category is usually included in the life-form category. The number of generic members is higher than that found in other categories. Such importance is due to morphological characteristics and/or economic importance. The generic is still considered the basic category for folk classification systems, as it presents a greater psychological salience and is among the first *taxa* learned by children.
8. Taxa belonging to the specific and varietal categories are less numerous than generic *taxa*, which appear in small groups. Specific *taxa* can be differentiated from *taxa* related to variety by a few characteristics, which are, in general, voiced.
9. Intermediate *taxa* appear as members of the intermediate category and are usually included in the generic level, being rare in folk taxonomy and also rarely named, leading Berlin et al. (1968) to refer to such members as “hidden categories.”

From Berlin's work, several studies have emerged to investigate whether there is in fact a cognitive pattern that follows Berlin's principles in terms of the way in which people identify, classify, and name the biota. Most of the research has been conducted to understand how we name living things, although there are some works that deal with local landscape classification, such as Oba and Kaitira (2006), Roba and Oba (2009), and Krohmer (2010). Based on this, it has been observed that humans possess identification and classification patterns that match what was proposed by Brent Berlin. For example, for Itzaj Mayans living in the village of San José, Guatemala, the generic name squirrel (*ku'uk*) has as a specific the red squirrel (*chäk ku'uk*) and as subspecifics the female red squirrel (*chäk ku'uk uch'upal*) and the male red squirrel (*chäk ku'uk uxib'al*) (Coley et al. 1997). In this naming structure, squirrels belong to a group identified by a generic category and are distinguished from each other by epithets, suggesting that people seek to hierarchically classify organisms. This form of classification is close to the scientific taxonomy, i.e., living things are grouped in hierarchically organized categories based on perceived characteristics.

The classification of living beings with consideration to their biological characteristics, such as morphology and life-form, has been observed in some research. Examples can be found in several studies developed in Brazil, given that this region was strongly influenced by Berlinean ideas, as seen in the works of Mourão and Montenegro (2006) and Souza and Begossi (2007). Additionally, in the semiarid northeastern region in Brazil, hunters define a mammal as "any animal that has a habit of feeding their young with milk" (Mourão et al. 2006:4). This is a classification criterion purely based on organic descriptors, wherein the group's life-form is recognized by people observing animals that suck or have mammary glands.

Another focus to which researchers have been drawn aims to verify the role of the generic category as a base or a core of folk classification. According to Brent Berlin et al. (1973), generic categories are the most important in folk classifications because they group organisms according to features that are easily visible (morphology, habits), requiring very detailed observations to be perceived. In this case, it would be expected that the initial category for classification would be the generic. For example, when asking people to classify a group of organisms, they would first indicate the generic name of each organism ("lion," "anteater," etc.), and, from that, they would organize higher levels of generic categories (life-forms and kingdom) and lower levels of categories (specific and varietal). Moreover, people make a large number of generalizations or inductive inferences in generic categories when considering the characteristics of living things (Coley et al. 1997). For example, when observing the characteristics of a determined number of fish, humans can make generalizations such as "all fish have scales" even without observing all the fish in the region. This is because generic categories group organisms that share visible characteristics, which facilitates inductive inferences.

This information reinforces the idea that the generic category is basal for folk classifications, given that inductive inferences that constitute the basis for the development of classification systems are made from it (Coley et al. 1997). Furthermore, the information presented highlights naming standards related to a hierarchical classification and to criteria based on morphological characteristics for the classification of living things. However, a more careful analysis does leave aside the idea that perhaps these findings are merely artifacts of the collection procedure or the interpretation of data, which forces an adaptation of the findings to the principles formulated by Berlin. Much criticism has been directed to the universality of Berlin's principles, such as suggesting that this system facilitates a close relationship between folk and scientific classifications, as well as structural similarities with distinct culture systems (see Boster 2005). Thus, such criticism has led several researchers to develop alternative visions to understand folk classifications.

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Alternative Views of *Folk* Classification

Washington Soares Ferreira Júnior, Paulo Henrique Santos Gonçalves, Reinaldo Farias Paiva de Lucena, and Ulysses Paulino Albuquerque

Abstract Brent Berlin suggested general and universal principles of classification and nomenclature for living beings, which have been undertaken by different researchers. However, some scientists have put forth a set of evidence that does not corroborate some of the Berlin principles. They suggest that classifications exhibit characteristics that can vary in different cultures, without following universal principles. Thus, criticism of the universal principles of *folk* taxonomy has emerged, showing that different cultures and societies use different cognitive schemes to classify living beings, without adherence to the plan devised by Berlin. Researchers are proposing competing ideas to the universal principles to better understand how different human groups classify living beings. Thus, the major criticisms of Berlin's *folk* classification model will be presented in this chapter, as well as discussion of an alternative proposal to understand folk classification and current advances in studies on this topic.

W.S. Ferreira Júnior, Ph.D. (✉) • U.P. Albuquerque, Ph.D.
Laboratory of Applied and Theoretical Ethnobiology, Department of Biology,
Federal Rural University of Pernambuco, Rua Dom Manoel de Medeiros s/n, Dois Irmãos,
52.171-900 Recife, Pernambuco, Brazil
e-mail: kba.bio@hotmail.com; upa677@hotmail.com

P.H.S. Gonçalves
Laboratory of Applied and Theoretical Ethnobiology, Department of Biology,
Federal Rural University of Pernambuco, Rua Dom Manoel de Medeiros s/n, Dois Irmãos,
52.171-900 Recife, Pernambuco, Brazil

Faculdade São Vicente de Pão de Açúcar, Rua Padre Soares Pinto,
Pão de Açúcar, Alagoas 57400-000, Brazil
e-mail: paulohenrsg18@gmail.com

R.F.P. de Lucena, Ph.D.
Laboratory of Ethnoecology, Department of Phytotechny and Environmental Sciences,
Center of Agricultural Sciences, Federal University of Paraíba, Bairro Universitário,
Areia, Paraíba 58397-000, Brazil
e-mail: reinaldo@cca.ufpb.br

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Ethnobiological investigations of folk classification systems have primarily been carried out from the intellectualist point of view, i.e., with consideration of the fact that these systems reflect an intellectual or cognitive process of understanding the world, motivated by an innate interest in classifying environmental items (Hunn 1982). Criticism has been levied against the intellectualist approach, which has led to relativization of the idea that folk classification follows universal principles, such as those proposed by Brent Berlin (Berlin 1992).

While the intellectualist approach has been profitable, as it facilitated perceptual, cognitive, and linguistic processes underlying the understanding of natural categorization systems, the observation that classification of the natural world can also have a utility aspect has also been suggested (utilitarian approach). For example, there are evidences that folk classification systems can be motivated by organisms of cultural significance (Hunn 1982; López et al. 1997). In this sense, this chapter presents some of the main criticisms directed at the Berlin universal principles within the intellectualist approach. Furthermore, an alternative proposal to folk classification understanding is discussed, and some current developments involving connections between traditional and scientific knowledge are highlighted.

Main Criticisms of Brent Berlin's *Folk* Classification Model

First Criticism: There Are Not Always Similarities Between Folk and Scientific Taxonomies

Scientists have observed that there is often a strong analogy between folk classification and scientific classification. This proximity between the two systems can occur due to the use of similar classification criteria, as a base classification criterion for both systems is the biological characteristics of living beings (morphology and behavior, among others). However, some studies generated findings that go against this idea. A study investigating local perceptions in the Puget Sound, Washington, noted that people grouped certain marine species without any analogy to scientific taxonomy. For example, two species of fish belonging to different orders, according to scientific taxonomy, were grouped in the same category (Beaudreau et al. 2011). There are also cases where resources identified in folk taxonomy as distinct may belong to the same scientific species (Kakudidi 2004; Jinxiu et al. 2004). In villages of Yunnan Province, China, a given plant species was identified by residents as two different types (Jinxiu et al. 2004). Thus, people also classify living beings based on different criteria from those found in the scientific taxonomy.

According to Berlin's model, one of the features that *folk* and scientific classifications share is the grouping of living beings into hierarchical categories (Atran 1998). In each categorization level (kingdom, life-form, generic, and specific), there is the grouping of organisms that share a number of characteristics, mainly biological. African-American groups living on the Pacific Coast of Chocó, Colombia, recognize certain plants that are named by the local term "cargadero," of which there are the following types: the "cargadero pita" (*Guatteria amplifolia* Triana and Planch.) and the "cargadero negro" (*Guatteria chrysopetala* (Steud.) Miq.) (see Galeano 2000). Therefore, hierarchically, "cargadero" may represent a higher level, and "cargadero pita" and "cargadero negro" may represent a lower level in the local classification hierarchical structure. However, this structure cannot be always verified. The classification by artisanal fishers from Mamanguape River, Paraíba, demonstrates several generic nomenclatures in fish families, such as the catfish family and sardine family, in which fishermen group fish according to their cultural and economic importance (Mourão and Nordi 2002). The authors suggest that there is no catfish family hierarchical subcategorization that groups them based on common biological attributes, as this family is based on cultural and economic criteria. Thus, if these generics are not formed by living beings that share certain biological attributes, it is possible to say that *folk* classification does not resemble scientific classification.

Second Criticism: The Biological Attributes of Living Beings Are Not Always Criteria for the Basis of Local Folk Classification

Differences between folk and scientific classification systems observed by some authors lead to the deeper investigation of what other criteria humans take into account to classify natural resources. From a utilitarian point of view, Hunn (1982) refers to residual categories, which refer to groups comprising a series of organisms that are unimportant for a human group. For example, North American Sahaptin call several herbaceous plant species that are not important from a utilitarian point of view "just a grass" or "just a flower." However, useful grasses and flowers have several names and are not considered within these broader categories (Hunn 1982).

Another interesting example is observed with the Itzaj Mayans, who distinguish two types of mahogany, red and white mahogany. When observing both types, there are no differences in color, as red mahogany is as red as white mahogany. The mahogany distinction occurs based on the benefit that they provide for the population because red mahogany produces deeper grains that are preferred over those of white mahogany. For Mayans, red is usually associated with winds that bring rain and kindness and white with winds that bring disappointment (Atran 1998). This explains the distinction between the two mahoganies and, moreover, shows that classification is not always associated with apparent characteristics of living beings (once it was possible to expect that plant color would be an important criterion to differentiate mahogany) and that the cultural context can be very important for classification (Atran 1998). Because of this situation, it was noticed that people follow their own classificatory logic. In this case, it goes against the logic provided by Berlin.

Third Criticism: Folk Classifications May Vary Between and Within the Same Human Group

There is a body of evidence that reinforces the notion that sociocultural characteristics can play important roles in *folk* classifications. Local classification of mammals by a group consisting of Americans living in industrialized regions and another classification generated by people from the traditional Itzaj-Maya region have allowed us to observe that, although there are similarities between the two classifications, there are distinctions between the two groups, such as higher organism differentiation in Itzaj-Maya taxonomy (López et al. 1997). This suggests that classifications vary between different human groups.

Folk taxonomy variations may also be observed within a human group. *Folk* taxonomies are related to local perceptions of biological resources in the environment (Atran 1998). In this sense, organism classification may differ, as there are people who perceive differences between resources, which may be associated with different factors (Boster 1986; López et al. 1997). Cassava (*Manihot esculenta*) identification and classification by the Aguaruna Jivaro tribe in Peru differ depending on gender (Boster 1986). Women are responsible for taking care of cassava plantations in this group, i.e., to plant, collect, and select new cassava varieties. Men, in turn, open new cassava planting areas but do not plant or maintain plantations. Women provided greater detail for the identification and classification of varieties, in addition to indicating a higher number of cassava varieties than men, making them subject matter experts (Boster 1986). Sociocultural factors may play important roles in folk classification variations within the same group.

Alternative Proposal to Folk Classification

Different authors have proposed approximations between universalist and utilitarian approaches in the same classification model (see Clément 1995; Atran 1998). The use of approximations notes the need to identify which *folk* classification aspects occur in all human groups, i.e., which are intrinsic to human categorizations (universal characteristics) and which aspects are inherent and important to a given culture, in the sense that cultural characteristics influence classification (utilitarian approach) (López et al. 1997).

One proposal was presented by Scott Atran, which indicated that generics (based on Berlin's classification) express folk classification universality, as all cultures group animal and plant categories into generics as an automatic and innate human process. When people observe an unknown organism with which they had no previous experience, they will associate it with the generic that this organism resembles, as part of an analogy association process (Atran 1998). However, what differentiates a generic into specifics and varieties depends on its cultural importance. Culture can play an important role in generic differentiation *folk* classification. Previously discussed examples of cassava identification and classification by Aguaruna (Boster 1986) and the differentiation between white and red mahogany by Itzaj (Atran 1998) show that if species do not play an important role in the routine of people in a region, there is no need for subdifferentiation, restricting the species to generic classification; this is because possible subdifferentiation criteria, such as morphological and utilitarian distinction criteria, among others, are not apparent to people.

Genomic Ethnobotany: The Interface Between Traditional Knowledge and Scientific Knowledge

A more recent approach in folk classification studies refers to what Newmaster and Ragupathy (2010) name genomic ethnobotany, which consists of comparing traditional knowledge and scientific knowledge (morphological and molecular systematics) to better understand biological diversity. Investigations that use this approach seek, among other objectives, to access the role of folk classification in cryptic species recognition (species that are difficult to distinguish by morphological characteristics but are accessed through DNA assessment). Some studies show that people can recognize generic variations in species with great cultural importance that are difficult to distinguish by morphological systematics. Such variations are supported by molecular systematics (Newmaster and Ragupathy 2009, 2010). For example, Newmaster and Ragupathy's (2010) research showed that two human groups in India recognized plant species through their classification that were only identified by means of DNA analysis and not only by assessing plant morphology (morphological systematics).

Another study conducted in India expressed the high degree of folk classification refinement in terms of rating species of high cultural importance when compared with morphological and molecular systematics. Maloles et al. (2011) investigated the folk classification of Malayali farmers in India as well as molecular and morphological systematics to identify possible variations in *minor millets* (grasses characterized by short and slender stems and small grains that have the remarkable ability to survive severe droughts). While molecular systematics results indicated five distinct taxa without intraspecific variation, morphological systematics indicated 16 taxa, including intraspecific variations. Malayali farmers, in turn, recognized 19 "ethnotaxa" (mostly corresponding to morphological systematics), including intraspecific variations that morphological systematics has not recognized. According to the authors, this more detailed Malayali farmer classification took into consideration morphological, ecological, sensory, and utilitarian characteristics. Possibly, such detailed intraspecific variations were not recognized by molecular systematics because variations perceived by people were not associated with differences in molecular markers. These findings show that there are still gaps that must be filled to understand the various criteria that people rely on to classify environmental resources, which is an important point for investigation in future research.

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Part III
Biota Use

Fungi

Washington Soares Ferreira Júnior, Paulo Henrique Santos Gonçalves, and Ulysses Paulino Albuquerque

Abstract Fungi have played a very important role throughout the history of mankind and have been used in different ways, such as for nutrition, medicine, and religion. Several human groups have used fungi to develop the fermentation process and improve production techniques for foods, condiments, and fermented beverages, such as beers and wines. A discussion of the degree of affinity that different human groups have for fungi will be presented, as well as several ways in which humans have appropriated these organisms.

When considering the importance of fungi to several human cultures, both mycophilic and mycophobic groups can be recognized (Mapes et al. 2002). *Mycophilic* societies or groups recognize and employ different fungi species for multiple uses. In turn, *mycophobic* societies or groups recognize and identify fungi but do not use them due to fear, usually associating them with danger (Lincoff 2010). For these societies, fungi are seen as negative information catalysts that cause nausea and anxiety (Mapes et al. 2002).

There are human groups in Continental Europe that are recognized as mycophilic, and there are many mycophobic groups in English-speaking and Asian countries (Lincoff 2010). The distribution of mycophilic and mycophobic societies may be related to historical human migration events. In the United States, for example, where most of the population is mycophobic, European immigrant communities are

W.S. Ferreira Júnior, Ph.D. (✉) • U.P. Albuquerque, Ph.D.
Laboratory of Applied and Theoretical Ethnobiology, Department of Biology,
Federal Rural University of Pernambuco, Rua Dom Manoel de Medeiros s/n, Dois Irmãos,
52.171-900 Recife, Pernambuco, Brazil
e-mail: kba.bio@hotmail.com; upa677@hotmail.com

P.H.S. Gonçalves
Laboratory of Applied and Theoretical Ethnobiology, Department of Biology,
Federal Rural University of Pernambuco, Rua Dom Manoel de Medeiros s/n, Dois Irmãos,
52.171-900 Recife, Pernambuco, Brazil

Faculdade São Vicente de Pão de Açúcar, Rua Padre Soares Pinto, Pão de Açúcar,
Alagoas 57400-000, Brazil
e-mail: paulohenrsg18@gmail.com

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considered mycophilic. In countries that are home to British colonies, such as India, there is a tendency to maintain the mycophobic standard (Lincoff 2010). This reflects how culture can modulate the relationship of the human species with fungi.

However, it is not always easy to identify groups that are mycophilic or mycophobic (see Yanim-Pasternak 2011). Some researchers suggest that mycophilia and mycophobia are complex phenomena that can be influenced by several factors (Mapes et al. 2002; Peintner et al. 2013; Ruan-Soto et al. 2013). A survey conducted in Chiapas, Mexico, for example, showed that people's attitudes toward fungi may be located within a mycophilia-mycophobia gradient, suggesting that it is very difficult to classify a human group as entirely mycophilic or mycophobic (Ruan-Soto et al. 2013). Researchers observed that people have intermediate mycophilia-mycophobia gradient degrees, with few people having extreme mycophilic or mycophobic degree attitudes (Ruan-Soto et al. 2013). This means that mycophilic and mycophobic attitudes should not be necessarily thought of as mutually exclusive categories. It was also noted that sociocultural factors (ethnicity, occupation, and gender) interfere with people's degree of mycophilia (Ruan-Soto et al. 2013). However, other researchers have suggested that environmental factors (such as an environmental variation gradient) can also influence mycophilic and mycophobic attitudes (Mapes et al. 2002).

Fungi and Their Uses

Traditional Fermented Foods and Beverages

Certainly, one of the most important uses of fungi among human populations is in the production of food and fermented drinks, although bacteria are also part of the microbiota in these processes. According to the FAO (2011), small-scale traditional fermentation technologies contribute to the promotion of food security for millions of people worldwide, especially in Africa, Asia, and Latin America. Moreover, it has been observed that people recognize fermented foods and beverages as crucial elements of their cultures, as they are unique expressions of local cuisine (Sõukand et al. 2015).

Despite the development of industrial fermentation technologies, rural and indigenous populations from different regions of the world also ingest traditional fermented foods, such as staple foods. The most common of these are breads and other types of pasta prepared from cereals such as wheat, corn, rye, and barley (Almeida and Pais 1996; Nout 2009). Typically, these food production fermentation processes are accomplished by substrates that are naturally present in the microbiota or with food that already contains the inoculated fermentative microbiota, which usually consists of lactobacilli and yeasts (Almeida and Pais 1996; Nout 2009). In some cases, fermented foods are used as a meat substitute, as is the case with "tempeh," a pasta composed of soybean seeds fermented by *Rhizopus* genus fungi, which is widely consumed in Indonesia (Nout and Kiers 2005).

Another traditional fermentation technique with widespread use is condiment preparation, such as vinegar and sauces, aiming at improving food organoleptic characteristics (FAO 2011). Traditional vinegar production can utilize different substrates, such as wine, molasses, honey, whey, potato, sugar beet, and cereals (Johnston and Gaas 2006). The traditional vinegar production process may involve a long fermentation period; for example, Shanxi aged vinegar production (vinegar prepared from cereals and widely used in North China) consists of approximately 30 days of cereal fermentation in two steps: (a) saccharification and an alcoholic fermentation period of up to 18 days (performed by filamentous fungi and yeasts that are naturally present in the substrates) and (b) nine days of acetic fermentation (performed by acetobacteria derived from a previously prepared product) (Wu et al. 2012).

Regarding traditional fermented beverages, the most popular are beers and wines, which differ in terms of preparation method. Beer preparation consists of malting (soaking, germinating, and sun drying), followed by brewing (grinding, cooking, and filtration) and fermentation, while wine preparation usually consists of fruit juice fermentation (FAO 2011). These drinks play important cultural roles in many local populations, as they are used in festivities, weddings, religious rituals, and funerals (Saikia et al. 2007). Some of these beverages also have significant nutritional value, as the fermentation process may result in vitamin production and increased nutrient bioavailability, such as iron and phosphorus (Chaves-Lopez et al. 2014). In addition, the moderate consumption of traditional beverages can have other effects, such as a relaxation after performing jobs that require a great deal of effort (Bhuyan and Baishya 2013).

As a result of fermentation technologies, some studies provide evidence that the diversity of certain *Saccharomyces cerevisiae* strains has been heavily influenced by human action through the domestication of plants used for the preparation of fermented foods and beverages (Fay and Benavides 2005; Legras et al. 2007). For example, in a phylogenetic study of *S. cerevisiae* strains, Legras et al. (2007) observed that the earliest grape wine-producing strains were likely from regions close to ancient Mesopotamia (where this practice potentially arose) and that genetic differences between European strains are correlated with historical human migration events involving wine-producing grapes.

Macroscopic Fungi Use

Fungi are extensively used for their medicinal and magical-religious properties. Many cultures use fungi with hallucinogenic properties. The ingestion of hallucinogenic mushrooms leads to changes in individual perception, such as changes in vision and hearing, which are interpreted by many cultures as contact with the spirit world (Schultes and Hofmann 1993). By observing this phenomenon in different cultures, Robert Wasson coined the term **entheogen** to designate resources or substances that allow the connection of people with god (Wasson et al. 1992). In entheogenic cultures, fungi act as mediators between the spiritual world and the human world.

From the pharmacological point of view, the hallucinogenic effects of fungi can be attributed to chemical substances with psychoactive properties that act on the central nervous system. Some of these substances have been isolated in laboratory, such as psilocin and psilocybin, which are responsible for the psychoactive activity of the *Psilocybe* genus (Gartz et al. 1994). Muscimol and ibotenic acid compounds have been isolated from *Amanita muscaria* (L.) Lam. fungus, which causes hallucinogenic effects in people who ingest the mushroom (Satora et al. 2005).

In traditional medicine, fungi are employed for the treatment of several diseases in human groups that are considered mycophilic (Akpaja et al. 2005). *Cordyceps* genus, for example, has been used throughout traditional Chinese medicine history in the treatment of respiratory, kidney, heart, and liver diseases, in addition to immune disorders (Holliday and Cleaver 2008; Khan et al. 2010). Fungi have an important history as antibiotics since the discovery of penicillin in 1927. In addition, they possess mutagenic compounds and substances identified to exert antitumor activity in the laboratory (Wainwright 2008; Aly et al. 2011).

The use of fungi as food is also significant. Historically, fungi have been used as edibles in China, Italy, Mexico, Turkey, and Central and South Africa (Boa 2004). Approximately 1000 species have already been reported to be edible and are consumed and marketed in countries on every continent of the planet (Boa 2004). Mushrooms are primarily used for food by the Bini language people in a rural community in Southern Nigeria; for example, approximately 90 % of people in this community consume fungi as food, while 21.6 % use it for medicinal purposes (Akpaja et al. 2005). Most of these people consume fungi as food based on the following criteria: taste, use as a meat substitute, and nutritional qualities. From a nutritional standpoint, fungi are important for health due to the presence of protein in their composition and being rich in vitamins, minerals (Lincoff 2010), and energy supplies (see Table 1).

Table 1 Chemical composition and energy value of certain fungi species that are used as important sources of food in different regions of the world

Species	Total fat	Crude protein	Carbohydrates	Total sugars	Energy
Agaricus arvensis Schaeff.	0.14 ± 0.00	2.87 ± 0.19	1.91 ± 0.24	0.35 ± 0.01	20.38 ± 1.71
Auricularia auricula (Bull.) Quél.	–	8.9	–	–	2.88
Boletus aureus Schaeff.	4.47 ± 0.02	27.17 ± 0.15	62.10 ± 0.10	–	–
Hericium erinaceus (Bull.) Pers.	1.75 ± 0.27	15.40 ± 0.38	79.36 ± 0.33	23.63 ± 0.94	394.79 ± 0.95
Lactarius deliciosus (L.) Gray	0.22 ± 0.00	2.96 ± 0.04	6.26 ± 0.15	1.63 ± 0.01	38.86 ± 0.75
Lentinus edodes (Berk.) Pegler	1.01 ± 0.10	12.76 ± 0.24	81.94 ± 0.40	38.31 ± 1.01	387.89 ± 0.26
Leucopaxillus giganteus (Sowerby) Singer	0.41 ± 0.02	3.40 ± 0.01	3.11 ± 0.21	0.64 ± 0.00	29.73 ± 1.05
Sarcodon imbricatus (L.) P. Karst.	0.09 ± 0.01	2.35 ± 0.02	3.38 ± 0.03	1.89 ± 0.01	23.73 ± 0.28
Tricholoma portentosum (Fr.) Quél.	0.38 ± 0.02	2.12 ± 0.08	3.64 ± 0.16	1.53 ± 0.03	26.46 ± 1.14
Xerocomus badius Quél.	4.22 ± 0.03	8.08 ± 0.14	80.38 ± 0.15	11.77 ± 0.03	391.83 ± 0.04

Energy component values are represented by the kcal/100 g unit. Remaining component values are represented by the g/100 g unit

Table information is based on Aletor (1995), Boas (2004), Barros et al. (2007), Ouzouni et al. (2009), Carneiro et al. (2013), and Heleno et al. (2015a,b)

Given their medicinal, food, and magical-religious importance in the histories of different societies, in addition to their importance in biomedicine development, fungi are important components in ethnobiological studies that try to understand the relationships between people and these uses, both in the past and in the present.

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Food Plants

Viviany Teixeira do Nascimento, Letícia Zenóbia de Oliveira Campos, and Ulysses Paulino Albuquerque

Abstract Food plants are characterized as having one or more parts that can be used in human food. In this group, there are nonconventional food plants that were for decades the main resources used by hunter-gatherer people. Although many of these species are common, their uses are currently neglected, even by human populations living in direct contact with native vegetation and developing subsistence practices. In this chapter, we elucidate the important contributions of nonconventional food plants in the diets of human populations over time. We will also highlight the factors that influence the selection of food plants that are used by different communities around the world. Finally, we discuss strategies for the dissemination and popularization of these species.

We will adopt the term "nonconventional food plants" to refer to both species considered as weeds or invasive and wild plants, generically called "bush plants," a type of genetic resource with potential food uses that often go unexplored (Kinupp and Barros 2007). These foods, which were essential in maintaining the food security of hunter-gatherer communities (Jaenicke and Hoschele-Zeledon 2006), are now virtually unexplored. This fact has been evidenced by recent studies that record an exacerbated loss of knowledge regarding nonconventional food plants, even when known are neglected (Nascimento et al. 2012; Crúz et al. 2013).

The decrease in the use and therefore in the knowledge of nonconventional food plants is the result of the influence of various factors, such as improvements to people's quality of life, ease of access to exotic plants and industrial products, and

V.T. do Nascimento (✉)
University of Bahia, State. Campus IX.Rodovia BR 242, Km 4, s/n, Loteamento Flamengo, 47800-000 Barreiras, Bahia, Brazil
e-mail: vivyteixeira@gmail.com

L.Z.O. Campos • U.P. Albuquerque
Laboratory of Applied and Theoretical Ethnobiology (LEA), Department of Biology, Federal Rural University of Pernambuco, Av. Dom Manoel de Medeiros, s/n, Dois Irmãos, 52171-900 Recife, Pernambuco, Brazil
e-mail: Leticia.zenobia@hotmail.com; upa@db.ufrpe.br

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migration to urban centers, which restricts contact with species present in the regions where people live (Ladio and Rapoport 2002; Crúz et al. 2013). Another aggravating factor is that, in many places, these plants are used in emergencies (famine foods), i.e., they are only used when there is a shortage of resources (Nascimento et al. 2012).

Nonconventional Food Plants in Human Food

The human species can obtain its food both from cultivated plants, some from a continuous process of domestication and from spontaneous plant populations. These plants are incorporated into several livelihood strategies of rural people, whether they are shepherds, farmers, or hunter-gatherers (Bell 1995). However, for the majority of the world's population, despite having at its disposal a wide range of species whose fruits, leaves, roots, flowers, stems, and seeds can be used for food diversification, in practice, very few species are consumed. When the use of these food plants, which are usually treated as nonconventional, is reported, it is usually restricted to a crop shortage; their harvest is primarily associated with women and children and is rarely mentioned as being important to complement family income (Grosskinsky and Gullick 2001; Ladio and Rapoport 2002).

Nevertheless, spontaneous food plants occupy different roles in the lives of the people who use them. They are primary characterized as complementary, seasonal, and intended for risk reduction (Bruce 1996):

- **Complementary role**: Resources that play this role help to complement diets based on agricultural productivity, providing essential nutrients and contributing to the global nutritional quality of food. The consumption of forest foods can also diversify the daily menu and consequently increase the amount of food consumed.
- **Seasonal role**: In this case, plants cover seasonal shortages of food because they can produce food even in the hardest seasons, a common situation in regions where productivity depends on the seasons. This happens, for example, with *Spondias tuberosa* L. ("umbu"), which fruits in the dry season due to the presence of water reserves in underground organs (Lins-Neto et al. 2010).
- **Risk reduction role**: Vegetation areas represent a reserve of food during the dry season or other emergency periods during which agricultural productivity is reduced to a minimum or even disappears. In this context, roots are more important than fruits because they have a greater amount of calories and are more resistant. Native species that assume this role have characteristics that are different from those exploited during other periods of time. This is because, despite having considerable energy content, they usually are difficult to prepare or are associated with other negative factors, such as difficulty in collection. Due to these characteristics, this type of food is often referred to in the literature as "starvation food," "emergency food," or "famine food." Nevertheless, these

resources have a major advantage in that they persist in the environment in situations where most plants do not survive, which is possible only due to the biological characteristics of a given species. For example, in situations where a lack of water is a limiting factor for traditional crops, the major emergency foods are xerophytes that are resistant to this factor, such as those belonging to the family Cactaceae. When the limiting factor is predation, the most resistant species are those that possess biochemical and structural defenses, such as thorns or certain chemical compounds that reduce palatability, and thus face a high probability of becoming emergency food (Minnis 2000). An example that illustrates emergency food is *Dioscorea dumetorum* (Kunth) Pax, a type of tuber consumed in Africa. Its inappropriate use can cause death within hours because its toxic active ingredient, dioscorin, paralyzes the nervous system. However, dioscorin is water soluble and can be removed by a washing process that can last up to 3 days (Irvine 1952).

Factors Affecting Use and Selection

Peoples who use nonconventional food plants employ various criteria for selecting them. However, the factors that can explain the use of these food resources are still poorly studied because they are difficult to measure. The first hypothesis that can explain the preference for one resource over another is taste. Taste can be pleasing or not pleasing and may alone lead to the approval or discrimination of a food plant (Ghirardini et al. 2007).

The availability and abundance of a species can also affect its selection and use. For example, in suburban communities in Bariloche, Argentina, the consumption of some plants is restricted to certain periods of the year due to the availability of the consumed part, for example, the fruit (Ladio and Rapoport 2002).

Another factor to be considered is the proximity of human settlements to areas of species collection. People often travel great distances in search of certain foods when the cost-benefit is satisfactory. This can be explained by the optimal foraging theory (OFT), which adopts the premise that the effort (energy expenditure) to pursue a particular resource is directly proportional to the benefit of having it. Regarding food plants, the benefit is the high calorific value of certain foods (MacArthur and Pianka 1966). The OFT can also be applied to the time it takes to prepare certain foods and their energy value.

Difficult access to green areas in which plants are available can also interfere with the consumption of these resources. In semiarid regions of Africa, for example, forest management by public institutions has often reduced the access of local populations to wild food resources (FAO 2011). Despite territorial control being in the hands of the government or private owners, restricted access to nonconventional food resources tends to exert negative effects on diet, especially for the most vulnerable human populations (FAO 2011).

The decline in the consumption of such plants can also be related to the social stigma attached to certain species because consuming them is considered a symbol of poverty. This happens, for example, with *Syagrus cearensis* Noblick, a native palm found in northeast of Brazil, whose high-calorie fruits (≅400 cal/100 g) are underutilized by local people (Nascimento et al. 2011). In this region, the habit of eating certain cultivated species (such as *Phaseolus vulgaris* L. and *Zea mays* L.), usually bought in the local market, is synonymous with modernity, convenience, and social status. Replacing the usual collection of grown nonconventional food plants with exotic plants has become even more common with government incentives that have subsidized the purchase of these foods (see Rapoport et al. 1998).

Another issue that may be related to not using a resource as food consists of local taboos. Taboos are part of everyday life and determine how different natural resources are used. These taboos, in a way, act by regulating access to and consumption of these resources by certain individuals within the same society. In Ethiopia, many food taboos are imposed by religious practices that do not allow the use of plants or wildlife, thereby reducing the variety of food available to people during times of food shortage. An example of this is what has happened to certain species belonging to the genera *Amaranthus* and *Solanium*, which had demonstrated production potential but whose consumption was discouraged at the expense of traditional crops (Guinand and Lemessa 2001).

Despite the abovementioned issues, some authors argue that the main factor that leads to the non-utilization of nonconventional food plants is ignorance. Many people are surprised when they discover that certain species that they considered "weeds" can be consumed (Rapoport et al. 1998).

Strategies for Knowledge Dissemination and Popularization

Thus, the solution to modify the panoramic decline of knowledge, above all in terms of nonconventional food plants, is not a simple measure. This solution may involve actions such as the inclusion of information regarding practices and traditional values of local people in the school curriculum, which may encourage the appreciation and use of these species (Reyes-García et al. 2010; Cruz-Garcia and Howard 2013). In this context, the inclusion of some local species in the daily diet at school can help to break taboos. Therefore, it is necessary to encourage studies on nutritional value of these species.

A species that fits this situation is *Sideroxylon obtusifolium* (Humb. ex Roem. & Schult.) T.D. Penn., popularly known as "quixaba" or "quixabeira" in the northeast of Brazil. The pulp of its fruit has approximately 28 g of carbohydrates and a caloric value higher than 200 cal in 100 g (Nascimento et al. 2011). Table 1 shows other nonconventional edible species, often neglected, that may be introduced into the daily diets.

The importance of the species presented in Table 1 for the feeding of people can be understood if we consider, for example, the daily protein requirement of a male teenager: 52 g per day (Giannini 2007). Therefore, we can infer that the daily

Table 1 Nutritional content of edible parts of nonconventional food plants typical of the Caatinga (seasonal dry forest) region in the northeast of Brazil (adapted from Nascimento et al. 2011)

Species	Analyzed part	Protein (g/100 g)	Lipid (g/100 g)	Carbohydrate (g/100 g)	TCV (kcal/100 g)
Cereus jamacaru DC	Fruit	1.8	1.98	9.76	64.06
Psidium schenckianum Kiaersk.	Fruit	1.64	1.36	26.60	125.20
Pilosocereus gounellei (F.A.C. Weber) Byles & G.D. Rowley	Fruit	2.65	3.16	15.83	102.36
Pilosocereus pachycladus F. Ritter	Fruit	2.10	2.66	8.72	67.22
Pilosocereus pachycladus F. Ritter	Central core	0.25	0.53	4.75	24.77
Sideroxylon obtusifolium (Roem. & Schult.) T.D. Penn.	Fruit	2.86	9.62	28.50	212.02
Syagrus cearensis Noblick	Fruit	8.95	69.33	17.01	393.67
Tacinga inamoena (K.Schum.) NP Taylor & Stuppy	Fruit	0.97	1.23	14.27	72.03
Ziziphus joazeiro Mart.	Fruit	2.19	1.11	19.38	96.27

TCV total caloric value

consumption of 100 g of *Syagrus cearensis* fruit, for example, is enough to supply 17.21 % of this requirement.

These actions demand the active participation of local people to improve their livelihoods, reduce their dependence on external food aid, and ensure food self-sufficiency and the sustainable management of these natural resources (Nyok 2001).

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Medicinal Plants

Thiago Antônio de Sousa Araújo, Joabe Gomes de Melo, Washington Soares Ferreira Júnior, and Ulysses Paulino Albuquerque

Abstract Most biological resources employed in traditional medical system healing processes worldwide are obtained from whole plants or their parts. In this chapter, the importance of this resource for humanity will be discussed. In addition, how investigations that employ medicinal plants as models have been important to traditional medical systems in the context of understanding and bioprospecting will be shown.

The use of medicinal plants has been maintained by human groups throughout history. In the past, naturalists described plant use by native indigenous groups of the Americas to treat diseases (Lee 2008; Ferreira Júnior et al. 2012). This use was not only restricted to the past: medicinal plants are currently used by several groups of humans and other nonhuman primates. In the case of the latter, it has been observed that chimpanzees use plants to treat parasitic infections (see Huffman 1997, 2001). In addition, several records show that humans use plants to treat domestic animal diseases (Njoroge and Bussmann 2006; Mwale and Masika 2009; Silva et al. 2014).

The theme of medicinal plants is undoubtedly one of the most studied and disseminated in ethnobiology, which can be explained by (1) the interest it generates in other knowledge areas, such as pharmacy, botany, and agronomy, among others; (2) its relationship to a vital issue, which is health; (3) its relevance for prospecting products aimed at obtaining new drugs of interest to pharmacy or medicine; (4) its well-known and widespread use type among indigenous and local communities around the world; and (5) its use as a research model in ethnobiological studies to

T.A. de Sousa Araújo, Ph.D. (✉) • W.S. Ferreira Júnior, Ph.D. • U.P. Albuquerque, Ph.D.
Laboratory of Applied and Theoretical Ethnobiology, Department of Biology,
Federal Rural University of Pernambuco, Rua Dom Manoel de Medeiros s/n,
Dois Irmãos, 52.171-900 Recife, Pernambuco, Brazil
e-mail: thiagocaruaru@hotmail.com; kba.bio@hotmail.com; upa677@hotmail.com

J.G. de Melo
Federal Institute of Alagoas, Rodovia AL 101 – KM 126, Centro,
57.955-000 Maragogi, Alagoas, Brazil
e-mail: jgm2005@ig.com.br

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understand interrelations between people and the environment. Thus, this chapter will discuss the study of medicinal plants as well as theoretical implications and practices in ethnobiology.

The Study of Medicinal Plants and Its Theoretical Implications: Investigating Traditional Medical Systems

In the study of medicinal plants, two disciplines stand out: ethnopharmacology and ethnobotany. Ethnopharmacology is an interdisciplinary science that dialogues with many fields, such as pharmacology, chemistry, biology, and social sciences (such as anthropology) (Etkin and Elisabetsky 2005; Reyes-García 2010). In this sense, ethnopharmacology follows certain lines of study. One of them is identifying and assessing the pharmacological activity of products used in traditional medical systems for disease treatment,[1] which also involves determining the frequencies of these diseases and understanding the restrictions of their use. These products can be of plant, animal, or mineral origin; this is a point of differentiation in relation to ethnobotany, which focuses on the study of people and plant species interrelations without necessarily having the aim to study medicinal use resources.

Investigations involving knowledge of the human population regarding medicinal plants and their use allow us to understand certain interesting phenomena regarding medical systems, particularly in observing that these systems are dynamic. In this case, the medicinal plant set that comprises the medical arsenal of a given culture is the result of a long cultural validation process, which is always dynamic (Stepp and Moerman 2001; Palmer 2004). Investigations have thus contributed to our understanding of the factors that modulate the selection of medicinal plants in medical systems over time. Factors such as environment resource availability and its effectiveness have been reported to be important for the selection of medicinal plants (see Phillips and Gentry 1993; Stepp and Moerman 2001).

Studies have shown that different cultures obtain plants for their medical systems in two ways: (1) selecting plants that naturally occur in vegetation adjacent to where the human group is situated and originate from a country or continent (such as native species) and (2) selecting species from other countries or continents through contact with other cultures (exotic species) (see Stepp and Moerman 2001; Van Andel et al. 2012). Some authors have made deductions based on the ratio between native and exotic medicinal plants used in a particular culture. When there is a higher proportion of exotics compared to native species, some authors credit this fact to an acculturation process (see Case et al. 2005; Quinlan and Quinlan 2007). However, there is another idea, in which a particular culture uses exotic species as a

[1] Medical systems consist of a set of knowledge, beliefs, and practices belonging to given human group that are related to the local recognition of diseases (as in disease symptom perception) and strategies used for their treatment (Kleinman 1978).

strategy to diversify its therapeutic arsenal or fill therapeutic gaps that are not addressed by plants in the region. This hypothesis has been called the *diversification hypothesis* (Albuquerque 2006; Alencar et al. 2010).

Practical Implications of Medicinal Plant Study: Bioprospecting Strategies

Around the world, different cultures exploit nature to meet their medical needs. However, a full understanding of these cultural strategies for nature appropriation has still not been achieved. For a long time, it has been said that primary forests are a precious source of new medicines. However, different peoples incorporate a significant portion of the exotic plants present in anthropogenic areas and secondary vegetation in their traditional pharmacopoeia (Stepp and Moerman 2001; Voeks 2004; Albuquerque 2006). Such areas could be highly relevant as sources of new medicine. Furthermore, different ecosystems appear to have different vocations from the pharmacological point of view (Albuquerque et al. 2012).

The search for plants that may have interesting compounds from the pharmacological point of view, which is also known as bioprospecting, may be enhanced in studies that take into account knowledge of medicinal plants by human groups. For example, the development of a medicine based on biological products can cost more than your economic return for industry. However, when ethnodirected studies, whether ethnobotanical or ethnopharmacological, are taken into consideration for the selection and choice of such materials, medicine production costs can be reduced, as some studies have demonstrated ethnodirected selection efficiency compared to other plant selection methods for some biological activities (Slish et al. 1999; Khafagi and Dewedar 2000; Oliveira et al. 2011). Costs reduction is related to the historical use of plant species by the people, who test such species, assigning them certain therapeutic indications, usage modes, and other information that may be useful for selecting and giving higher accuracy to the industry. Although an ethnodirected approach has potential for the discovery of new candidates via bioprospecting, it is still necessary to advance in terms of problems that have been observed in ethnopharmacological studies that use an ethnodirected approach (Albuquerque et al. 2014). Problems reflect limitations in ethnopharmacological data collection procedures (Albuquerque et al. 2014) and pharmacological test interpretation biases (Gertsch 2009), among others (Fig. 1).

However, advances in medicine discovery from medicinal plants can be observed. The World Health Organization, from a report published in 2011, estimates that at least 25 % of all modern medicines are derived, directly or indirectly, from medicinal plants, mainly through the application of traditional knowledge to modern technology. In the case of anticancer and antimicrobial drugs, this percentage may reach 60 % (WHO 2011).

The world market for plant-derived medicine had an estimated value of $18 billion in 2005, and between 2000 and 2006, 26 new plant-based medicines were approved

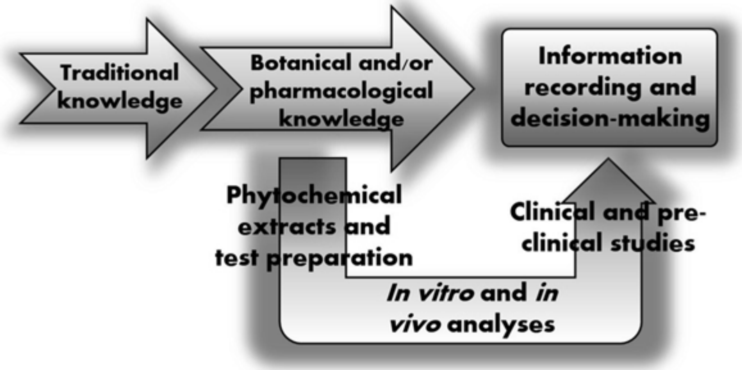

Fig. 1 Drug development chain based on traditional knowledge

and/or released, such as Taxol® and Taxotere®, which are derived from *Taxus baccata* species and are used to treat cancer (Saklani and Kutty 2008). This shows why the pharmaceutical industry is interested in this type of raw material. According to Newman and Cragg (2012), in 2010, natural products were responsible for the production of or were involved in approximately 50 % of new active small molecule substances.

A classic example of a synthetic drug derived from a natural product is Aspirin®, initially isolated from willow (*Salix alba* L.), a species that Hippocrates (460 BC) mentioned to relieve pain and reduce fevers (Setty and Sigal 2005; Varghese and Lockey 2008).

Products like Acheflan®, a Brazilian herbal medicine indicated for inflammation and the local treatment of muscle pain, are produced from *Cordia verbenacea* DC., popularly known as "erva baleeira." This example shows that local knowledge is a rich information source for obtaining new medicine. However, legal factors regarding benefit return and sharing must be respected (see Elisabetsky 1991; Reyes-García 2010).

Medicinal plants based on traditional knowledge use are of such importance that the Brazilian government implemented a national list of medicinal plants of interest to the public health system (RENISUS) in 2008 (Brasil 2012). Currently, 12 herbal medicines are offered in public networks of 14 states (Table 1).

Thus, ethnobiology is important in the study of medicinal plants and how they can help the development of certain sectors of society, such as industry, public health, and local communities. Moreover, the growing appreciation and interest in studies developed by professionals of the public and private sectors in these areas, to ascertain which species can be selected for a certain process, has been noted based on the objectives of each of these sectors.

Some factors related to these studies must be observed, such as well-designed ethnobotanical or ethnopharmacological approaches as well as taking into account methodological aspects and accurate data analysis, i.e., correct species identification

Table 1 Unified Health System (SUS), Brazil, herbal medicine list. Adapted from Brasil (2012)

Popular name	Scientific name	Indication
"Espinheira-santa"	*Maytenus ilicifolia* Mart. ex Reissek	Helps in the treatment of gastritis and duodenal ulcers and dyspepsia symptoms
Guaco	*Mikania glomerata* Spreng.	Has expectorant and bronchodilator action
Artichoke	*Cynara scolymus* L.	Used in the treatment of functional dyspepsia (postprandial distress syndrome) symptoms and mild to moderate hypercholesterolemia. Has choleretic and cholagogue actions
Mastic	*Schinus terebinthifolius* Raddi	Has healing, anti-inflammatory, and topical antiseptic actions for gynecological use
Cascara buckthorn	*Rhamnus purshiana* DC.	Helps in cases of possible intestinal constipation
Devil's claw	*Harpagophytum procumbens* DC.	Used in the treatment of acute lower back pain, acts as adjunct in cases of osteoarthritis, and has anti-inflammatory action
Soy isoflavone	*Glycine max* (L.) Merr.	Assists in relieving menopause symptoms
Cat's claw	*Uncaria tomentosa* (Willd. ex Roem. & Schult.) DC.	Helps in arthritis and osteoarthritis cases and has anti-inflammatory and immunomodulatory actions
Peppermint	*Mentha piperita* L.	Used in irritable colon syndrome treatment and has antiflatulent and antispasmodic action
Aloe	*Aloe vera* (L.) Burm. f.	Used in topical treatment of first- and second-degree burns and as an adjunct in psoriasis vulgaris cases
Willow	*Salix alba* L.	Used in the treatment of acute low back pain, has anti-inflammatory action
Plantago	*Plantago ovata* Forsk.	Assists in habitual intestinal constipation and is used in the treatment of irritable colon syndrome

by trained professionals and compliance with current legislation in the country regarding intellectual property rights of traditional knowledge-derived information and medicinal species use and sustainable management (see Oliveira et al. 2005).

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Fortifier, Tonic, and Rejuvenating Plants and the Adaptogen Concept

Danilo Ribeiro de Oliveira and Suzana Guimarães Leitão

Abstract Medicinal plants are frequently used nonspecifically to improve body functions, especially when a reduction of muscle function, cognition or sexual performance, or resistance to infections is perceived. In such cases, people often turn to tonic, rejuvenating, and restorative plants. These plants deserve more attention and scrutiny to find scientific evidence to support their popular use. In modern medicine, the adaptogen term was coined for the class of compounds that is capable of increasing nonspecific resistance of the organism by improving its ability to adapt to environmental factors and stressor agents. Adaptogen plants can also be used by healthy individuals to improve cognitive and physical performance or as geriatric agents to prevent or minimize physical and cognitive deficits. Through efficacy and safety evidence, plants known as aphrodisiacs or sexual, energizing, or rejuvenating stimulants or that are indicated for weakness or impaired memory could be regarded as potential new herbal adaptogens.

Holistic View of Health and Disease

There are many definitions of health and disease. Nevertheless, to understand the use of fortifier, tonic, and rejuvenating plants that led to the emergence of the adaptogen concept, it is of paramount importance to know the holistic view. In traditional medicine, health and disease are seen in a global context where the body, the environment, and different natural or spiritual phenomena can influence the individual. Definitions of health are highlighted below from a completely holistic approach to a non-holistic approach:

> "Holistic health" broadens the focus of modern medicine on symptoms and disease to include other health-related domains such as nutrition, psychological and spiritual well-being, interpersonal relations, and environmental influences (Lowenberg and Davis 1994).

D.R. de Oliveira, Ph.D. (✉) • S.G. Leitão, Ph.D.
Faculdade de Farmácia, Departamento de Produtos Naturais e Alimentos,
Universidade Federal do Rio de Janeiro, Av. Carlos Chagas Filho, 373, sala A2-4, Centro de Ciências da Saúde, Ilha do Fundão, Rio de Janeiro, Rio de Janeiro 21.941-902, Brazil
e-mail: oliveiradr@pharma.ufrj.br; sgleitao@pharma.ufrj.br

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> “Health” is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity (WHO 1948).

> “Health” is believed to be achieved by maintaining the body in harmony with respect to internal psychological functions as well as external social and ecological conditions (Chen and Swartzman 2001).

> “Health” as freedom from disease is then statistical normality of function, i.e., the ability to perform all typical physiological functions with at least the typical efficiency (Boorse 1977).

All the above definitions are important in understanding the employment of tonic plants in traditional medicine, but the last two are more relevant in understanding adaptogens in a scientific context and biomedical practice.

In a holistic view, considering that many factors can interfere with health, concepts of disease can be understood as “cultural classifications of adversity” (Lieban 1977). In this context, Hesllow (1993) highlights that the concept of disease is not very relevant because the vital functions of the individual could be better served without identifying a disease. This idea is contrary to the mechanical model of disease, where the disease is a deviation from some kind of ideal design. This author says that although the term disease is helpful, much is lost in trying to conceptualize it; he uses as an example a car that does not need to have a recognizable “mechanical fault” in order to present a malfunction requiring some adjustment or repair.

In a non-holistic vision, Boorse (1977) considered disease as a type of internal state that impairs health, i.e., depresses a functional ability, in order to interfere with the performance of some natural functions, such as survival and reproduction. Roughly, disease is a state of the organism that compromises some physiological functions.

To stay alive, an organism obviously requires a whole complex of functions to be in action. A decrease in the efficiency of such biological functions, completely or partially, is a determinant of disease processes. In this context, the use of fortifiers, tonics, and stimulants is the key to the recovery of health and the quality of life in many cultures.

Tonic, Restorative, and Rejuvenating Plants

Weakness, fatigue, and debility are seen as limiting states of health in traditional medicine in several countries around the world. In this context, medicinal plants are frequently used nonspecifically to improve body functions. The use indications of these plants and their properties, often mentioned in ethnobotanical or ethnomedical surveys, are diverse, as exemplified in Table 1.

In such cases, people often turn to tonic, rejuvenating, and restorative plants, especially when a reduction of muscle function, cognition or sexual performance, or resistance to infections is perceived. These adversities are more pronounced during aging because this process leads to a progressive loss of capacity. However, they

Table 1 Use indications and properties of tonic plants (Adapted from Mendes 2011)

Indications
Aging, Alzheimer's disease, bad memory, burnout, dementia, despondency, difficulty in reasoning, diseases caused by nervous exhaustion, fatigue, forgetfulness, general debility, infertility, lack of attention, laziness, listlessness, loss of memory, memory weakness, old age, organic weakness, physical and mental exhaustion, physical or intellectual weariness, physical or sexual debility, poor memory, rundown, senility, sexual impotence, sexual weakness, stress, tiredness, to improve health, weak head, weakness of nerves, unwillingness
Properties
Anti-stress, aphrodisiac, brain function exciter, cleanse the brain or ideas, energizer, enhancer of performance, fortifier, fortifier for nerves, general or muscular tonic, increase libido and fertility, invigorating, memory enhancer or activator, neurotonic, panacea, preventive/prophylactic, protector, regenerator, regulator of organic functions, reinvigorator, rejuvenator, restorative, restorer of strength, sexual stimulant, strengthen weak minds and memories, strengthen the brain

can happen, regardless of age, in cases of weakness that are caused by infectious diseases or by stress or psychosomatic problems.

In the Brazilian Amazon (Oriximiná City, Pará State), there are several traditional quilombola (maroons) communities that have sprung up in remote areas of the forestry after African slaves escaped at the beginning of the nineteenth century. An ethno-directed study was carried out with these communities, focusing on some biological activities. The first was about plants used for memory-related disorders that were expected to present a high inhibitory activity of the acetylcholinesterase enzyme that is useful in the symptomatic treatment of Alzheimer's disease, as it is responsible for the hydrolysis of acetylcholine, a neurotransmitter that is essential for cognition. From 36 ethnospecies surveyed, 11 were assayed and 38.5 % were shown to be active. However, it was observed that the most active ones were rich in tannins, a class of compounds that is characterized by precipitating proteins that can interfere with enzymatic assays, leading to false-positive results. After a tannin precipitation reaction with all positive samples, only one ethnospecies, rich in indole alkaloids known to inhibit acetylcholinesterase, remained active. This shows that treatment of memory disorders by the quilombolas is not only directly addressed to ameliorate some form of dementia but that the adversity and limitations of the body imply a malfunction of memory because the plants that are recommended are mostly also indicated as tonic (Oliveira et al. 2012).

The second ethno-directed survey was carried out focusing on plants to treat dry cough, angry cough, pneumonia, tuberculosis, and infectious diseases of the chest. Surprisingly, although all these terms guide in selecting plants for bioprospecting, it was observed that the term "weakening" is specially used for TB (Oliveira et al. 2011a). As these traditional communities consider body weakness as an important factor in the development of the disease, the tonic and fortifying plants are part of the therapeutic arsenal for TB treatment and prophylaxis. The weakness of the body and depression of the immune system as a factor for developing tuberculosis are also perceived by other traditional communities around the world. In Papua New

Guinea, for example, most plants used in TB treatment have the purpose of treating the disease symptoms or improving the immunological system. Thus, in general, bioprospecting studies with these plants did not find antimycobacterial activity, suggesting that they should be subjected to immune-modulating assays to better understand and assess the biological properties according to traditional medicine (Case et al. 2006).

Finally, the third survey with the quilombolas from Oriximiná focused on plants against malaria and the related symptoms and revealed a close relationship between the infectious diseases and the use of tonic plants. For instance, *Ampelozizyphus amazonicus* showed 100 % of the use agreement for malaria among the informants and the greatest cultural importance against this disease. However, in several studies, *A. amazonicus* was shown to be totally inactive against blood forms of plasmodium in vitro and in vivo. This result demonstrates that the main focus of an antimalarial treatment is not always a direct antiplasmodial action because this species is known for its depurative, stimulatory, energetic, and revitalizing properties (Oliveira et al. 2011b). Malaria is seen as a disease that affects the individual as a whole, making it necessary to treat all symptoms (fever, liver and spleen swelling, headache, body pain, malaise, etc.) as well as cleansing and strengthening the body for healing. Clarkson et al. (2004) also highlighted that some plants act as antipyretics or immunostimulants to relieve the symptoms of malaria, rather than having antiparasitic activity.

Emetic, purgative, and depurative plants are widely used traditionally, with the aim to "clean inside the body," in a concept where the disease is considered as an entity within the body (Geest and Whyte 1989). In popular vision, it is necessary to stimulate/promote the excretory functions of the ill body, aiming to flush out what is causing the ills internally, promoting bodily purification or detoxification. For example, in Chazuta traditional medicine from the Peruvian Amazon, according to Sanz-Biset and Cañigueral (2013), depurative practices are frequently used in the treatment of diseases where pain, inflammation, and infection are present. Such practices are based on the use of plants and restriction in food intake. These authors also highlighted that depurative practices are frequently used to tone and strengthen the body in ways such as (a) augmenting work performance, (b) enhancing endurance, (c) increasing weight carrying, (d) extending cold resistance, (e) sharpening the senses, (f) lessening sluggishness, (g) preventing illnesses, or (h) improving sexual function.

Additionally, sexual disorders are another problem in societies because they are common and adversely affect mood, well-being, and interpersonal relationships of both men and women. Convalescence situations, psychological problems, and advancing age are some of the factors that lead to disorders such as loss of sex drive, impotence, and fertility. In traditional medicine, it is very evident that plant diversity that is used as aphrodisiacs is, in most cases, the same that is used as a tonic.

Below, we present a table with plants that are notoriously used as tonics to fortify and rejuvenate and as an aphrodisiac, especially the most used plants in South America (Table 2). Popular uses reported that such plants, supported by scientific evidence of efficacy and safety in preclinical and clinical studies, could justify their use as adaptogen herbal medicines.

Table 2 Examples of fortifier, tonic, aphrodisiac, and rejuvenating plants

Plant name/family	Folk name	Active principles	Main traditional uses	Biological activities
Ampelozizyphus amazonicus/Rhamnaceae	Saracuramirá, little beer, Indian beer	Dammarane saponins and triterpenes	Bark and roots—as prophylactic against malaria, tonic, stimulant, nerve tonic, aphrodisiac, depurative	Prophylactic activity against malaria and immunostimulant activity in vivo
Heteropterys tomentosa/ Malpighiaceae	Nó-de-cachorro (dog's knot)	Flavonoids, nitrocompounds, tannins	Roots—as tonic, aphrodisiac, depurative, against weakness and nervous debility	Improved spermatogenesis, testosterone levels, muscle contraction, and cognition functions and has stimulant and neuroprotective effects in vivo
Lepidium meyenii/ Brassicaceae	Maca, Peruvian ginseng	Glucosinolates, steroids, and alkaloids	Hypocotyl and taproot—as sexual stimulant, energizer, and aphrodisiac and to improve sexuality and fertility	Increased sexual performance, spermatogenesis, and offspring. Improved memory and learning. Anti-stress, antioxidant, neuroprotective in vivo. In humans, increased sexual desire and reduced scores in depression and anxiety
Pausinystalia johimbe/ Rubiaceae	Yohimbe	Índole alkaloids (yohimbine)	Barks—as a general tonic and as an aphrodisiac	In vivo action against erectile dysfunction. In humans improved modestly erectile disorder
Pfaffia glomerata/ Amaranthaceae	Fáfia, Brazilian ginseng	Saponins, triterpenes, ecdysteroids, and steroids	Roots—as general tonic, rejuvenating, and aphrodisiac, to chronic fatigue, stress	Anti-inflammatory, antinociceptive. Improves learning and memory in vivo

(continued)

Table 2 (continued)

Plant name/family	Folk name	Active principles	Main traditional uses	Biological activities
Ptychopetalum olacoides/ Olacaceae	Muira puama, marapuama	Triterpenes and diterpenes	Roots—as aphrodisiac, restorative, and nerve tonic	Neuroprotective
Tribulus terrestris/ Zygophyllaceae	Tribulus, burra gokhru, puncture vine	Steroidal saponins, alkaloids, and flavonoids	Fruits—as sexual stimulant and aphrodisiac, to improve sexuality and fertility	Stimulates spermatogenesis, increase in mount and intromission frequencies, and improvement of the sexual behavior parameters
Trichilia catigua/ Meliaceae	Catuaba	Steroids, procyanidins, and phenylpropanoids	Barks—to forgetfulness, poor memory, nervousness, neurasthenia, and aphrodisiac and as a tonic and stimulating energy of the nervous system	Antinociceptive, vasorelaxant, anddopamine-mediatedantidepressant-like effects in vivo
Uncaria guianensis, *U. tomentosa*/Rubiaceae	Unha-de-gato	Oxindole and indole alkaloids, poly-oxygenated triterpenes, catechins, and procyanidins	The barks—to inflammation in general, arthritis, rheumatism, and infections in general and as depurative and tonic	Immunostimulant, anti-inflammatory, antiviral, antioxidant, hypotensive, and others

The Adaptogen Concept

The term adaptogen was coined in 1947 by the Russian scientist Nikolai Lazarev in experiments with the drug dibazol (2-benzyl-benzimidazole) that were designed to stimulate the nonspecific resistance in humans (Panossian et al. 1999a, b). The term may have presumably came from the Latin *adaptare*, to adjust or fit, and "gen" from the Greek *genes* or born of or produced by (Davydov and Krikorian 2000). Later on, Brekhman and Dardymov (1968 apud, Panossian and Wagner 2005) developed the original concept that an adaptogen was a substance that showed a nonspecific effect, such as increasing bodily resistance to physically, chemically, or biologically noxious agents; had a normalizing effect on a pathological state, independent of the nature of that state; and was innocuous and did not disturb body functions at a normal level (Panossian et al. 1999a, b; Mendes 2011).

More recently, plant adaptogens have been defined as "compounds that increase the ability of an organism to adapt to environmental factors and to avoid damage from such factors by increasing the non-specific resistance against stressors, improving one's ability to adapt to stress" (Panossian and Wagner 2005). Since its definition, the term has been criticized by some researchers who have even suggested that it should be dropped from the literature because it is vague and does not convey into any specific mechanism(s) of action (Davydov and Krikorian 2000). They state that if a precise action can be attributed to them, the exact term for such an action should be used (Davydov and Krikorian 2000). However, despite this view, the authors recognize that galenical preparations or herbal mixtures similarly intended for nonspecific use(s) were formerly referred to as "tonics," and even if the expression "tonic" is rarely found in the contemporary American herbal medicine literature, it is in widespread use in the traditional medical systems of East, Northeast, South, and Southeast Asia (Davydov and Krikorian 2000).

The difficulty in accepting the term adaptogen comes from the fact that it is difficult to differentiate between them and drugs with immune-stimulant, anabolic, nootropic, and tonic actions. However, there is no doubt that many plant adaptogens are able to modulate the distinct phases of Selye's general adaptation syndrome (Fig. 1) by reducing the stress reactions in the so-called alarm phase and retarding or eliminating the "exhaustion phase" (Wagner et al. 1994; Mendes 2011). Hans Selye was an Austrian endocrinologist who conducted important scientific work on the nonspecific response of an organism to stress and was the first, together with W. Cannon, to use the term that was borrowed from physics in 1936 in a biochemical context. Selye defined stress as a state of "threatened homeostasis," being homeostasis a complex dynamic equilibrium that is constantly challenged by intrinsic/extrinsic adverse forces or stressors (Fig. 1) (Panossian et al. 1999a, b).

In 1998, the Food and Drug Administration (FDA) recognized the term adaptogen, and health authorities have been using it as a functional term (Panossian et al. 1999a). Since then, the interest in dietary supplements and herbal products that exploit this effect has been growing (Wong Bandyopadhyay and Chen 2011; Panossian et al. 1999b). Repeated doses of adaptogens have been shown to be of

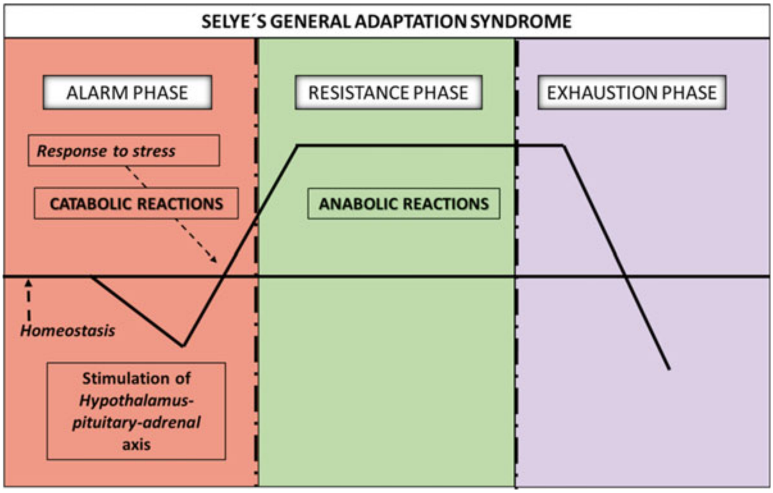

Fig. 1 Selye's general adaptation syndrome: **Alarm** is the first stage where the organism's resistance to the stressor temporarily drops below the homeostasis level and there is activation of the hypothalamic–pituitary–adrenal (HPA) axis. **Resistance** is the following stage and comprises increased secretion of glucocorticoids. If the stressor persists, the body cannot maintain this indefinitely; thus its resources are gradually depleted. The third and last phase is the **exhaustion** phase where all of the body's resources are eventually depleted and the body is unable to maintain normal function. The result can be the onset of illnesses

particular value in sports medicine in which the antifatigue effect can lead, for example, to the increased endurance of long-distance runners during competitions or to a more rapid recovery from a strenuous event (Panossian and Wagner 2005). Indeed, plant adaptogens can also be used by healthy individuals to improve their cognitive and physical performance or as geriatric agents to prevent or minimize physical and cognitive deficits resulting from aging (Mendes 2011).

In this context, plants prescribed as aphrodisiacs or sexual, energizing, or rejuvenating stimulants or indicated for weakness and impaired memory could be regarded as potential adaptogens.

Plant adaptogens stimulate the nervous system by mechanisms that are totally different from those of traditional stimulants, being associated with metabolic regulation of various elements of the stress system and modulation of stimulus–response coupling (Panossian and Wagner 2005). A modulation of the hypothalamic–pituitary–adrenal (HPA) axis seems to be one of the main mechanisms of action of the adaptogens, but the immune system also plays an important role in the set of positive actions of the adaptogens. A number of plants considered adaptogens are immunostimulants. Other important mechanisms are the antioxidant activity (because their role in the prevention of neurodegenerative disease is well established) and the modulation of the cholinergic and other neurotransmission systems

Table 3 Example of some validated/partly validated adaptogens from plants

Plant name/family	Folk name	Active principles
Panax ginseng/Araliaceae	Korean ginseng	Dammarane-type saponins called ginsenosides, derived from 20-(*S*)-protopanaxadiol (R_{b1}, R_{b2}, R_c, R_d) and from 20-(*S*)-protopanaxatriol (R_{g1}, R_{g2}, etc.)
Eleutherococcus senticosus/ Araliaceae	Siberian ginseng	Phenylpropanoid glycosides (eleutheroside B or syringin), lignans (eleutheroside E or (+)-syringaresinol; eleutheroside E2), saponins (β-hederin also called eleutheroside K)
Rhodiola rosea/Crassulaceae	Arctic root	Phenylethanoid glycosides (salidroside), phenylpropanoid glycosides (rosin, rosarin, rosavin, triandrin, etc.), and flavonoids
Schisandra chinensis/ Schisandraceae	Gomishi, hokugomishi	Lignans (schizandrin B)
Echinacea purpurea/ Asteraceae (also *E. pallida* and *E. angustifolia*)	Cone flower	Alkamides, caffeic acid derivatives (chicoric acid, echinacoside, caffeoylquinic acids), and polysaccharides
Withania somnifera/ Solanaceae	Ashwagandha	Withanolides

that improve cognitive performance (Mendes 2011). Additional mechanisms and involvement of other factors such as the modulation of the expression of molecular chaperones, especially Hsp72 (Panossian et al. 2009), have been proposed to explain the multifaceted action of the adaptogens.

Innumerous plants have been studied for their adaptogen properties, and some of them find vast support in the literature for their use. Table 3 summarizes some important ones.

Conclusion

Fortifier, tonic, rejuvenating, and aphrodisiac plants are also used by healthy persons, not only prophylactically but also to improve physical and cognitive performance, among other reasons that are strictly related to a holistic view of health. These aspects are not always able to be objectively and scientifically observed, measured, or tested; however, the holistic view deserves further attention and scrutiny. In this context, plants prescribed as aphrodisiacs or sexual, energizing, or rejuvenating stimulants or indicated for weakness and impaired memory could be regarded as potential adaptogens.

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Magic Plants

Rainer W. Bussmann

Abstract More than 20,000 of the about 400,000 known vascular plants are known for their medicinal use. A very small number of medicinal plants contain compounds that alter the function of the human mind. Although entering Western culture mostly since the 1960s, "magic" plants have been part of traditional medicine for millennia. Most of these hallucinogens are derived from plants. Interestingly, New World cultures have always been known to employ more magic plants than their counterparts on the Old World, although botanical diversity does not provide a conclusive explanation to this phenomenon. Hallucinogenic plants are traditionally used to induce altered perceptions, and ultimately mystic/religious experiences, and contact to the spirit world. In addition, such plants are often employed in traditional healing, to divine the type of illness and the needed remedy, as well as to put patients at ease to allow for a better diagnosis. The present chapter attempts a very short introduction into the world of "magic plants."

Introduction

In many societies, the use of magic plants dates back millennia. Such plants are most prominently known to be used for mind-altering purposes; however, in many societies, "magic" plants are also very frequently employed to cleanse patients (e.g., Albuquerque et al. 2007; Bussmann and Sharon 2006). In Western cultures, the present use of magic plants dates mostly back to the 1960s and focuses almost entirely on their hallucinogenic properties. The latter has led to a plethora of detailed publications on the subject (Schultes and Hofmann 1992).

The most common hypothesis on the discovery of magic plants is that, while ingesting plants for food and medicine, humans found that some species had profound mental effects and caused visions, allowing transgressing reality. These effects are generally visual, but some hallucinogens can also involve other senses.

R.W. Bussmann (✉)
William L. Brown Center, Missouri Botanical Garden,
P.O. Box 299, St. Louis, MO 63116, USA
e-mail: rainer.bussmann@mobot.org

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The active principle in most magic plants are alkaloids—nitrogen-containing compounds essentially derived from the amino acid tryptophan. The compounds causing such effects most likely evolved as protective compounds in plants, essentially in defense against being eaten by animals. All magic and hallucinogenic compounds are organic, i.e., contain carbon atoms, and most of them also contain nitrogen. The latter are classified as alkaloids, a large and very diverse group, and thousands of different types have been found. Alkaloids are only found in plants, and their name simply indicates that they react slightly alkaline. Many alkaloids are derived from the amino acid tryptophan and are classified as indoles. Many medicinal plants, as well as species used as stimulants, are active due to their alkaline content. Coffee (*Coffea arabica* and *C. canephora*), for example, contains the alkaloid caffeine; other examples are tea (*Camellia sinensis*), which contains L-theanine, theanine, and theine, cocoa (*Theobroma cacao*), which contains theobromine, and tobacco (*Nicotiana tabacum* and *N. rustica*), which contain nicotine. Well-known medicinal species include opium poppy (*Papaver somniferum*) that yields morphine and derivatives and the fever tree (*Cinchona officinalis*) used to produce quinine for the treatment of malaria.

Many hallucinogenic species, for example, *Anadenanthera* and *Virola*, however contain *N*-*N*-dimethyltryptamine (DMT) and closely related compounds, which are structural analogues to serotonin and melatonin in the human brain, which easily explains their psychotropic effects. Most of these compounds are easily broken down in the digestive tract, which is why they are traditionally snorted or ingested with other plant additives that contain beta-carbolines, especially harmaline and harmine, that block monoamine oxidase, the enzyme that breaks down tryptamines. In South America, these plants are collectively known as "ayahuasca," but the same compounds are also found in *Peganum harmala* (Syrian rue), which is found in the Middle East and Central Asia (Schultes and Raffauf 1992). The most important DMT-containing plants are species of *Virola* and *Anadenanthera*. The use of *Anadenanthera* (huilco) as hallucinogen in South America is documented archaeologically for at least 3000 years, and many place names, e.g., "Vilcabamba," derived from "huilco-pampa," i.e., "plain of the huilco tree," refer to this use. Other important hallucinogenic alkaloids include psilocybin, found in "magic mushrooms," and mescaline, only known from psychotropic cacti like *Echinopsis pachanoi* (San Pedro cactus) and *Lophophora williamsii* (peyote) (Schultes and Hofmann 1992).

The most important psychoactive non-nitrogen compounds are cannabinols, e.g., THC and CBD, the active ingredients in marijuana, derived from *Cannabis sativa* and *C. indica. Cannabis* is probably the most popular psychotropic species but is now also widely used medicinally and for that purpose legal in many countries.

The use of hallucinogenic has always had profound meaning in traditional uses. They are employed to diagnose and treat illness, help to divine the future in normal life, and allow deciding on when to plant and hunt, on peace and war, and are used to manage relations among individuals as well as between different villages.

Many hallucinogens are used in initiation ceremonies that mark the transition from adolescence to adulthood and often literally take the initiates into a zone between death and rebirth and are highly dangerous. Native North Americans, e.g., the Algonquin, used Jimson weed (*Datura stramonium*, wysoccan) that caused profound memory loss over a period of time. In West Africa, iboga (*Tabernanthe iboga*) serves the same purpose, while in Amazonian South America, ayahuasca (mostly from *Banisteriopsis caapi* and *Psychotria viridis*) is used. Both ayahuasca and preparations of *Datura* and *Brugmansia* are widely used for divination, prophecy, and healing rituals (Schultes and Raffauf 1998).

Magic Plants in Northern Peru: A Case Study

A great example for the traditional use of hallucinogens is the north coast of Peru. The use of sacred psychoactive plants (entheogens), in particular the San Pedro cactus (*Echinopsis pachanoi*), is a vital component in Andean healing practices and has been around for millennia (Camino 1992; Polia 1988; Sharon 1978). Archaeological evidence for this sacred cactus has been found at Guitarrero Cave (8200–6800 B.C.) in the highlands of Peru (Lynch 1980) and Garagay (1643–879 B.C.) on the central coast (Burger 1992). The San Pedro cactus is frequently depicted in Cupisnique, Chavín, Moche, Nazca, and Lambayeque iconography (Glass-Coffin et al. 2004). At Chavín, Torres (2008) has also identified *Anadenanthera* (vilca, cebil), *Brugmansia* (borrachero, floripondio, misha), *Nicotiana* (tobacco), and *Erythroxylum* (coca) in the religious iconography of the site. Early ethnobotanically oriented studies focused mainly on the famous "magical" and "mind-altering" flora of Peru. A first study on "cimora"—another vernacular name for the San Pedro cactus—dates back to the 1940s (Cruz Sánchez 1948). The first detailed study of a hallucinogen in Peru focused on the San Pedro cactus (*Echinopsis pachanoi*) (Dobkin de Rios 1968, 1969). A variety of works including some on the "daturas" (*Brugmansia* spp.) followed (Bristol 1969; Dobkin de Rios 1977; Dobkin de Rios and Cardenas 1980). Coca (*Erythroxylum coca*) also attracted early scientific attention (Martin 1970; Naranjo 1981; Plowman 1984a, b) as did the Amazonian ayahuasca (*Banisteriopsis caapi*) (Rivier and Lindgren 1972; McKenna et al. 1986; Schultes and Raffauf 1992; Bianchi and Samorini 1993). More comprehensive accounts followed (Cabieses Molina 1990; Schultes and Hofmann 1992).

Five hundred years of suppression of traditional healing practices starting in colonial times and continuing to manifest in the prejudices of contemporary national administrations have not managed to destroy this tradition. The use of San Pedro cactus, together with additives like angel's trumpet (*Brugmansia* spp.) and tobacco (*Nicotiana tabacum* and *Nicotiana rústica*), is still a central part of the curing ceremonies of healers in Northern Peru. Healers are in fact experimenting with what for them are new hallucinogens, with some northern *curanderos* including decoctions of ayahuasca (*Banisteriopsis caapi*) in their rituals (Bussmann and Sharon 2009a).

Healing altars (*mesas*) in Northern Peru often follow the old tradition by including all kinds of "power objects," frequently with a "pagan" background. Objects such as seashells, pre-Hispanic ceramics, staffs, stones, etc., are very common on Peruvian *mesas* and are blended with Christian symbols such as crosses and images of saints. As also found in other studies (Albuquerque et al. 2007), patients are often cleansed by spraying them with holy water and perfumes, and herbal baths or "spiritual flowerings" (*baños de florecimiento*) are very important components of the healing tradition. In most cases, the cleansing of the patients involves the nasal ingestion of tobacco juice and perfumes. While the incantations and songs (*tarjos*) used by healers during their curing sessions include Christian components, e.g., the invocation of Christ, the Virgin Mary, and any number of saints, references to Andean cosmology, e.g., to the sacred lagoons (lagunas) and mountain spirits (*apus*), are very common as well. The use of guinea pigs as diagnostic instruments is standard (Bussmann and Sharon 2007).

Magic Plants in a Global World

There is no standard way hallucinogenic preparations are traditionally ingested. In some cases, plants might simply be eaten, either fresh or dry, such as peyote or magic mushrooms. More often, a concoction is prepared and drunk, as in ayahuasca, preparations of San Pedro cactus and *Datura*, or tobacco. In particular in Northern Andean culture, liquid preparations of San Pedro cactus, tobacco, and *Brugmansia* are often inhaled through the nose, thus potentiating the effect. Most of these hallucinogens have a long-lasting effect—from a whole night curing session to various days. The use of *Brugmansia* and *Datura* is so dangerous, however, that in traditional context, these plants are only employed in particularly serious cases of illness and divination. In contrast, DMT-containing hallucinogens derived from *Virola* and *Anadenanthera* are almost entirely snuffed, as a simple way to avoid the need to also ingest a MAO inhibitor (Bussmann and Sharon 2006; Bussmann et al. 2010).

Interestingly, there are clear differences in hallucinogen use between the Old and the New World—the floras of both regions have a large number of plants potentially containing psychotropic compounds, but only about 20 species of hallucinogenic plants are used in the Old World, compared to over 100 in the New World.

Eastern psychotropic plants include *Cannabis* sp. (marijuana) in Asia and various members of the nightshade family (Solanaceae), such as *Atropa belladonna* (belladonna), *Solanum nigrum* (nightshade), *Mandragora officinalis* (mandrake), and *Hyoscyamus niger* (henbane), mostly known from "witch balms," in Europe. Fly agaric mushrooms (*Amanita muscaria*) were widely used in shamanism in Siberia and Northern Europe, while African hallucinogenic use mostly centered on iboga and *Datura* sp.

In great contrast, hallucinogenic use in the Western hemisphere seems to be much more widespread. Cultures in North America used relatively few hallucinogens, especially *Datura* sp., *Sophora* sp. (mescal beans), and *Lophophora williamsii* (peyote), which spread to the north from Mexico only in the second half of the nineteenth century. In Mexico itself, the use of mushrooms (*Psilocybe* sp., *Panaeolus* sp.) is particularly noteworthy. Other commonly used species are *Salvia divinorum* (divine sage) and *Turbina corymbosa* (morning glory). In the latter case, the seeds are the plant part used. However, recent studies indicate that the effective alkaloids (*psilocybin* and derivatives) are in fact not the product of the plant itself but produced by endophytic fungi colonizing the plant. In Andean culture, *Echinopsis pachanoi*, *Nicotiana rustica*, and *Brugmansia* sp. are still the most widely used psychotropic plants, while the use of *Anadenanthera* sp. essentially disappeared already in pre-Columbian times. Similarly, the use of *Guarea* sp. (ulluchu) as hallucinogen is only reported in a short period in Moche culture (Bussmann and Sharon 2009b). In the Amazon, the most widely used hallucinogenic mixture is ayahuasca (yage, caapi), employing most often a mixture of *Banisteriopsis caapi* (with MAO-inhibiting) compounds and *Psychotria viridis* (as DMT source). Depending on the region, dozens of other species are employed to substitute for one or both of these species. In some small areas, snuffs derived from *Virola* sp. and *Anadenanthera colubrina* are used.

In Western society, the use of psychotropic plants has become more common since the 1960s, mostly as a tool to achieve "enlightenment" or simply as recreational activity. This use however occurs mostly without any traditional context that would help to mediate unexpected and possibly dangerous side effects and thus has nothing to do with the traditional use regarded as sacred in many areas of the world.

Conclusions

Interestingly, but not surprising, the sanctioned stimulants of contemporary Western society, e.g., coffee, tea, and tobacco, are all geared toward making people work longer and more efficiently or are, such as alcohol, used as a rather sloppy way to relieve stress. Compounds that lead to longer intoxications, or allow for more mystic experiences, are outlawed for societal and religious reasons, because they do not fit the traditional Calvinist-capitalist model. Which species should be controlled and/or prohibited is of course also a matter of debate, but it is interesting to note that *Cannabis* is generally a controlled substance, while *Datura* sp. and *Brugmansia* sp., all of which are much more lethal in often very small dosages, are freely available in horticulture.

However, the use of psychotropic plants in nontraditional context and for recreation clearly remains problematic. None of the plants mentioned, when used traditionally, provide anything of a "pleasant" experience. All are employed to profoundly purify both patients and healers, and nausea and vomiting are some of the lesser side effects. The use of hallucinogenic plants is, in a traditional context, always tightly controlled by a healer or shaman and covered by taboos. Nonexpert use of such plants or nontraditional mixtures of hallucinogens, as often employed by self-designated "shamans" catering to "enlightenment tourists," especially in South America (Fig. 1), is irresponsible, highly controversial, and very dangerous, leading to frequent cases of poisoning and sometimes death.

Fig. 1 "Shamanism" artifacts, including skulls of endangered species (e.g., jaguar, tapir, caiman), snakeskins, and packages of hallucinogenic plants and plant mixtures from both the Amazon and Andes, sold without any control in Belen market, Iquitos, Peru

To provide a setting accepted as legal by mainstream society or a context similar to a traditional "sacred" context, religious movements in the Western world have in the last decades tried to develop new settings for the use of psychotropic plants in a ritual context. The best examples are the Native American Church, formed already in 1918, to legalize the Native American use of peyote, or the Santo Daime church, started in Brazil in the 1930 as a syncretic movement using ayahuasca.

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Ornamental Plants

Julio Alberto Hurrell

Abstract Ornamentals constitute a group of plants employed by humans throughout history. From the point of view of ethnobotany, the use of ornamental plants responds to local botanical knowledge that guides diverse strategies of cultivation and consumption in different cultural contexts. What is the place of ornamental plants in current ethnobotany? The role of the ornamentals in ethnobotanical studies, particularly in relation to horticulture (homegardens) and related contexts, and their aesthetic and symbolic values are discussed.

Ornamentals in Ethnobotany

Ethnobotany is the study of relationships between people and plants in different cultural contexts and inside the framework of biocultural ecology where both natural and cultural dimensions are thought together (Albuquerque and Hurrell 2010; Hurrell and Albuquerque 2012). From a theoretical standpoint, ethnobotany is mainly based on the comprehension of the local botanical knowledge that guides the people actions regarding to plants, e.g., the selection of plants to cultivate or consume. In a methodological sense, the knowledge guides diverse actions (discourses, practices), and through analyzing these actions, it is possible to reformulate the knowledge that generated them (Hurrell 2014).

Applying these principles to the context of ornamental plants, we might ask: Why we consider that a plant is ornamental? What botanical knowledge allows that consideration? What effective actions trigger that knowledge? What meaning have these plants in people's lives? And also, in a reflective sense: What meaning have ornamentals for the ethnobotanists? What is the place of ornamental plants in ethnobotany?

Many ethnobotanical studies around the world have focused on plants used for food and medicinal purposes. Some examples are the abundance of papers dealing

J.A. Hurrell (✉)
Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET). Laboratorio de Etnobotánica y Botánica Aplicada (LEBA), Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Calle 64 Nro. 3, 1900 La Plata, Buenos Aires, Argentina.
e-mail: juliohurrell@gmail.com

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with the search of new active principles from plants with registered local medicinal uses (Fabricant and Farnsworth 2001; Rates 2001), the scientific validation of folk therapeutic uses (Mukherjee et al. 2007; Trivellato Grassi et al. 2013), the assessments on chemical properties and nutritional value of neglected crops (Seminario et al. 2003), and many studies on plants for "eating and healing," where food and medicinal plants are treated together (Chen 2009; Pochettino et al. 2012a). In contrast, the ornamentals have not received an equivalent attention within the ethnobotanical research scenario.

The concept of *ornamental plants* is used here in its broadest sense including plants that are grown for decorative purposes in gardens, homegardens, landscape design projects, squares, parks, street trees, indoor plants, and cut flowers. The decorative purposes respond to aesthetic values assigned by people in different cultural contexts, e.g., in Western culture usually, that are related to some plant features: flowers, fruits, leaves, foliage texture, color, and scent (Li and Zhou 2005; Oloyede 2012; Estrada-Castillón et al. 2014). The importance of plants as food, medicine, fiber, fuel, timber, and others often has been treated by many researchers, but the aesthetic dimension was not very analyzed (Nirmal Kumar et al. 2005; Dafni et al. 2006; Kumbhar and Dabgar 2014).

In some studies, the ornamental use is indicated but explicitly relegated to a secondary position regarding its medicinal and food uses, e.g.: "*Ficus pseudopalma* is an endemic medicinal plant with great ethnobotanical applications. Aside from being an ornamental plant, it is also being consumed as food and medicine" (Santiago et al. 2014). Less frequently, ornamental plants are considered as important as other useful plants (Estrada-Castillón et al. 2014).

Ornamentals sometimes constitute a starting point to evaluate its food, medicinal, and/or toxic properties (Maroyi 2012; Radji and Kokou 2014). Alike, some ornamental flowers are analyzed as source of nutrients and nutraceuticals (Mlcek and Rop 2011; Rop et al. 2012), and the aesthetic values of the edible flowers (color, scent) are subordinated to the alimentary and medicinal uses. Less often, the situation is the opposite: the ornamental meaning of certain medicinal plants is evaluated (Sharma et al. 2014).

Ornamentals in Homegardens and Related Contexts

A large number of studies in ethnobotany show the rising interest in *homegardens*, both in rural and urban contexts, in different countries (Albuquerque et al. 2005; Pochettino et al. 2012b, 2014). Ornamentals have its place in homegardens, but its relative relevance varies in different gardens and places and also depending of the researchers' interest. Thus, in certain works on homegardens, the ornamentals are excluded, e.g., because its presence is considered transient and hard to count (Vlkova et al. 2010). Many studies about homegardens in rural areas indicate that food and medicinal plants are more abundant than ornamentals (e.g., Aworinde et al. 2013). In contrast, also for rural areas, ornamental species outnumber the food/

medicinal plants (e.g., Neulinger et al. 2013). A particular case is that of rural homegardens where the management of the gardens depends on local ecotourism planning: the inhabitants need to improve the scenic beauty of their own houses (Pamungkas et al. 2013). In urban homegardens, often the amount of ornamental species cultivated exceeds that of plants of other use categories (Gasco 2008; Eichemberg et al. 2009).

With regard to homegardens and also to larger crop areas and dwellings, some ethnobotanical studies deal with ornamentals for biofences, shelterbelts, and even wind erosion control (Borkataki et al. 2008; Rovere et al. 2013).

Another aspect related to ornamental plants of gardens and homegardens, mainly in peri-urban areas, is linked to the fact that many ornamentals escape from cultivation. This is a neglected topic in ethnobotany but has special interest for the science of *biological invasions*, because horticultural practices are considered the main source of exotic species into the naturalization process, which could become invasives. In this sense, invasive species perturb the local biocultural diversity as a whole, whereby it requires not only a biological approach but also ethnobotanical and ethnoecological (Hurrell and Delucchi 2013). Ethnobotanical studies that connect the ornamentals introduced in gardens with the biocultural impact of its naturalization are needed. That is, investigate the local botanical knowledge about why plants are cultivated and also about how they expand and grow spontaneously. For the ethnobotany field, this issue is still *terra incognita*, and we hope that it will serve as an encouragement for future explorations.

Ornamentals: Aesthetic and Symbolic Values

The aesthetic value of plants is present through human history, e.g., the legendaries *Hanging Gardens of Babylon* (Finkel 1988) and the *tulipmania* in the Netherlands in the seventeenth century (Ryan 2012), among other remarkable examples. Likewise, gardening is at present one of the fastest-growing hobbies in North America, and the ornamental industrial production contributes with billions of dollars annually to the economy (Hopkins 2007; Palma et al. 2011). The aesthetic values of plants are based on an implicit concept of *beauty*, e.g., when it is said: "Human culture and evolution have been directly impacted by the beauty of plants in our environment and in our gardens since the earliest known humans" (Relf and Lohr 2003). But beauty *depends* on the cultural context in which it acquires meaning.

When it argues that the ornamentals "add beauty" to our houses, workplaces, schools, shopping centers, sports stadiums, and religious buildings (Oloyede 2012), it is clear that beauty of plants is placed in its physical features. This is characteristic of many Western societies where, e.g., they were studied, "the effects of product attributes, consumer characteristics (demographics) and seasonal factors affecting consumer demand for ornamental plants" (Palma et al. 2011).

In Western cultures, it also strongly consolidated the predominance of the vision over other sensorial pathways, like the olfactive and/or tactile (Ryan 2010).

In another cultures, aesthetic values of ornamentals are linked to another framework, as it occurs in India where they are closely related to religion and involve visual, olfactory, and other features (Nirmal Kumar et al. 2005; Sharma et al. 2014).

According to some authors, ornamental plants evoke "pleasant feelings" and provide a sense of "well-being" which is why we preserve urban parks, we surround our homes with gardens, and we consider that flowers are the most common gift for weddings, births, birthdays, and funerals (Kravanja 2006; Hopkins 2007; van den Eynden 2013). In this context, the aesthetic values of ornamentals are strongly connected with symbolic cultural aspects.

The value of ornamental plants as *symbols*, i.e., that it represents some aspect of the people's life, depends on each cultural context. There are several examples: flowers that represent purity or love, trees or flowers employed in heraldry or to represent communities or countries ("national flowers"), metaphorical expressions as "solid as an oak" or "flexible as a willow," certain mythological figures as the biblical "tree of knowledge of good and evil," or the huge ash called *Yggdrasil*, the "tree of life" in Norse mythology; also ornamentals that represent aspects connected to ritual, ceremonial, and religious dimensions; in ancient Egypt, flowers of a particular sacred tree were considered life giving ("flowers of life"); in Roman funerals, the corpses were adorned with flowers as an expression of honor and affection, and nowadays, ornamental trees (like cypresses) are grown in graveyards, or flowers (like lilacs and lilies) are used in funerals and for garnish tombs (Dafni et al. 2006; Ryan 2012; van den Eynden 2013; García Pérez 2014).

Ornamentals can be considered from a utilitarian point of view, such as the medicinal, food, fiber, and timber plants, among others. Nevertheless, the ornamentals in ethnobotany should also be evaluated in its symbolic dimension, from a non-utilitarian perspective (Ryan 2012). A comprehensive approach could enrich the ethnobotanical studies about relationships between people and ornamental plants.

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Timber Resources

Marcelo Alves Ramos, Maria Clara Bezerra Tenório Cavalcanti, and Fábio José Vieira

Abstract An introductory scenario regarding the use of human subsistence timber resources based on discussed experiences on the subject in the scientific literature will be presented. The aim was to position the reader on general patterns used in ethnobiological studies. However, any generalization on this subject is limited, given the limited scientific knowledge accumulated thus far for this theme. Thus, in this short reading, regions where timber forest resource studies are concentrated and the main wood categories and forms of use will be discussed. In addition, factors that influence timber forest resource selection and the socio-environmental implications of this activity will be presented.

People generally associate the acquisition of timber vegetation cutting with clear-cutting practices,[1] i.e., extractions that are performed in great magnitude, mainly by logging companies. However, logging is also carried out on a smaller scale, which is practiced by human populations to meet their subsistence needs. This exploitation form is very common in tropical forests, and given that it is continuously carried out by many human groups, it deserves more attention.

[1] Clear-cut corresponds to general woody vegetation being cut down. There is also selective cut practice, which involves the collection of specific targets. This mainly occurs in cases in which species are recognized as having higher quality.

M.A. Ramos (✉)
Departamento de Ciências Biológicas, Universidade de Pernambuco,
Campus Mata Norte, Rua Amaro Maltez, 201, Centro, Nazaré da Mata, Pernambuco, Brasil,
CEP: 55800-000
e-mail: marcelo.alves@upe.br

M.C.B.T. Cavalcanti
Departamento de Ecologia, Universidade Federal do Rio Grande do Norte,
Campus Universitário Lagoa Nova, Caixa Postal: 1524, Natal, Rio Grande do Norte, Brasil,
CEP: 59078-900
e-mail: mclara.btc@gmail.com

F.J. Vieira
Departamento de Biologia, Universidade Estadual do Piauí, Campus Prof. Barros Araújo,
BR 316, Km 299, s/n, Altamira, Picos, Piauí, Brasil, CEP: 64602-000
e-mail: fabiojosevieira75@gmail.com

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In ethnobiology, there is a shortage of studies dedicated to investigating timber uses by human populations. Some authors suggest that this occurs for historical reasons, because ethnobiological studies have always been more focused on medicinal and food use research. What can be safely said is that there are many vague aspects regarding the standards related to timber use at the domestic scale. This is reflected in the methodological issues related to the subject, for example, what a researcher should consider as logger use. Ramos et al. (2014) reported the lack of uniformity within this category. These authors exemplified that some studies may treat full products, such as chairs, tables, and house roofs, as a single timber use, while others may consider these product parts: a chair leg, the backrest, the table foot, the table board, the house roof beams, and the rooflines and slats.

It is important to establish timber resource ethnobiological research methods. If this is not done, it will be difficult to compare data from different studies, as well as identify patterns. Timber use classification must differentiate each part that makes up a wooden structure, as different species can be employed for each of these parts. Thus, specific resource use must be taken into account, as timber use for different purposes may require distinctive dynamics and collection standards, and this can contribute to differential impacts on accessed forest areas. Factors that influence timber resource selection will be discussed later.

Where Are Timber Resource Studies Concentrated?

Most ethnobiological research directed toward human subsistence timber resource use is concentrated in the tropical region. Therefore, what is known about this subject mainly consists of information acquired from human populations of this region. There are some African, Asian, and Latin American countries that still heavily use forest-collected firewood. In general, these nations have developing economies (emerging) or are underdeveloped, with low to average Human Development Indexes (HDI). Outside the tropics, the use of domestic wood as fuel is less intense.

One explanation for this scenario is that there is a direct correlation between poverty and forest resource dependence (Gaugris et al. 2006). Regarding the exploitation of timber products, this correlation is even more narrow, as a great amount of timber is required to provide essential components for the daily lives of families, such as fuel to cook food and heat the house (Kakudidi 2007). Additionally, it is in the tropical region where most of the world's forest formations are located. Thus, human populations in this region can still acquire timber resources more easily through collection, instead of having to purchase them in the market.

How Do Communities Use Timber Resources and How Are They Classified?

Human beings have a natural tendency to classify things. In ethnobiology, individual uses cited by informants are also usually classified into use categories (e.g., food, medicine, veterinary, fuel). These categories relate to the most significant uses of a group of species.

Forest timber products are used for several purposes by local communities, especially to ensure their subsistence. The most common uses are fuel burning (firewood or charcoal), building structures that enclose spaces (roofs, walls, fences), and manufacturing goods used in people's daily activities (such as work tools, hunting traps, and containers for food and water reserves), which is designated as technology. There is also timber use for making artifacts related to magical-religious practices, although this record is less frequent in the scientific literature. Such major categories (fuel, construction, technology, and magic-religious) (Ramos et al. 2014) have been identified through ethnobiological studies analyzing timber use. However, the emergence of new categories is possible, but it is necessary to develop more research to register new uses and indicate their respective utility categories.

Some research has shown that fuel use is very representative in terms of the amount of timber consumed. It is usually associated with human populations with low purchasing power. Firewood appears as an alternative to petroleum-based fuel use, such as cooking gas, which has a higher cost. The purposes of firewood include home heating, food cooking, and environmental lighting. Timber can also be used as a fuel in different household activities, as in the case of human populations that manufacture ceramic pieces from clay and need to use fuel to burn the produced parts and complete the firing process.

Regarding construction timber, timber is collected in forests to meet needs related to domestic and/or rural buildings, such as house building (walls, roofs, doors, and windows) and land delimitation (stakes and fences). Fuel and construction categories are peculiar in that they do not require extensive raw material manipulation (timber), unlike some cases that fall under the technology category. The latter usually requires craftsmanship of wood structures. Therefore, this use has been more easily abandoned by people, as it requires higher dedication and local experts. This category covers many different items with uses ranging from kitchen utensils (wooden spoons) to transportation (wagons).

Timber uses intended to meet religious needs have also been observed. In northeastern Brazil, for example, many human communities assemble campfires with natural vegetation timber to honor three Catholic saints in annual June festivities: Antony, John the Baptist, and Peter (Almeida et al. 2008). It is a strongly rooted custom in popular Catholicism in the region and promotes the extraction of large amounts of timber.

Which Factors Influence Timber Forest Resource Selection?

Human populations recognize and select species with the most suitable characteristics for each use purpose. Some species can be better used in certain situations over others. Perceptions about which plants are best for a particular purpose may vary among human groups. Some environmental factors (forest plant availability, ease of resource access), characteristics that are inherent to the species (wood quality, diameter, shape, density), and individual cultural formations have a strong influence on this selection process (Almeida et al. 2008; Ramos et al. 2008; Medeiros et al. 2011).

For every timber use category, there are some species selection strategies that are more frequently observed; these are treated as selection patterns in ethnobiology. However, there are exceptions to the observed general patterns. In this section, only the most reported patterns in the literature for each timber use category cited in this chapter will be discussed.

Fuel

It is common to find some local communities selecting firewood species based on the perception of calorific potential (see Chettri and Sharma 2009; Tabuti et al. 2003). In this use category, dry plant branches and trunks are usually collected to be used as firewood, as green timber is not appropriate because it has more water in its plant tissues. The fuel category accounts for a high plant material consumption, given that demand for this resource occurs on an almost daily basis for populations that make use of it. Another wood-derived fuel is charcoal, whose use is more harmful to the environment than timber. This is due to the need for large-diameter trees for its production, in addition to the fact that the timber does not need to be dry to be collected.

Construction

In this category, the collection frequency is lower, because timber generally tends to last for a long period of time without being constant replenishment (Medeiros et al. 2011, 2012). Therefore, the total volume of wood used in these cases is smaller than that used as fuel. This use usually requires plants that do not have many substitutes in the forest. That is, particular and specific characteristics of timber are required, which is why collection pressure is not equally distributed among other species. Another aspect of this category is that it primarily requires green wood collection to make structures, as dry wood deteriorates faster. This selection pattern can result in higher impact on the species of plant populations used, as collectors must eliminate the living individual to remove the material needed for use.

Technology

Smaller amount of wood has been collected for the creation of raw material in the category of technology instruments. This is because timber resources are being replaced for manufactured products, which are produced from timber obtained in planted forests and other materials, such as plastic, plaster, rubber, and metal. However, some products of this category of use usually need of constant collection, such as production of handcrafts by communities, which provide wooden products to meet demand for a large commercial market oriented for tourism.

A positive point is that produced utensils in this category have durability and do not need to be frequently replenished. However, tool making requires specific selection criteria. For example, in the case of work tools (hoe, ax, or hammer handle), people tend to choose woods that are popularly called “light” and “cold,” i.e., that do not produce heat with prolonged contact. In domestic instrument production (wooden spoons, tables, pestles), people tend to choose low-density species that are recognized as “soft or smooth woods,” as this facilitates the craftsmanship to shape the wooden structure (Medeiros et al. 2012).

Magical-Religious

Developing a timber use standard for magical-religious purposes is not possible, as this use is not highly exploited. As stated before, some northeastern Brazil rural and urban communities create bonfires in front of their homes to honor Catholic saints in June. This tradition is very important, even in areas where native species logging is banned. In this case, villagers use wood from exotic species or pioneer native species, which are abundant in disturbed areas, rather than giving up the practice (Almeida et al. 2008). This scenario may signal a use pattern: woods with specific characteristics are not required because the purpose is to honor the saints and be part of the local tradition. In South Africa, there are also magical-religious artifacts made from wood, locally called *igoqo*, *krall*, and *ubuhlanti*, which are present in different social class residences. These artifacts more frequently occur among the richest people, indicating that cultural factors can be decisive for this logging activity (Cocks et al. 2006).

Socio-Environmental Implications of Timber Uses

Despite the obvious importance of minimizing the impact of the unsustainable use of woody species, it is important to remember that many families depend on these resources. Many local low-income communities have forest products as their sole subsistence source.

Studies that propose more participatory approaches to ensure resource protection already exist (Cai and Jiang 2010; Montes et al. 2011). Examples are (1) the adoption of a minimum trunk diameter for logging, thus stimulating regeneration; (2) the establishment of energy forest programs, promoting joint participation with local populations to combine local species preferences and plant regenerative potential (Kumar et al. 2011; Montes et al. 2011; Sharma and Samant 2014); and, finally, (3) more rational use, subject to basic needs of the family, such as more efficient stove use or utensils that consume less firewood, as examples (Türker and Kaygusuz 1995; Samant et al. 2000; Top et al. 2004).

Many communities live in protected areas where there are timber resource use restrictions, which can have positive and negative biodiversity conservation implications. On one hand, due to the imposition of restrictions associated with little supervision, local populations can circumvent rules and perform unsustainable extraction, mainly because local needs are not considered when establishing these collection criteria. On the other hand, norms can promote use that meets local consumption demands and conserves resources through proper management. However, it is emphasized that in areas governed by management plans, periodic reviews of established rules are needed, as people's needs and culture are constantly changing.

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Animal Resources

Rômulo Romeu Nóbrega Alves

Abstract Directly or indirectly, people depend on the animals for different reasons. Throughout history, humans have been using animal-derived products especially for food and also for clothing, tools, and medicinal and magic-religious purposes. Live animals are main attractions in zoos, safaris, and oceanariums. They are also crucial in scientific research and in military, agricultural, sporting, and crime- and drug-fighting activities. Additionally, fauna serves as the inspiration for myths, legends, and tales in various societies. This chapter provides a brief review on the main forms of interactions between humans and other animals and its biological, socioeconomic, and cultural implications.

Earth is inhabited by humans and an enormous variety of other animals, resulting in a series of interactions that were established over time (Alves 2012; Alves and Souto 2015). An important part of these interactions is related to the use value of fauna, which represents a source of products essential for the survival of humans since their origin. Animals are used in various ways, such as for food, clothing, tools, artisanal crafts, entertainment (zoos, aquariums, oceanariums, and safaris), pets, and even medicinal and magical-religious purposes. Additionally, fauna serves as the inspiration for myths, legends, and tales in various societies. Fauna has also been used in the production of energy (draft animals), in the fight against illegal drugs, and in military and sporting activities (Fig. 1).

An animal species can have multiple uses, supplying different products that serve different purposes, which enhances even more the importance of particular animals for humans. Clearly, one of the most essential aspects of fauna is the utilization of its products to meet nutritional needs (Reitz and Wing 2008). Archeological studies show evidence that humans have consumed a large variety of animals over millennia (Emery 2007), emphasizing the role of fauna as the principal source of protein in many human cultures (Gross 1975). The search for these resources is reflected in the development of a series of techniques and strategies that characterize

R.R.N. Alves (✉)
Departamento de Biologia, Universidade Estadual da Paraíba
Avenida das Baraúnas, Campina Grande, Paraíba 58109-753, Brasil
e-mail: romulo_nobrega@yahoo.com.br

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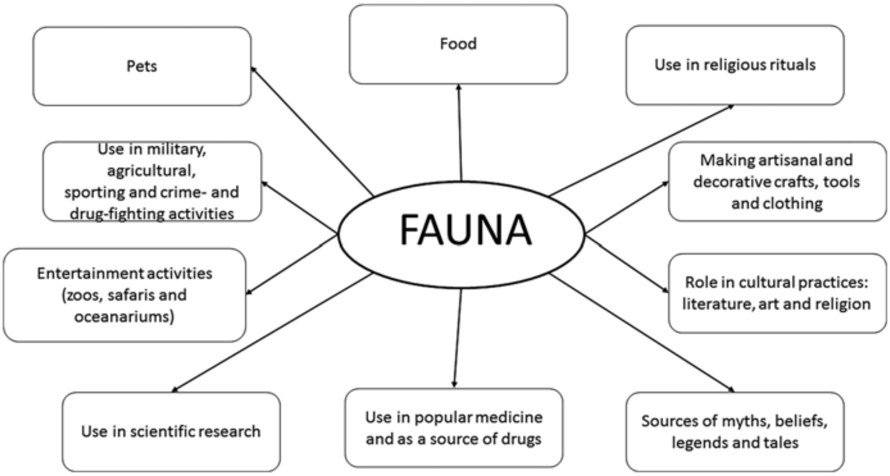

Fig. 1 Representation of principal uses of fauna for humanity

two of the oldest activities of humanity, hunting and fishing (Alves 2012). The former predominates in continental areas and the latter in coastal areas, where terrestrial vertebrates and fishing resources, respectively, are the animals directly useful to humans. In general, the main animal groups involved in hunting are, in order of preference, mammals, birds, and reptiles (Alves et al. 2009; Robinson and Redford 1991), and in fishing, resources such as fishes and invertebrates (e.g., crustaceans, mollusks, and echinoderms) are usually more exploited in coastal areas, although aquatic reptiles and mammals are also exploited.

Fauna also plays an important role in human health. Along this line, animals have been used as source of medicines, in both traditional medical systems and the pharmaceutical industry. In the first case, whole animals or their parts constitute, along with plants, the main ingredients for the preparation of traditional remedies. This practice, utilized for millennia, still exists today and is one of the alternative therapies practiced in the whole world, in urban and rural areas (Alves and Rosa 2013). But in the second case, recent studies have demonstrated that products of animal origin are highly promising resources in the search for new drugs of medical or pharmaceutical interest (Alves and Albuquerque 2013). Besides their use in traditional medicine or as a source of new drugs, animals are essential in research, in which results have direct or indirect implications on human health (Chorilli et al. 2009). The discovery of new drugs and the development of organ transplants and various surgical techniques and practically all research protocols regarding the safety, toxicity, efficacy, and quality control of new drugs require the use of laboratory animals (Fagundes and Taha 2004).

Among the forms of interaction between people and fauna, which involve the use of live animals, the breeding of pets is one of the most common. This practice involves millions of people who interact with a variety of taxa, domestic and wild (Alves 2012; Alves et al. 2013). Although there is a predominance of mammals (mainly dogs and cats) and birds, other animals such as reptiles, amphibians, and some groups of invertebrates have also become increasingly common domestic animals (Alves 2012).

Besides the important role of fauna, from a functional and economic perspective, animals have played a role in cultural practices in all parts of the world (Shepard 1996). The cultural importance of animals is reflected in art, literature, symbolism, mythology, and religion, among other important cultural aspects of humanity (Alves 2012; Kalof and Resl 2007; Kothari 2007). As pointed out by Klingender (1971), in all periods of the history of humanity, animals have been utilized by humans in art and literature to symbolize their religious, social, and political beliefs, and artists have found constant inspiration in the grace and beauty of animal forms. Many species have been and continue to be associated with religious practices. Animals are considered sacred, where zoomorphic or anthropo-zoomorphic deities continue to be worshipped; animals are involved in religious rituals, and products of dead animals are utilized to decorate altars and religious temples in different countries of the world (Alves et al. 2012).

There are various other forms of use of fauna by humans, including products used as personal accessories, decoration, and tools. Parts such as horns, bones, ivory, and skins have been used by humans as ornaments and decorative material (Pedersen 2004). The first humans hunted animals, to eat their meat and use other products such as skins, bones, and teeth for construction material, ornaments, or weapons (Pedersen 2004). Marine animals also supplied a series of products used and traded as curiosities, souvenirs, decorative items, handicrafts, and jewelry (Dias et al. 2011).

The influence of animals on human life is striking, and our culture is richly permeated by zoological components (Bryant 1979). As a result, a variety of interactions developed between humans and other animals in the course of history, obviously having implications on both. Sadly, in the last years, the exploitation of fauna through hunting and fishing has intensified more and more, resulting in serious threats to the populations of many exploited species. Nevertheless, there are still examples of human communities that have used animal resources in a sustainable way (Alves 2012). Thus, it is increasingly necessary to understand the multidimensional context (biological, socioeconomic, political, and institutional factors) of interactions between humans and animals, a panorama that reveals the importance of ethnozoological studies in confronting the challenge of finding forms of exploitation that minimize the impact on animal species, an increasingly clear necessity in the context of animal conservation and human survival as well.

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Part IV
Biota Management and Domestication

Plant and Landscape Local Management

Ulysses Paulino Albuquerque and José Ribamar Sousa Júnior

Abstract People have long been managing natural resources. This management can consist of two types: community and individual species. Community management can be understood at the landscape level when territory, biotic, and physical components are modeled, as well as their interactions and processes. Individual species management is well documented for semidomesticated plant species under domestication processes, particularly in the Mesoamerican region. Different management types (community and individual species) can be observed in agroforestry systems, which are land-use forms in which there is high biocultural diversity. These systems, which are widespread in tropical regions, maintain natural vegetation components through local management practices.

There has been much discussion of the negative impact of human society on biodiversity, particularly due to the strong imbalance generated by modern industrialized societies, which has led, among other things, to genetic diversity reduction and the overexploitation and extinction of many animal and plant species (Caballero 1994). However, there has been little study of how local people exploit, conserve, and enrich biodiversity (Caballero 1994), influencing the distribution of plants and animals that are useful to them. Ethnobiological studies have been documenting different forms of interactions between people and plants (Caballero 1994; Casas et al. 1996, 2007), including individual species and community management (Blancas et al. 2010). Natural resource management is a complex process involving the interaction of numerous factors, such as culture, environment, economy, and ecology. Thus, studying plant management by different human groups can offer new perspectives on the conservation and sustainable use of these resources.

This text is an extensively modified, updated, and translated version of Albuquerque (2005).

U.P. Albuquerque (✉) • J.R. Sousa Júnior
Laboratory of Applied and Theoretical Ethnobiology (LEA), Department of Biology,
Federal Rural University of Pernambuco, Av. Dom Manoel de Medeiros, s/n, Dois Irmãos,
52171-900 Recife, Pernambuco, Brazil
e-mail: upa677@hotmail.com; riba_jrsjunior@hotmail.com

U.P. Albuquerque, R. Alves (eds.), *Introduction to Ethnobiology*,
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Local Management of Natural Resources

Tropical forest resource management follows two manipulation types: community manipulation and individual species manipulation (Table 1). This framework has been recognized by other researchers as well: Alcorn (1981) refers to mass manipulation and individual plant manipulation. Medellín-Morales (1990) discussed what he calls forestry management, which corresponds to mass manipulation, and arboreal management, which corresponds to individual manipulation. In turn, Irvine (1989) introduced the idea of succession management, which includes the two methods mentioned above and was defined as tropical forest succession natural course change by favoring useful species distribution.

Community and individual species management are not mutually exclusive in terms of time and space, and both methods may be concurrently exercised (Irvine 1989). The difference between the methods is that, in the first, actions are concentrated in the plant community as a whole, and in the second, they are focused on a particular species.

Community Management

Many studies have revealed that tropical indigenous cultures manipulate their natural resources (Toledo et al. 2003; Bandeira et al. 2005). Balée (1989) estimated that approximately 11.8 % of the Amazonian non-flooded forest is anthropogenic, and this human manipulation of resources was a cultural factor of great importance for people adapted to this region. In this sense, the existence of large anthropogenic areas is attributable to the plant management system exercised by various ethnic groups, as some researchers argue.

The management processes indicated in Table 1 can be exemplified in the case of Kayapó Amerindians (North Brazil), which intentionally manipulate a vast repertoire

Table 1 Summary of management strategies performed by local people in the neotropical region

Community management	Individual species management
1. Species plantations[a–e]	1. Collected plants[f–h]
A. Domesticated plants B. Semidomesticated plants	2. Semidomesticated plants (under incipient management)[f–j] A. Tolerance B. Promotion C. Protection
2. Useful species transplant (primary or secondary forest)[e]	3. Cultivated plants[f–h]
3. Selective weeding[k]	
4. Canopy pruning[k]	

References: [a]Alcorn (1981), [b]Alcorn (1989), [c]Balée and Gély (1989), [d]Irvine (1989), [e]Posey (1987), [f]Casas and Caballero (1996), [g]Casas et al. (1997), [h]Casas et al. (2007), [i]Blancas et al. (2010), [j]Cruse-Sanders et al. (2013), [k]Medellín-Morales (1990) of useful plants concentrated in old crop and barn fields, where both primary and secondary forest species were transplanted. The habit of transplanting species to places along trails and campsites artificially produced forest fields. These fields reproduce "natural resource islands," concentrating useful plants and animals. The study by Anderson and Posey (1989) showed that of the total species recorded in these "islands," 98 % of them were useful for the Kayapó, and a large percentage of these plants (75 %) had been planted by the Amerindians. Some authors argue that the Kayapó have contributed to the protection and conservation of the vast tropical forest territory (see Zimmerman et al. 2001; Zimmerman 2010). According to these authors, social organization is one of the most important factors in the success of Kayapó territory conservation.

Community management reflects a pattern that involves planting, transplanting, species protection, and other actions, aimed at full resource utilization, and making temporal and spatial aspects compatible. The Kayapó habit of transplanting species, described by Posey (1987), is an important step for community management systems. Plant community modification through fruit species transplantation is an example of human intervention in natural biotic communities through species management (see Smith 2011). In addition, according to this author, plant community manipulation, with the intention of increasing the relative abundance of plants as food resources, is a niche construction form. Landscape mosaic establishment with high plant community variety is an effective strategy to increase environmental load capacity (Smith 2011).

Community management can also be seen at the landscape management level when territory biotic and physical components are modeled, along with their interactions and processes, to meet human group needs (Parra et al. 2012). From this perspective, a large number of plant species are managed through practices such as tolerance, protection, and cultivation, favoring native biodiversity maintenance (Blancas et al. 2010; Moreno-Calles et al. 2012). Good examples are landscapes where *Araucaria araucana* (Mol.) C. Koch and *Araucaria angustifolia* (Bert.) O. Kuntze species occur; the territorial expansion of these plants was favored by human groups (Reis et al. 2014), constituting *Araucaria* cultural landscapes. In addition, according to the authors, these cultural landscapes show the role of human societies as natural landscape modelers through *Araucaria* forest use practices and conservation. Another example is southern Brazil *caívas*, which are considered *Araucaria* forest cultural landscape ecotypes, in which plant resources are maintained by local management practices (Mello and Peroni 2015).

Individual Species Manipulation

Individual species manipulation corresponds to particularly devoted attention to certain plants of great interest. Among the three plant categories represented by this management type, as indicated in Table 1, based on their manipulation level and exerted selection pressure, semidomesticated plants (or under incipient management)

Table 2 Semidomesticated plant manipulation forms and their biological effects

	Used part	Manipulation forms	Modifications
Jaltomata procumbens (Cav.) L. Gentry	Fruits	Tolerated or protected individuals during agricultural work	Phenotypes with fewer fruits but with larger fruit size
Solanum mozianum Dun.	Leaves	Plow use favors individuals that grow in cornfields via vegetative reproduction	Gigantism and fruit dehiscence loss
Amaranthus hypochondriacus L.	Leaves	Exceptional individuals that grow in cornfields resulting in selection and grain spreading	Increased leaf biomass, inflorescence biomass reduction, shorter life cycle
Leucaena esculenta (Moc. et Sessé ex A.D.C.) Benth	Fruits	Individual tolerance, selection, and promotion due to farming operations	Reduction in the amount of grain secondary compounds, increasing grain and pod size
Opuntia spp.	Fruits	Exceptional individual transplantation, tolerance, and development in natural vegetation and crop fields	Larger fruit size and weight; greater color, weight, and fruit size variation
Porophyllum ruderale (Jacq.) Cass. subsp. *macrocephalum* (DC) R.R. Johnson	Leaves	Tolerance and promotion of adventitious forms, cultivation	Individual size reduction, higher leaf biomass, and lengthening

Compiled from several sources by Caballero (1994)

concentrate certain actions: *tolerance*, which allows selected individuals to remain in certain places, such as crop fields; *promotion*, which are actions that favor species distribution and dispersion by vegetative or sexual pathways; and *protection*, which consists of protecting certain individuals by eliminating competitors, for example, and increasing the chances of survival for these plants (Caballero 1994; Blancas et al. 2010).

These different methods of semidomesticated plant manipulation produce important biological effects (Table 2). Casas and Caballero (1996) found morphological divergence in populations subjected to different traditional management forms in *Leucaena esculenta* (Moc. Et Sessé ex A. D. C.) Benth. Plants selected for vegetable use morphologically differ from those in which the grains are used (Mapes et al. 1997). A good example is that of *Amaranthus hypochondriacus* L., in which individual promotion via seed dispersion has resulted in increases in leaf biomass and its life cycle as biological effects (Caballero 1994). Another interesting case is that of *Stenocereus stellatus* (Pfeiffer) Riccobono, which is widely used in Mexico for food purposes. Indigenous groups are able to distinguish and classify species variations based on fruit morphological characteristics, verifying that wild plants have small fruits, which are red and sour flavored, with a thick and thorny pericarp, differing from plants grown by people, which vary in one or more of these characteristics (Casas et al. 1997). According to these authors, *S. stellatus* is experiencing a domestication process via artificial selection mechanisms. Plant manipulation by means of traditional management is also producing woody plant biological effects. *Sideroxylon palmeri* (Gonzáles-Soberanis and Casas 2004), *Ceiba aesculifolia* (Avendaño et al. 2006), *Spondias tuberosa* (Lins Neto et al. 2012), and *Crescentia cujete* (Aguirre-Dugua et al. 2013) tree species are among the primary examples. For these species, local management has favored morphological modifications of human selection target characteristics (fruit size).

These studies have serious implications on new plant resource detection and discussions of diversity and overall evolution. In addition, local management can contribute to plant genetic resource sustainable use and conservation (Ekue et al. 2010), as well as to our understanding of the plant domestication process. The different plant resource management forms add important genetic diversity to that which already exists through the selection and maintenance of different genotypes that are useful to human populations (Casas et al. 2006; Cruse-Sanders et al. 2013).

Tropics Agroforestry Systems

The management systems noted in this chapter may also be present in agroforestry systems. Agroforestry systems are widely spread land-use forms in the tropics, which include natural vegetation components that are managed through agricultural and forestry practices, among others (Albuquerque et al. 2005; Moreno-Calles et al. 2010; Parra et al. 2012). These are high biocultural diversity systems (Moreno-Calles et al. 2012), among which "backyards" can be highlighted; these are areas located around homes or small properties that are characterized as management and land-use areas. Such systems undoubtedly represent germplasm test and exchange sites in the communities in which they are practiced and are important connections between natural populations and agroforestry systems (Parra et al. 2012).

Agroforestry systems can be practiced in several ways. Some of their features include long-term support, risk reduction through a combination of market and subsistence products, and dependence on local knowledge and technology sources. These characteristics result from the ecosystem knowledge of local populations, who are capable of making their practices ecologically and economically sustainable through the use of locally available resources (Altieri and Koohafkan 2008; Blancas et al. 2010). Thus, agroforestry systems guided by local experience and techniques can be created, maintaining the right proportions, as an alternative to the highly destructive and unsustainable conventional cultivation techniques that are currently employed in the tropical region.

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Indigenous Use of Tropical Biodiversity and Ecosystem Domestication

Maximilien Guèze

Abstract People have long-induced modifications of ecosystems to enhance the suitable conditions for useful plant species; similar to plant domestication, these modifications can be regarded as a continuum of use and management. In tropical forests, indigenous people have contributed to these modifications by using ecosystems both actively and passively through a process called *ecosystem domestication*. In this chapter, we explore the gradient of ecosystem domestication and its implications to biodiversity. Historically, indigenous societies actively managed ecosystems to make their livelihoods possible in areas otherwise inadequate; the effects of such past management systems are still observable in present biodiversity. Currently, indigenous people continue to modify the ecosystems in which they live, using a diverse range of management practices (e.g., forest gardens, fallow improvement, and agroforestry techniques) which can be equated to different degrees of anthropogenic disturbances. These practices have deep consequences for overall biodiversity, often enhancing it. Therefore, areas inhabited by indigenous people show a high potential for new approaches of biocultural conservation.

In studying human-plant interactions, researchers acknowledge that plant domestication is better understood as a continuum which ranges from wild species and varieties to fully domesticated and even genetically modified crops, containing a wide range of species and varieties with different levels of domestication in between (Clement et al. 2010). However, what is often less considered is that plant domestication has not occurred alone, but rather has also involved a deep modification of the biophysical environment—a process Michon and De Foresta (1997) called *artificialization* and of which *cultivation* represents the ultimate degree. Similar to what happens at the species level, modifications of the environment leading to artificialization have to be understood as a gradient: people have modified the ecosystems in which they live from less to more active degrees to enhance or create suitable conditions for plants of interest. Thus, in addition to the cultivation of a particular plant

M. Guèze (✉)
Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, Barcelona, Spain
e-mail: maximilien.gueze@uab.cat

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species, a continuum of actions—at different scales—modify ecosystem conditions (Wiersum 2004), resulting in *ecosystem domestication* (Michon et al. 2007). Such actions have profound consequences on the overall biodiversity of the ecosystem and not only for the favored species.

The livelihoods of indigenous societies living not only in the past but also nowadays have been based on different forms of the use and management of ecosystems. Such variety allows for the study of the continuum of ecosystem domestication, from zero management to fully agricultural systems, and its impacts on biodiversity.

Research on historical ecology has shown that, worldwide, large tropical areas and the biodiversity they shelter have been shaped by millennia of active management (Smith and Wishnie 2000; van Gemerden et al. 2003; Sheil et al. 2012). For example, in the Amazon, past indigenous societies built earthworks, such as canals, ditches, and raised fields for agriculture, in areas where flooding would have otherwise hindered settlement and cultivation (Denevan 1966; Erickson 2008). These human transformations have contributed to create different ecosystems, such as forest islands (Heckenberger et al. 2007; Lombardo et al. 2015), still observable nowadays. All across the Amazon, large areas of *terra preta* (Amazonian dark earths) are also observable. Such soils originated from repeated burning in past societies (McMichael et al. 2014) and support forest with different composition from forest found in non-dark sites (Quintero-Vallejo et al. 2015), thus representing another example of long-lasting impact on current biodiversity by past ecosystem management.

As in the past, contemporary indigenous societies continue to modify the environment in which they live, mostly in their effort to maintain their livelihood. Through such interactions, indigenous people have developed knowledge, beliefs, and practices not only about particular species but also about larger ecological units (Posey 1985). The pathways through which indigenous people modify tropical forest diversity are varied and range along a gradient of use-management intensity from minimal management to the engineering of ecosystems (Smith and Wishnie 2000). Although the effects of current landscape management practices on ecosystem artificialization are not always predictable, it is important to note that ecosystem use and management practices can be equated to other anthropogenic disturbances and as such play an important role in maintaining biological diversity in ecosystems (White and Jentsch 2001). Thus, different forms of forest management can be related to different levels of forest biodiversity (see Gueze et al. 2015), since anthropogenic disturbances in tropical forests can range from severe modifications of forest structure (e.g., logging or clearing of forest for agriculture) to smaller-scale below-canopy disturbances that do not necessarily imply structural changes, such as slashing around some trees of interest, sapling transplantation, and hunting (Peres et al. 2006).

Sacred forests provide a good example of minor management forms that do not always imply structural changes of the forest. People's dynamic social and political norms and beliefs are directly associated with management practices of sacred forested areas, hence with biodiversity (Sheridan 2008). The relationship between cultural management and biodiversity conservation within sacred forests is complex, and much debate is left on the role of these forests as conservation elements, particularly in fragmented landscapes where sacred groves do not always show significant differences in biodiversity with surrounding elements of the landscape (Bhagwat et al. 2005). While certain sacred groves are just a fraction of a forested area associated with dangerous spirits and thus intended to completely prevent the human presence, as it is the case among the Tsimane' of Bolivia (Huanca 2008), others are maintained to shelter a relatively high level of biodiversity and also contain many useful species and are thus designed to provide some basics of people's daily life, such as food, fibers, and firewood (Nyamweru et al. 2008).

Other forms of forest management, such as management for daily uses, represent intermediate stages in artificialization. Although forest management by hunter-gatherers is debated (Gadgil et al. 1993), the gathering of species that appear "wild" to Western conceptualization, such as wild yams for the Baka of the Congo Basin (Yasuoka 2006) and sago palms for the Punan of Borneo (Sellato 1994), seems to include other management practices similar to agricultural practices (Dounias 1994). Among other indigenous peoples that are not only hunter-gatherers but also agriculturalists, the literature provides many examples of indigenous agroforestry and forest gardens—the management of useful species in situ, often involving enrichment planting (Peters 2000; Wiersum 2004). Similarly, researchers have documented that people purposefully maintain species or groups of species within created or managed forests, something known as "domestic forests" (Michon et al. 2007). In the example of benzoin forests among the Batak Toba of Sumatra, people progressively include benzoin trees and manage forest mainly by selective cuts to allow young benzoin trees to develop (García-Fernández et al. 2003). The benzoin forest system thus involves mostly nonstructural disturbances, whereas other kinds of domestic forests are, in fact, secondary forest regrowths or "enriched fallows," involving a first stage of clear-cutting the forest for agricultural purposes. Both the management of the forest itself and the management of surrounding non-forest elements, such as agricultural fields or home gardens, lead to the creation of mosaics of ecosystems which, taken as a whole, enhance biodiversity at the landscape level (Gadgil et al. 1993).

The mosaics of ecosystems created by the combination of areas under different levels of disturbance represent what some researchers have termed *cultural landscapes* or areas where traditional ecological knowledge and biodiversity are closely interrelated through the incorporation of culturally valued biodiversity (Cocks and Wiersum 2014). Such biodiversity value can stem from the way people use species for material purposes or from the sacred or religious value they attribute to species and ecosystems. For example, Mulyoutami et al. (2009) have shown that many of the social norms of the Dayak of Borneo are highly interconnected with the management of different elements of the landscape, such as enriched fallows. As well, indigenous people have developed classification systems for landscape elements, which show the importance they attribute not only to species but also to the whole ecosystems (Hunn and Meilleur 2010; Riu-Bosoms et al. 2014).

Understanding the process of ecosystem artificialization has important implications in the light of biocultural conservation. The perception that tropical forests are "pristine" natural areas, without human intervention, still prevails among some ecologists, conservationists, and the general public. Although more research is needed to understand the interaction between indigenous people and ecosystems (e.g., on different spatial scales), this perception has led to conservation schemes—such as exclusionary protections—that often fail to effectively protect biodiversity (Vermeulen and Sheil 2007). Rather, growing evidence shows that primary forests appear to be a chimera and that conservation plans designed to conserve the "untouched" and restore the "damaged" are biased (Vandermeer and Perfecto 2014); areas inhabited by indigenous people seem more appropriate for biodiversity conservation (Porter-Bolland et al. 2012). Tropical forests should be seen as ecosystems used and managed in a dynamic way by the people who inhabit them; since indigenous people depend on tropical forests to survive, they have the need to conserve them, and bottom-up approaches to conservation, such as community-based strategies, should be prioritized.

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Extractivism of Plant Resources

Juliana Loureiro de Almeida Campos, Ivanilda Soares Feitosa, Julio Marcelino Monteiro, Gilney Charll dos Santos, Cristina Baldauf, and Ulysses Paulino Albuquerque

Abstract Extractivism of non-timber forest products (NTFPs) is often seen as an alternative to unsustainable modes of plant resource extraction. In this chapter, the reader will find a brief description of the main methods to collect these resources, as well as some consequences of these actions, both for the extracted plant populations and for the local communities that perform extraction. Examples of works and case studies reveal the trends in research conducted in this area of study and encourage participatory research, approaching the ecological studies of local communities in a joint search for alternatives that might sponsor both the livelihoods of these communities and plant diversity.

Human beings have used plants for thousands of years for support and autonomy. Throughout our evolutionary history, we have used these resources to meet our various demands. Among the several products that have been central to the livelihoods of human populations are non-timber forest products (NTFPs), which are characterized as "all biological materials other than timber which are extracted from natural forests for human use" (De Beer and McDermott 1989). Leaves, flowers, fruits, seeds, barks, roots, oils, and resins are examples of this category of resources.

J.L.A. Campos (✉) • I.S. Feitosa • G.C. dos Santos • U.P. Albuquerque
Laboratory of Applied and Theoretical Ethnobiology, Department of Biology, Federal Rural University of Pernambuco, Rua Dom Manoel de Medeiros s/n, Dois Irmãos, 52.171-900 Recife, Pernambuco, Brazil
e-mail: loureiroju@hotmail.com; lilithbio@hotmail.com; gilneycharll@hotmail.com; upa677@hotmail.com

J.M. Monteiro
Department of Biology, Federal University of Piauí, BR 343, km 3.5, Campus Amílcar Ferreira, Sobral, Piauí, Brazil
e-mail: juliommonteiro@ufpi.edu.br

C. Baldauf
Laboratory of Ethnoecology and Biodiversity, Department of Animal Sciences, Federal Rural University of Semiarid Region, Avenida Francisco Mota, 572, DCAN—Campus Oeste—UFERSA, Mossoró, Rio Grande do Norte, Brazil
e-mail: crisbaldauf@ufersa.edu.br

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At the end of the 1980s, the collection of NTFPs was presented as an alternative to unsustainable modes of extraction of natural resources, given that it apparently had a low impact both on the exploited species and the plant communities. Thus, generating income from these products would integrate biodiversity conservation with the development of local populations (Boot and Gullison 1995). However, currently, it is believed that the use of NTFPs exerts a wide range of impacts on biodiversity conservation. In many cases, market demands have led to the overexploitation of species (Ruiz-Pérez et al. 2004; Sunderland et al. 2011). In such cases, it appears that economic return can trigger a contrary action, encouraging disordered collection of the resource to obtain higher income arising from its sale. In general, the intensity of the collection is linked to the low prices paid to extractivists, leaving most of the profit in the final links of the production chain.

Recent reviews of the sustainability of NTFP collection have expressed a more optimistic outlook, especially for Latin America (Stanley et al. 2012; Shackleton et al. 2015). In a compilation of 101 studies on NTFPs, it was found that only 17.8 % of the studies reported the unsustainable collection of species studied, and the other cases exhibited different degrees of sustainability (Stanley et al. 2012).

From an ecological point of view, there is a wide range of responses of species to extractivism, ranging from increased exploitation of plant populations to the decline of these populations (Ticktin and Shackleton 2011). Extractivism can affect the physiology and life processes of individuals, change genetic and demographic patterns of populations, and change processes at the levels of communities and ecosystems (Ticktin 2004). The most direct consequences of NTFP extraction are the changes in survival, growth, and reproduction rates of individuals collected (Ticktin 2004). However, the impact depends on a number of factors, including the part of the plant that is exploited and its regeneration potential, the frequency and intensity of the collection, the time of year of collection, and the stage of the plant life cycle (pre- or postbreeding), among others (Ticktin and Shackleton 2011). Moreover, it is possible that extractivism has more severe consequences for a species that has multiple uses (e.g., fruits and firewood) compared to another species that is extracted for a single purpose.

Extractivism in Practice

Fruit collection for food is a common practice carried out by local or traditional communities around the world. In general, this activity tends to be sustainable, as the exploited plants generally produce many fruits for a long period of time (Ticktin 2004), as verified by Sampaio and Santos (2015) for the palm species *Mauritia flexuosa* L.f. (buriti). However, when performed unsustainably, usually due to market pressure, fruit extraction can lead to a decreased dispersion process, thus affecting species recruitment and the maintenance of its natural stocks. This trend was observed by Santos (2012), studying the extractivism of *Caryocar coriaceum* Wittm. (pequi) in the Brazilian savanna. As for fruits, the collection of leaves has

Fig. 1 Individuals of the species *Stryphnodendron rotundifolium* Mart. (barbatimão, **a**) and *Himatanthus drasticus* Mart. (Plumel) (janaguba, **b**) subjected to the extraction of stem bark in Chapada do Araripe, Ceará, NE Brazil. Photos: Ivanilda Feitosa/Cristina Baldauf

great potential for sustainable management, although eventually the allocation of resources in a plant can change, leading to a decrease in the number of reproductive structures (Endress et al. 2004).

Exudates such as oils, resins, and latexes represent intermediate potential for sustainable management, as the collection of such products can also reduce the production of flowers and fruits of the exploited species, a fact noted by Rijkers et al. (2006) for the African species *Boswellia papyrifera* (Caill. ex Delile) Hochst, a producer of an important medicinal resin (frankincense). On the other hand, no negative ecological impacts were observed with copaíba oil (*Copaifera reticulata* Ducke) extraction in the Amazon rain forest (Herrero-Jáuregui et al. 2011).

Among the features that have low potential for sustainable management are the barks of trees that are usually collected for medicinal use. Depending on the form of collection and the amount of bark removed, extractivism can lead to death of individual plants due to stem girdling and the interruption of phloematic flow (Fig. 1a). For the collection of bark to be ecologically viable, the removal of bark must be performed in a superficial way, without damaging the xylem and phloem, which can only be performed by experienced extractivists supported by traditional and/or technical knowledge (Fig. 1b).

With regard to resource sustainability, collection must be carried out with consideration to the regenerative capacity of each species. In cases where the resource to be collected is stem bark, the removal of strips on opposite sides of the trunk, below the level of the first branch, is suggested (Cunningham and Mbenkum 1993).

For species that possess fruits as exploitation targets, collection may be limited by the minimum amount necessary for their dispersion and fauna feeding (Peters 1994). However, these more generalized alternatives may not be sufficient because the response to extractivism is species specific and also varies among different ecosystems in which a species occurs. In addition, socioeconomic and political contexts profoundly influence plant collection strategies. In many cases, feature demand will define how intensely a plant product will be extracted. If the extraction is carried out for domestic use, the impact of this action will be lower, given that the resource will be extracted, in principle, to a lesser extent. However, the extractivism intensity of a certain plant resource also depends on other factors such as the value of this resource for the people who extract it and social and economic factors that modulate the relationship between the people and the resource.

Given the above and in view of the lack of research for most of NTFPs, the most suitable thing to do would be to invest in participatory studies (with teams of scientists and local people) to examine the ecological and socioeconomic impacts of extractivism and to jointly search for alternatives that may sponsor both the livelihoods of local populations and plant diversity. Until recently, the collection of NTFPs was considered the ideal alternative for balancing biodiversity conservation with income generation in communities. However, the accumulation of research on the extractivism of NTFPs in recent decades has shown that the sustainability of a resource requires the difficult conciliation of ecological and economic factors (Guimire et al. 2004). Furthermore, management strategies for sustainability must be culturally accepted: without the involvement of the local community in the development and maintenance of sustainable practices for the collection of NTFPs, the chances of success are very small. Cunningham and Mbenkum (1993) reported that in the region of Cameroon, in Africa, a plan consisting of guidelines was developed for the collection of sustainable bark of the species *Prunus africana* (Hook. f.) Kalkman. However, despite efforts to maintain this practice, in many cases, these guidelines are not followed, and the collection is not sustainable.

Chart 1. Case Study: Linking Extractivist Perceptions with Ecological Analyses of Sustainability

The extraction of the species *Rhizophora mangle* L. for the use of its stem in buildings is a common practice in urban and rural populations living near a mangrove forest in Venezuela. Thus, López-Hoffman et al. (2006) integrated ecological studies with the knowledge of extractivists to generate strategies for creating a program of management and conservation of this species in the region. Researchers interviewed 50 extractivists, questioning their perceptions of sustainable extractivism, the forms of collection and management of the species, and the average number of individuals of the species collected daily, in addition to verifying the socioeconomic profile of the extractors. At the same time, researchers performed a population dynamics study in populations of *R. mangle* undergoing different collection intensities, performing the same analyses on a control population (with no extraction). It was found

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that the extraction levels considered sustainable by extractivists were not sustainable from an ecological point of view. Even the populations that underwent a low intensity of extraction had significantly lower amounts of adults when compared to populations that did not undergo extraction. The authors suggest some collection strategies for extraction to be performed in the least harmful way possible for the species populations and indicate the incorporation of extractivists as monitors in conservation programs. Moreover, they suggest actions for the transfer of knowledge between adults and young people to be effective, as it was observed that older extractivists collect in a more sustainable way than younger extractivists.

Based on the scenarios discussed above and considering the strong impact caused by the extraction of many NTFPs, mitigating actions, in addition to the studies mentioned above, can be suggested and adjusted to each case: farming and the participatory improvement of species; the selection of substitutes that are more resistant to extractivism, containing characteristics or similar amounts of bioactive compounds (in the case of medicinal plants); certification of sustainable management practices; and adoption of public policies based on studies of the impact of extractive activities, among others (Monteiro et al. 2011). Additionally, it is recommended to ensure that conservation actions are appropriate to local conditions, incorporating the knowledge of the extractive populations in developing conservation strategies, as many conservation actions can backfire if they are not conducted with these populations.

Human activities modify ecosystems, and the management of NTFPs is one of these activities. In view of this, it is common to find an arena for debates based on extreme positions. On one hand, it is believed that people who depend on collecting plants are increasingly threatened by the loss of biodiversity and habitats; on the other hand, some argue the opposite: natural resource diversity is threatened by the extractive activities of these people at different scales. Both positions are extreme because this relationship cannot be viewed dichotomously and uniformly across the board, and additionally, the solution is not to disadvantage one side to favor another. Over time, professionals have come to the conclusion that the conservation of natural resources is complex and therefore requires the active participation and involvement of all social actors related to the problem: conservation biologists, human and social scientists, environmental managers, and local or traditional communities.

Chart 2. Case Study: Relating the Regeneration of Brazilian Chestnut to Collection Intensity

Given its great economic importance, the seeds of Brazilian chestnut (*Bertholletia excelsa* Bonpl, Lecythidaceae) are highly exploited by various human populations that inhabit the Amazon rain forest. In addition to intensively collecting the

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seeds of this species, extractivists also hunt their main disperser, the "cutia" (*Dasyprocta* spp.), during collection periods, which can be detrimental to the regeneration of *B. excelsa*. However, extractivists could potentially contribute to the regeneration of this species, acting as additional dispersers during collection activity. Given this scenario, Scoles and Gribel (2012) assessed, over 3 years, the natural regeneration of *B. excelsa* in sites with intensive, little, and no extractive activity in the state of Pará, northern Brazil. To do so, the authors correlated regeneration indicators (densities of seedlings, young, and juveniles) with potential explanatory ecological variables (collection intensity, canopy openness, agouti activity, density of mature trees, basal and crown area of *B. excelsa*). The study showed that the region is characterized by a low proportion of juveniles, a domain of large trees, and a tendency for tree aging. There were no seedlings or young trees at 52 % and 80 % of the sites studied, respectively. It was found that low regeneration rates were independent of both the collection intensity and the dispersion by "cutia." The study found no significant effect of the intensity of collection on the regeneration of species, revealing that in extractive areas closer to extractivists, for the collection and transport of seeds, the densities of young and juvenile trees were higher. The authors concluded that the implementation of restrictions on the collection of Brazilian nuts may be ineffective in the study area, which could generate great socioeconomic damage to the extractivists who are dependent upon the collection of this resource. Thus, the authors suggest that rather than banning the collection of seeds, compensatory measures should be implemented involving and encouraging local communities, such as the production of seedlings in nurseries followed by the enrichment of clearings, forest edges, and altered areas, to promote the growth of new populations of *B. excelsa* in the region.

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Plant Domestication

Ernani Machado de Freitas Lins Neto, José Ribamar Sousa Júnior, Alejandro Casas, and Ulysses Paulino Albuquerque

Abstract Animal and plant domestication phenomena have allowed people to "domain" the environment, ensuring food predictability and safety. As a result, gradually moving away from hunter-gatherer behavior to a social organization characterized by securing human fixation and developing agricultural practices was a natural tendency. In this context, this chapter presents some of the key discussions regarding plant domestication, emphasizing Latin American examples and models.

The verb "to domesticate" etymologically means to bring into the house (*domus*, in Latin, means house) or build the house, which has an environment in which it is possible to people to exercise plant or animal domination (including microorganisms). This idea leads to the identification of domestication as the process by which plants and animals are shaped to be incorporated into the home (Darwinian approach to domestication), as well as the process of shaping the house (landscape and ecosystem domestication, etc.).

E.M.F. Lins Neto (✉)
Laboratory of Ecology and Ethnobiology, Federal University of Vale do São Francisco, campus Senhor do Bonfim, Av. Tomaz Guimarães, S/N Bairro Santos Dumont, Senhor do Bonfim, Bahia, Brazil
e-mail: ernani.linsneto@univasf.edu.br

J.R. Sousa Júnior • U.P. Albuquerque
Laboratory of Applied and Theoretical Ethnobiology, Department of Biology, Federal Rural University of Pernambuco, Rua Dom Manoel de Medeiros, s/n, Dois Irmãos, 52.171-900 Recife, Pernambuco, Brazil
e-mail: riba_jrsjunior@hotmail.com; upa677@hotmail.com

A. Casas
Instituto de Investigaciones en Ecosistemas y Sustentabilidad (IIES), Universidad Nacional Autónoma de México, campus Morelia, Michoacán. Antigua Carretera a Pátzcuaro 8711, Col. San José de la Huerta, C.P. 58190 Morelia, Michoacán, México
e-mail: acasas@cieco.unam.mx

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Plant and animal domestication by humanity clearly indicates how the species has evolved, as it is a way to control nature and direct it to specific needs. The structural and technological organization of human society today is partly due to a coevolutionary process. Agriculture emergence, for example, was gradual and decisive for the formation of society as it is known today (Childe 1952; Braidwood 1960; Harlan 1975). Thousands of years ago, hunter-gatherer societies were already developing agricultural practices (Harlan 1975). Today, humanity is found in an advanced technological state, which is directly and indirectly attributable to agriculture onset and development.

Studying the interactions between people and plants allows us to deepen our understanding of one of the closest relationships between human beings and natural resources, as well as understanding one of the main phenomena responsible for the development of human society. In this chapter, the main theories and concepts regarding plant domestication will be presented.

Explanations for the Rise of Agriculture

Agriculture arose between 9000 and 11,000 years ago in different parts of the world and independently. This statement, which can be found in most texts that address domestication, leads to an intriguing question: how it was possible for such a complex phenomenon to arise independently, in a similar way and in the same time frame in several places in the world? This is an issue that has greatly mobilized research efforts regarding plant domestication. Studies show that agriculture mostly likely emerged in the late Pleistocene, a period characterized by climate change, which, according to most studies, such as that of Piperno (2011), brings together environmental characteristics that appear to be associated with the hunter-gatherer transition to agricultural development. Among these environmental changes, weather pattern stability is highlighted as the most important variable, as well as global warming onset, the emergence of more humid environments, and increased CO_2 levels (Piperno 2011).

Different hypotheses have been suggested to explain the rise of agriculture and plant domestication. From these attempts at explanation, the struggle for food is highlighted, as proposed by Brian Hayden (1998). According to this author, domestication did not begin with an external cause, such as environmental context, but with an internal cause, whose driving force is provided by social motives and powerful relationships. Other hypotheses consider environmental issues to be a major factor for the rise of plant and animal domestication. This applies to the Oasis Theory, created by Childe (1952), which proposes that, after glaciation, some African and Asian regions have undergone prolonged droughts, forcing human groups to settle in regions with water supplies. Thus, for plants and animals that were found in these irrigated valleys, domestication was possible. Population size was another variable considered in attempts to explain agriculture emergence.

According to Cohen (1977), population increase generated food supply pressure, which inevitably resulted in the emergence of farming practices.

These are only some of the ideas proposed for the rise of agriculture. In fact, considering the complex nature of this phenomenon, it seems to be more plausible to accept the idea first suggested by Harlan (1975) that, in the face of different environmental and social contexts, agriculture emergence could have several explanations.

It is now possible to reconstruct the history proposed by agriculture origin theorists. Blancas et al. (2013) suggested that because plant management and domestication motivations are currently known, it is possible to study the factors that influenced and still influence human decisions. The authors studied how plant management and domestication decisions are made and how different ecological, sociocultural, economic, and technological factors significantly contribute to these decisions.

Domestication Centers

Domestication occurred independently in several regions of the world. After years of study and plant material collection, Nikolai Vavilov proposed the concept of origin and diversity centers. This concept was based on higher genetic variability and the presence of the wild relatives of certain plant species in certain places when compared to other regions of the world (Vavilov 1951, 1992). Thus, eight domestication centers proposed by Vavilov arose. They are the Chinese center (oats and soybeans), Indian center (cotton, rice, and sugarcane), Central (lentils, peach, and wheat) and Minor (alfalfa and barley) Asian centers Mediterranean center (cabbage and lettuce), Ethiopian center (barley and flax), Central American center (beans, corn, and pumpkins), and South American center (potatoes, cassava, peanuts, and tomatoes). In some cases, certain plant species are referred to as originating from more than one center. This is due to some doubts that still persist with regard to their origins.

Paying particular attention to origin and diversity centers in the Americas, four regions are currently considered (Smith 2011), instead of two, as proposed by Vavilov: Western North America, Mesoamerica, the Andean region, and the South America tropical lowlands, with the main examples of domesticated plants in these areas being the sunflower (*Helianthus annuus* L.), corn (*Zea mays* L.), beans (*Phaseolus vulgaris* L.), and potatoes (*Solanum tuberosum* L.), among others (Smith 2011).

Discussions with respect to origin centers and species domestication are still strongly maintained due to the constant emergence of new findings, more robust explanatory theories, and new analytical methods. Stating that a particular species originated in a specific place but was domesticated in another, for example, involves more factors than merely species geographic occurrence. Therefore, to understand this coevolution, it is necessary to focus attention on plant selection and management by people.

Selective Forces and Management Influences on Domestication

Charles Darwin was one of the first naturalists to credit human action as a plant change or variation promoter. Darwin explained this observation in the early chapters of his famous work *On the Origin of Species* and subsequently deepened the discussion in *Variation of Animals and Plants Under Domestication*. The author called "artificial selection" the selective force exerted by people on organisms of interest. This concept was subsequently extended to develop the idea of natural selection. Over the years and as a result of scientific and technological advances, plant domestication began to be conceptualized as a process by which humans determine plant population genetic structure changes by favoring the genotype frequency that represents advantages for their subsistence and social and cultural life development (Lira and Casas 1998). This process is directly linked to human group survival needs, i.e., plant selection criteria are based on the plant's cultural importance as a resource.

Artificial selection can occur through two main mechanisms, defined by Darwin (1868): the unconscious, when it acts to preserve the domestication target species characteristics that are desired by people, and the methodical, which determines different characteristics within the same species (Heiser 1988). Both selection forms, unconscious and methodical, determine differences; the difference is in the generation speed of such differences, which is higher under methodical selection. This selection is strongly associated with the fact that human groups deliberately select individuals with interesting characteristics to be maintained in the population, intentionally increasing certain phenotype frequencies. In addition, methodical selection is accompanied by reproductive management techniques that help to increase the likelihood that a crossing will determine progeny with a desirable phenotype.

Among domestication models that give special emphasis to cultural aspects of plant domestication, Mesoamerican models are highlighted, which focus on understanding the early stages of this complex relationship between people and plants. Mesoamerica, which comprises Southeastern Mexico to the Northwest of Costa Rica (Casas et al. 1997), is one of the main agriculture origin centers in the New World. In this region, prehistoric cultures manipulated a wide range of plants (Harlan 1975; Piperno and Pearsall 1998).

Such studies developed in Mesoamerica identified the existence of three traditional community plant population management levels: collection, in situ management, and cultivation. According to González-Insuasti and Caballero (2007), considering the levels shown above, in situ management can be still divided into nonselective in situ management and selective in situ management. Moreover, according to the authors, in the first case, selection is directed toward increasing and maintaining desirable phenotype availability in a population, which can lead to the decrease of undesirable phenotypes. In the second case, the desired resource increase and availability maintenance not only are achieved, but the desired trait quality is also increased, given that attention is directed to the selected phenotypes. In summary, González-Insuasti and Caballero (2007) concluded that it was possible to distribute plant functions on an ascending management scale, following a manipulation intensity gradient arranged as follows: gathering, nonselective incipient management, selective incipient management, occasional ex situ cultivation, and cultivation. The authors also highlighted the fact that intensity not only depends on the already-described management practices but also on the number of people involved in this activity. Subsequently, Blancas et al. (2010, 2013) found that management intensity is a response to risk level and resource availability uncertainty. Risk or uncertainty is related, on the one hand, to cultural and economic importance levels of the resource as well as, on the other hand, to resource scarcity.

Incipient management forms, which are selective and nonselective, may also be classified according to the attention directed at the resource, distinguishing on the basis of tolerance, protection, and promotion (Caballero 1990; Salinas et al. 1993; Casas et al. 1997). Individuals that have desirable characteristics for these resources sponsor cultures that can tolerate other crop areas. For promotion, people directly engage in the distribution and dispersion of species via vegetative or sexual pathways, and people also protect species within the environment created by man, especially from competitors (Salinas et al. 1993; Casas et al. 1997). In addition to the management forms described above, systematic collection must also be considered a management form. Although it does not have the same evolutionary and management strength of the others, the most important consequences of this practice involve the selective collection of particular phenotypes, collection area rotation, and resource exploitation restrictions. These human activities can influence the early-stage domestication process that a certain species may be subjected to (Casas et al. 2007; González-Insuasti and Caballero 2007).

This model has been applied in other regions of Latin America, like Peru (Piperno 2011) and Brazil (Lins Neto et al. 2010). In Brazil, studies have applied these Mesoamerican models for two fruit tree crops. In Northeastern Brazil, the relationship between people and *Spondias tuberosa* Arruda (umbu), a native species of the "Caatinga," was studied. According to the authors, based on the results for *S. tuberosa*, it can be inferred that individuals of this species are in the incipient domestication process given the employed management forms (Lins Neto et al. 2013). Still, in the Northeastern region, another species that has gained attention for its human population management is the pequi (*Caryocar coriaceum* Wittm), which will be addressed in detail in Chart 1. In southern Brazil, a study examining the use and management of *Acca sellowiana* ("goiabinha-serrana") found that the traditional knowledge patterns associated with local management practices are crucial to the development of breeding programs as well as conservation of this species (Santos et al. 2009).

Chart 1: Pequi Management in Chapada do Araripe, Northeastern Brazil

Pequi (*Caryocar coriaceum* Wittm) is one of the plant species that is more intensely extracted by local people of the Chapada do Araripe region in Northeastern Brazil. This species is managed in different forms and intensities throughout the region. Fruit collection is the main management form, especially inside the Araripe National Forest (FLONA), but other management forms, such as sowing and individual protection, may be observed in the forest surrounding areas, where this management intensity is higher. Strong pequi extraction can be credited to its food and economic importance. An ethnobotanical study conducted in the region showed that food use, in addition to commercial purposes, of the oil extracted from the fruit was most frequently cited by local informants (Sousa Júnior et al. 2013). During harvest, people often form camps near the forest, facilitating collection and even serving as oil production sites and sites for a pequi traditional festival that takes place at the end of the season. Fruit size and flavor are the main characteristics perceived by local people and are used to differentiate pequi tree populations. In this context, a study conducted at FLONA pointed to the morphological divergence of *C. coriaceum* population fruits in three distinct region areas, with one of those being a collector community area. In this area, it was observed that fruits were significantly different from those of the forest interior based on the following variables: seed length, dry seed weight, and pulp thickness. This may be because the community area has higher management form diversity. In this area (community), pequi tree fruits are considered better because they are protected. Fruit collection, on the other hand, is more intense inside the forest, and this may be related to *C. coriaceum* abundance in this area compared to adjacent forest areas. Therefore, pequi is considered a very important species in terms of food use, economic factors, and cultural life for the Araripe region people.

Perspective

As highlighted throughout the text, cultural variables play a central role in domestication studies. In addition to this strong aspect to be considered in domestication studies, Blancas et al. (2013) and Larson et al. (2014) highlighted that researchers face three major challenges in this process: filling geography and genomic map gaps between domesticated species lists and their wild relatives; considering the environmental and ecological contexts of agricultural practice origins, such as global temperature change processes; and answering one of the main issues previously mentioned in the text: why did hunter-gatherers become farmers and pastoralists? It is evident that domestication studies are complex, therefore requiring the involvement of different disciplines to jointly clarify issues related to the coevolution process between people and plant origin and development.

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Domestication of Animals

Rômulo Romeu Nóbrega Alves

Abstract Humans have shared the planet with millions of other animals and have historically exercised dominance over them. Throughout of this long coexistence, one of the most important ethnozoological phenomena of history emerged—the domestication of animals. Domesticated animals have been fundamental to the well-being of humans, providing nutrition, income, transport, company, and entertainment. The historical, economic, social, and cultural importance of animal domestication is briefly discussed in this chapter.

Humans have historically exercised dominance over other biological species, many of them being fundamental to our survival. This domination culminated in one of the greatest accomplishments in the development of human civilization—the domestication of plants and animals. These processes date to remote times and involved the selection and maintenance of certain living organisms in order to suit human needs. In the case of the fauna, Clutton-Brock (2007) pointed out that domestication can be defined as the maintenance of animals in captivity by human communities, with total control over their reproduction, territorial organization, and feeding.

From a historical perspective, the domestication of biological resources resulted in extremely important modifications of human lifestyles, allowing populations to abandon nomadic practices (carried out since the very beginning of human evolution) and become sedentary and occupy certain territories where plants could be cultivated and animals domesticated. This situation progressively decreased human dependence on gathering activities, hunting, and fishing. The domestication of other living organisms therefore allowed humans to progress beyond a hunting and gathering stage to become farmers and pastoral agents—a transition that profoundly transformed humanity. Diamond (2002) pointed out that those civilizations that domesticated animals (and plants) gained more power and were more capable of disseminating their cultures and languages.

R.R.N. Alves, Ph.D. (✉)
Departamento de Biologia, Universidade Estadual da Paraíba
Avenida das Baraúnas, Campina Grande, Paraíba 58109-753, Brazil
e-mail: romulo_nobrega@yahoo.com.br

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Human societies have always maintained close interactions of dependence or codependence on faunal resources. Animals have always played critical roles and will continue to have important roles, in the lives of humans, and many different species have been domesticated by human civilizations in every part of the world—varying only in terms of the animals available in those regions and the products that they could provided. Within this context, the domestication of animals arose to supply the critical necessities of humans, resulting in the selection and maintenance of species considered useful, especially those that provided meat. According to Kisling (2001), domestication was a long-term biological process that required the maintenance of wild animals for many generations and was only fully accomplished when significant changes occurred in the behavior, physical attributes, and genetics of the captive species. These alterations were presumably not initially envisioned by those human communities, leading us to conclude that domestication was not premeditated or predetermined.

Although the principal motivation for the domestication of most species was their potential to furnish products consumed as food by humans (Diamond 2002; Muller 2002; Russell 2002), the very first domestication was apparently not, in fact, directly associated with this basic directive. It is believed that the first domesticated animal was the wolf (*Canis lupus*), somewhere in the Middle East about 14,000 years ago—giving rise to domesticated dogs (*Canis lupus familiaris*, a subspecies of wolves) (Muller 2002). These animals proved to be extremely useful as guards and in helping humans during their hunting activities (Muller 2002), a role which they still fulfill even today (Koster 2008). Later, other mammals were also domesticated, such as cattle, sheep, goats, and pigs, with the goal of providing meat and milk; domesticated birds supplied both meat and eggs. Sheep and goats were domesticated in the Middle East between 7000 and 9000 years ago. Cattle were domesticated approximately 8000 years ago in what is now Iraq and, independently, about 7000 years ago in modern-day Pakistan. Pigs were domesticated in the Far East approximately 9000 years ago, and horses in modern-day southern Russia approximately 5000 years ago (Allaby 2010).

In relation to birds, geese appear to have been domesticated first, although it is possible that ducks were domesticated about the same time. The Romans were familiar with Angolan chickens, and the original inhabitants of North America maintained domesticated turkeys and may have domesticated rabbits for their meat. Traction animals, another important category of domesticated mammals, have likewise been domesticated for thousands of years (although more recently than animals kept principally for their meat and milk). Donkeys and camels were probably the first beasts of burden, with horses being used for that purpose slightly later. Llamas have been used to carry burdens in remote Andean regions of South America since distant times (Barsa 1969).

It is clear, therefore, that the historical motivations that led humans to domesticate animals were quite varied. Hunters and gatherers used domesticated dogs to aid in their daily activities, and later, the husbandry of vertebrates allowed human societies to supplement their diets with regular sources of meat, milk, and eggs and use their skins as protection against the elements (Alves and Souto 2010). Additionally,

Table 1 Motivations/uses associated with domesticated animals and the principal groups of animals involved

Motivations associated with domesticated animals	Principal animal groups involved
Dietary use	Bovines, swine, birds, and Leporidae
Pets	Dogs, cats, birds, Leporidae, rodents
Manufacture of belts, wallets, handbags, accessories, coats, hats, shoes, etc.	Bovines, swine, llamas
Animals of traction and for transport	Bovines, camels, horses and llamas
Assistance in hunting and herding, guides for the visually impaired	Dogs
Warfare activities and combating drugs and crime	Horses and dogs
Treating human infirmities through contact with domestic animals	Horses, dogs, and cats
Use in scientific research	Dogs, cats, and rodents

cattle provided fertilizer for their fields, and some domestic animals later became useful for transportation and as sources of muscle power for plowing and transporting goods—therefore multiplying the productive capacities of humans and increasing their spatial mobility (Ribeiro 1998).

Domesticated animals continue to be fundamental to the well-being of our species, providing nutrition, income, transport, company, and entertainment (Scanes 2003). The food sources derived from domesticated animals (meat, milk, and eggs) contribute significant sources of protein, thus satisfying the nutritional needs and eating pleasure of essentially all human populations (Givens et al. 2004). Not surprisingly, the production of domestic animals for their meat represents one of the principal economic activities worldwide (FAO 2013). The industries that cater to domesticated animals kept as pets likewise generate billions of dollars in revenue annually (Brady and Palamari 2007). Other domestic animals have taken on important roles in human activities, such as warfare, rescue work, combating crime, and sports (Table 1). Animals currently have an important role in medical and pharmacological research, as test subjects for new drugs and surgical techniques before liberating their use by humans (Alves 2012).

The domestication of animals has had profound impacts on both past and present human societies and has attracted the attention of numerous researchers for examination from many angles. Domestic animals have been studied by zoologists and scientists from associated disciplines such as animal husbandry and veterinarian medicine—the latter having its origin strongly related to the domesticated fauna of our planet (Dunlop and Williams 1996; Fernández 1978). Animal husbandry is an applied discipline that seeks to develop and perfect the potential of domesticated animals, as well as those with potential for domestication, to increase their production as food resources (and other ends). Veterinary medicine focuses on animal health, with domesticated animals being one of its principal concerns. Another discipline that has taken special interest in the domestication of animals and plants is archaeology, with many researchers concentrating their attention on dating processes that could lead us to better understand when and how domestication occurred (Digard 1994). The relationships between people and domestic animals have likewise been studied in disciplines such as psychology (Wilson 1991) and sociology (Sanders and Arluke 1993).

It is therefore evident that different aspects of animal domestication have been examined from the point of view of various academic disciplines, due to the extremely relevant roles of these vertebrates in human societies. Within this context, ethnobiology and, especially, ethnozoology (which focuses on interactions between humans and animals) (Alves and Souto 2015) can furnish relevant contributions to our comprehension of these important themes. Relationships between humans and domestic animals occur in all human societies to greater or lesser extents and involve historical, social, cultural, economic, psychological, and sociological aspects that can be studied through ethnozoological research.

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Ethnobiology and Biodiversity Conservation

Ulysses Paulino Albuquerque and Daniel Carvalho Pires de Sousa

Abstract To talk about biodiversity conservation today means relating biological aspects to inseparable social and cultural aspects. Ethnobiology stands out in this field of study because it offers a perspective on the relationships between people and the environments in which they live. Many ethnobiological works help understand how human populations survive, manage, and exploit the resources of an area. These works may be useful in planning conservation policies and management strategies for natural resources.

Conserving biodiversity necessarily involves, in addition to the usual biological aspects, important and inseparable social and cultural aspects. Certainly, local knowledge systems provide strong elements for the conservation of natural resources, as these systems are developed from the interrelation between nature and culture. Therefore, efforts to understand how different human groups exploit, handle, and perceive the environment in which they live are critical to understand how these cultures can be sustained over different generations (see Pardo-de-Santayana and Marcia 2015). Thus, there is a great interest from the scientific community to understand how the practices of local communities can assist in public health policies and biodiversity conservation (King and Furgal 2014). Ethnobiology has emerged as the science that seeks to understand the importance of local knowledge to overcome various social challenges, among them the conservation of biodiversity (Vandebroek et al. 2011; Silvano et al. 2007).

Data from ethnobiological research can be used in planning decisions, which could (and should) include local communities as an interested party, as they can actively participate in various initiatives for the conservation of their own environment, maintaining, for example, plants and animals that are important to them (Aymoz et al. 2013).

This text is an extensively modified, updated, and translated version from Albuquerque (2005).

U.P. Albuquerque (✉) • D.C.P. de Sousa
Laboratory of Applied and Theoretical Ethnobiology (LEA), Department of Biology,
Federal Rural University of Pernambuco, Av. Dom Manoel de Medeiros, s/n, Dois Irmãos,
Recife 52171-900, Pernambuco, Brazil
e-mail: upa677@hotmail.com; danielcarvalho099@gmail.com

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In addition to seeking to include the will of people in policy development for the conservation of their areas, ethnobiology also identifies cultural traits that indirectly converge to the maintenance of biodiversity. Conservation principles can be found, for example, in myths and food taboos[1] (Chernella 1987), thus rationalizing the use of natural resources. Some people declare that natural resources will be exhausted if not used properly. Quiroz and van Andel (2015), in a study involving two African communities, found that endangered plants present in the official IUCN list were protected by supporters and religious leaders. They were likewise perceived by the population as scarce, therefore demonstrating the existence of a strong relationship between taboos associated with restrictions on the use of these species and the intention to preserve them.

Knowledge of biological cycles allows many cultures to exploit resources according to the capacity of nature by observing the behaviors and habits of each animal or plant species. It is possible to mention, as an example, a case study in northern Brazil with fishermen regarding the eating habits of fish in the Rio Negro (Amazonas) (Silvano et al. 2007). The study found that fishermen knew how to differentiate various ecological patterns of aquatic habitats, some known by scientists, by applying this knowledge in their practices so as not to degrade or overexploit the environment. Another example is from the Tukano Indians of northern Brazil, studied by Chernella (1987) and also mentioned by Primack (1993), who have a diet based on roots and fish that involves strict observation of the life cycles of the fish in that environment.

The techniques and management practices used by some local populations may be ecologically sustainable while respecting the complexities and sensitivities of ecosystems. A classic and well-documented case is that of the Kayapó Indians of Northern Brazil (Posey 1979; Overal and Posey 1990). The Kayapó control pests by properly managing the environment, using species of ants to protect farms and medicinal and fruit plants against *atta* ants and other insects. Posey (1979) notes that among the Kayapó, crops are also protected from pests by utilizing the land at regular intervals and changing the positions of fields. Local practices and techniques can also indirectly help sustainability. In a study conducted in New Mexico (United States), it was found that local irrigation in agriculture brought several benefits to the maintenance of riparian vegetation biodiversity of nearby rivers, recharging groundwater in the hydrological system of the region (Fernald et al. 2015).

Data obtained from different indigenous groups can have serious implications for conservation policies. Prance et al. (1987), in an ethnobotany study with four Amazonian indigenous groups, the Kayapó, the Brazilian Amazon Tembé, the Panare (Venezuela), and the Chacabo (Bolivia), quantified the percentage of useful species for each of these groups. Through a forest inventory, together with an ethnobotanical study, they found the following percentages of useful species: Kayapó (76.8 %), Tembé (61.3 %), Panare (48.6 %), and Chacabo (78.7 %). These data, combined with that obtained by other researchers, show that tropical forests possess

[1] It is often claimed that traditional communities do not overexploit their resources. Some of these claims are made without collecting biological and ecological data to support them.

a large number of useful species, and this fact, for some, already makes a strong case for conservation (see Gavin 2009). The study by Prance et al. (1987) indicated that, due to the intense use of species and high endemism, there is a need to create many conservation areas in the Amazon. However, conventional conservation projects are generally focused on natural resources, completely excluding local people and their perceptions and experiences, even though these people are responsible for the maintenance of these areas (Nastran 2015). In this regard, a recent work by Gavin et al. (2015) proposes the idea of investing in sustainability projects with biocultural approaches, which, according to the authors, provide unique approaches because they take into account all parties involved in the process. Bennett (1992) states that the preservation of tropical forests requires the preservation of indigenous communities and their knowledge.

To characterize a biocultural sustainability-based system, some authors suggest that the idea of "natural forests" should be rethought, as well as the modalities of conservation, prohibiting, with their own management systems, the use of natural resources by local people (Diegues 1993). The creation of parks and reserves without considering local populations generates greater problems with uncontrolled exploitation because locals can exploit resources that they once protected (see Diegues 1993). A study conducted in Mexico by Méndez-López et al. (2014) perfectly translates these consequences. The authors interviewed the residents of communities that have suffered under various government conservation initiatives and found that about two-thirds of those involved were not even consulted on the rules and regulations of the new protected areas. Thus, protected areas created under these circumstances project an outdated image of untouched biodiversity, creating various conflicts and contradictions with the reality of residents.

Sustainable Development in Tropical Forests

It is possible to state that present society has revealed itself to be extremely unsustainable. If nothing changes, in 2030, we will have three billion new middle-class consumers and will use approximately 40 % more water (Sircova et al. 2015). It is possible to point to four factors that may justify this statement: "(1) exponential human growth; (2) depletion of the natural resource base; (3) productive systems that use clean technologies and low energy efficiency; and (4) value systems that provide unlimited expansion of material consumption" (Rohde 1994). These factors, added to the combined results of economic, ecological, social, cultural, and ethnobiological studies, show that biodiversity conservation and sustainable development issues extend through different levels. The very idea of sustainable development appears utopian given the consumption standards of our society and the moral and ethical values we cherish. However, what usually occurs in development policies is the import of techniques and practices that are foreign to the local reality, to the detriment of models developed by local people with their resource management strategies, which are often overlooked in decision-making processes (Diegues 1993; Aymoz et al. 2013).

Ethnobiology can contribute to research on the evaluation of areas for conservation and on sustainable development in the tropics. Thus, the incorporation of local knowledge in development programs becomes interesting, especially when short-, medium-, and long-term strategies are developed (see Aymoz et al. 2013). Medellín-Morales (1990) conducted a study in a Totonac community in Veracruz, Mexico, that exemplifies this issue. The Totonac community consists of 165 families and 754 inhabitants. They have a deep knowledge of their environment and how other indigenous groups from the tropics exercise shifting cultivation systems alongside other productive activities. The Totonac farmer recognizes eight ecological units in which he performs management practices, manipulating approximately 234 species of plants, 110 species of animals, and 39 species of fungi. Based on a multiple-use ecosystem strategy, the Totonac achieve high ecological and energy productivity and an economic surplus through the sale of various products (Toledo 1995).

Local natural resource management methods can point to alternative strategies for the development and use of the environment. An important factor that must be considered is that in the tropics, farming practices and management of natural resources are not isolated activities, as the former is based on the latter (Alcorn 1984). In fact, local ecological knowledge can be the guide for further research and studies aimed at building a sustainable management model in tropical ecosystems. Gavin et al. (2015) outlined eight principles to maximize the positive results of sustainable approaches: "(1) Acknowledge that conservation can have multiple objectives and stakeholders. (2) Recognize the importance of intergenerational planning and institutions for long-term adaptive governance; (3) Recognize that culture is dynamic, and this dynamism shapes resource use and conservation; (4) Tailor interventions to the social-ecological context; (5) Devise and draw upon novel, diverse, and nested institutional frameworks; (6) Prioritize the importance of partnership and relation building for conservation outcomes; (7) Incorporate the distinct rights and responsibilities of all parties; (8) Respect and incorporate different worldviews and knowledge systems into conservation planning."

The success of conservation and development programs relates to the necessary attention that must be given to local knowledge systems. Local knowledge documentation of methods and selection, pest control, cultivation, and use of natural resources management techniques can bring great benefits to the rational management of natural resources and the development of sustainable agriculture in the tropics, for example. When we talk about sustainable agriculture, interpretations may be different without necessarily involving commitments to the future (Matson et al. 1997). For these authors, the great challenge is to increase production by eliminating undesirable effects on local resources. Certainly, it is naive to assume that the practices of local people can meet the world's food needs and other plant products.

Ethnobiology can collaborate in the development of more environmentally friendly farming systems and help integrate aspects of local knowledge. As a result, it can reduce local impacts on natural resources. It is also important to record local ecological knowledge and make it available for future generations, as this knowledge is increasingly losing ground (King and Furgal 2014). This contribution will help to overcome the aforementioned challenges, and it requires the participation and integration of various segments of society for its implementation (see Noble and Dirzo 1997; Matson et al. 1997; Reyes-Garcia et al. 2013).

Final Considerations

How can ethnobiology contribute to biodiversity conservation and sustainable development? By (1) identifying the sustainable use of natural resource processes, (2) identifying native biological resources, (3) assessing the economic potential of forests and promoting the marketing of non-timber products (Bennett 1992), and (4) developing projects for biodiversity conservation in situ based on the traditional knowledge of local populations. However, ethnobiology can only fulfill this role if it receives ever-increasing incentives and ample institutional support to apply the information obtained toward solving problems that threaten the stability and integrity of ecosystems and local people.

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Part V
Factors Affecting Local Biological Knowledge

Local or Traditional Knowledge Transmission and Natural Resource Use

Gustavo Taboada Soldati

Abstract Several subjects aim to understand human behavior and the factors that influence it. Many theorists value genetic, individual, and environmental paths, while little attention is aimed at social interactions, such as knowledge transmission. Factors related to cultural transmission that influence natural resource knowledge and use will be discussed from an ecological-evolutionary point of view, assuming that these processes are essentially a representation of human behavior.

Imagine a culture system composed of a set of individuals with or without kinship, what is also known as social peers. Each of these individuals stores a set of information (traits) that determines their behavior. This information may have three different origins. It can be derived from a genetic basis, knowledge produced by the individual, and cultural transmission (Laland 2004; Soldati 2015), the latter process being synonymous with "social learning" (see Heyes 1994). In the first case, the content present in the genes produces or predisposes to certain types of behavior. Individual production occurs when an individual, via individual experiments, produces new knowledge or an innovation. Despite being a costly process, as it demands time and energy, this new information is always adapted, as it was designed in line with current environmental and social conditions (Rogers 1988; Feldman et al. 1996).

Cultural transmission is also defined as the process by which "*we acquire a multitude of beliefs, attitudes, preferences, knowledge, skills, customs, and norms from other members of four species culturally, through learning processes such as imitation, teaching, and language*" (Mesoudi 2013). The transmission process involves four elements: (a) *information*, content to be transferred; (b) a *model*, those that initially had the information; (c) an *apprentice*, the individual who will receive the trace; and (d) and a social and environmental *context* in which the process takes

G.T. Soldati, Ph.D. (✉)
Department of Botany, Federal University of Juiz de Fora,
Rua José Lourenço Kelmer, s/n, Brazil Bairro São Pedro, Juiz de Fora, Minas Gerais
36036-900, Brazil
e-mail: gtsoldati@gmail.com

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place. Knowledge transmission does not occur immediately from one generation to another but from individual to individual because, although occurring in a context that brings many people together, the individual is always the social agent of acquisition or the knowledge source. Therefore, it makes little sense to continue based on the common maximum in the literature, according to which "traditional knowledge is transmitted from generation to generation," because there are many information transfer channels.

From an evolutionary point of view, copying another person's information (from peers) is a highly advantageous process (Rogers 1988; Feldman et al. 1996). To understand why, it is necessary to bear in mind that human behavior has two natures: genetic information (genes) and cultural information (trait). Genetic information transmission occurs exclusively from parents to children. Therefore, many generations are required for an advantageous gene to be set in a population, which implies a long period of time. Cultural transmission allows a person to acquire information throughout their life and from many models in addition to parents, such as cousins, uncles, experts, television, and radio. As a result, cultural adjustments occur much faster and in a more flexible way, accelerating human evolution beyond genetic adaptations (Mesoudi 2011). In addition, peer copying is advantageous in certain situations because it allows the acquisition of seemingly useful information, freeing the individual from individually produced knowledge, which is a high-cost alternative process (Laland 2004; Mesoudi 2011).

Despite evolutionary benefits, random copying provides no advantage, as knowledge acquisition without any direction does not guarantee that the entered information will be fruitful (Rogers 1988). In order for cultural transmission to be evolutionarily justified, that is, to have increasing adaptive value for a population, it is necessary for this process to undergo some direction or selection. As this chapter is dealing with cultural information, cultural selection will be referred to, which is defined as "*any condition in which a cultural trait is more likely to be acquired and transferred over other alternative traits*" (Mesoudi 2011). New information in a cultural system, for example, also known as innovation, is more likely to be transferred among group members (Rogers 1998). A good example of this cultural selection process is offered by evolutionary psychology. The human mind was modulated in critical situations involving food limitations, diet changes, and new social structures, in which cultural transmission was extremely important for the survival of the human species (Nairne et al. 2007). As a result of this selection process, humans have structural adaptations that can detect certain characteristics (clues) in the behavior of peers, indicating which information is most useful.

Therefore, knowledge copying is not random but follows certain trends, which are called biases. These biases, which are mechanisms that act as cultural selection bases that influence local knowledge learning processes, will now be addressed. This process changes information frequency in a group and promotes cultural evolution (Rogers 1988; Enquist and Ghirlanda 2007).

Cultural Transmission Is Affected by Several Trends

There are several trends (biases) associated with cultural transmission, but three will be highlighted here: (1) content bias, (2) prestige bias, and (3) cost-effective bias. In the first case, information is more likely to be spread based on content type, that is, based on specific information characteristics, such as attractiveness and memorability. Thus, knowledge can have an objective and concrete nature, or certain information can be more subjective and abstract, which determines its transmission. Natural resource names, such as plant names, for example, are objective and concrete information. It is possible to precisely distinguish that rosemary is different from basil. This knowledge type is usually learned during childhood (Aunger 2000). However, use and collection forms are tacit skills that demand experience for acquisition. They are less specific and more subjective. Thus, they are acquired only at older ages, through other models, such as through local experts (Aunger 2000). Other content bias is associated with the adaptive importance of information. Nairne et al. (2007) concluded that the human mind is biased to store and recall the most valuable information for individual survival, and this trend is called adaptive bias. In this case, knowledge adaptability renders information more prone to transmission. Keeping the example presented above, it is expected that medicinal resource therapeutic indications and application types are more easily stored and accessed, for example, than a learning model (see Soldati et al. 2015).

The second previously indicated trend, prestige bias, comes from the understanding that the human mind was also shaped to assess potential available models and copy those that are most successful, optimizing the adaptive acquisition of information (Henrich and Gil-White 2001; Demps et al. 2012). One of the features evaluated by the learner in this process is the social prestige of the model to be copied. Henrich and Gil-White (2001) found that, in relation to learning about fishing and medicinal plants, people tend to learn from peers who are recognized as the best experts or who have more prestige. However, this bias can also allow the transmission of irrelevant information, also known as bad adjustments, because even a local expert may not necessarily possess evolutionarily useful information (Wood et al. 2012).

The last bias to be discussed, cost-effective bias, analyzes the learning process based on energy logic. When learning, an individual spends (invests) energy, recognizing and accessing the model. However, information provided by models available to the learner is not of equal quality, varying in relation to the energy return they guarantee to its bearer (Heinrich and Broesh 2011). Knowing medicinal plant X can guarantee instant healing of some diseases. However, knowledge about plant Y, which will also lead to healing, may require longer treatment. There is, therefore, a cost-benefit ratio in learning, influencing the knowledge transmission process.

In a practical situation, children learn primarily from parents because, according to Heinrich and Broesh (2011), these are their closest models, with easier access. Thus, parental learning is less expensive for children. During adulthood, learning return is guaranteed by the quality of information acquired from other models, especially from specialists, although its cost is high. Therefore, adults essentially do not learn from parental peers. Regarding animal hunting, children learn the necessary skills to achieve this natural resource as long as they acquire a physical structure that permits its implementation and, in particular, as long as the benefits from hunting activities justify the investment in learning complex and sometimes dangerous skills (Walker et al. 2002). In this sense, there is an eco-evolutionary relationship that determines the learning models and, consequently, the acquired knowledge, as well as the life stage at which this process occurs.

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Gender and Age

Wendy Marisol Torres-Avilez, André Luiz Borba do Nascimento, Leticia Zenobia de Oliveira Campos, Flávia dos Santos Silva, and Ulysses Paulino Albuquerque

Abstract Traditional biological/ecological knowledge (TBK) of natural resource use is dynamic, thanks to the innovation and experimentation that different human groups have performed throughout their evolutionary history. However, this knowledge may suffer from variations that reflect intrinsic characteristics of the human species. In this chapter, how gender and age influence the knowledge of different resources used by human populations and the possible contexts in which these variations can be analyzed will be discussed.

Gender

Reported differences in natural resource knowledge in several studies suggest a link between gender and occupation or social role (Voeks and Leony 2004; Voeks 2007). For example, in situations in which men are usually in charge of providing family support, they often demonstrate the use of timber resources for fuel, employ plants in handicrafts, and show a higher knowledge of wild animals for hunting. In turn, in situations in which women tend to be responsible for the health of family members, they hold more knowledge regarding medicinal plants (Camou-Guerrero et al. 2008; Bruschi et al. 2011). In Nanga Juoi, Indonesia, women tend to know more about secondary vegetation areas because these are closer to their homes, while men know more about primary vegetation species, as they often visit primary vegetation areas to obtain sustaining family resources (Caniago and Siebert 1998). However, in communities where the division of labor is different from those previously discussed, logic can also change. In the upper Kullu villages in India, women have greater practical knowledge about the forest than men, as men are not responsible for

W.M. Torres-Avilez, M.Sc. (✉) • A.L.B. do Nascimento
L.Z.O. Campos, Ph.D. • F.d. S. Silva • U.P. Albuquerque, Ph.D.
Laboratory of Applied and Theoretical Ethnobiology (LEA),
Department of Biology, Federal Rural University of Pernambuco
Av. Dom Manoel de Medeiros, s/n, Dois Irmãos, Recife, Pernambuco 52171-900, Brazil
e-mail: w_torres_5@hotmail.com; andreborba_3@hotmail.com;
leticiazenobia@hotmail.com; flavynha-santos@hotmail.com; upa677@hotmail.com

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searching for forest products (Bingeman 2003). Another interesting situation is the case of some African communities in which women collect firewood (Biran et al. 2004), unlike Brazilian rural communities, in which men are usually the collectors (Ramos et al. 2008).

In this context, Howard (2006) questioned whether knowledge of useful resources between genders can be understood only through labor division and people's roles in a culture. This reflection leads to the following question: what are the other relevant factors to understand resource use between genders? Kristoffersen et al. (2014) suggested that differences between genders may be linked to specific characteristics of each gender, such as psychological mechanisms (Buss and Schmitt 1993). In this sense, Andel and Carvalheiro (2013) have observed that psychological factors influence traditional medicine use by individuals from the same community. Thus, the following variables may modulate possible gender differences: differences in biological processes, daily living conditions, environmental experiences, risk behaviors, psychological differences, and different responses to stressful events (see also Doyal 1995, 2001). These aspects lead to the notion that such factors, along with the social conduct to which every gender is subjected, can direct local knowledge regarding natural resource use.

The existence of variation between genders within a community and between communities makes it important to study knowledge distribution between genders to understand natural resource use and management. Additionally, resource use strategies between genders may vary according to the use category (medicinal, food, firewood, etc.), the access to resources that each gender has, the space where each gender develops its activities in daily life, and the resource availability in nearby environments (Caniago and Siebert 1998; Camou-Guerrero et al. 2008; Reyes-García et al. 2010). In addition to the issues raised, gender differences can direct bioprospecting research. Voeks and Nyawa (2001), in Brunei, on the island of Borneo, found that women hold knowledge related to the treatment of spiritual diseases, while men have knowledge about organic diseases.

Age

Several researchers have tried to assess the effect of age on natural resource knowledge and use. A very common way to do this is to use the number of known species for certain purposes as an indicator of knowledge. In the case of age, several studies suggest a positive correlation between the number of known resources (e.g., species richness) and the age of those who know them. Many scientists have assumed that older people, who have interacted with natural resources for a greater amount of time, have more knowledge than the young. However, this is not a standard because there is evidence that people above a certain age (60 years old) exhibit reductions in known species richness, perhaps as a result of memory loss with advancing age (see Almeida et al. 2012). Sometimes, age can explain knowledge of a particular category defined by researchers in their study, such as medicinal plants, but it does not explain knowledge variations in other categories (see Hanazaki et al. 2000).

There are researchers that assume that differences found between age groups may be the result of knowledge erosion. However, most of these studies are based on the total number of reported species for every age, and possible differences may not be the result of knowledge erosion but of learning dynamics. In addition, knowledge is not analyzed over time, and it is not possible to portray the actual knowledge dynamics of a situation. It is important to consider that knowledge of resource use is part of a social-ecological system that is strongly influenced by the environment, which offers choice possibilities for the human population (Ferreira Júnior et al. 2013). Knowledge in each age group can be the product of landscape and changes in the abundance of resource use, for example. Thus, older people can know of certain resources that are no longer available for younger people and thus do not exist as a reference, which is a consequence of environmental changes. Young people, in turn, have the new environment as a reference, a factor that can generate variations in knowledge within the community.

This situation leads to the notion of shifting baselines syndrome, a concept first used by Pauly (1995). Pauly (1995) noted that each generation of fishermen perceived a different abundance of the existing fish stock because they had the availability of existing fish from early in their careers as a reference, but that amount may have changed over time due to natural and/or anthropogenic events. The study of Hanazaki et al. (2013) brought this idea under the scope of ethnobotany, showing that this might happen in studies investigating differences in plant knowledge in human populations. Fernández-Llamazares et al. (2015) verified differences in the perception of environmental change in the context of age, in which each informant was asked about changes as a child (from the decade of their birth) and in the current state regarding bird and game species composition and abundance. The study found differences related to the informants' age regarding the perceived availability of these resources, where older people demonstrated more accurate knowledge about ecosystems of the past.

Thus, traditional biological knowledge variations as result of age and gender should be understood in broader contexts, as these differences may be the result of several variables associated with the socio-environmental location.

Chart 1: Quantitative and Qualitative Differences in Medicinal Plant Knowledge Among People of Different Genders and Ages

Knowledge of medicinal plants acquired by people of different ages and genders, inserted in a "caatinga" (seasonal dry forest) area, can vary in terms of the amount of known plants and/or quality of information. Researchers from the Laboratory of Applied and Theoretical Ethnobiology (LEA) at the Federal Rural University of Pernambuco noted this in a study conducted in a northeastern Brazil semiarid region rural community. In a knowledge dynamic analysis of people over 18 years old, it was observed that there was a positive correlation between the number of cited medicinal plants and the age of the informants.

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To determine how this variation behaves throughout different ages, the researchers compared age classes at intervals of 10 years, ranging between 18 and 90 years (18–26, 29–38, 39–48, 49–58, 59–68, 69–78, 79–90). They found that, in terms of plant diversity and medicinal uses, those belonging to the younger class knew significantly less than those of later classes, except for the 29–38-old- and 79–90-year-old classes. It is possible that people belonging to the latter class might have forgotten some information due to advanced age. Knowledge among men and women was also assessed, but no significant differences were observed regarding the numbers of uses and plants. However, the researchers realized that there were differences regarding the species that were known. Men, for example, cited 11 (10 %) species that had not been mentioned by women, who, in turn, mentioned 27 exclusive species (24 %). According to the study, knowledge similarity can be influenced by the role that each gender plays in the community. Finally, when assessing the data relating to knowledge among people of different ages and genders, it was observed that men demonstrated more uniform knowledge among the different age groups, although with no significant quantitative differences between them. Among women, there were differences in all classes, except the last. With this study, researchers have shown that gender and age variables can influence knowledge in terms of quantity and the type of information provided. Thus, they noted the need to assess knowledge distribution through different perspectives to identify patterns that regulate the relationships between people and plants (Silva et al. 2011).

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Ethnicity, Income, and Education

Patrícia Muniz de Medeiros, Juliana Loureiro de Almeida Campos, and Ulysses Paulino Albuquerque

Abstract In this chapter, we discuss the role of ethnicity, income, and education in the knowledge and use of plant resources. Ethnicity often influences not only knowledge itself but how the plant resources are perceived. Populations of different ethnic origins situated in the same region may have different bodies of knowledge. With longer residence time, people have had more time to interact with local resources and with other residents to expand knowledge. Income is usually one of the factors with the most explanatory power for the knowledge and use of plant resources, and it operates mainly in the context of resources that can be replaced by alternative assets. Finally, education has been inversely related to the knowledge and use of plant resources. However, this relationship remains unclear in ethnobiological literature, as other variables may underlie this relationship (such as income and occupation).

Ethnicity

Ethnicity may influence not only the knowledge and use of natural resources but also the way they are perceived. For example, three distinct cultural groups living in the Manu Islands, Papua New Guinea, apparently relate differently to natural resources (Case et al. 2005). The Usiai demonstrate the greatest knowledge and use of plant resources in the region, likely because they live in the interior of the island and are thus closer to the resources. However, when there is marriage between a Usiai and a member of a different group, botanical knowledge decreases; this knowledge is higher when both members of the couple are Usiai.

P.M. de Medeiros, Ph.D. (✉) • J.L. de Almeida Campos, M.Sc.
Ethnobiology and Human Ecology Group, Center of Agricultural Sciences, Universidade Federal de Alagoas BR 104 Norte KM 85, s/n, Rio Largo, Alagoas 57100-000, Brazil
e-mail: patricia.medeiros@ceca.ufal.br; loureiroju@hotmail.com

U.P. Albuquerque, Ph.D.
Laboratory of Applied and Theoretical Ethnobiology, Department of Biology, Universidade Federal Rural de Pernambuco, Rua Dom Manoel de Medeiros, s/n, Dois irmãos, Recife, Pernambuco 52171-900, Brazil
e-mail: upa677@hotmail.com

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With globalization and modernization, many ethnic groups have come into contact with each other, which ends up resulting in the exchange of ideas and cultural information. Hence, contact can change the knowledge standards of these groups, as is expected in most cases. However, there are situations in which this does not occur. Serbs and Albanians, who have been in contact for 300 years, maintain their knowledge of plant resources separately and do not share, despite contact (Pieroni et al. 2011). Another example of the lack of sharing knowledge was observed by Huai et al. (2011), in southwest China. The authors found that yard sizes and the number of species in them were significantly different among eight ethnic groups, even those dwelling in villages near each other.

In this way, we can say that every culture can develop different ways of using the natural resources existing around them to meet their varied needs. Indigenous groups of the Brazilian Amazon know of a larger number of species of palm trees than riverines and tappers who live in the same place (Campos and Ehringhaus 2003). This may be related to their long existence on site, which allowed the greater accumulation of knowledge.

Residence Time

Another variable that has a great influence on the knowledge and use of natural resources is residence time. Studies have shown that people who reside for a longer time in a particular location have greater knowledge of local natural resources compared to those residing for a shorter amount of time. It is expected that knowledge is constructed through interactions between people and local resources and increases according to contact time. Generally, older residents have greater knowledge of local biodiversity, while newcomers bring knowledge of their places of origin, leading over time to a mixture of knowledge. Residents who have lived for more than 30 years in a coastal area of the island of Florianópolis, Santa Catarina, Brazil, know more native plants than those who have lived for a shorter time in the same place and that came, primarily, from urban areas (Gandolfo and Hanazaki 2014).

Residence time not only influences knowledge of natural resources but also their use. People who live for a longer time in a place usually draw more resources than newer residents, regardless of the origin group of the latter. This was noted by Gavin and Anderson (2007), who sought to determine which socioeconomic variables influenced more strongly the use of forest resources in the Peruvian Amazon.

Income

Income is one of the socioeconomic variables with greater explanatory power for the knowledge and/or use of natural resources (Godoy et al. 1995; Medeiros et al. 2011; Specht et al. 2015). In general, families with lower incomes are more dependent on natural resources for their subsistence, especially native resources. This dependence not only translates to stronger use of these resources but higher knowledge as well, given that greater use and greater familiarity generally lead to higher knowledge.

What we are suggesting, then, is that income interferes, at first, with the need to use a given resource. If this need persists, it is likely that the family will keep its body of knowledge regarding plants, animals, or minerals directed toward the purpose in question. However, if an increase in income reduces the dependence on a given resource by this family to zero, it is possible that nonuse will reflect knowledge that will no longer be transmitted due to the immediate irrelevance of maintaining this information. Thus, we will often discuss here the influence of income on the use of resources but will keep in mind the consequences of this relationship for knowledge.

Given that native resources are "free goods" or at least assets (in most cases) not accounted for by economic logic, what is their relationship to household income? The answer to this question lies in the fact that the effects of income should not be understood only as to what is gained but rather what is not spent. Thus, using "free goods" interferes with the final family income in the sense that the family avoids spending on alternative goods (such as allopathic medicines, cooking gas, and masonry material for building houses). Thus, an increase in income can permit investment in alternative goods without lowering surplus to purchase other products.

Most research on the influence of income on the knowledge and use of natural resources involves, either exclusively or additionally, plants (see Godoy et al. 1995; Lacuna-Richman 2002; Gavin and Anderson 2007; Medeiros et al. 2011). Thus, the question arises: what types of plant use exert greater influence on family income or per capita family income? The literature has shown that the uses that are most dependent on fluctuations in income are those that can be replaced by alternative goods. Medicinal and timber uses have been designated as income dependent.

Studies with medicinal plants often use knowledge as a variable to be related to income. Many studies have found an inverse relationship between variables, such that the higher the income, the lower the knowledge of medicinal plants (measured by the number of known plants). However, income is not always inversely related to the knowledge and/or use of medicinal plants. A study by Almeida et al. (2010), for example, noted that the number of plants known by the residents of two communities in the northeastern semiarid region increased depending on income. Investigations have also pointed to a trend in the middle and upper classes in developed countries to use medicinal plants to replace allopathic plants as a means to return to the natural (Elvin-Lewis 2001; FAO 2005). This trend is often accompanied by the search for organic food and a better quality of life.

The lack of a relationship between income and knowledge and the use of resources in ethnobiological studies can also occur for other reasons. Some studies discuss the difficulty in acquiring reliable data on family income because people often do not feel comfortable revealing their real income, whether due to its low value or due to apprehension of losing government aid if their real income is shown. Thus, inaccurate income data can skew all analyses relating to its effects.

Timber uses perhaps suffer the most from the effects of income. A study developed by our research group observed the effects of various socioeconomic factors on timber volumes and on the number of timber species used in an urban-rural community living in an Atlantic Forest area of Pernambuco (Medeiros et al. 2011). The results showed that income alone explains 23 % of the variation in the volume of wood used at this location and 22.3 % of the variation in the number of species used, which are quite high values when compared to other studies utilizing this approach. It was noted in the study of Medeiros et al. (2011) that income affects more strongly the overall consumption of wood than the consumption of each category of use alone (fuel, construction, and technology). One hypothesis to explain this result is that people with low income can opt for different ways to save money: some may choose to reduce gas consumption and increase the use of wood, while others may prefer not to buy building material and to use wood for this function, and others can employ all of these strategies.

In several rural communities in areas of caatinga and Atlantic forest in northeast Brazil, there is an interesting pattern involving the joint use of firewood and cooking gas. It is noted that, despite the large wood consumption in these regions, most homes have a gas stove. In this case, income interferes in the use of wood/use of cooking gas proportion. It is common in lower-income homes that the gas stove is only used at night to heat water or fast-cooking foods, while foods that require a longer cooking time are left to the wood stove.

Regarding food plant resources, rather than increase or decrease total consumption, often income interferes in terms of which of these resources will be consumed. Studies conducted in the Brazilian semiarid region found that, in times of prolonged drought, low-income families must rely on emergency food from the native flora for their livelihood, given their inability to buy food combined with the damaging effects of prolonged drought on family farming.

Education

The nature of the relationship between education and knowledge and use of natural resources is still obscure in the ethnobiological literature. This is often because education itself is not the main factor but rather the variables related to it, such as income and occupation. People with higher incomes often have higher levels of education than people with lower incomes. Thus, we would expect an inverse relationship between level of education and knowledge and the use of resources.

Some studies also suggest that education interferes in the nature of people's occupations, and this in turn interferes with the knowledge and use of natural resources. In rural and urban-rural areas, people with more education tend to have jobs that are not related to agriculture and forestry. People working in the field, in turn, have greater familiarity with natural resources, which would explain their greater knowledge and/or use. These statements, however, must be tested appropriately.

Among the studies that identified a relationship between education and knowledge and the use of natural resources, we can mention an investigation conducted by our research group (Medeiros et al. 2011), which found an inverse relationship that, although weak, was significant between education and the use of firewood. In this case, we observed that in the studied community, located in the coast of NE Brazil, the most educated people worked in the trade/services sector and, therefore, did not have frequent contact with work in the field. On the other hand, residents with fewer studies tended to work in the harvest and planting of sugarcane, which gave them frequent contact with the areas close to forests and the forests themselves.

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Urbanization, Modernization, and Nature Knowledge

Washington Soares Ferreira Júnior, Flávia Rosa Santoro, Ina Vandebroek, and Ulysses Paulino Albuquerque

Abstract The process of urbanization and modernization has led to a growing approximation between local populations and urban environments. An important question in ethnobiology is to understand the effects that this process can exert on the knowledge of human groups regarding environmental resources. In this chapter, we discuss the effects of urbanization and modernization in local ecological knowledge, and we take the use of medicinal plants in local medical systems as an example to discuss the issue. Here, as well, we show evidence from studies demonstrating that urbanization processes negatively affect the knowledge of medicinal plants as well as the evidence to suggest that a negative effect on knowledge does not necessarily occur. In addition, we note certain mechanisms that are associated with the influence of urbanization on the knowledge of medicinal plants.

Urbanization is the redistributional shift of populations from the countryside to towns and cities. From a global perspective, urbanization is a process of constant and rapid growth, such that the boundaries between urban centers and previously isolated rural communities become increasingly blurred. Contemporary urbanization is intimately linked to modernization, which is a more elusive term to define. As a process, modernization involves industrialization and the adoption of a scientific worldview by the majority of the population. Like urbanization, modernization is also responsible for this process, which blurs rural-urban boundaries. As a result, this increasing proximity has led to a hybridization of knowledge and practices of local communities with those related to modernity and new technologies (see Soldati and Albuquerque 2012).

W.S. Ferreira Júnior, Ph.D. (✉) • F.R. Santoro, M.Sc. • U.P. Albuquerque, Ph.D.
Laboratory of Applied and Theoretical Ethnobiology, Department of Biology,
Federal Rural University of Pernambuco, Rua Dom Manoel de Medeiros, s/n, Dois Irmãos,
Recife, Pernambuco 52171-900, Brazil
e-mail: kba.bio@hotmail.com; flaviarsantoro@gmail.com; upa677@hotmail.com

I. Vandebroek, Ph.D.
The New York Botanical Garden, Institute of Economic Botany
2900 Southern Boulevard, Bronx, NY 10458, Brazil
e-mail: ivandebroek@nybg.org

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In ethnobiology, many researchers have sought to understand how urbanization and access to certain services affect traditional biological knowledge. Most of the available evidence comes from studies that have investigated traditional medical systems that primarily involve the knowledge and use of natural resources for the treatment of diseases. Some of these studies show that urbanization, increased physical accessibility of communities, and modernization exert negative effects on local medicinal plant knowledge (Vandebroek et al. 2004; Reyes-García et al. 2013a).

In this chapter, we will address the impact of urbanization on local medical systems. We define local medical systems as the body of knowledge, beliefs, and practices held about health, the maintenance of health, and the treatment of ill health with natural resources by indigenous and local communities (see Kleinman 1978). Our focus on medical systems is important because the knowledge of a human group regarding the medicinal use of environmental resources is a dynamic process, comprising both acquisitions (addition of knowledge) and losses (erosion of knowledge) over time. Thus, it is necessary to consider the dynamics and flexibility of local medical systems and their ability to self-organize in response to the events to which they are exposed, such as access to biomedicine and public health services.

Mechanisms Associated with Urbanization and Modernization that Affect Local Medical Knowledge

Studies that have addressed the consequences of urbanization and modernization in local communities are mainly based on the changes in medical knowledge held by local populations. Access to public health services associated with the insertion of biomedicine into the traditional pharmacopeia is considered to be an important modifier of local knowledge. Some studies have shown that increased access to public services also increases the use of pharmaceutical drugs by human groups and decreases knowledge about local medicine based on plants and animals (Nolan and Robbins 1999; Vandebroek et al. 2004). This shows that access to public health services correlates negatively with local medicinal knowledge.

On the other hand, it has been suggested that urbanization and modernization do not always interfere with the use of natural resources (Perry and Gesler 2000) or may even increase the knowledge of human groups (Greene 1998; Amorozo 2002; Medeiros et al. 2013). In urban Suriname, predictors of medicinal plant *use* were illness and traditional knowledge rather than poverty or limited access to modern health care (Van Andel and Carvalheiro 2013). Rural-urban changes in plant knowledge were only partly observed in the knowledge of and the use of medicinal plants by migrant women who lived in a peri-urban slum in Brazil. The knowledge of these women was not correlated with their length of urban residence or their former residence on rural farms; however, there was a positive correlation between their former length of residence in the jungle and medicinal plant knowledge (Wayland and Walker 2014). In a study in the Dominican Republic, rural people had the same amount of knowledge regarding food plants that were used as medicines as urban people; however, rural people did have more knowledge about plants that are exclusively used as medicines compared to urban Dominicans. The authors speculated that it is the widespread availability and easy access to these food plants that maintain and even increase their popularity as medicines (Vandebroek and Balick 2014). In another study, rural Dominican women showed a tendency to know more about medicinal plants for women's health than urban women, except for uterine fibroids. More urban women and healers in the Dominican Republic and New York City knew of plants for uterine fibroids (Ososki et al. 2007). These studies show that the relationship between urbanization, modernization, and plant knowledge can be quite complex.

Urbanization and Modernization Negatively Affect Local Knowledge

Evidence indicating loss of knowledge in medical systems due to urbanization and modernization is based on the observation that there is greater use of biomedicine (and a corresponding lower degree of plant knowledge) by human groups that have increased access to public health services (Vandebroek et al. 2004). One of the processes that can explain this trend is that communities near urban areas have restricted access to forests, which makes the search for environmental resources more costly and the use of biomedicine more convenient.

Another mechanism that may be related to the loss of knowledge is the separation of younger generations from local activities due to growing interest in activities related to urban centers. For example, a study in five villages in Thailand showed that the process of urbanization and local development had led young people to abandon practices related to agriculture and seek jobs in the factories of the towns (Inta et al. 2013). This same study showed that younger people held less knowledge about medicinal plants than older people. In this case, the loss of knowledge about medicinal plants over time may be associated with an adaptation of local communities to new social, economic, and environmental conditions related to growing urbanization, the availability of more profitable economic activities, the constant environmental degradation (Reyes-García et al. 2013a), and a new epidemiological context (Antonio-Nkondjio et al. 2005; Angkurawaranon et al. 2014). Under these new conditions, it may be less advantageous to retain knowledge about the use of medicinal plants than to use other resources.

Urbanization and Modernization Do Not Negatively Affect Local Knowledge

Despite the trend presented above, there are other points of view to consider. Appropriation of new knowledge or practices during urbanization and modernization does not necessarily lead to the abandonment of traditional knowledge, which may lead to the coexistence of the local medical system with biomedicine, resulting in a scenario of intermedicality (Greene 1998) or medical pluralism (Singer and Baer 2012). An example is seen in urban Lagos, Nigeria, where traditional strategies are considered essential as first aid measures, whereas modern medicine represents a last resource, showing that the health-care system is somewhat flexible (Järvelä and Rinne-Koistinen 2005). Another interesting example occurs with the Fulni-ô Indians in northeastern Brazil, who use pharmaceutical drugs together with natural resources for health promotion in their medical system (Soldati and Albuquerque 2012).

We can associate urbanization with increasing access to new information about medicinal plants. This is particularly visible in transnational urban settings, such as those that exist in big cities, where immigrants may gain new cultural knowledge about plants through intercommunity alliances and transethnic social networks (Lidia 2011). Thus, urbanization can also promote the growth of medical knowledge about plants. There are cases of people who hold a great amount of knowledge regarding local systems, such as the use of plants in that region, and who also have great knowledge about tools for modern agriculture (Reyes-García et al. 2013b). Thus, local knowledge and the products of urban development are not necessarily mutually exclusive, showing flexibility in the choice of strategies by human groups. Public markets located in urban centers are another example involving the trading of a wide variety of products (plants and animals) for medical purposes (Monteiro et al. 2010). Furthermore, there exists an intense exchange of information in markets, indicating a mixture of different traditions involving the use of resources for the treatment of diseases. In this case, markets may be considered spaces that represent the diversity of knowledge and practices of a region related to the use of natural resources (Albuquerque et al. 2007).

Finally, from another perspective, there is also the possibility that local people reject knowledge stemming from biomedicine. In a peri-urban community in the Brazilian Amazon, people prefer to use natural resources at the expense of biomedical health centers, due to the lower cost and greater perceived effectiveness of the former. In addition, lack of familiarity with public health resources can also cause people to not use public health systems (Perry and Gesler 2000).

Final Considerations

It appears reasonable to correlate a low level of knowledge regarding natural resources in a community to its proximity to urban centers, as urbanization offers a number of alternatives to livelihoods that could result in the abandonment of traditional practices and knowledge. However, there does not always exist a negative correlation between urbanization and plant knowledge because the use of plants can be maintained over time, which is less costly from an economic point of view, for example, or perceived with greater efficacy by a given human group. For a better assessment of the impact of urbanization on local knowledge, studies would be necessary to investigate the dynamics of knowledge held by the same community over time during the process of urbanization. Given that the dynamics of knowledge can change in the short term and the growth of cities has increased in recent years, such studies should be appealing to ethnobiological research.

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How Does Social Status Relate to Traditional Ecological Knowledge?

Victoria Reyes-García and Sandrine Gallois

Abstract Considering that knowledge transmission processes might be affected by prestige bias, this chapter explores the relation between traditional ecological knowledge and social status. Data collected among three hunter-gatherer societies (the Punan in Borneo, the Baka in the Congo Basin, and the Tsimane' in the Amazon) and regarding three domains of knowledge (medicinal plant, hunting, and agricultural knowledge) suggest that measures of knowledge and skills are associated with an evaluation of the person's knowledge provided by fellow community members, i.e., social status. We highlight that this relation might vary according to the domain of knowledge and might be shaped by other individuals' characteristics, such as own implication in social organization. Moreover, social status might present varied associations with different bodies of knowledge, as it is the case with some specialized traditional ethnomedicinal plant knowledge which is not shared by all the members of a community.

Researchers have developed different models to explain the mechanisms that drive the transmission of traditional ecological knowledge (Cavalli-Sforza et al. 2005; Cavalli-Sforza and Feldman 1981; Feldman and Laland 1996; Henrich and McElreath 2003). Such research suggests that imitation of cultural traits is necessary but not sufficient for cultural transmission (Boyd and Richerson 1985; Rogers 1988). To answer the question of how cultural transmission operates, anthropologists have hypothesized that people do not imitate behaviors from other people at random; rather, the transmission of cultural traits is biased (Boyd and Richerson 1985; Henrich and McElreath 2003; Laland 2004). Boyd and Richerson (1985) propose three categories of biases that might influence the transmission of cultural

V. Reyes-García (✉)
Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, Campus UAB, Edifici Z, Carrer de les columnes, Bellatera, Barcelona 08193, Spain

Institució Catalana de Recerca i Estudis Avançats (ICREA), Barcelona, Spain
e-mail: victoria.reyes@uab.cat

S. Gallois
Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, Campus UAB, Edifici Z, Carrer de les columnes, Bellatera, Barcelona 08193, Spain
e-mail: galloissandrine@yahoo.fr

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traits. Direct biases favor the acquisition of one cultural trait over another because the selected traitis inherently better or more attractive than others. Frequency-dependent biases favor the acquisition of one variant over another because of the trait's distribution in the population, i.e., bias toward copying the most frequent variant (Henrich and Boyd 1998). Indirect biases favor the use of other information about the model, such as status or prestige to determine who to copy.

Henrich and Gil-White (2001) discuss the causes and consequences of transmission of cultural knowledge that follow prestige bias. They note that:

> *Natural selection favored social learners who could evaluate potential models and copy the most successful among them. In order to improve the fidelity and comprehensiveness of such rank-biased copying, social learners further evolved dispositions to* sycophantically *ingratiate themselves in their chosen models, so as to gain close proximity to, and prolonged interaction with, these models. Once common, these dispositions created, at the group level, distributions of deference that new entrants may adaptively exploit to decide who to begin copying*. (Henrich and Gil-White 2001: 165)

Prestige-biased transmission enables new learners to accurately determine which individuals in a community are likely to have above-average information in a particular domain. Because learners need to be in close proximity or to directly interact with the models they want to imitate, they render deference, thereby conveying prestige, to obtain that proximity. The deference can include goods or leniency in social obligations, and it might be a necessary requirement for the transmission of some specialized knowledge, as Barth (1990) suggests for Southeast Asia. The novice might have to involve herself in a long process of learning, which could last during years and imply several episodes of rituals, where both his physical and psychological perseverance over time would shape learning. Because individuals will only provide these benefits to role models when their information is worth the cost of supplying the benefit, the amount of deference that individuals receive becomes a good indicator of their skills in a domain. New entrants and naïve individuals can avoid the costs of evaluating all potential role models and instead determine the individuals who receive the most deference and try to learn from them. If this model is true, then there should be a relation between a person's prestige, or the freely conferred deference enjoyed by individuals in a group, and her knowledge (Henrich and Gil-White 2001 pp. 180–181).

Such intuition finds support in our current research in which we find that the peer evaluation of an informant's knowledge and skills in any given domain of traditional ecological knowledge is correlated with standard measures of traditional ecological knowledge (Reyes-García et al. 2016). Specifically, data collected among three hunter-gatherer societies (the Punan in Borneo, the Baka in the Congo Basin, and the Tsimane' in the Amazon) and regarding three domains of knowledge (medicinal plant, hunting, and agricultural knowledge) show that measures of knowledge and skills are associated with an evaluation of the person's knowledge provided by fellow community members. Interestingly, across the three domains of knowledge and across the three studied societies, the association of the average rating seems to be weaker with our measures of theoretical knowledge, or the ability of people to name and recognize elements of their natural environment, that with our measures of skills, or the—self-reported—ability to put such knowledge in practice. This might be due to the fact that skills are more explicitly manifested than theoretical knowledge (Reyes-García et al. 2007), thus making easier the evaluation of a person's performance (skills) than of her theoretical knowledge.

An important consideration regarding those results, however, relates to how social status is assessed. In the research just described, we considered the status of a person only in relation to a specific domain of knowledge, which is not necessarily a good proxy for the overall prestige of the person. Furthermore, previous research suggests that such findings do not necessarily hold when using a more comprehensive measure of social status. Thus, based on the same theoretical intuition that knowledge and prestige should be associated, Reyes-García et al. (2008) used data collected among Tsimane' adult males (>16 years; $n=288$) to test whether prestige is positively associated with traditional knowledge. In such case, researchers measured prestige by asking all Tsimane' adults in a village to list the name of all "important" village members and then counted the number of nominations each person received. In such research, the proxy of traditional knowledge referred to knowledge and uses of medicinal plants. Researchers found weak evidence that prestige was associated with ethnomedicinal plant knowledge. Rather, prestige bore a positive association with other attributes, such as participation in village organizations.

This leads, again, to an interesting consideration regarding the differentiation between forms of social status, as it is possible that disparate forms of social status bear dissimilar associations with traditional ecological knowledge. Henrich and Gil-White (2001) specifically mention that their model refers to prestige, or the freely conferred deference enjoyed by individuals in a group, which they differentiate from dominance obtained through coercion. They acknowledge that the two concepts are separable psychologically but often correlated in the real world. Under such framework, the lack of association between the overall measure of prestige and ethnomedicinal plant knowledge could be explained because the measure of prestige used captures political leadership rather than deference generated by holding traditional ecological knowledge.

Finally, in examining the associations between social status and traditional ecological knowledge, it is worth to consider that not all constituents of the traditional ecological knowledge of a group are equally shared. Thus, while—in each society—some traditional ecological knowledge is widely shared, other parts of such knowledge are held by specialists (i.e., traditional healers), who precisely derive their status from holding this specialized knowledge. The Tsimane' example illustrates how changes in contemporary indigenous societies might affect the association between social status and traditional knowledge. Thus, because at present the Tsimane' lack shamans, the figure that concentrated Tsimane'-specialized ethnomedicinal plant knowledge, and they have started to enjoy increasingly easy access to Western medicine, ethnomedicinal plant knowledge is less important on contemporary Tsimane' society. In sum, it is possible that the hypotheses about the association between knowledge and prestige are only applicable to egalitarian societies lacking a sharp division of labor and institutions designed to transmit knowledge and that the association disappears once societies grow in social complexity and become less autarkic.

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Plant Knowledge and Use in the Context of Migration

Patrícia Muniz de Medeiros, Diego Batista de Oliveira Abreu, and Ulysses Paulino Albuquerque

Abstract The influence of migration on plant knowledge and use, which are key cultural elements in many societies, will be addressed in this chapter. Medicinal plants will be emphasized, as these are the most studied resources in the context of migration. The importance of differentiation between knowledge and use in migration studies will be discussed because many plants known to migrants cannot be used due to unavailability in a new environment. Strategies for the use of medicinal plants by migrant people will also be discussed; these have been classified into (1) acquisition of original plants and (2) adaption to the new flora. Such strategies can gain or lose strength based on certain factors, such as climate or floristic similarity between areas, sanitary barriers present in the new environment, and others. Finally, changes in health systems resulting from the migration process will be discussed, and a little-reported process in the literature is noted: medical systems based on the incorporation of plants when there is urban-rural migration.

When people migrate, they face a new scenario. Depending on source locations and distances, strong cultural, political, economic, geographical, and environmental differences can be found. These differences often influence how migrant people relate to other migrants, native peoples, and the environment. This chapter will focus on the influence of migration in plant knowledge and use, which are key cultural elements in many societies. Medicinal plants will be emphasized, as these represent the most studied resource in the context of migration.

P.M. de Medeiros, Ph.D. (✉) • D.B. de O. Abreu, M.Sc.
Ethnobiology and Human Ecology Group, Center of Agricultural Sciences, Universidade Federal de Alagoas, BR 104 Norte KM 85, s/n, Rio Largo, Alagoas 57100-000, Brazil
e-mail: patricia.medeiros@ceca.ufal.br

U.P. Albuquerque, Ph.D.
Laboratory of Applied and Theoretical Ethnobiology, Department of Biology, Universidade Federal Rural de Pernambuco, Rua Dom Manoel de Medeiros, s/n, Dois irmãos, Recife, Pernambuco 52171-900, Brazil
e-mail: upa677@hotmail.com

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Between Knowing and Using: Migrants and Plants

In quantitative terms, it is possible to ask: *when a group of people migrate, does their plant knowledge increase, decrease, or remain the same as before the migration event?* If attention is focused only on the generation that migrated, it is expected that knowledge would increase or at least remain the same (the possibility of "forgetfulness" was excluded in this case). New experiences and exchanges can often extend the repertoire of useful plants known to migrant generations.

However, this knowledge amplification is often not maintained over generations. This is because some plants from the migrants' place of origin are not available in the new environment and are not easily acquired there (Volpato et al. 2009; Medeiros et al. 2012). Thus, part of the knowledge body, once implemented, becomes stock knowledge (knowledge that exists but is not practiced). The greatest issue for stock knowledge is that, if it is not practiced, it may not persist in future generations (Albuquerque 2006) (Fig. 1). For plants with useful features, it is common to have knowledge transmission pathway blockages, simply because there is no need or opportunity to teach something that is not part of the current reality. Many vertical transmission events of knowledge (from parents to children) happen with practice and the observation of plant resource collection, handling, and preparation. Thus, in the context of migration, the need to study not only the knowledge of migrant peoples but also what they are actually putting into practice, i.e., what they use, is very clear.

Now the nature of the question will be changed. *When a group of people migrate, which plants do they use?* When jumping from quantitative to qualitative and from knowledge to use, phenomena that were not covered by the previous question may be observed. Many ethnobotanical studies have classified plants used by migrants as (1) plants that they have already used before migration and (2) plants that they have started to use after migration. Other classificatory arrangements can be (1) plants that are found (or obtained) in the source location and (2) plants that are only found (or obtained) in the new environment (Pieroni et al. 2005; Volpato et al. 2009;

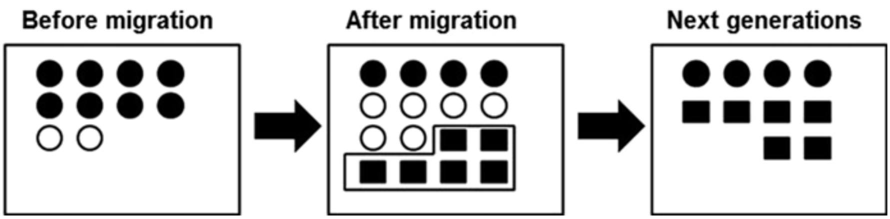

Fig. 1 Hypothetical scheme that emphasizes stock knowledge fragility among migrant people. Black figures represent the knowledge put into practice (mass knowledge) and white figures represent stock knowledge. *Circles* are useful plants that were already employed prior to migration, and *squares* are those that have been employed after migration. The third scenario is the repertoire of useful plants for the next generation (children of migrants and subsequent generations). Plants from the source location that may not be acquired in the new environment may move to the knowledge stock and disappear from the medical system in succeeding generations

Medeiros et al. 2012). It is noted that the two classifications are different because it is possible that a plant occurs in the migrants' place of origin, but it is only used by them after migration. Imagine that plant X naturally occurs in the place of origin and in the new environment of the migrants. It is possible that the migrants had not known about use of the plant before leaving the place of origin. Thus, they began using this plant only after arriving at the new environment and receiving information from the people of this new location.

Migration and Medicinal Plant Use

A study developed by a research group (Medeiros et al. 2012) analyzed several investigations related to migrant people's ethnobotany and suggested two medicinal plant use strategy profiles: (1) flora acquisition strategies from the place of origin and (2) strategies to adapt to new flora. Among strategies in the first group are material acquisition from the source location (market purchase, direct acquisition from friends or family, import, etc.) and cultivation and use of plants that spontaneously occur in both environments. The second main group strategy is essentially the replacement of previously used plants by plants in the new environment. The plant repertoire used by a migrant people can, therefore, be the result of several joint strategies.

Each strategy can gain or lose strength based on migration site characteristics. When there are strong sanitary barriers in a country, for example, it is possible that plant import strategies would lose strength. If the two environments (place of origin and new location site) are geographically close, it is reasonable to infer that these plants will continue to be used, either because they also occur in the new local vegetation or by acquisition via the continuous contact of migrants with their local source. Moving to a place that is a large geographic distance from the place of origin but with similar environmental characteristics can strengthen farming strategies. In addition, migrant contact with native peoples can encourage substitutions (Lacuna-Richman 2006), although cultural or religious differences can sometimes lead to the blockage of information exchange between people (Pieroni et al. 2015). Thus, it is observed that plants that will be used by migrants depend on all these factors and that cultural, political, geographical, and environmental contexts cannot be disregarded.

Traditional Medicine and Official Medicine in the Context of Migration

Something that has not been considered until now in this chapter is that, after migration, not only can the amount and the repertoire of medicinal plants change but also a whole medical system (or at least a part of it). Many studies have shown that, after migration to large urban centers, adherence to global consumption patterns is common for these peoples, including the official health system. Thus, traditional medical practices may be abandoned or pluralistic (or hybrid) systems may emerge where traditional medicine and official medicine coexist. In the aforementioned study conducted with Guatemalan migrants (Nesheim et al. 2006), many respondents reported to use plants when pills failed or vice versa. Waldstein (2006), in a study of Mexican migrants in the USA, also noted the coexistence between the official medical system and the traditional.

However, changes in medical systems for migrant people do not happen only in the context of the adoption of official medicine. The opposite, although studied very little, also happens. Recent efforts from this research group have been conducted in the context of "Capão Valley" (Palmeiras municipality, state of Bahia, Brazil). This site has been the choice of migrants from all over the world who search for a better quality of life. Many of them come from urban areas and began to use medicinal plants in a significant way only after migration to the "valley." Preliminary observations of this phenomenon indicate that traditional knowledge restructuring at that site usually begins with the use of a "kit" of medicinal plants, which is composed of a wide distribution of popular exotic species; as migrants interact with former residents, they may add native species to their repertoire.

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Cultural Comparisons in Ethnobiological Research

Ina Vandebroek

Abstract A research focus on cultural comparisons in ethnobiology can answer questions about the incidence, distribution, and causes of cultural variation in ethnobiological knowledge. It also provides insight into the rich diversity of ways in which communities interact with and use biological resources to sustain a living. Cross-cultural research has shown that the same biological resources accessible to different cultural groups are often used and valued in different ways and thus occupy specific cultural niches. This research has also been instrumental in showing that even though native communities tend to possess a larger body of knowledge about natural resources than immigrants and people of mixed ancestry who share the same living areas, the former can still acquire plant knowledge from the latter groups. As such, cross-cultural research adds depth and richness to ethnobiological data and contributes to hypothesis testing and theory building in ethnobiological research. In addition, understanding the patterns by which people know and use their biological resources is of central importance to projects that aim to reconcile biological conservation and local development through the identification of species that hold high cultural importance.

Why Cultural Comparisons?

A research focus on cultural comparisons in ethnobiology gives insight into the rich diversity of ways in which communities interact with and use ethnobiological resources to sustain a living. This includes the study of cultural knowledge, beliefs, and practices through observation, participation, and field surveys. Cross-cultural research involves the systematic comparison of "culture to culture and explicitly aims to answer questions about the incidence, distributions, and causes of cultural variation." Olatundun (2009) eloquently states that the goal is not to compare cultures in order to "deny their individual uniqueness," but to better understand what is shared between different cultures. Studying knowledge variation in culturally and/

I. Vandebroek, Ph.D. (✉)
The New York Botanical Garden, Institute of Economic Botany
2900 Southern Boulevard, Bronx, NY 10458, USA
e-mail: ivandebroek@nybg.org

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or linguistically distinct ethnic groups that live in close proximity and face similar environmental and economic conditions, but have remained relatively isolated from each other, provides an opportunity to investigate how cultural factors shape people's understanding and use of the local flora (Pardo-de-Santayana and Macia 2015). Cross-cultural comparisons in ethnobiology can answer important questions such as, but not limited to:

1. Are the same plant species growing in multiple localities of similar importance to different cultural groups and used in similar ways?
2. What patterns of similarities and complementarities exist in the use of biological resources between cultural groups sharing the same geographic areas and ecosystems?
3. How do immigrant communities use ecosystems that are new to them as compared to native groups? In other words, who knows what about local biodiversity?

Examples of Cross-Cultural Comparisons

One of the pioneering ethnobiological studies on cross-cultural comparisons was the study by Heinrich et al. (1998) on healer's consensus and the relative importance of medicinal plants in four indigenous groups of Mexico (Maya, Nahua, Zapotec, and Mixe) whose surrounding flora is similar but not identical. The species used by these groups varied considerably. Only four of the 50 principal species used to treat gastrointestinal disorders were shared between all groups. For dermatological and respiratory disorders, none of the species were shared.

Vandebroek et al. (2004) asked the question how well two groups of healers living in two distinct ecological regions in Bolivia, the Andes and the Amazon, knew the medicinal plant resources in their living environment. The authors hypothesized that the rich biodiversity of the Amazon would imply the highest degree of plant knowledge. Each group of healers was queried about a set of plants from their living environment. However, Andean healers demonstrated a higher level of knowledge about their medicinal plants than Amazonian healers. The authors inferred from their results that social factors, such as family history of practicing traditional medicine, play an important role in the transmission, and hence continuity, of medicinal plant knowledge.

Van Andel et al. (2014) made a comparison between Afro-Surinamese (Sranantongo and Maroon) and West and Central African vernacular plant names. Their study revealed that 20 % of the Sranantongo and 43 % of the Maroon plant names closely resembled names currently used in diverse African languages for related taxa, represented translations of African names, or directly referred to an Old World origin. Their study thus confirmed the role of African people as active agents of environmental knowledge in the Americas.

De Boer et al. (2012) used the Jaccard similarity coefficient (in short Jaccard index) to calculate pair-wise similarity in medicinal plant knowledge between three sympatric ethnic groups living in Laos. This index compares the number of shared species (or species uses) in relation to the number of unique species (or species uses) in each group (Chao et al. 2005). The Jaccard index fluctuates between zero (no similarity) and one (maximum similarity). The authors hypothesized that the groups would share a high degree of knowledge about medicinal plants since they lived closely together in the same geographic area, had been challenged by the same external hazards for generations, including diseases and accidents, and commonly exchanged knowledge related to social and practical aspects of life. However, they found a low overall degree of shared plant knowledge, which they attributed to "a process of continual innovation through empirical testing" of new plant-based cures, concluding that "remedies of cultural importance are likely to spread within a community or ethnic group, but only proven effective cures are likely to spread between cultures" (de Boer et al. 2012).

Mustafa et al. (2015) compared the uses of plants as medicines, foods, and handicrafts in three ethnic populations living in the same area in Kosovo and identified small distinct sets of plant knowledge but a large overlap in knowledge about foods and handicrafts, suggestive of a hybrid character. These authors also found that *Chamomilla recutita* (chamomile) was the most highly valued species among Albanians, Bosniaks, Gorani, and Turks surveyed in Kosovo. Quave and Pieroni (2015) reported significant variation in the plant species used for medicinal purposes by the Gorani and Albanians in the Balkans, two culturally and linguistically distinct but neighboring ethnic groups that have remained relatively isolated from each other. There appeared to be more convergence in the food plants used by the two groups. The authors suggested that cultural barriers about wild edible species (as compared to plant medicines) may be more permeable to ensure food security during periods of famine. In addition, Thomas et al. (2008) hypothesized that food plants are partly selected and used in an "immediacy context, whereby *emic* [and thus cultural] perception of efficacy may be of secondary importance." These authors defined food plants as "diversity laggards," because in transects the number of food species increased only moderately with increasing diversity. In contrast, medicinal plants were considered "diversity followers" because the number of medicinal species kept increasing with increasing plant diversity, perhaps as a result of continued cultural experimentation and innovation.

Low Jaccard index values were calculated from other studies, possibly owing to geographic separation of communities. For example, the Laklei and Idate in East Timor live only 10–20 km apart but are separated by a mountain range, which has likely impeded cultural exchange of information (Collins et al. 2006). The limited number of medicinal species shared between these ethnic groups consisted of plants widely used throughout Asia. In Mexico, the linguistically related Zoque Populaca and Lowland Mixe Mayans have not been in contact for many centuries but live in similar ecological environments in the Isthmus of Tehuantepec; they also showed low similarity in medicinal plant knowledge (Leonti et al. 2003). Comparison of knowledge of palm uses between indigenous communities, rubber tappers, and river dwellers in southwest Brazil demonstrated that each community used different palm species of their preference to satisfy the same general needs and purposes (predominantly food, house construction, technology, and crafts), resulting in low Jaccard indices (Campos and Ehringhaus 2003). Thus, each community made different cultural choices on how to fulfill their needs with palms.

Putative factors that can influence similarity indices include the degree of cultural exchange, acculturation, assimilation, environmental similarity, and language and religious barriers, as well as the (perceived) effectiveness of plant remedies (de Boer et al. 2012). According to Pardo-de-Santayana and Macia (2015), dealing with ill health is a sensitive topic for which advice would only be accepted from knowledgeable relatives or friends belonging to the same ethnic group. In addition, these authors stated that the symbolic component of plant remedies may be an important factor leading to a shared cultural understanding, and thus resulting in the culturally specific use of those healing remedies. Without this cultural understanding, the remedies may not have meaning, and without meaning there is no motivation for their use. Future studies can aim at better understanding the drivers and barriers for sharing plant knowledge.

What Have We Learned from Cross-Cultural Research?

First, cross-cultural research has shown that the same biological resources accessible to different cultural groups are often used and valued in different ways and thus occupy specific cultural niches. This means that in a different cultural context, one species can be replaced by another, depending on variables such as the species' abundance, the technology used to process the species, cultural history of the community, and integration of the culture into the market economy (Campos and Ehringhaus 2003). Sop et al. (2012) list environmental and context-specific sociocultural factors as determinants of diverging plant use patterns, including type of culture (ethnicity), geographic location, degree of intercultural mixing with neighboring groups, and local availability of the targeted species. According to Alcorn (1981), it is imperative to analyze plant use within its own natural, social, and cultural context because changes in people's personal and social lives, as well as variations and changes in the natural environment, can all influence plant use.

Second, cross-cultural research has been instrumental in showing that native communities tend to possess a larger body of knowledge about natural resources than immigrants and people of mixed ancestry (such as caboclos, ribereños, mestizos, creoles) sharing the same living area (Atran et al. 2002; Campos and Ehringhaus 2003; Hoffman 2013). However, traditional knowledge about biological resources is dynamic and continuously adapts through cultural exchanges that promote shared uses. For example, Campos and Ehringhaus (2003) showed that more than one-third of the uses cited by indigenous participants for 17 palm species in the Brazilian Amazon were learned from people of mixed ancestry inhabiting the same region. On the other hand, the dynamic character of traditional knowledge is also derived from ongoing experimentation within the same culture and guided by the availability and accessibility of plants over space and time, cultural perception of plant efficacy, and sensory perception of smell, taste, and touch (Heinrich et al. 1998; Thomas et al. 2008). Pieroni and Quave (2005) attributed the differences in medicinal plant knowledge between Albanians and native Italians in a southern Italian community to differences in cultural beliefs between both groups, in particular the perceived spiritual origin for most illnesses and the prevalence of ritual magic-healing practices in Albanians. Discordance in overall woody plant knowledge among three ethnic groups in the sub-Sahel of Burkina Faso was explained by differences in culture and local environmental conditions, the latter influencing species distribution and availability (Sop et al. 2012).

Third, the mere existence of a biological resource in a geographic area does not necessarily mean that all cultural groups in the area would use this resource, as is the case, for example, with the palm *Euterpe precatoria* in the Brazilian Amazon (Campos and Ehringhaus 2003). The same observation holds true for ecosystem units. In comparing knowledge of tribal Afro-American people and native indigenous people in the Surinamese tropical forest, the former demonstrated a special relationship with fallow forest, which reflected a combination of cultural, economic, and biological influences. These fallow forests contained softwood species that are good for woodcarving, an important cultural and economic activity in the Afro-American group. In contrast, native indigenous people of the area demonstrated no habitat preference to meet their subsistence needs (Hoffman 2013). As such, cross-cultural comparisons add depth and richness to ethnobiological research.

On a more philosophical note, changes in plant knowledge witnessed in migrant groups open a debate about what constitutes "traditional" knowledge. Knowledge of biological resources picked up by migrants along the route of migration should perhaps be called "local" knowledge because it represents a combination of practical knowledge, ancestral knowledge, and other types of knowledge more formally acquired, for example, from agricultural extension officers (Nesheim et al. 2006).

What Are the Benefits of Cross-Cultural Research?

The value of ethnobiological knowledge has long been recognized, among others for conservation. Understanding the patterns by which people know and use their biological resources is of central importance to rural development projects that try to reconcile improved quality of life with conservation of natural resources. In finding a large overlap in plant knowledge of foods and handicrafts by ethnic groups living in Kosovo, Mustafa et al. (2015) concluded that "cross-cultural studies could be important for proposing culturally sensitive ways of using plant natural resources in future sustainable economic development initiatives."

Careful documentation of the hybrid and dynamic nature of knowledge about biological resources as a result of cultural exchanges is important during the planning and implementation of programs for development and resource management in which the voices of local people can inform decisions on which resources and practices should be prioritized (Campos and Ehringhaus 2003; Sop et al. 2012).

Pardo-de-Santayana and Macia (2015) advocate for studies that can "help to integrate traditional local knowledge with efforts to conserve biocultural diversity… " and "promote culturally appropriate, sustainable development strategies." In their study on vernacular names across Afro-Surinamese and African cultural groups, Van Andel et al. (2014) pointed out that comparing local plant names to study their origin can be a useful outreach instrument in cultural awareness programs aimed at promoting biocultural heritage.

Finally, cross-cultural comparisons of plant knowledge can be useful for the sometimes heated debate on intellectual property rights. Analyzing to what extent biological resources, knowledge, and practices are shared between different cultural groups can pinpoint species and uses that are unique to certain cultures and thus represent an inherent part of their cultural patrimony. Also, understanding that a certain degree of species and uses is shared, some to a large extent, such as the use of *Dysphania ambrosioides* (Amaranthaceae) as a vermifuge, can be of a pacifying nature in this debate. It is a universal trait of human nature, part of what makes us human, to be curious and learn about and exchange information and biological resources in the light of the survival of our species.

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Dictionary of Ethnobiology and Related Areas[1]

Maria Franco Trindade Medeiros Unidade Acadêmica de Biologia e Química, Universidade Federal de Campina Grande, Campus Cuité, Sítio Olho D'Água da Bica, s.n., 58195-000 Cuité, Paraíba, Brazil

Ângelo Giuseppe Chaves Alves Federal Rural University of Pernambuco, Av. Dom Manoel de Medeiros, s/n, Dois Irmãos, 52171-900 Recife, Pernambuco, Brazil

Cecília de Fátima Castelo Branco Rangel de Almeida Departamento de Ciências Biológicas, Centro de Ensino Superior do Vale do São Francisco, BR-315, s/n, Nova Olinda, 56440-000 Belém de São Francisco, Pernambuco, Brazil

Eraldo Medeiros Costa-Neto Laboratory of Ethnobiology and Ethnoecology (LEE), Department of Biology, State University of Feira de Santana, Av. Trandnordestina, s/n, Novo Horizonte, 44050-512 Feira de Santana, Bahia, Brazil

Ernani Machado Freitas Lins Neto Universidade Federal do Vale do São Francisco, Avenida José de Sá Maniçoba, Centro, 56304205 Petrolina, Pernambuco, Brazil

Fabio Kessler Dal Soglio Laboratory of Agroecology, Department of Plant Health, Federal University of Rio Grande do Sul, Av. Bento Gonçalves, 7712, Agronomia, 991540-000 Porto Alegre, Rio Grande do Sul, Brazil

Francisco José Bezerra Souto Laboratory of Ethnobiology and Ethnoecology (LETNO), Department of Biological Sciences, State University of Feira de Santana, Av. Transnordestina, s\n, Novo Horizonte, 44036-900 Feira de Santana, Bahia, Brazil

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Gabriela Coelho-de-Souza Departamento de Economia e Relações Internacionais, Programa de Pós-Graduação em Desenvolvimento Rural, Universidade Federal do Rio Grande do Sul, Av. João Pessoa 31, 90040-000 Porto Alegre, Brazil

Gustavo Taboada Soldati Departament of Botany, Federal University of Juiz de Fora, Rua José Lourenço Kelmer, s/n, Campus Universitário, 36036-900 Juiz de Fora, Minas Gerais, Brazil

Hilton Pereira da Silva Laboratório de Estudos Bioantropológicos em Saúde e Meio Ambiente, Universidade Federal do Pará, Instituto de Filosofia e Ciências Humanas, R. Augusto Corrêa, 01 – Campus Universitário do Guamá, 66075-900 Belém, Pará, Brazil

Joabe Gomes de Melo Instituto Federal de Alagoas – Matriz, Campus Maragogi, Rodovia AL 101 – KM 126, Centro, 57955-000 Maragogi, Alagoas, Brazil

José Geraldo Marques Laboratory of Ethnobiology and Ethnoecology (LETNO), Department of Biological Sciences, State University of Feira de Santana, Av. Transnordestina, s\n, Novo Horizonte, 44036-900 Feira de Santana, Bahia, Brazil

Julio Marcelino Monteiro Laboratory of Botany, Campus Amílcar F. Sobral, Federal University of Piauí, BR 343, km 3,5, Meladão, 64800-000 Floriano, Piauí, Brazil

Lin Chau Ming Depatment of Horticulture, Laboratory of Ethnobotany and Medicinal Plants, Agronomical Sciences College, São Paulo State University, 18603-970 Botucatu, Sao Paulo State, Brazil

Luiz Vital Fernandes Cruz da Cunha Center for Biological Sciences and Health, Courses of Biological Sciences, Herbarium of the Catholic University of Pernambuco, Rua do Príncipe, 526, Boa Vista, 50050-900 Recife, Pernambuco, Brazil

Marcelo Alves Ramos Universidade de Pernambuco, Campus Mata Norte, Rua Amaro Maltez, 201, Centro, 55800-000 Nazaré da Mata, Pernambuco, Brazil

Natalia Hanazaki Laboratory of Human Ecology and Ethnobotany, Department of Ecology and Zoology, Universidade Federal de Santa Catarina, Campus Reitor João David Ferreira Lima, 88040-900 Florianópolis, Santa Catarina, Brazil

Rômulo Romeu Nóbrega Alves Departamento de Biologia, Universidade Estadual da Paraíba, Campus I – Campina Grande, Av. Baraúnas, 351, 58109753 Campina Grande, Paraíba, Brazil

Ulysses Paulino Albuquerque Laboratory of Applied and Theoretical Ethnobiology (LEA), Department of Biology, Federal Rural University of Pernambuco, Av. Dom Manoel de Medeiros, s/n, Dois Irmãos, 52171-900 Recife, Pernambuco, Brazil

Abstract

In this chapter, a synthesis of 67 terms used in ethnobiology and related areas is presented. To elaborate the meanings of each term, we aimed to address their particularities and provide multiple meanings, when necessary. The bibliography at the end of the chapter can serve as a source for further and more detailed study. Following a systematic organization, the entries shown here are presented in *italics* and maintain the same graphic typology whenever mentioned throughout this dictionary, including in direct quotes. Obviously, this dictionary does not assume to provide an exhaustive list of the terms used in this scientific field and related areas. However, this is a first effort to publish such content. We intended for each entry to reflect the views of more than one expert in the area; however, this was not always possible because either we did not obtain more than one opinion or because the definition of the entry achieved a certain consensus.

Agrobiodiversity

Agrobiodiversity is the result of the management of biological diversity over time and across generations by different cultural groups using locally developed technologies, thus influencing the structure and maintenance of agroecosystems (see *Agroforestry System* and *Agroforest*). Agroecosystems are the result of the coexistence of cultures and ecosystems, a relationship that shapes various categories of landscapes: promoted, managed, and/or cultivated, sensu Clement (1999). According to Santilli (2009), agrobiodiversity is the result of the creativity and inventiveness of local communities in interaction with ecosystems over the past 12,000 years. It comprises the variability at the phylogenetic, organismic, and ecological levels (of population and community) in agroecosystems. Variability at all levels is associated with the adaptive values of all species, which confer resilience to agroecosystems, providing greater stability to the structuring and maintenance functions of agroecosystems under different topographical, climate, vegetation, and soil quality conditions.

Agroecology

The concept of *agroecology* has been much discussed and still lacks a consensus, especially in Brazil, where the disagreement follows two different currents. It can be said that there is an academic concept and a common sense concept. The concept that is more widely adopted in academic contexts is that *agroecology* is a science based on a systemic approach and an interdisciplinary perspective that addresses the development of more sustainable and contextualized agriculture models based on the redesign of agroecosystems, which are its units of study, and considering mainly, but not exclusively, ethical, social, cultural, ecological, technological, and economic aspects, incorporating academic and local knowledge. At the end of the twentieth century, the concept of *agroecology* began to be widely adopted in various regions of the world, particularly in Brazil, as a form or model of ecologically based agriculture and even as in resistance to the conventional agriculture model. It incorporates the search for nonchemical, socially, and ecologically contextualized solutions that approach the ideal of sustainability. This concept originated in the search among certain "pragmatic" groups of farmers and technicians for a more comprehensive name to represent them. These groups were originally referred to as advocates of "alternative agriculture"; however, they sought to replace the term "alternative," which is sometimes viewed negatively as conveying indolence or even antisocial attitudes. Proponents of these ecological models of agriculture adopted the term *agroecology*, which was already in evidence, as a way of communicating their ideals of agriculture work that considered the social and environmental dimensions and not just the economic ones. Therefore, everything that concerned the development of ecologically based agriculture, including knowledge, interactions, and the practices themselves, came to be called *agroecology* (Dal Soglio and Lemos 2009). The conceptual differences in *agroecology*, however, are not fundamental to a systemic perspective that aims to analyze and develop redesigned strategies that allow agroecosystems to take more sustainable forms. From this perspective, a complementary relationship between science and practical application, which currently coexist in the construction agroecological knowledge, is essential. Thus, *agroecology* is both the science and the practices that result in knowledge applied to the development of sustainable agriculture models and rural development.

Agroforestry System and Agroforest

Agroforests are characterized by maintaining the succession dynamics of native ecosystems by promoting the native floristic ensemble and/or replacing native species with functional types that reproduce the ecological structure and processes. In forest environments, *agroforests* reflect the diversity of strata shaped by the presence of trees, shrubs, palm trees, lianas, epiphytes, herbaceous, and/or agricultural species. *Agroforest*, according to Götsch (1997), is synonymous with *successional agroforestry system*, one of the categories of *agroforestry systems* (AFSs). According to May and Trovatto (2008), *agroforests* are classified as static and successional agroforestry, agrosilvopastoral systems, and silvopastoral systems. In the gradient of the diversity of *agroforestry systems*, these are considered, at their simplest, systems with a forest species among the component species, whether native or exotic, planted, or of natural regeneration. In their most complex form, *agroforests* are *successional agroforestry systems*, managed in a way that incorporates agroforestry production into the dynamics of natural succession, leading to an increasingly complex forest structure that approaches, over time, the structure of advanced stages of natural regeneration. Among the main products of agroforestry, sociobiodiverse products stand out; such products link cultural diversity to environmental diversity (see *Sociobiodiversity*). In this context, emphasis is placed on traditional systems of agrobiodiversity management adapted to the characteristics of local ecosystems. This knowledge involves management practices that generate models more adapted to the ecological conditions of native ecosystems, with which *agroforests* are associated. The maintenance of the structure of native ecosystems associated with the production of food species enables the continuity of the wildlife dynamics that govern gene flows. With respect to mammals, generally, the larger their size, the more they move within the territory. At the same time, there are productive spaces aimed at food and nutrition security, agrobiodiversity conservation, increasing and diversifying family incomes, and the appreciation of cultural and biological diversity. Because of their importance in the conservation and sustainable use of biodiversity, *agroforests* are being considered in environmental policies as tools for sustainable agroforestry and for connecting wildlife corridors, thus ensuring the viability of ecosystems and gene flows. Their implementation is being stimulated by the restoration of Legal Reserve and Permanent Preservation Areas (BRASIL 1965). In the context of Food and Nutrition Security (FNS) policies, the management of *agroforests* promotes healthy eating practices via the production of sociobiodiverse products and environmental conservation—seeking to maximize food production through natural succession—with respect for cultural diversity. Within the ambit of rural development policies, since the 2000s, there has been a connection between the products of family farming among local peoples and traditional communities and institutional markets. Such connections have resulted in the inclusion of *agroforestry/sociobiodiversity* products, such as açaí (*Euterpe oleracea* Mart.) in the Northern region and jussara (*Euterpe edulis* Mart.) in the Southern region, in the School Feeding Program.

Anthropology of Disease

See *Medical Anthropology*.

Applied Ethnobotany

Applied ethnobotany can be understood as an approach within ethnobotanical research that aims to meet specific demands. For example, *applied ethnobotany* can concentrate on efforts for the conservation and sustainable use of biodiversity or the development of drugs of medical and/or pharmacological interest. According to

Hamilton et al. (2003), *applied ethnobotany* is a key theme when referring to conservation and sustainable development, especially for developing countries. Unlike traditional ethnobotanical studies, applied ones are designed from the outset using theoretical methods and references to address practical issues.

Benefit Sharing

The Convention on Biological Diversity (CBD) (2000) approved by the Federal Senate on February 3, 1994 (see Ministério do Meio Ambiente 2006) states in Chapter VII, *Da Repartição de Benefícios* [*On Benefit Sharing*], that "the benefits arising from the economic exploitation of a product or process developed from the sampling of a component of genetic heritage and associated with *traditional knowledge*, obtained by a national institution or an institution with its headquarters abroad, shall be shared in a fair and equitable way between the contracting parties, in accordance with the concerning regulation and legislation." The contracting parties may be established "on one side, by the owner of the public or private area or the representative of the indigenous community and the official indigenous body or the representative of the local community and, on the other, the national institution authorized to gain access and the receiving institution." The benefits may include, for example, profit sharing, royalty payments, access and technology transfer, the licensing of products and processes, and human resource training.

Biodiversity Management

Biodiversity management is synonymous with *biodiversity conservation* or *sustainable management of natural resources*. This approach adopts the concepts of management and biodiversity at the expense of conservation and natural resources, respectively, by expressing one of the strategies applied to the issue of the loss of biological diversity. The strategies are preservationism, conservationism (utilitarian and applied to ecosystemic processes (Barbault 2006), and ethnoconservationism (see *Ethnoconservation*).

Biological Anthropology or Bioanthropology

Biological anthropology or *bioanthropology* is the field or area of anthropology that investigates the origins and evolution of human biocultural variability. It originated from physical anthropology, a name by which it is still known in many countries. Biological anthropology can be considered an evolution and maturation of physical anthropology because in addition to the elements traditionally studied in the late nineteenth century and the first half of the twentieth century, when the term was coined and gained precedence, studies involving genetics, molecular biology, physiology, ecology, and sophisticated methodologies for quantitative analysis were later incorporated, which expanded the scope of the field beyond the "physical" (morphology) aspects that were traditionally studied until the middle of the last century. Currently, this field comprises several subdisciplines, such as paleoanthropology, which studies the evolution of primates, including man, in archaeological contexts; primatology, which analyzes the behavior and biology of nonhuman primates as possible models for the evolution of human groups; osteology, which studies human skeletal material to understand its variability and biomechanics and the diseases that affect the bones; biomedical anthropology, which uses anthropological theories and methods to understand the processes of health and disease in contemporary human groups and how these processes are influenced by the environment, culture, and ecology; human biology, which analyzes how human physiology, biology, and culture influence the species' adaptation to the different environments of the planet; paleopathology, which is the study of human disease in the populations of the past; and forensic anthropology, which is the use of anthropological methods and techniques to identify victims and resolve legal issues.

Bioprospecting

The term to *bioprospecting* applies to "studies of biological resources (including genetic ones) and/or derivatives for commercial exploitation purposes by the chemical, pharmaceutical, cosmetic, or food industries" (Azevedo 2003).

Climate Seasonality Hypothesis

The *climate seasonality hypothesis* emerged from observations of the strategies that human populations in semiarid regions used to forage for medicinal resources (Albuquerque 2006). Some researchers working in seasonal dry forests recorded greater use of the perennial structures of plants (e.g., stem bark) than ephemeral parts for medicinal purposes, even when both have the same therapeutic indications. One explanation is that this pattern reflects an adaptive strategy that populations living in semiarid regions use to access the resource, even though it is not as effective as other resources that are more ephemeral in time and space (Albuquerque 2010a). The strategy is based more on secure access to the resource than on its therapeutic effectiveness in the case of medicinal plants. There are studies that provide evidence that in the scenario presented about, the parts that the people select for medicinal purposes may not have the same therapeutic effectiveness as the alternatives parts that are less used.

Community(ies)

The term *community*, which comes from the Latin *communicate*, can be understood from different angles, depending on the theoretical approach used. In the definition that is found in the main dictionaries of the Portuguese language, the term refers to some quality that is common or that implies common participation. From the viewpoint of the social sciences, *community* has a meaning that implies social relationships, including a sharing of ideas or features and often a common territory. From the ecological viewpoint, *community* is an analytical construction of the investigator. Usually, we refer to communities as some unit of the natural world that we (human investigators) can categorize according to characteristics that mean something to us (Begon et al. 1996). The ecological definition of *community* is also closely associated with scale issues in ecology and with levels of biological organization. Within this context, a *community* consists of a greater or lesser number of biological populations, together with the physical environment where interactions occur and where the distribution and abundance of organisms are studied. From the point of view of human ecology, which studies the relationships between the use of natural resources and human groups, the term *community* refers to the human population in a particular place and at a particular time and the environmental resources to which this population relates. The term *community* also appears in ethnobiological studies, but that denomination is not always the most appropriate. The terms *community* and *population* are often used interchangeably when referring to groups of people, especially when the work is not intended to emphasize the political nuances of the terms. The use of the term *population* rather than *community* is recommended in these situations when the clear existence of a sense of community and communal forms of social organization within a given human group are not assumed.

Comprehensive Ethnoecology

Comprehensive ethnoecology is a transdisciplinary field of (scientific) research that studies the thoughts (knowledge and beliefs), feelings, and behaviors that mediate the interactions between the human populations that possess them and the other elements of ecosystems that include them, as well as the environmental impacts arising therefrom (Marques 2001).

Cultural Evolution Theory

The *cultural evolution theory (CET)* is a theoretical approach that considers cultural systems as endowed with evolutionary properties and therefore approachable with an understanding of modern evolution theory (Cavalli-Sforza and Feldman 1981;

Mesoudi et al. 2004; Mesoudi et al. 2006; Mesoudi 2007). The authors who support CET consider that the cultural and genetic bases of human beings are two heritage information systems that interact during human evolution, and they use basic concepts of biological theory to explain cultural diversity and its historical development. Assuming these considerations, the same tools, methods, and approaches used in studies of biological evolution can be applied to cultures (Mesoudi et al. 2006). CET is characterized by (1) considering cultural systems as dynamic systems with evolutionary properties; (2) recognizing the coevolutionary dynamic between genes and culture; (3) arguing that the evolution of cultural systems is justified by cultural change, competition between cultural traits, and the accumulation of cultural characteristics (inheritance); (4) analyzing cultural evolution from a populational perspective and examining the correlations between micro-evolution and macroevolution; (5) rejecting progressive linear or multilinear development; (6) assuming the possibility of acquiring non-parental characteristics (horizontal transmission); and (7) working with the concept of non-discrete traits or information (Cavalli-Sforza and Feldman 1981; Mesoudi et al. 2004; Boyd and Richerson 2005; Richerson and Boyd 2005; Mesoudi et al. 2006; Mesoudi 2007).

Diversification Hypothesis

The *diversification hypothesis* has been proposed by Albuquerque (2006) as an alternative explanation for the presence of exotic plants in traditional pharmacopeias. One of the premises of this hypothesis is based on the idea that exotic plants are introduced consciously and actively in a culture to fill gaps that native plants do not seem to fill, either from a chemical point of view or in terms of their specificity and effectiveness for "therapeutic targets." The first formal testing of this hypothesis was performed by Alencar et al. (2010), who found strong evidence that exotic plants have a greater chemical diversity than native plants. Thus, the explanation of acculturation, which is usually raised in the literature to explain the presence of such plants in a culture's medical systems, was challenged.

Ecological Anthropology

Like *biological anthropology* and *medical anthropology*, *ecological anthropology* derives from the interdisciplinary nature of the four traditional fields of Boasian anthropology (social/cultural anthropology, physical/*biological* a*nthropology*, archaeology, and anthropological linguistics) and is a subarea dedicated to investigating the relationships between humans and their natural environment in time and space. *Ecological anthropology* seeks to break the hegemonic dichotomous division of nature and culture that is common to both the social and biological sciences (Morán 2011). Utilizing information from a combination of other areas, such as ecology, physiology, geography, and history, *ecological anthropology* aims to understand the ways in which human groups from the past and the present physically, culturally, and intellectually interact with their natural environment to construct their biosocial niches, which places it in close relationship with *ethnoecology*, human ecology, and environmental anthropology disciplines that are still little known in Brazil (Neves 2002; Morán 2011). Roy Rappaport (1926–1977), a pioneer of human ecology, published a book called *Pigs for the Ancestors* (Rappaport 1968), which featured a case study that has become classic in *ecological anthropology*. The case study examined the roles of culture and ritual in the adaptation of a tribal group, the Tsenbaga Maring, from Papua New Guinea. In this study, Rappaport uses an ecosystem perspective to understand the biocultural adaptive processes through which the natives interact with the local environmental diversity. The book remains an essential reference for those interested in the topic.

Ecological Apparency Hypothesis

The *ecological apparency hypothesis* was first proposed by Feeny (1976) to explain how plants' defenses are distributed in response to herbivory. Steep and Moerman (2001), when considering the large presence of herbs in the traditional pharmacopeia of various peoples, suggested that the *apparency hypothesis* could explain this phenomenon. According to a premise of this hypothesis, the short life cycle of herbaceous plants, for example, would cause them to invest in compounds highly toxic to herbivores, and these compounds would be those that exhibit wide therapeutic applications to biological activity in humans (Albuquerque and Lucena 2005). Phillips and Gentry (1993) were the first to propose that the "appearance" of a plant (which can be measured by its local availability) may explain its importance for *local communities*.

Ecozone

An *ecozone* is an ecological area recognized in traditional/local cultural systems that corresponds to a cognitive (emic) category and which may or may not coincide with scientific typologies (Posey 1987a).

Enculturation

Individuals of a particular social group must share the values, practices, rites, and knowledge of their culture (see Hewlett Cavalli-Sforza 1986; Zarger and Stepp 2004; and Garcia 2006). The process that makes an individual culturally fit to live in a society is called *enculturation*. A significant amount of this process takes place in childhood and occurs through the transmission of information, knowledge, and behaviors via various means.

Entomoprojective Ambivalence Hypothesis

Humans tend to project feelings of harm, danger, irritability, repugnance, and contempt on noninsect animals (including people) and associate these feelings with the culturally determined category of *insect* (Costa-Neto 2000). The idea of ambivalence is used in the sociological sense of an attitude that oscillates between different and sometimes antagonistic values. The *projection* is the result of the psychological process by which a person attributes to another being the reasons for her own conflicts. The hypothesis is testable by recording information that portrays the emotional-situational nature of the perception of animals that are labeled as *insects* but are not actual insects in terms of their Linnaean classification.

Ethnobiology

Ethnobiology is the study of the relationships between living organisms and social-cultural systems. It has been classically defined as the study of interactions between people and their environment, i.e., the study of the knowledge and concepts of biology that a culture develops. Given the variety of approaches, objectives, and methods observed in ethnobiological studies and the perspective of articulating local and academic knowledge and natural, social, and human sciences, *ethnobiology* is characterized as an interdisciplinary field (see Marques 2001).

Ethnobotany

Ethnobotany refers to the study of the interrelations between man and plants throughout time and in different environments (Xolocotzi 1983). Albuquerque (2005) defines *ethnobotany* as the study of the "direct interrelation between peoples from living cultures and the plants in their environment." *Ethnobotany* studies this interrelation between people and plants from the perspective of Western science (Albuquerque and Hurrell 2010).

Ethnoconservation

Ethnoconservation is a multidisciplinary applied scientific field that exists in the interface between conservation biology, rural development, *ethnoecology*, and anthropology. It focuses on territorial dynamics and the management of biodiversity/natural resources. It is strongly influenced by socioenvironmentalism, which recognizes the inseparability of cultural and biological diversity given the interrelationships among indigenous peoples, *traditional populations*, *traditional knowledge*, and ecosystems. The socioenvironmentalist conceptions of the Federal Constitution in 1988 and the Convention on Biological Diversity in 1992 strengthened the involvement of peoples and *traditional populations* as political actors in the construction of Brazilian public policies (Santilli 2005). *Ethnoconservation*, as a political and academic proposal for the issue of biodiversity loss, is in opposition to the field of conservation biology. *Ethnoconservation* proposes, among its approaches, the *utilitarian conservationist approach* and the *conservationist approach to ecosystemic processes*. These approaches are based on the integration of the population and ecosystemic levels, including the cultural context of management systems. *Ethnoconservation* and conservation biology both develop strategies for conserving biodiversity and/or the sustainable use of natural resources. In its sustainability focus, *ethnoconservation* resembles the multidisciplinary scientific field of ecological economics (Constanza 2011). In its applied dimension, *ethnoconservation* is a socioecological management model that, within the ambit of land management, includes the right of peoples and *traditional communities* to their territories, recognizing the value of culture and the importance of territory as means of maintaining culture. In this model, management meets the objectives of each territory (maroon territories, indigenous lands, conservation units for sustainable use and integral protection, permanent preservation areas, legal reserves, mosaics of protected areas, wildlife corridors, and biosphere reserves) and values the contribution of traditional, scientific, technical, and legal knowledge to the shared biodiversity management processes of the State and society.

Ethnoecology

The term *ethnoecology* was first presented by Conklin (1954) in his classic study of the Hanunoo in the Philippines. However, this author did not provide a definition for the term. Among the available definitions, some emphasize the position of *Ethnoecology* in relation to preexisting disciplines, such as Johnson's (1974) reference to "*Ethnoecology*, a characteristic focus of Human Ecology, which defines its objectives and methods from *Ethnoscience*." Marques (1995, 2001) was the first Brazilian author to design an original proposal for the field. In 1995, he published the following definition of the term: "… the study of interactions between humanity and the rest of the ecosphere through the pursuit of understanding the feelings, behaviors, knowledge and beliefs about the nature characteristic of a highly polymorphic, phenotypically plastic and ontogenetically dynamic biological species (*Homo sapiens*), whose new emergent properties provide it with multiple discontinuities with the rest of nature. Its emphasis, therefore, should be on biocultural diversity and its main goal, the integration of traditional ecological knowledge and scientific ecological knowledge." In 2001, the same author presented a modified definition of the same term: "… the field of (scientific) transdisciplinary research studying the thoughts (knowledge and beliefs), feelings and behaviors that mediate the interactions between the human populations that possess them and the other elements of ecosystems that include them, as well as the environmental impacts arising therefrom." Reflecting on the great diversity of definitions of *ethnoecology*, Alves and Souto (2010) made the following comment: "As a recent hybrid field of knowledge, there is not a unified and consensual definition about what *Ethnoecology* is, and such consensus may not yet be necessary. Rather than presenting a problem, this lack of consensus can also be an exciting challenge. The very diversity of conceptions can be considered a positive aspect. Considering that one of the assumptions of *Ethnoecology* is the valuing of the cultural diversity manifested within each society, which should perhaps also be applied within the academic community itself through a greater tolerance and the attempt to establish connections between seemingly divergent theoretical and methodological conceptions."

Ethnoecozoning

Ethnoecozoning is the interdisciplinary study of the spatiality resulting from the perception, characterization, and definition of *ecozones* in traditional/local communities (Souto 2010).

Ethnoentomology

The term *ethnoentomology* first appeared in the scientific literature in the 1950s with the publication of a study on the traditional methods that Navajo Indians used to control pests (Wyman and Bailey 1952). However, the term did not appear in a book title until 1964, with the publication of Navajo Indian Ethnoentomology, also by Wyman and Bailey. *Ethnoentomology* can be defined as the branch of *Ethnobiology* that investigates the perception, knowledge, and uses of insects in different human cultures (Posey 1987b). Paraphrasing Berlin (1992), we can identify it as the field that studies, in the broadest sense possible, the complex set of interactions that human societies, both past and present, have with insects. Gabdin (in Maya 2000) says *ethnoentomology* is the science that establishes the functional interactions of human societies with the world of insects. Paraphrasing D'Olne Campos (1995), *ethnoentomology* can also be understood as the branch of *ethnobiology* that investigates the entomological science of by a given ethnic group, based on the parameters of Western science. From the perspective of Marques' *comprehensive ethnoecology* (1995), *ethnoentomology* can be defined as the interdisciplinary study of the knowledge, feelings, and behaviors that mediate the relationships of the human populations that possess them and the plethora of insect species.

Ethnoichthyology

Ethnoichthyology is the interdisciplinary study of the relationships between humans and fish, focusing on knowledge, practices, and perceptions about fish and the environmental consequences resulting from these interactions.

Ethnoknowledge

Basically, *ethnoknowledge* is the knowledge of the "other" or the research subject. Such knowledge is produced by the experiences and experiments of a population (e.g., indigenous, African descendants, caiçaras, rural communities, or even herbalists) and essentially passed on orally and from generation to generation. This knowledge is usually dynamic and permits adaptation (e.g., the exclusion or incorporation of information to meet specific demands), although it is based on values and beliefs deeply rooted in everyday know-how. "We can then consider as *Ethnoknowledge* the knowledge produced by different ethnic groups in different locations on the globe from popular knowledge" (Miranda 2005). Alves and Albuquerque (2005) observed that "ethnoknowledge" has frequently been used in the literature to replace *local knowledge* or *traditional knowledge*. They also pointed out that *ethnoknowledge* tends to be general and thus excludes possible dubious interpretations of certain aspects of the knowledge produced by the "other."

Ethnomedicine

Ethnomedicine refers to the study of different medical systems and healing practices, especially, but not exclusively, traditional medicines (non-allopathic). The primary focus of *ethnomedicine* (albeit not the only one) is the knowledge and practices transmitted orally by different peoples, cultures, and ethnic groups over the centuries (Erickson 2008). *Ethnomedicine* is concerned with cultural interpretations of health, disease, and illness and attempts to understand how society and culture intervene in these processes (Lowe et al. 2000). It investigates the use of natural drugs and poisons in a traditional context (Rivier 2012). It focuses on cultural healing systems and the cognitive parameters of disease as well as cultural values and social roles (McElroy 1996). The term *ethnomedicine* can also be used to characterize multidisciplinary systems used by specific agents (faith healers, midwives, witch-doctors, shamans) of peoples and *traditional populations* that include the joint use of plants, spirituality, and other ecological resources for treatments and cures (Cox and Balick 1994). Some anthropologists prefer to define *ethnomedicine* as a subarea of *medical anthropology* (McElroy 1996), which also investigates the social, political, and economic relationships of health, the ecology of disease, and the various interpretations of human suffering and health in time and space (Erickson 2008). Academically, very different disciplines are involved in *ethnomedicine*, such as cultural anthropology, bioanthropology, ethnology, linguistics, history, botany, zoology, chemistry, pharmacology, toxicology, and medicine (Rivier 2012; Erickson 2008); furthermore, *ethnomedicine* may overlap somewhat with *ethnopharmacology* by broadening the general knowledge about the human relationship of drugs from a cultural and historical perspective (Rivier 2012).

Ethnoornithology

Ethnoornithology began as a field of scientific study in the 1880s, when inventories of bird species and their vernacular names, uses, and meanings and related stories evolved into more comprehensive studies. It can be stated, however, that the interactions that humans maintain with birds have varied across times and places and differ according to the cultural patterns of each society. In this sense, different approaches to *ethnoornithology* have been taken, revealing the principles of classification, nomenclature, and identification of bird species in the multiple connections that individuals establish with these animals: ludic, social-affective, therapeutic, trophic, economic, and mystical-religious, among others.

Ethnopedology

The term *ethnopedology* was introduced in the literature by Williams and Ortiz Solorio (1981) in their study about the ethnotaxonomy of soils among the peasants of Tepetlaoztoc, Mexico. These authors presented the following definition of e*thnopedology*: "Folk perception of soil properties and processes, folk soil classification and taxonomy, folk theories and explanations of soil properties and dynamics, folk soil management, folk perceptions of the relationships between soil and plant domains, comparison between folk and technical soil science, assessment of the role of folk soil perception in agricultural practices and other behavioral realm […]. The term is used here in a broader sense than is usually implied in *Ethnoscience*, or in the terms ethno-plus academic discipline (for example, *Ethnoichthyology*, *Ethnoornithology*, *Ethnobotany*)." Recently, in Brazil, Marques and Alves (2005) proposed a definition more directly related to ecology and *ethnoecology*: "The term *Ethnopedology* designates the set of interdisciplinary approaches dedicated to studying the interfaces between soils, the human species and the other components of the ecosystems. Thus, *Ethnopedology* is characterized as one of the possible sources of the ethnoecological approach."

Ethnopharmacology

Ethnopharmacology is a relatively new science defined as the observation, identification, and description of and experimentation with the ingredients and effects of herbal drugs (Efron et al. 1970). It is also defined as the scientific exploration of biologically active agents, including plants and other resources, which are traditionally employed or observed by humans (Bruhn and Holmstedt 1981). Another author argues that *ethnopharmacology* aims to evaluate the effectiveness of "traditional" medicinal techniques, making use of a large number of pharmacological models (Waller 1993). Thus, *ethnopharmacology* goes beyond the simple recording of herbal drugs; ethnopharmacological study requires interdisciplinary scientific collaboration between pharmacology, toxicology, chemistry, anthropology, and sociology (Schuktes 1962; Malone 1983; Etkin 1993). *Ethnopharmacology* focuses not only on drugs of plant origin but also on other products derived from nature, such as animal, mineral, and fungi products, as well as dyes, fibers, poisons, and fertilizers (Heinrich 2000).

Ethnoscience

Ethnoscience (also known as *new ethnography*, *ethnosemantics*, or *semantic ethnography*) emerged in the mid-twentieth century as a new anthropological approach through which cultures were no longer seen as sets of artifacts and behaviors and instead were considered systems of knowledge or mental abilities revealed by linguistic structures. Ethnoscientists consider knowledge a set of possible skills to be transmitted between people; they want to discover the principles that organize cultures and determine the extent to which these principals are universal (Brown 1999; Alves and Souto 2010).

Ethnosilviculture

Ethnosilviculture focuses specifically on an ethnoecological approach that seeks to understand the relationship between human societies and forests (Silva et al. 2011).

Ethnospecies

An *ethnospecies* is a living being framed within a terminal or subterminal level of a folk taxonomy. The term is sometimes used in the literature as a synonym for "popular name."

Ethnozoology

The term *ethnozoology* emerged in the United States in 1899; it was proposed and defined by Mason as "the zoology of the region, as narrated by the savage." When investigating the hunting techniques used by some Native American peoples, Mason said that all fauna found in a region, directly or indirectly, enter the life and thought of every human group. After Mason's proposition, the term *ethnozoology* did not appear in the literature until 1914, specifically in the book Ethnozoology of the Tewa Indians by Henderson and Harrington.

Historical Ethnobotany

Historical ethnobotany studies the evolution of relationships between man and the plant world while considering historical contexts. Based on historical studies of cultures, *historical ethnobotany* presents direct evidence of the historical uses and cultural significance of different plant species (Medeiros 2009, 2010).

Indigenous Knowledge

According to Posey (2000), *indigenous knowledge* is the collection of information, practices, beliefs, and philosophy that are unique to an indigenous culture. This knowledge may be held collectively within an indigenous community or society or can be exclusive to experts (e.g., shamans), genders, lineage groups, or tribal ancestors. It has been used as a synonym for *traditional knowledge*, and, accordingly, one should be careful, as it does not apply to projects, policies, and programs that seek to work with other peoples, such as rural farmers. In addition, in some countries, the term "indigenous" has a negative connotation, as it is associated with "backwardness" and has ethnic and political connotations (see Warburton and Martin 1999). See *Local Knowledge* and *Traditional Knowledge*.

Informant Consensus

Informant consensus is a set of techniques based on the quantification of *local knowledge*. It aims to reflect the degree of agreement among informants, starting with the idea that culture is shared knowledge. *Informant consensus* measures have the advantage of proposing comparisons between informants' responses about the cultural field being researched and allowing statistical analysis. Such techniques are well known for their convenience and relatively quick application. However, there are discussions about the limitations of this approach because quantifying or measuring knowledge is no simple task. One must keep in mind that these tools express knowledge measures and not actual use, even though they may reflect the expressed uses to a greater or lesser degree.

Informant/Interviewee/Participant

In principle, all of these terms designate the person(s) in an ethnobiological or ethnoecological study who shares their own knowledge system, usually a nonacademic system, with the researcher. As critical and active participants in the production of ethnobiological knowledge resulting from the connection between the academic system and the local system, *informants* should also be recognized as "partners in research." However, according to Albuquerque et al. (2014), these three terms may have different definitions depending on the researcher's training. In such cases, *informants* are "persons with whom a more lasting relationship was developed, that is, a relationship that was not restricted to the time of only one interview" (Albuquerque 2010a). In the latter case, the same authors state that the appropriate term is *interviewee*. In the case of a participatory research, Albuquerque et al. (2014) advocate the use of the term *participant*.

Informed Consent Term

In Brazil, the *informed consent term* (ICT) is one of the measures required by the National Health Council (Conselho Nacional de Saúde—CNS), through Resolution No. 196 of 10/10/1996, for the legal completion of all studies involving humans (BRASIL 1996; Albuquerque et al. 2010a). This resolution, and consequently the ICT, specifies the ethical duties of the scientific community—namely, autonomy, non-maleficence, beneficence, and justice with regard to human participants in investigations (BRASIL 1996). In this sense, the ICT should be a document that, in accessible language, clarifies to individuals, groups, and/or their legal representatives the following issues: "(a) the rationale, aims and procedures to be used in the research; (b) the discomforts and possible risks and expected benefits; (c) existing alternative methods; (d) the form of monitoring and assistance and the persons accountable for providing them; (e) the assurance of clarifications, before and during the course of research, about the methodology, informing the participants of the possibility of inclusion in a control or placebo group; (f) the individual's freedom to refuse to participate or withdraw his consent at any stage of the research, without any penalty and without prejudice to his care; (g) the assurance of confidentiality to guarantee the privacy of subjects regarding the confidential data involved in the research; (h) forms of reimbursement of the costs arising from participation in the research; (i) forms of indemnity to cover possible injury resulting from the research (BRASIL 1996).

Intermedicality

This concept was developed in the field of health anthropology, especially in studies related to indigenous health issues. It attempts to address contexts characterized by the coexistence of several different medical systems, such as allopathic, biomedical, Western, and traditional indigenous medicine, the holistic forms of oriental medicine, and other perspectives and procedures related to health and disease among culturally different groups.

Knowledge Transmission

Knowledge transmission (sometimes also known as *information copy* or *social learning*) is any process by which knowledge and behaviors are transmitted in a social group, e.g., by interactions among peers or between group members and the products of this interaction (Heyes 1994; Boyd and Richerson 2005; Hoppitt and Laland 2008; Mesoudi and Whiten 2008). In this sense, the transfer of information between individuals of the same group (culture) or between individuals of different groups may occur directly or indirectly. In general, studies of *knowledge transmission* based on an evolutionary approach (see *Cultural Evolution Theory*) attempt to answer four basic questions as follows:

(a) What is transmitted? Is there any information that is favored during transmission?
(b) When is information transmitted? In what situations should individuals choose to copy knowledge?
(c) How is information transmitted? What is the mechanism of information copy (e.g., observation, teaching, emulation)?
(d) From whom is the information copied? Is there any feature that makes an individual a model to be copied?

This last question evokes one of the most widespread models of *knowledge transmission*, described by Cavalli-Sforza and Feldman (1981) and reworked by Cavalli-Sforza and Hewlett (1986). According to those authors, information in a group can be transferred (1) from parents to children (*vertical transmission*); (2) between individuals of the same generation (*horizontal transmission*); (3) between generations when youngsters copy adults who are not their parents (*oblique transmission*);

(4) from a teacher, leader, or medium such as television or radio to many individuals in the group (o*ne-to-many transmission*), usually pupils, apprentices; or (5) from the oldest to the youngest members of the social group (*many-to-one* or *concerted transmission*).

Local Communities (Local Populations)

The use of the term *local* to qualify *populations* (or *communities*) is adopted by extending the use of this term to describe local knowledge (Berkes 1999). The term *local knowledge* began to be adopted because it was less problematic than the expressions *traditional* or *indigenous*. When referring to knowledge, the term *local* is usually associated with recent, or *neotraditional* knowledge. Apparently, the use of the expression *local* has also been supported by opposing local contexts with global contexts (see, e.g., Nazarea 1999). A *local population* can be regarded as a population that is less absorbed in a global scenario of urban-industrial populations and that has particular and shared characteristics; however, it should be noted that these qualifications are often based on contrasts or comparisons. It is also important to consider, especially in the Brazilian context, that the national population is formed by a confluence of different groups (Ribeiro 1995); in this regard, many groups that for some period of time were kept separated from the urban-industrial populations can be considered *local populations*. See *Communities*, *Traditional Communities*, and *Neotraditional Communities*.

Local Knowledge

Often used interchangeably with *traditional* or *indigenous knowledge*, *local knowledge* consists of beliefs, perceptions, traditions, practices, and worldviews developed and supported by different communities over time (Vandebroek et al. 2011; Warburton and Martin 1999). *Local knowledge* is not confined to tribal groups or to the original inhabitants of an area nor is restricted to people living in rural areas. Rather, all communities can build this knowledge, whether rural or urban, settled or nomadic, or whether they include native or migrant inhabitants. It is believed that the term "local" has emerged as a way to reduce the problems related to the use of the expressions *traditional* and *indigenous* as a result of the ideological and conceptual implications of these words (see Berkes 1999). However, the term "local" itself also carries some implications that are disputed by some scholars, especially because it underestimates the potential and actual value of this knowledge in relation to global issues. See *Indigenous Knowledge* and *Traditional Knowledge*.

Medical Anthropology

Medical anthropology investigates how human societies build their rationality and attribute meanings to diseases using their ecological and social characteristics (i.e., their adaptive mechanisms) and determines the potential evolutionary implications of these constructs. *Medical anthropology* proposes critically questioning the notions of body, corporeality, health, and disease in their biological, cultural, social, political, and ecological dimensions among the different societies and different ethnic or social groups, with the aim of identifying similarities and differences (Scheper-Hughes and Lock 1987). It uses the four traditional fields of anthropology (social/cultural anthropology, biological/physical anthropology, archaeology, and anthropological linguistics) to analyze and compare the health and disease situations of diverse populations from the past and the present with the goal of understanding how they work, using particular etiologic and therapeutic models (Hill 1991). As a subdiscipline and a specific area of knowledge defined as such, *medical anthropology* emerged in the United States in the 1950s, and William Caudill was a pioneer in the use of the term (Caudill 1953). *Medical anthropology* currently has at least three main orientations: medical ecology, which investigates the relationship between human populations and their biosocial environment from an evolutionary point of view; *ethnomedicine*, which analyzes the cultural and cognitive mechanisms of disease and healing in different human groups; and *applied medical anthropology*, which uses the tools of anthropology to analyze the socioeconomic forces that influence the differential distribution of conditions and health services among human groups, to help interpret and prevent diseases, and to plan and implement public health care policies (McElroy 1996). Other commonly associated terms are anthropology of health, anthropology of disease, medical ecology, and *ethnomedicine*, although the term *medical anthropology* is the most widely recognized internationally and incorporates the other terms.

Medical Ethnobotany

Medical ethnobotany is concerned with the relationship between individuals in "traditional" groups and their use of local flora for medicinal purposes (Pearn 2004). It can also be linked to the search for prospective plant sources of chemicals that could provide selective advantages for the survival of all living organisms (Briskin 2000). For Telban (1988), *medical ethnobotany* is a practice of people living in remote areas, whose medical beliefs (social, magical, and spiritual causes of the disease) guide their use of plant treatments. This aspect makes *medical ethnobotany* an extremely important and lasting specialty in general *ethnobotany*; it contributes to the knowledge and conservation of features of the ancestral popular culture and enables the discovery of new plant-derived medicines (Hedberg 1993). *Medical ethnobotany* promotes traditional therapies and focuses on the context of plant use (Berlin 1992), in contrast with its "sister field," *ethnopharmacology*.

Neotraditional Communities (Neotraditional Populations)

According to Begossi (1998), *neotraditional populations* are those with both traditional knowledge and access to new knowledge from outside, which can increase their resilience to changes. Examples of these populations include the caiçaras of the Atlantic Forest and the caboclos of the Amazon (Brazil). The same effect appears in Berkes (1999) for the concept of *Neotraditional Knowledge*. However, because it is assumed that *traditional knowledge* is dynamic by nature, any *traditional population* that is in contact with other groups may incorporate, even unconsciously, new knowledge, with different intensities. See *Communities*, *Local Communities*, and *Traditional Communities*.

Phytotherapeutic Drug

A *phytotherapeutic drug* "is any drug obtained using solely plant-active raw materials. It is characterized by knowledge of the effectiveness and risks of its use and the reproducibility and constancy of its quality. Its efficacy and safety are validated through ethnopharmacological surveys of use, technical and scientific documentation in publications, or phase 3 clinical trials" (BRASIL 2004).

Phytotherapy

Phytotherapy "is a treatment method characterized by the use of medicinal plants in their different preparations, without the use of isolated active substances" (BRASIL 2012).

Plant Medicine

Plant medicine refers to the use of "a medicinal plant or its parts, after collection, stabilization, and drying processes, which may be used in its entirety, blotted, crushed, or ground" (BRASIL 2004).

Quantitative Ethnobotany

The term *quantitative ethnobotany* appeared in several studies as a way to bring more robustness to the analyzed data. Albuquerque (2010b), by analyzing the evolution of the use of the term *quantitative ethnobotany*, noticed that this approach contributed to the methodological advances of *ethnobotany*. However, Albuquerque states that the term has become synonymous with quantification in *ethnobotany*, which is not necessarily associated with the hypothetical-deductive method that was used in the original design of Phillips and Gentry (1993). Since the 1990s, ethnobotanists' research of local knowledge has incorporated quantitative analysis tools to estimate the relationship between biological and cultural diversity and to examine the importance of natural resources for local populations (Medeiros et al. 2011). Thus, in *ethnobotany*, quantification includes applying indices or quantitative techniques and/or the application of statistical analysis.

Reliability of Ethnoknowledge or Traditional Knowledge

Reliability of ethnoknowledge or traditional knowledge refers to the testing or verification of *ethnoknowledge* accuracy. Scientific validation of *traditional knowledge* occurs through the pharmacological, nutritional quality, or insecticidal activity testing of plants (Cotton 1996). In a way, the purpose of such testing is not to prove the statements collected by the researcher (empirical); rather, it is an attempt to reconcile this accumulated knowledge with technical findings that are tested and duly verified in the light of strict scientific standards.

Return of Results

The *Return of Results* is guaranteed by the Declaration of Belém, which was developed during the I International Congress of Ethnobiology held in the city of Belém (State of Pará) in 1988. This document, which guides the professional work of ethnobiologists, establishes that "procedures must be developed to compensate native peoples for the utilization of their knowledge and their biological resources." Regarding the *Return*, the declaration also requires that "ethnobiologists make available the results of their research to the native peoples with whom they have worked, especially including dissemination in the native language."

Sociobiodiversity

Literally, *sociobiodiversity* refers to the relationship between biological diversity and cultural diversity. It is based on the understanding that in the contemporary world, environmental issues are not divorced from social issues, especially in the context of mega-biodiversity countries with great cultural diversity, such as Brazil. *Sociobiodiversity* has its origin in socioenvironmentalism, a social and academic movement with repercussions in the legal sphere; based on the

Federal Constitution of 1988 and the Convention on Biological Diversity of 1992, socioenvironmentalism strengthened social and environmental rights by involving peoples and traditional populations as political actors in the construction of Brazilian public policies (Santilli 2005). Complex issues emerge in the contemporary world, particularly the debate about climate change, biodiversity conservation, the recognition of cultural diversity, and the rights of traditional and native populations. These issues are reconfigurations of previous debates, such as land issues, development, and human rights, which are sources of tension against the power structures of the wider society. Although society is grounded in principles such as liberty, equality, and fraternity, property provides a base for putting these principles into practice, creating a structure in which the society dominates biodiversity and peoples and communities with other values and approaches. New issues, which some authors consider hybrids, are recognized as social and environmental issues; Boaventura Santos (2005) regards these hybrids as evidence of an epistemological crisis of scientific knowledge. It is in this context that, within the ambit of science, the interfaces between scientific fields become spaces that provide tools for a complex analysis of these new issues, such as *sociobiodiversity. Ethnoecology* is a field of knowledge within the interface of various sciences, with an emphasis on anthropology and ecology; it is permeated by *traditional knowledge*, which is a space for dialogue among traditional, scientific, technical, and legal knowledge sources (Coelho-de-Souza et al. 2011).

Subjective Allocation

Subjective allocation is a set of techniques for evaluating the value or importance of a species according to the members of a particular community. The subjective nature of this approach stems from researchers who assign predetermined values to plants. Among the main examples of *subjective allocation* is the cultural significance index (Turner 1988; Stoffle et al. 1990; Silva et al. 2010).

Traditional Communities (Traditional Populations)

Currently, the expression *traditional populations*, in Brazil and in several other countries, has very important political significance. Almeida and Carneiro da Cunha (2001) define *traditional populations* as "groups that have conquered or are struggling to conquer (practically and symbolically) a conservationist public identity that includes some of the following characteristics: the use of low impact environmental techniques, equitable forms of social organization, the presence of legitimate institutions entitled to enforce its laws, local leadership, and, finally, cultural traits that are selectively reaffirmed and restated." In the Brazilian context, since 2007, the government has adopted some definitions related to *traditional communities*, peoples, and territories. Federal Decree no. 6040, of February 7, 2007, established the National Policy for the Sustainable Development of *Traditional Communities* and Peoples and defined *traditional communities* and *peoples* as "culturally different groups that recognize themselves as such and that have proper forms of social organization; occupy and use territories and natural resources as a condition for their cultural, social, religious, ancestral and economic reproduction; and use knowledge, innovations and practices generated and transmitted by tradition." It should be emphasized that the first objective of the National Policy for the Sustainable Development of *Traditional Communities* and Peoples is to ensure that *traditional communities* and peoples retain their territory and their access to the natural resources that they traditionally use for their physical, cultural, and economic reproduction. Therefore, two main elements are linked to the recognition of *traditional communities* and people: the territorial issue and the access to traditionally used natural resources. For a contextualized discussion of the term, see the text by Lucila Pinsard Vianna on the expressions *traditional population* and *tradition* (Vianna 2008, pp. 240–281). See *Communities*, *Local Communities*, and *Neotraditional Communities*.

Traditional Knowledge

Traditional knowledge consists of the collection of knowledge, practices, and beliefs about the natural and supernatural world built by a traditional culture and generally transmitted through oral tradition (see Diegues and Arruda 2001). The term "traditional" carries a negative connotation in the sense that it conveys a static and primitive view of this knowledge that ignores its adaptive and dynamic nature. This knowledge differs from scientific knowledge because it is not intended for generalizing observations about universal laws or making predictions about nature, although it is extremely useful for solving issues that are part of the sociocultural context of both the traditional communities that hold this knowledge and of modern societies. In the latter, it may even provide insights, for example, in matters relating to biodiversity conservation and the discovery of new drugs. See *Local Knowledge and Indigenous Knowledge*.

Traditional Territory

According to Brazilian Federal Decree number 6040 of February 7, 2007, *traditional territories* are "the spaces necessary for the cultural, social and economic reproduction of traditional peoples and communities, whether used permanently or temporarily, observing, with regard to the indigenous and quilombola peoples what is provided by the articles 231 of the Federal Constitution and 68 of the Temporary Constitutional Provisions Act, respectively, and by other regulations." Article 231 of the Federal Constitution provides that "The indigenous peoples have their social organization, customs, languages, beliefs and traditions recognized, in addition to the original rights to the lands they traditionally occupy, being incumbent upon the Union to demarcate them, protect and ensure that all their goods are respected." According to the first paragraph of the same article, the lands traditionally occupied by indigenous peoples are those "inhabited by them on a permanent basis, those used for their productive activities, those indispensable to the preservation of the environmental resources necessary for their well-being and for the their physical and cultural reproduction, according to their customs and traditions." The other paragraphs of this article concern the inalienability of these lands, the right of permanent ownership of these lands, and the exclusive use of the riches of soils, rivers, and lakes, with the need for authorization by the Federal Congress for the use of these resources. Article 68 of the transitional provisions of the Federal Constitution says that "the remnants of maroon communities who are occupying their lands have the definitive ownership recognized, and the State shall grant them the respective titles." The reading in full of Federal Decree 6040 of 2007 and of articles 231 of the Federal Constitution and 68 of the Temporary Constitutional Provisions Act and other regulations is recommended. Almeida et al. (2010) should also be consulted.

Utilitarian Redundancy Hypothesis

Also known as a *Utilitarian Redundancy* model (Albuquerque and Oliveira 2007), this hypothesis foresees scenarios in which great richness of species used for the same purpose would reduce the pressure on each species individually because the use would be theoretically distributed among species. This ideal situation does not occur when a particular species is preferred for a given use. Some premises are that (1) *Utilitarian Redundancy* is an operational concept used to analyze the function of redundant species in a given cultural system as well as their resilience and their effects on local biodiversity; (2) species may have different functions within these systems, and there may be a certain degree of overlap among their functions (i.e., redundancy); (3) the presence of redundant species ensures the resilience of the system; (4) redundancy is strongly associated with the characteristics of the local knowledge system and the practices of a particular community (Albuquerque and Oliveira 2007). The hypothesis has already been studied using ethnomedical data (see *Ethnomedicine*) and ecological data on the use of plants (Albuquerque and Oliveira 2007; Ferreira Júnior et al. 2011, 2012) and medicinal animals (Ferreira et al. 2012).

Zootherapeutic Universality Hypothesis

This hypothesis, proposed by Dr. José Geraldo Wanderley Marques, states that "every human culture that has developed a medical system uses animals as sources of medicines" (Marques 1994).

Zootherapy

The treatment of human diseases using products that are considered potentially medicamental formulated from an animal's body parts; from its metabolic products, such as body secretions and excrement; or from materials built by animals, such as nests and cocoons (Costa-Neto 2010).

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