Acta Botanica Brasilica - 33(2): 376-385. April-June 2019.
doi: 10.1590/0102-33062018abb0331

Viewpoint

Ten important questions/issues for ethnobotanical research

Ulysses Paulino Albuquerque[1*], André Luiz Borba Nascimento[1], Gustavo Taboada Soldati[2], Ivanilda Soares Feitosa[1], Juliana Loureiro Almeida Campos[1], Julio Alberto Hurrell[3], Natalia Hanazaki[4], Patricia Muniz de Medeiros[5], Rafael Ricardo Vasconcelos da Silva[5], Rafaela Helena Ludwinsky[4], Washington Soares Ferreira Júnior[6] and Victoria Reyes-García[7,8]

Received: September 27, 2018
Accepted: February 19, 2019

ABSTRACT

For at least 30 years researchers have called for a deeper reflection on the paths we desire for ethnobotanical research. Although the discipline of ethnobotany is growing, as measured by the number of publications in the area, there is still work to be done regarding the homogeneity of theoretical and methodological approaches and the implications of ethnobotanical research findings for society as a whole. In this article we present 10 questions/issues that we believe can guide the research and actions of ethnobotanists for the coming years.

Keywords: biocultural conservation, ethnobiology, local botanical knowledge, local ecological knowledge, social-ecological systems

Introduction

Ethnobotanists seek to understand how people interact with the environment and obtain plant resources to meet their cultural and physical needs. The first ethnobotanical contributions, dating from the first half of the nineteenth century, consisted of descriptive texts that sought to list plants and their uses (Hunn 2007; Albuquerque *et al*. 2013; Gaoue *et al*. 2017). Over the last four decades, however, this type of descriptive contribution has been criticized, largely on the basis that, while the information provided might be of interest, the knowledge gained has a fragile or even nonexistent theoretical basis and little methodological

1 Laboratório de Ecologia e Evolução de Sistemas Socioecológicos, Centro de Biociências, Departamento de Botânica, Universidade Federal de Pernambuco, 50670-901, Recife, PE, Brazil
2 Laboratório de Etnobiologia e Agroecologia, Departamento de Botânica, Universidade Federal de Juiz de Fora, 36036-900, Juiz de Fora, MG, Brazil
3 Laboratorio de Etnobotánica y Botánica Aplicada, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Calle 64, La Plata, Argentina
4 Laboratório de Ecologia Humana e Etnobotânica, Departamento de Ecologia e Zoologia, Centro de Ciências Biológicas, Universidade Federal de Santa Catarina, 88040-900, Florianópolis, SC, Brazil
5 Laboratório de Ecologia, Conservação e Evolução Biocultural, Centro de Ciências Agrárias, Universidade Federal de Alagoas, 57100-000, Rio Largo, AL, Brazil
6 Laboratório de Investigações Bioculturais no Semiárido, Universidade de Pernambuco, 56328-903, Petrolina, PE, Brazil
7 Institució Catalana de Recerca i Estudis Avançats, 08010, Barcelona, Spain
8 Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, 08193, Barcelona, Spain

* Corresponding author: upa677@hotmail.com

rigor (see Phillips & Gentry 1993; Albuquerque 2009; 2013; Gaoue *et al*. 2017). Moreover, rapid changes in livelihoods have resulted in rapid changes in the way people relate to the environment, making the relationship between people and plants increasingly complex. As a result, ethnobotanists have been increasingly compelled to move beyond descriptive studies and develop a theoretical framework that explains human behavior in relation to plant resource use (Gaoue *et al*. 2017).

Thus, in recent decades, ethnobotany has incorporated theoretical insights from several disciplines, including ecology, economics and anthropology (Oliveira *et al*. 2009; Ritter *et al*. 2015). This has resulted in an increase in the number of publications and the types of approaches used (Albuquerque *et al*. 2011; 2013; Campos *et al*. 2016). The question, however, is whether these changes answer new questions and contribute to the elucidation of gaps that provide scientific growth. To answer these questions, the discipline needs to reflect on its main challenges and develop new theoretical and methodological research proposals. This reflection exercise has already been undertaken in other sciences and has proven to be quite challenging (Grierson *et al*. 2011; Sutherland *et al*. 2013). Indeed, almost a decade ago, Albuquerque & Hanazaki (2009) proposed that the main problems faced in ethnobotany become a field of research. Reflecting on the issues and challenges faced should be the first step in implementing contemporary and relevant research agendas aligned with the advances of recent years.

In this article, we aim to suggest new research proposals based on how current needs are perceived by some researchers working in the field. The questions that follow result from the personal history of each researcher, their theoretical and epistemological orientations, and their academic approaches. Unquestionably, they do not represent a consensus in the community of ethnobotanists but result from the reflections and debates that some of us have been developing over the last few years. Thus, our text is not exhaustive but limited to the experience and vision of the authors. Despite this limitation, we hope that this article may motivate future contributions so that we can implement a research agenda for the future of ethnobotany. An alternative would be to hold discussion workshops so that experts can revisit the issues presented here and propose new ones together. In our view, this is imperative. Although ethnobotany produces more knowledge than other ethnobiological subdisciplines, the scientific community, similar to other fields of knowledge, has been experiencing a process of self-criticism and self-analysis. This requires reflecting on the relevance and current importance of studies based mainly on lists of species and descriptions of their uses, since the field has provided few updates that are usually redundant.

In this article, we present some topics that are not exclusive. However, they can serve as starting points and a way to reach more relevant objectives. We present 10 large questions that are ordered not by any judgment of relevance but by the affinity between them.

Some major questions

How is indigenous and local knowledge in ethnobotanical research best represented?

As ethnobotanical studies rely heavily on indigenous and local knowledge (ILK)[1], they face the challenge of adequately bringing evidence from these knowledge systems. The challenge arises not only because unwritten forms of knowledge can be difficult to transpose to into written scientific studies (Reid *et al*. 2006; Berkes 2018), but more importantly because scientific studies might decontextualize the information and remove it from the cultural environment that gives it meaning (Stevenson 1996). While there is a growing and laudable tendency to include indigenous peoples and local communities (IPLCs) as coauthors in ethnobotanical research (e.g., Paniagua-Zambrana *et al*. 2017), this procedure alone does not guarantee the proper representation of ILK in ethnobotanical research (Turnhout *et al*. 2016). Since this procedure is not commonly employed, perhaps it generates difficulties for decision makers to operationalize the use of this data when monitoring species or systems.

Recently, some authors have suggested that, where relevant, information and data from ILK systems should be considered through a 'multiple evidence-based' (MEB) approach (Tengö *et al*. 2014), which puts ILK on equal footing with globally generated academic science. The MEB approach notes that there are *"parallels whereby indigenous, local, and scientific knowledge systems are viewed to generate different manifestations of knowledge (...)"* (Tengö *et al*. 2014: 571). Ethnobotanists could engage with this or similar frameworks to continue in the quest to better represent ILK in ethnobotanical research.

Ethnobotany has sustained development in recent decades. However, reflections on ethnobotanical research itself have experienced little development, especially in the theoretical-methodological domain, as mentioned earlier. Reflection is understood here as a recursive process (nonlinear) that involves rethinking our thoughts in a way that interpolates our fundamental assumptions (Maturana 1996; Morin 2009). Numerous ethnobotanical studies address ILK, but an important fact is not considered because the knowledge system of "the Other" is not directly accessible to us (see Ludwig 2017). Conversely, it is indirectly accessible through the actions that knowledge

[1] The terms indigenous, local and traditional are often employed in the literature indistinctively. In this article we consider indigenous knowledge as the knowledge that comes from autochthonous peoples. We reserve the term local to the knowledge of other peoples.

guides, including narratives (verbal language), behaviors, practices, and selective strategies, which can be evaluated. Knowledge is retroactively and recursively embodied in actions that in turn inspire knowledge, thus forming a recursive relationship. The researcher starts with actions to reconstruct the knowledge that generated them (Hurrell 2014).

The interview aims to rebuild the local knowledge system using verbal language (Hurrell 2014). Nevertheless, its value as a complex communication experience is often underestimated or ignored. An initial reflection indicates that the interview is a conversation (Maturana 1996), which necessarily implies a context that gives it meaning. However, nonverbal language (gestures, use of space) (Hall 2005) is not considered a descriptive variable, although in human communication, nonverbal language is frequently more relevant than verbal language in terms of meaning. In addition, the presence of the researcher usually seems to be overlooked, and the conversation becomes a unilateral narrative of the interviewee outside the interview context. In this case, the self-excluded researcher acts as a mere translator. A second reflection shows that the researcher rebuilds knowledge because he is included in the conversation (Auge 2014). Researcher "absence" generates a risk: he transfers his own categories to the interviewee, e.g., the distinction between native and exotic species, or what a resource is.

What methodological innovations can capture the dynamic nature of local/traditional botanical knowledge?

ILK systems, including botanical knowledge, are dynamic by nature in that they adapt to new ecological and social conditions (Gomez-Baggethun *et al*. 2013). In most regions of the world, IPLCs are subject to increasing social, economic, political and environmental/ecological pressures, experiencing high rates of social and environmental changes. These changes, no doubt, have an impact on plant-based knowledge systems (PBKS). While these changes have mostly resulted in the loss of knowledge (Reyes-Garcia *et al*. 2013; Aswani *et al*. 2018), in other circumstances, they have just led to changes in the knowledge system (Reyes-Garcia *et al*. 2014). In several parts of the world, current studies can benefit from past studies, using them as baselines in cross-sectional approaches (Aswani *et al*. 2018). The use of such approaches can help in understanding dynamic aspects of ILK over time.

Given the fast pace of socioenvironmental changes and their impact on ILK systems, an ethnobotanist's tool kit might not be adequate to document such changes (for methods, see, for example, Albuquerque *et al*. 2014a; 2019a). The use of information and communication technologies (ICTs) by knowledge holders presents an untapped methodological innovation for capturing the dynamic nature of botanical knowledge. Through online platforms that allow the collection of data, knowledge holders could have more active participation in ethnobotanical research, especially if access to the internet is improved. While some authors have started to explore these methodological innovations (e.g., Reyes-Garcia *et al*. 2018), ethnobotanists should continue to explore its strengths and weaknesses to develop methodological innovations that allow for the dynamic nature of botanical knowledge to be captured.

What theoretical innovations can capture the dynamic nature of ILK systems?

There are several possibilities and alternatives for integrating different theoretical scenarios in order to advance the contribution of ethnobotany for understanding the dynamic relationships between IPLCs and plants. Albuquerque & Ferreira Júnior (2017), for example, list several research questions from an ecological and evolutionary perspective. Gaoue *et al*. (2017) describe and systematize different hypotheses that have been added to ethnobotanical studies in the last 30 years that still need to be tested in different social-ecological contexts[2]. Given the interdisciplinary nature of ethnobotany, the field is receptive to different theoretical articulations, and ethnobotanists could continue to explore these opportunities (see, for example, opportunities to integrate phylogeny and taxonomy to understand plant selection: Saslis-Lagoudakis *et al*. 2014; Toneu *et al*. 2018 – and the new theory in ethnobiology and related fields proposed by Albuquerque *et al*. 2019b).

Researchers from different disciplines have agreed that humans have modified environments throughout history to favor their survival, producing persistent effects (Laland *et al*. 2010; Levis *et al*. 2017; Sullivan *et al*. 2017). In this case, new generations inherit modified environments that result from past decisions, and this may affect the knowledge and current use of plants for different uses (Albuquerque *et al*. 2018; Lins Neto & Albuquerque 2018), especially in the face of climate change (see Ladio 2017).

A recent study showed that IPLC groups in Africa, located in regions with a high incidence of malaria, knew of a great number of plants that could be used for treatment (Santoro *et al*. 2017). This relationship occurred before the adoption of public policies to control the disease, which seems to have negatively affected the knowledge of antimalarial plants. In these groups, the incidence of malaria may be a result of changes in the environment that occurred in the past, which has generated pressure to increase plant richness in the treatment of malaria. Similarly, for plants used as fuel in northeastern Brazil, the number of known exotic plants is favored in environments with a scarcity of forest areas, which will increase fuel availability (Silva *et al*. 2018). Thus,

[2] For information on hypothesis-guided research in ethnobiology see also Gonçalves-Souza *et al*. (2019).

it is possible that human strategies that were applied in the past and altered the availability of native species have driven the selection and use of exotic species over time.

In other words, we need to better understand how the action of the human species has modified and still modifies ecosystems and other species and how past human decisions may have affected the way we interact with plants in the present (see examples of approaches in Silva *et al*. 2017; 2019). Research guided by this approach can reveal how past human decisions affect the evolution of plant-based knowledge systems (PBKS).

What challenges do we need to face to better understand the structure and function of social-ecological systems?

Social-ecological systems comprise plants and other elements of the environment known and/or used by people, information flow (cultural transmission), storage and retrieval of this information (cognition), and other factors (see some research questions in Albuquerque & Ferreira Junior 2017). Despite this complexity, we need to understand relatively simple things for which we still do not have good answers. For example, some ethnobotanical studies often record the categories of PBKS. However, few studies have examined the interaction between the elements of these categories. For example, one could test whether uses considered more "noble" in a species stop or block uses considered less noble for the same species. The rationale is that people would adopt the most relevant use for the plant and use substitute species for other purposes in which the species would fit. Information in the literature supports this argument. Lins Neto *et al*. (2010), for example, in a study in the Brazilian semiarid region, observed that the species *Spondias tuberosa* Arruda was of great food importance but was generally only used for logging when there was a natural fall of the trunk. This indicates that special use would limit or protect plants for other uses. Ritualistic species are also normally not used for other purposes, even if they have the potential for it (see Colding & Folke 2001).

Answering this question is important because the use of a species for one purpose may increase the chances that it will be tried and harvested for another purpose. For example, in a compilation of studies from the northern region of South America, Bennett & Prance (2000) suggest that most medicinal plants have been adopted because of their value as food or medicine. Thus, plants used as ornamental and food products would be more likely to be incorporated into local pharmacopoeias (see an implication of this idea in the hypothesis of versatility - Gaoue *et al*. 2017).

The elucidation of these interactions can help in understanding why certain species, even when exhibiting high potential for a given use, are barely used for that purpose. From a conservation point of view, such information would help predict what would happen, for example, with the use of a species for wood purposes when other uses were added to or removed from the social-ecological system. Some specific questions could be the following: Can the use of a species for a given purpose curb or block its use for other purposes? Can the use of a species for a given purpose increase the chances that it will be used for other purposes?

Another important and relevant issue in ethnobotany is to study the transmission of cultural information (Santoro *et al*. 2018). Social transmission or social learning is the process of learning with other individuals by interaction or observation of them or their products (Kendal *et al*. 2018). The capacity of learn from others allow us to obtain an adaptive information without the cost of experimentation (Mesoudi 2011). Moreover, it is possible to create more complex knowledge by using the previous transmitted information as basis to innovate (Boyd *et al*. 2011). Humans have psychological mechanisms that indirectly favour the acquisition of cultural information (Enquist *et al*. 2007). These mechanisms or social learning strategies are related with different kinds of decisions (see Kendal *et al*. 2018).

The majority of research in ethnobotany related with these aspects just describes the different types of social transmission. There is a necessity to go deeper in this subject. Some important questions are: What makes an information on a plant more transmitted than others for a same purpose? Who are the people considered by the community as sources of knowledge about plants? Do the learning models change if plant use (food, medicine, timber, construction) is different? What are the cues used by people to detect the learning models? Expertise? Similarity (e.g. women learning with women)? Are possible that people copy information about one cultural domain (e.g. medicinal plants) with people that are recognized as knowledgeable about other cultural domains (e.g. agriculture)?

How can ethnobotanical research better contribute to strengthening biodiversity governance?

The potential of ethnobotanical knowledge for biodiversity conservation is acknowledged in the academic literature (e.g., Porter-Bolland *et al*. 2012; Turnhout *et al*. 2012; Pardo-de-Santayana & Macia 2015; Mistry *et al*. 2016), and is experiencing a growth in recognition among policy-makers and science-policy platforms (Vohland *et al*. 2011; Ford *et al*. 2016; Díaz *et al*. 2018). A notable development that largely contributed to the recognition of ILK in international policy-making was the establishment of the Convention on Biological Diversity (CBD) in 1992. Specifically, Article 8j of the CBD establishes that signatory countries should respect, preserve, and promote the contributions of traditional knowledge to biodiversity conservation, which includes local/traditional botanical

knowledge. ILK and associated practices are considered important and relevant for achieving conservation goals and are treated with the same importance and relevance as any other form of knowledge in the implementation of the CBD. Even within conservation goals, the CBD encompasses targets such as target 13 of the Global Strategy for Plants Conservation (GSPC), which concerns ILK about plant use and the dependence of these peoples on plants. However, at least in Brazil, there is still a lack of integrative and effective policy initiatives, and profound changes are necessary for the achievement of such goals that articulate conservation and IPLCs (Hanazaki *et al*. 2018).

Despite interest among scientists and policy-makers, few countries are making systematic efforts to preserve and, to a lesser degree, promote the use of ethnobotanical knowledge to strengthen environmental governance. There have been several initiatives in that direction (see Benyei *et al*. 2019; Lakshmi *et al*. 2014 for reviews). However, only a few have the capacity to influence policy making. Over the last two years, the IPBES Global Assessment has developed one of the first global-scale mechanisms for operationalizing ILK in sustainability decision-making (McElwee *et al*. 2019). Ethnobotanists should engage in this and similar initiatives to bring ethnobotanical research results into the applied domain.

How can ethnobotanical research better contribute to strengthening the political interests of IPLCs?

IPLCs are the main interlocutors of ethnobiological research and have always been the target of threats to their identities, knowledge, and, above all, their territories (Soldati & Albuquerque 2016). This situation was formally denounced in 1988 in the "Carta de Belém". However, when this document was reprinted thirty years later during the International Congress of Ethnobiology in 2018 (Belém, Brazil), the same themes were highlighted, which suggests that ethnobotanical research could have more strongly benefitted local people. In other words, ethnobotanists have not succeeded in vocalizing the need for a more inclusive socio-biodiversity conservation project despite growing political agreement regarding its relevance.

Therefore, the moment becomes opportune for a "Political Ethnobotany" (see also Alexiades 2003), starting from the premise that society is divided among different social actors who present different projects that are irreconcilable in most cases. This scientific project can be synthesized by the challenge of answering two major questions. First, "How are threats to territories, identities and ILK organized, structured and advanced?" Second, "What are the strategies of resistance of IPLCs for the use of the plant resources in their territories?"

Political Ethnobotany should also be concerned with the construction of bridges between concepts and theories of fields close to ethnobotany and the real demands of our interlocutors. For example, it should advance studies on historical ecology and landscape domestication to evaluate the role of ILK in the construction and modification of landscapes, especially in protected areas occupied by these peoples. Wolverton *et al*. (2016) analyze three case studies in which ethnobiological research talks with Political Ecology and "the relations of power" in our society. Finally, rather than describing specific processes and cases, political ethnobotany could benefit from dialogue with other fields of knowledge that reflect a more socially engaged ecology (see Martínez-Alier 2003; Santos 2014).

How have current and past migrations been shaping PBKS?

Human movements are reflected in the cultural and social characteristics of people due to historic changes that spit, merge, and reorganize the distribution of people in space. Migration is an old phenomenon that is ongoing; there were approximately 244 million international migrants in the world in 2015, both across borders and within countries, which is 3.3 percent of the global population (International Organization for Migration 2018). The separation of human species into ethnic, cultural, and linguistic groups was an outcome of migration, and it has also been the basis of the transmission of genes, cultures, and knowledge (Marsella & Ring 2003). While migrating, people not only carry, adapt, and transform their own culture and society but also transform other living beings.

Not only people migrate; a whole set of local or traditional knowledge migrates with them (Pieroni & Vandebroek 2007; Ceuterick *et al*. 2008; 2011; Andel & Westers 2010; Abreu *et al*. 2015), and propagules, seeds and plants can also be transported and adapted (see Medeiros *et al*. 2012). The study of the migration of human populations is fundamentally important for understanding the dynamics of biocultural knowledge and transformations in natural and urban landscapes through times past and in the current globalized world (Pieroni & Vandebroek 2007; Waldstein 2008; Salpeteur *et al*. 2016).

This biocultural knowledge changes as a function of adaptive processes (Pieroni & Vandebroek 2007), which can be interpreted through a variety of explanatory models (see, for example, Turner *et al*. 2003; Erten 2018; Fonseca & Balick 2018). However, every model needs to be fitted to differing local realities. Depending on the social-ecological context in which the immigrant groups are located, there may be incorporations of native species and changes of perceptions towards species considered culturally important (Medeiros *et al*. 2012; Pirker *et al*. 2012; Kujawska *et al*. 2017). From this framework, we raise two main questions: How can we study ethnobotany of past and present migratory movements considering that they occur in different timeframes? How can the movement of people be related to changes in local environments and local floras?

Ethnobotany and urbanization: how do we understand PBKS in cities?

Along with migration, urbanization has become an important issue, especially in the last half century. More than half of the world's population lives in urban areas (55 %), and the projections are for this percentage to increase to 68 % by 2050 (United Nations 2018). Urbanization results in deep transformations to the environment, with changes in the abundance, diversity, and composition of species in the urbanized area and beyond (Faeth *et al*. 2005). Moreover, urbanization can lead people to shift to a sedentary lifestyle, consume processed food and disconnect with nature (Hawkes 2006; Soga & Gaston 2016; Turreira-García *et al*. 2017).

In cities, several spaces remain or are created where people interact with the plant world (see Ladio & Albuquerque 2014). Home gardens, for example, survived and evolved over centuries of biocultural transformations as one of the oldest systems of land use (Nair & Kumar 2006). Green lands and home gardens in urbanized areas promote diversity and food security, allow for adaptation to climate change, improve life quality and wellbeing and can also increase the connectivity between urbanized landscapes and remnant forest areas (Galhena *et al*. 2013; Larios *et al*. 2013; Mattsson *et al*. 2013; Capaldi *et al*. 2014; Peroni *et al*. 2016; Ávila *et al*. 2017; Shackleton *et al*. 2017).

Considering multicultural societies, especially in large cities, most exotic plants can represent the diversity in home gardens and green spaces in urban areas, and perceptions and preferences of natural resources can govern the purpose of a green area in the city. In this context, some major issues surrounding ethnobotany and urbanization can be proposed: How does increasing urbanization result in changes in the local and regional diversity of useful plants? How are people transforming urban landscapes through their dependence on plants? Are there cultural signatures of ILK in green spaces of urban areas? How can we rethink conservation strategies considering the increasing disconnect with nature – and the consequent knowledge of native plants – and the increase of exotic plants in urban areas?

How can we go beyond searching for medicinal plants?

Classically, ethnobotany has accumulated great knowledge about medicinal plants. The focus on medicinal plants has been lacking, and this can be due to several reasons. One of the reasons is based on the argument that by investigating this very specific knowledge, we can advance the discovery of new drugs. However, different researchers have long criticized the fact that few new developments have arisen in this sense, and this is often due to several problems in how the research is conducted (see Albuquerque *et al*. 2014b; Medeiros *et al*. 2014).

Moreover, several other uses require an ethnobotanist's attention. Exploitation of wood, for example, is among the oldest and most frequent forest uses (Almeida *et al*. 2008). Timber forest products include all woody material with potential use as stakes, firewood, buildings, power generation, cellulose production and others. This resource is widely used by IPLCs, especially with regard to the socioeconomic reality found in developing countries, where wood is a resource for fuel, buildings, fences, hedges, etc. (Walters 2005; Ramos *et al*. 2008). Additionally, little is known about the influence of logging resources on the ecology of tropical forests, since this practice can substantially affect canopy cover and the basal area of trees (Kumar & Shahabuddin 2005) and have consequences for the plant community of the entire region. For example, above-ground biomass and plant species diversity are generally higher in older forests compared to younger forests (Álvarez-Yépiz *et al*. 2008).

Thus, ethnobotanists could try to answer some important questions from uses other than medicine, such as: Are the population dynamics of extracted species influenced by the extractive practice? How can the extraction of one species for logging purposes alter the population structure of other plant species? Is the composition and richness of species in a plant community influenced by logging? Finally, what are the consequences of these environmental changes on the extractive practices of IPLCs?

How can the interface between ecology and ethnobotany explain the processes associated with the collection of plant resources?

The collection of plant resources by IPLCs has been the subject of several studies over the decades. Many of them focused on aspects related to the knowledge and use of plants to infer how a selection pattern is formed for the collection (Feitosa *et al*. 2014). However, to understand the process of collecting a resource by human populations, it is necessary to have the greatest amount of information possible on all stages, from the selection of the resource to the time when the resource regenerates in nature and is available for collection again. Little is known about the variables that influence the strategies adopted by people in the foraging process, the levels of damage that species are able to withstand after collection, or the time required for species to regenerate (Mariot *et al*. 2014; Baldauf & Santos 2014; Feitosa *et al*. 2017).

Depending on the intrinsic characteristics of the species, evidence shows that it is possible to keep collecting large amounts in a sustainable manner (see Lopes & Begossi 2011). Another issue not yet known by researchers is how the behavior of foragers influences the decision-making process of others, especially how

the collection patterns affect the conservation of PBKS. Currently, the first questions are based on the influence that collection exerts on the sustainability of the practice. Moreover, ILK is an important variable in harvesting practices, and it is important to understand how it interacts with other variables.

Related to this, plant resources constitute part of the local, regional, national and international markets, forming the so-called chain of biodiversity. Although many of these chains are directed to local markets, which are already recognized as an excellent field for ethnobotanical research, it is still necessary to explain the influence of these commercial relationships on collection behavior, consumption and the production environment.

Thus, ethnobotanical surveys are capable of generating important insights about the influence of trade on the behavior of harvesting and consumption of resources by IPLCs (Ruiz-Pérez *et al*. 2004) as well as on the impacts on the production environment (Varghese & Ticktin 2008). However, to gain this knowledge, it is necessary to adopt an integrative perspective for the analysis of the different interdependent stages of production, from resource collectors to final consumers (see Booker *et al*. 2012; Silva *et al*. 2014).

Important ethnobotanical questions regarding the role of markets in spreading ILK and plant materials include: How do markets influence, and how are markets influenced by, social-ecological systems over time? What are the factors and how do they contribute to the emergence of socio-biodiversity chains and the capacity to sustain themselves in the market in a sustainable way? The answers to these questions may strongly support ethnobotany for developing conservation strategies of sociobiodiversity with income generation for IPLCs.

Future directions

The issues we posed earlier for reflection and action represent opportunities to advance ethnobotany as a science but also highlight the potential role of ethnobotanists in mediating between different sectors of society. Answering the above questions requires an interdisciplinary approach, which is key to a complex science such as ethnobotany. More efforts will be needed to answer the suggested questions (and others of interest in the area), which may involve integrating theoretical scenarios and methods proposed by other fields. This is challenging because it is necessary to adjust concepts, methods and explanations from other areas to the particularities of PBKS. Nevertheless, from the evidence obtained from these efforts, we can develop our own theoretical field. However, we will only be able to move forward effectively if different research groups in different parts of the world are willing to address these issues so we can compare and systematize the findings.

Acknowledgements

UPA thanks the financial support from FACEPE (Foundation for Support to Science and Technology of the State of Pernambuco - Grant number: APQ-0562-2.01/17). ISF thanks to CAPES/FACEPE for providing a post-doctoral scholarship (grants number: APQ-0700-2.05/16 and BCT-0259.22-05/17). Thanks to CNPq for the productivity grant awarded to NH, PMM and UPA, and to the post-doctoral fellowship (151518/2018-1) granted to ALBN. Thanks to CAPES through the Ph.D. scholarship awarded to RHL.

References

Abreu DBO, Santoro FR, Albuquerque UP, Ladio AH, Medeiros PM. 2015. Medicinal plant knowledge in a context of cultural pluralism: A case study in Northeastern Brazil. Journal of Ethnopharmacology 175: 124-130.

Albuquerque UP. 2009. Quantitative ethnobotany or quantification in ethnobotany? Ethnobotany Research & Applications 7: 1-7.

Albuquerque UP. 2013. How to improve the quality of scientific publications in ethnobiology. Ethnobiology and Conservation 2: 4. doi: 10.15451/ec2013-8-2.4-1-05

Albuquerque UP, Cunha LVFC, Lucena RFP, Alves RRN. 2014a. Methods and techniques in ethnobiology and ethnoecology. 1st. edn. New York, Human Press.

Albuquerque UP, Cunha LVFC, Lucena RFP, Alves RRN. 2019a. Methods and techniques in ethnobiology and ethnoecology. 2nd. edn. New York, Human Press.

Albuquerque UP, Ferreira Junior WS. 2017. What do we study in evolutionary ethnobiology? Defining the theoretical basis for a research program. Evolutionary Biology 44: 207-215.

Albuquerque UP, Gonçalves PHS, Ferreira Júnior WS, *et al*. 2018. Humans as niche constructors: Revisiting the concept of chronic anthropogenic disturbances in ecology. Perspectives in Ecology and Conservation 16: 1-11.

Albuquerque UP, Hanazaki N. 2009. Five problems in current ethnobotanical research-and some suggestions for strengthening them. Human Ecology 37: 653-661.

Albuquerque UP, Medeiros PM, Ramos MA, *et al*. 2014b. Are ethnopharmacological surveys useful for the discovery and development of drugs from medicinal plants? Revista Brasileira de Farmacognosia 24: 110-115.

Albuquerque UP, Ramos MA, Medeiros MFT. 2011. Experiences of ethnobotanists with publication: a first approach. BioScience 61: 706-712.

Albuquerque UP, Silva JS, Campos JLA, *et al*. 2013. The current status of ethnobiological research in Latin America: gaps and perspectives. Journal of Ethnobiology and Ethnomedicine 9: 72. doi: 10.1186/1746-4269-9-72

Albuquerque UP, Medeiros PM, Ferreira Júnior WS, *et al*. 2019b. Social-ecological theory of maximization: basic concepts and two initial models. Biological Theory (in press). doi: 10.1007/s13752-019-00316-8

Alexiades MN. 2003. Ethnobotany in the Third Millennium: expectations and unresolved issues. Delphinoa 45: 15-28.

Almeida ALS, Medeiros PM, Silva TC, *et al*. 2008. Does the June tradition impact the use of woody resources from an area of Atlantic Forest in Northeastern Brazil? Functional Ecosystems and Communities 2: 32-44.

Álvarez-Yépiz JC, Martínez-Yrízar A, Búrquez A, Lindquist C. 2008. Variation in vegetation structure and soil properties related to land use history of oldgrowth and secondary tropical dry forests in northwestern Mexico. Forest Ecology and Management 256: 355-366.

Andel T, Westers P. 2010. Why Surinamese migrants in the Netherlands continue to use medicinal herbs from their home country. Journal of Ethnopharmacology 127: 694-701.

Aswani S, Anne L, Warwick HH, Sauer WHH. 2018. Global trends of local ecological knowledge and future implications. PLOS ONE 13: 4. doi: 10.1371/journal.pone.0195440

Auge M. 2014. El antropólogo y el mundo global. Buenos Aires, Siglo XXI.

Ávila JVC, Mello AS, Beretta ME, *et al*. 2017. Agrobiodiversity and in situ conservation in quilombola home gardens with different intensities of urbanization. Acta Botanica Brasilica 31: 1-10.

Baldauf C, Santos FAM. 2014. The effect of management systems and ecosystem types on bark regeneration in *Himatanthus drasticus* (Apocynaceae): recommendations for sustainable harvesting. Environmental Monitoring and Assessment 186: 349-359.

Bennett BC, Prance GT. 2000. Introduced plants in the indigenous pharmacopoeia of northern South America. Economic Botany 54: 90-102.

Benyei P, Arreola G, Reyes-García V. 2019. Storing or sharing: a review of traditional knowledge conservation initiatives. Ecology and Society (in press).

Berkes F. 2018. Sacred ecology: Traditional ecological knowledge and resource management. New York, Taylor & Francis.

Booker A, Johnston D, Heinrich M. 2012. Value chains of herbal medicines: research needs and key challenges in the context of ethnopharmacology. Journal of Ethnopharmacology 140: 624-633.

Boyd R, Richerson PJ, Henrich J. 2011. The cultural niche: why social learning is essential for human adaptation. Proceedings of the National Academy of Sciences of the United States of America 108(2):10918–25. doi: 10.1073/pnas.1100290108

Campos JLA, Sobral A, Silva JS, *et al*. 2016. Insularity and citation behavior of scientific articles in young fields: the case of ethnobiology. Scientometrics 109: 1037-1055.

Capaldi CA, Dopko RL, Zelenski JM. 2014. The relationship between nature connectedness and happiness: a meta-analysis. Frontiers in Psychology: 5. doi: 10.3389/fpsyg.2014.00976

Ceuterick M, Vandebroek I, Pieroni A. 2011. Resilience of Andean urban ethnobotany: A comparison of medicinal plant use among Bolivian and Peruvian migrants in the United Kingdom and in their countries of origin. Journal of Ethnopharmacology 136: 27-54.

Ceuterick M, Vandebroek I, Torry B, Pieroni A. 2008. Cross-cultural adaptation in urban ethnobotany: The Colombian folk pharmacopoeia in London. Journal of Ethnopharmacology 120: 342-359.

Colding J, Folke C. 2001. Social taboos: "invisible" systems of local resource management and biological conservation. Ecological Applications 11: 584-600.

Díaz S, Unai P, Marie S, *et al*. 2018. Assessing nature's contributions to people. Science 359: 270-272.

Enquist M, Eriksson K, Ghirlanda S. 2007. Critical social learning: a solution to Roger's paradox of non adaptative culture. American Anthropologist 109: 727-34.

Erten EY, Berg P, Weissing FJ. 2018. Acculturation orientations affect the evolution of a multicultural Society. Nature Communications 9: 58. doi: 10.1038/s41467-017-02513-0.

Faeth SH, Warren PS, Shochat E, Marussich W. 2005.Trophic dynamics in urban communities. BioScience 55: 399-407.

Feitosa IS, Albuquerque UP, Monteiro JM. 2014. Knowledge and extractivism of *Stryphnodendron rotudifolium* Mart. in a local community of the Brazilian Savanna, Northeastern Brazil. Journal of Ethnobiology and Ethnomedicine 10: 64. doi: 10.1186/1746-4269-10-64

Feitosa IS, Sobral A, Monteiro JM, Araújo EL, Albuquerque UP. 2017. Impact of collection on bark regeneration from *Stryphnodendron rotudifolium* Mart. in northeastern Brazil. Enviromental Monitoring Assessment 189: 234. doi 10. 1007/s10661-017-5908-4

Fonseca FN, Balick MJ. 2018. Plant-knowledge adaptation in an urban setting: Candomblé ethnobotany in New York City. Economic Botany 72: 56-70.

Ford JD, Cameron L, Rubis J, *et al*.2016. Including indigenous knowledge and experience in IPCC assessment reports. Nature Climate Change 6: 349-353.

Galhena D, Freed R, Maredia KM. 2013. Home gardens: a promising approach to enhance household food security and wellbeing. Agriculture & Food Security 2: 8. doi: 10.1186/2048-7010-2-8

Gaoue OG, Coe MA, Bond M, *et al*. 2017. Theories and major hypotheses in ethnobotany. Economic Botany 71: 269-287.

Gomez-Baggethun E, Corbera E, Reyes-Garcia V. 2013. Traditional ecological knowledge and global environmental change: Research findings and policy implications. Ecology and Society 18: 4. doi: 10.5751/ES-06288-180472

Gonçalves-Souza T, Provete DB, Garey MV, *et al*. 2019. How to master the art of making scientifically sound questions. In: Albuquerque UP, Lucena R, Cruz da Cunha L, Alves R. (eds.) Methods and techniques in ethnobiology and ethnoecology. Springer Protocols Handbooks. New York, Humana Press. p.71-86.

Grierson CS, Barnes SR, Chase MW, *et al*. 2011. One hundred important questions facing plant science research. New Phytologist 192: 6-12.

Hall ET. 2005. La dimensión oculta. Buenos Aires, Siglo XXI.

Hanazaki N, Zank S, Fonseca-Kruel VS, Schimidt IB. 2018. Indigenous and traditional knowledge, sustainable harvest, and the long road ahead to reach the 2020 Global Strategy for Plant Conservation objectives. Rodriguesia 69: 1587-1601.

Hawkes C. 2006. Uneven dietary development: linking the policies and processes of globalization with the nutrition transition, obesity and diet-related chronic diseases. Global Health 2: 1-18.

Hunn E. 2007. Ethnobiology in four phases. Journal of Ethnobiology 27: 1-10.

Hurrell JA. 2014. Urban Ethnobotany in Argentina: Theoretical advances and methodological strategies. Ethnobiology and Conservation 3:2. doi:10.15451/ec2014-6-3.3-1-11

International Organization for Migration. 2018. World migration report. http://publications.iom.int/system/files/pdf/wmr_2018_en.pdf. 03 set. 2018.

Kendal RL, Boogert NJ, Rendell L, Laland KN, Webster M, Jones PL. 2018. Social learning strategies: Bridge-building between fields. Trends in Cognitive Sciences 22: 651-665.

Kujawska M, Hilgert NI, Keller HA, Gil G. 2017. Medicinal plant diversity and inter-cultural interactions between indigenous guarani, criollos and polish migrants in the subtropics of Argentina. PLOS ONE 12: 1. doi: 10.1371/journal.pone.0169373

Kumar R, Shahabuddin G. 2005. Effects of biomass extraction on vegetation structure, diversity and composition of forests in Sariska Tiger Reserve, India. Environmental Conservation 32: 248-259.

Ladio AH. 2017. Ethnobiology and research on global environmental change: what distinctive contribution can we make? Ethnobiology and Conservation 6:7. doi: 10.15451/ec2017-07-6.7-1-8

Ladio AH, Albuquerque UP. 2014. The concept of hybridization and its contribution to urban ethnobiology. Ethnobiology and Conservation 3:6. doi: 10.15451/ec2014-11-3.6-1-9

Lakshmi PR, Mymoon M, Hariharan A. 2014. Preservation and protection of traditional knowledge - diverse documentation initiatives across the globe. Current Science 107: 1240-1246.

Laland KN, Odling-Smee J, Myles S. 2010. How culture shaped the human genome: bringing genetics and the human sciences together. Nature Reviews Genetics 11: 137-148.

Larios C, Casas A, Vallejo M, *et al*. 2013. Plant management and biodiversity conservation in Náhuatl homegardens of the Tehuacán Valley, Mexico. Journal of Ethnobiology and Ethnomedicine 9: 74. doi: 10.1186/1746-4269-9-74

Levis C, Costa FRC, Bongers F, *et al*. 2017. Persistent effects of pre-Columbian plant domestication on Amazonian forest composition. Science 355: 925-931.

Lins Neto EMF, Albuquerque UP. 2018. Theories of niche construction and optimal foraging: weaknesses and virtues in understanding the early stages of domestication. Ethnobiology and Conservation 7: 7. doi:10.15451/ec2018-04-7.7-1-6

Lins Neto EMF, Peroni N, Albuquerque UP. 2010. Traditional Knowledge and management of umbu (*Spondias tuberosa*, Anacardiaceae): An endemic species from the semi–arid region of Northeastern Brazil. Economic Botany 64: 11-21.

Lopes PFM, Begossi A. 2011. Decision-making processes by small-scale fishermen on the southeast coast of Brazil. Fisheries Management and Ecology 18: 400-410.

Ludwig D. 2017. The objectivity of local knowledge. Lessons from ethnobiology. Synthese 194: 4705.

Marsella AJ, Ring E. 2003. Human migration and immigration: An overview. In: Adler LL, Gielen UP. (eds.) Migration: immigration and emigration in international perspective. London, Praeger. p. 3-22.

Mariot A, Mantovani A, Reis MS. 2014. Bark harvesting systems of *Drimys brasiliensis* Miers in the Brazilian Atlantic Rainforest. Anais da Academia Brasileira de Ciências 86: 1315-1326.

Martínez-Alier J. 2003. The Evironmentalism of the poor: a study of ecological conflicts and valuation. Cheltenham, Edward Elgar Pub.

Mattsson E, Ostwald M, Nissanka SP, Marambe B. 2013. Homegardens as a multi-functional land-use strategy in Sri Lanka with focus on carbon sequestration. Ambio 42: 892-902.

Maturana H. 1996. El sentido de lo humano. Santiago de Chile, Dolmen.

McElwee P, Ngo H, Gueze M, *et al*. 2019. Including indigenous knowledge in the work of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES): Outcomes and lessons for the future. In: Thornton TF (ed.) The Routledge handbook of indigenous environmental knowledge. Abingdon-on-Thames, Routledge.

Medeiros PM, Soldati GT, Alencar NL, *et al*. 2012. The use of medicinal plants by migrant people: Adaptation, maintenance, and replacement. Evidence-Based Complementary and Alternative Medicine 2012: 807452. doi: 10.1155/2012/807452

Medeiros PM, Ladio AH, Albuquerque UP. 2014. Sampling problems in Brazilian research: a critical evaluation of studies on medicinal plants. Revista Brasileira de Farmacognosia 24: 103-109.

Mesoudi A. 2011. Cultural evolution: how Darwinian theory can explain human culture and synthesize the social sciences. Chicago, University Chicago.

Mistry J, Bibiana AB, Berardi A. 2016. Community owned solutions for fire management in tropical ecosystems: case studies from Indigenous communities of South America. Philosophical Transactions of the Royal Society B: Biological Sciences 371: 1696. doi: 10.1098/rstb.2015.0174

Morin, E. 2009. Introducción al pensamiento complejo. Barcelona, Gedisa.

Nair PKR, Kumar BM. 2006. Introduction. In: Kumar BM, Nair PKR. (eds.) Tropical homegardens: A time-tested example of sustainable agroforestry. Dordrecht, Springer. p. 2.

Oliveira F, Albuquerque UP, Fonseca VS, Hanazaki N. 2009. Avanços nas pesquisas etnobotânicas no Brasil. Acta Botanica Brasilica 23: 590-605.

Paniagua-Zambrana NY, Bussmann RW, Hart RE, *et al*. 2017. Traditional knowledge hiding in plain sight – 21st century ethnobotany of the Chácobo in Beni, Bolivia. Journal of Ethnobiology and Ethnomedicine 13: 57. doi: 10.1186/s13002-017-0179-2

Pardo-de-Santayana M, Macia MJ. 2015. Biodiversity: The benefits of traditional knowledge. Nature 518: 487-488.

Peroni N, Hanazaki N, Begossi A, *et al*. 2016. Homegardens in a micro-regional scale: contributions to agrobiodiversity conservation in an urban-rural context. Ethnobiology and Conservation 5: 6. doi: 10.15451/ec2016-8-5.6-1-17

Phillips O, Gentry AH. 1993. The useful plants of Tambopata, Peru: II. Additional hypothesis testing in quantitative ethnobotany. Economic Botany 47: 33-43.

Pieroni A, Vandebroek I. 2007. Traveling cultures and plants: the ethnobiology and ethnopharmacy of human migrations. New York, Berghahn.

Pirker H, Haselmair R, Kuhn E, *et al*. 2012. Transformation of traditional knowledge of medicinal plants: The case of Tyroleans (Austria) who migrated to Australia, Brazil and Peru. Journal of Ethnobiology and Ethnomedicine 8: 44. doi: 10.1186/1746-4269-8-44.

Porter-Bolland L, Ellis EA, Guariguata MR, *et al*. 2012. Community managed forest and forest protected areas: An assessment of their conservation effectiveness across the tropics. Forest Ecology and Management 268: 6-17.

Ramos MA, Medeiros PM, Almeida ALS, Feliciano ALP, Albuquerque UP. 2008. Can wood quality justify local preferences for firewood in an area of Caatinga (dryland) vegetation? Biomass and Bioenergy 32: 503-509.

Reid WV, Berkes F, Wilbanks T, Capistriano C. 2006. Bridging scales and local knowledge in assessments. Washington, Island Press.

Reyes-Garcia V, Aceituno-Mata L, Calvet-Mir L, *et al*. 2014. Resilience of traditional knowledge systems: The case of agricultural knowledge in home gardens of the Iberian Peninsula. Global Environmental Change-Human and Policy Dimensions 24: 223-231.

Reyes-García V, Benyei P, Calvet-Mir L. 2018. Traditional agricultural knowledge as commons. In: Vivero-Pol JL, Ferrando T, Schutter O, Mattei U. (ed.) Routledge handbook of food as a commons. London, Routledge.

Reyes-Garcia V, Gueze M, Luz AC, Paneque-Galvez J, *et al*. 2013. Evidence of traditional knowledge loss among a contemporary indigenous society. Evolution and Human Behavior 34: 249-257.

Ritter MR, Silva TC, Araújo EL, Albuquerque UP. 2015. Bibliometric analysis of ethnobotanical research in Brazil (1988-2013). Acta Botanica Brasilica 29: 113-119.

Ruiz-Pérez M, Belcher B, Achdiawan R, *et al*. 2004. Markets drive the specialization strategies of forest peoples. Ecology and Society 9: 4. doi: 10.5751/ES-00655-090204

Salpeteur M, Patel HHR, Molina JL, *et al*. 2016. Comigrants and friends: Informal networks and the transmission of traditional ecological knowledge among seminomadic pastoralists of Gujarat, India. Ecology and Society 21: 20. doi: 10.5751/ES-08332-210220

Santoro FM, Nascimento ALB, Soldati GT, Ferreira Júnior WS, Albuquerque UP. 2018. Evolutionary ethnobiology and cultural evolution: opportunities for research and dialog. Journal of Ethnobiology and Ethnomedicine 14:1. doi: 10.1186/s13002-017-0199-y

Santoro FR, Santos GC, Ferreira Júnior WS, *et al*. 2017. Testing an ethnobiological evolutionary hypothesis on plant-based remedies to treat malaria in Africa. Evolutionary Biology 44: 216-226.

Santos BS. 2014. Epistemologies of the south: justice against epistemicide. London, Routledge.

Saslis-Lagoudakis CH, Hawkins JA, Greenhill SJ, *et al*. 2014. The evolution of traditional knowledge: environment shapes medicinal plant use in Nepal. Proceedings of the Royal Society B: Biological Sciences 281:20132768. doi: 10.1098/rspb.2013.2768

Shackleton CM, Hurley PT, Dahlberg AC, *et al*. 2017. Urban foraging: A ubiquitous human practice overlooked by urban planners, policy, and research. Sustainability 9: 1884. doi: 10.3390/su9101884

Silva APT, Medeiros PM, Ferreira Júnior WS, *et al*. 2018. Does forest scarcity affect the collection and use of firewood by rural communities? A case study in the Atlantic Forest of Northeastern Brazil. Economic Botany 72: 71-80.

Silva RRV, Gomes LJ, Albuquerque UP. 2014. Methods and techniques for research on the supply chains of biodiversity products. In: Albuquerque UP, Lucena RFP, Cunha LVFC. (eds.) Methods and techniques in ethnobiology and ethnoecology. New York, Springer Protocols Handbooks. p. 335-347.

Silva TC, Peroni N, Medeiros MFT, Albuquerque UP. 2017. Folk classification as evidence of transformed landscapes and adaptative strategies: a case study in the semiarid region of northeastern Brazil. Landscape Research 42: 521-532.

Silva TC, Campos LZO, Balée W, Medeiros MFT, Peroni N, Albuquerque UP. 2019. Human impact on the abundance of useful species in a protected area of the Brazilian Cerrado by people perception and biological data. Landscape Research 44: 75-87.

Soga M, Gaston KJ. 2016. Extinction of experience: the loss of human–nature interactions. Frontiers in Ecology and the Environment 14: 94-101.

Soldati GT, Albuquerque UP. 2016. Are the evolutionary implications of vertical transmission of knowledge conservative? Ethnobiology and Conservation 5. doi: 10.15451/ec2016-6-5.2-1-09

Stevenson MG. 1996. Indigenous knowledge in environmental assessment. Arctic 49: 278-291.

Sullivan AP, Bird DW, Perry GH. 2017. Human behaviour as a long-term ecological driver of non-human evolution. Nature Ecology & Evolution 1: 65. doi: 10.1038/s41559-016-0065

Sutherland WJ, Freckleton RP, Godfray HCJ, *et al*. 2013. Identification of 100 fundamental ecological questions. Journal of Ecology 101: 58-67.

Tengö M, Brondizio ES, Elmqvist T, *et al*. 2014. Connecting diverse knowledge systems for enhanced ecosystem governance: The multiple evidence base approach. Ambio 43: 579-591.

Toneu IT, Jordan FM, Hawkins JA. 2018. Comparative phylogenetic methods and the cultural evolution of medicinal plant use. Nature Plants 4. doi: 10.1038/s41477-018-0226-6

Turner NJ, Davidson-Hunt IJ, O'Flaherty M. 2003. Living on the edge: ecological and cultural edges as sources of diversity for social–ecological resilience. Human Ecology 31: 439-461.

Turnhout E, Bloomfield B, Hulme M, *et al.* 2012. Conservation policy: Listen to the voices of experience. Nature 488: 454-455.

Turnhout E, Dewulf A, Hulme M. 2016. What does policy-relevant global environmental knowledge do? The cases of climate and biodiversity. Current Opinion in Environmental Sustainability 18: 65-72.

Turreira-García N, Vilkamaa AM, Byg A, Theilade I. 2017. Diversity, knowledge, and use of leafy vegetables in Northern Thailand—maintenance and transmission of ethnobotanical knowledge during urbanization. Natural History Bulletin of the Siam Society 62: 85-105.

United Nations. 2018. Revision of world urbanization prospects. https://goo.gl/Zd2B5y. 6 Sep. 2018.

Varghese A, Ticktin T. 2008. Regional variation in nontimber forest product harvest strategies, trade, and ecological impacts: the case of black dammar (*Canarium strictum* Roxb.) use and conservation in the Nilgiri Biosphere Reserve, India. Ecology and Society 13. http://www.ecologyandsociety.org/vol13/iss2/art11/

Vohland K, Mlambo MC, Domeignoz Horta L, Jonsson B, *et al.* 2011. How to ensure a credible and efficient IPBES? Environmental Science & Policy 14: 1188-1194.

Waldstein A. 2008. Diaspora and health? Traditional medicine and culture in a mexican migrant community. International Migration 46: 95-117.

Walters BB. 2005. Patterns of local wood use and cutting of Philippine mangrove forests. Economic Botany 59: 66-76.

Wolverton S, Barker A, Dombrosky J. 2016. Paleoethnobiology. In: Albuquerque UP, Alves RRN. (eds.) Introduction to ehnobiology. New York, Springer. p. 25-32.