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The Contribution of Ethnobotany to Studies of Plant Population Ecology in Northeastern Brazil

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ABSTRACT

Ethnobotany maintains clear relationship with the ecology of plant populations. Actually, the ethnobotanical studies are more advanced that of the plant population's ecology approaches in northeastern Brazil, but are concentrated in few places. The results of the researches show that together ethnobotany and ecology population are enables the identification of useful species in a region (and those with future potential uses); determines how local communities use each species, identifies preferred sites for resource collection; characterizes the ways in which a resource is exploited; indicates the intensity of resource exploitation; identifies alternative management strategies from the perspective of local communities; determines the age structure of the population; determines the growth, reproduction and survival rates of plants both under natural conditions and under conditions of frequent use by human populations; identifies key ecological factors for the self-renewal of populations and the maintenance of communities; describes numerical changes in populations over time and when under exploitation pressure; distinguishes short- and long-term fluctuations and to determine the stability of populations over space and time, identifies species conservation priorities and identifies social demands that should be addressed through public policies.

Keywords: demography, natural resources management, sustainability

CONTENTS

ETHNOBOTANICAL STUDIES OF CAATINGA VEGETATION

Northeastern Brazil contains various vegetation types (including Atlantic Forest, Cerrado, Restinga, Dunes, Mangroves and Caatinga). However, the Caatinga is remarkable because it occupies more than 50% of the northeastern region (Araújo *et al.* 2007) and because it is the subject of many ethnobotanical studies (Albuquerque *et al.* 2005; Lucena *et al.* 2008). Therefore, the focus of this review is to assess how ethnobotany has contributed to plant population studies in the Caatinga.

The Caatinga is a dry forest located in a climatic domain in which rainfall is concentrated during certain times of the year; there is a three- to six-month rainy season and a six- to nine-month dry season. The months of rainy and dry seasons vary among different localities with Caatinga vegetation (Sampaio 1995; Araújo 2005). Such heterogeneity in water availability, coupled with other abiotic features of the environment (such as geomorphology and soil fertility), gives rise to many physiognomic variations within this vegetation, locally known as shrub Caatinga, shrub-arboreal Caatinga and arboreal Caatinga (Araújo *et al.* 2007). Such niche differentiation produces considerable endemism in the Caatinga, as well as promoting differentiation in population structure among habitats, the occurrence of rare species and a distinct biodiversity pattern.

The human population in northeastern Brazil is large (about 51 million people, in 2010) and has a rich culture, but the area is unfortunately also home to many low-income inhabitants (earning between one and two minimum salaries – or approximately US$ 300, IPEA 2010). The large number of people living in the region, coupled with their economic conditions, forces many rural communities to use plant resources to meet their needs (in terms of both subsistence and additional needs). This situation indicates that some Caatinga species are not only economically important but are also useful for the population (Figueroa *et al.* 2005; Ferraz *et al.* 2006; Ramos *et al.* 2008; Monteiro *et al.* 2010).

Many Caatinga species have food (e.g., umbu – *Spondias tuberosa* Arruda, see Almeida *et al.* 2011; Lins-Neto *et al.* 2010), ornamental (e.g., ipê roxo - *Tabebuia impetiginosa* (Mart. ex DC.) Standl., see Barreto *et al.* 2005) or medicinal value (e.g., aroeira - *Myracrodruon urundeuva* Fr. All., see Almeida *et al.* 2006; Monteiro *et al.* 2006; Albuquerque *et al.* 2007, 2008, Melo *et al.* 2009; Monteiro *et al.* 2011a). In addition, Caatinga plants are used to feed livestock (several herbaceous plants, e.g., *Pavonia cancellata* (L.) Cav., see Batista *et al.* 2005), in apiculture (several woody and herbaceous species, e.g., *Hyptis suaveolens* (L.) Poit., see Santos *et al.* 2005) and as timber (e.g., *Caesalpinia pyramidalis* Tul., see Figueroa *et al*. 2005). The timber may also be used in fences, for civil construction and as firewood (Figueroa *et al.* 2006; Nascimento *et al.* 2007; Ramos and Albuquerque 2007; Santos *et al.* 2008; Nascimento *et al.* 2009).

The products derived from Caatinga species can be

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exploited and sold by people either directly (such as seeds, fruits, roots, bark and leaves) or indirectly, after some processing (e.g., oils, potions, jewelry, cages, baskets, bags, wooden spoons and ox carts). In the Caatinga, the diversity and intensity of plant resource use reflects the knowledge and characteristics of the social structure of the rural communities that interact with the vegetation (Souza *et al.* 2008; Albuquerque *et al.* 2011a, 2011b; Monteiro *et al.* 2011b). The number of ethnobotanical studies carried out in the Caatinga has significantly increased since the beginning of this decade. Before then, studies were essentially descriptive, reflecting a common trend in Brazilian ethnobotany (see Oliveira *et al.* 2009). Furthermore, hypothesis testing in ethnobotany is a recent phenomenon, and descriptive studies are still quite common (Oliveira *et al.* 2009).

HUMAN ACTIVITIES AND SUSTAINABILITY OF PLANT RESOURCE USE

The growth of the human population and the corresponding increase in its socio-economic needs and the intensive use of local resources (for both local and regional markets) have promoted intensive exploitation of useful and "not useful" plant species. This exploitation has resulted in landscape fragmentation, habitat destruction and local extinction risk for some species, reaching social exclusion in some regions. In other words, besides the environmental problems people affected by the extinction of exploited resource may pass through many social and financial constraints that do not find other productive activity to develop (Araújo *et al.* 2007; Albuquerque *et al.* 2009).

For example, from the 1930s to the 1960s, the economic activity of one city in Pernambuco state (northeastern Brazil) was based on products extracted from an herbaceous fiber-rich plant of the family Bromeliaceae, known as caroá (*Neoglaziovia variegata* (Arr. Cam.) Mez.). Mills and industries extracted caroá intensively, but after years of inadequate management, the resource became scarce, and the local economic model was rendered unsustainable. The industry went bankrupt in 1970, causing a great crisis, unemployment and social exclusion (social restriction arising from unemployment). In the 1980s, the factory was converted into a museum that displays machinery and photos of the activities previously developed in the region (Arteviver-pernambuco 2011).

In addition, destructive methods employed in resource collection promote deforestation. As the resource becomes scarce, people search for it in other areas, causing increasing habitat fragmentation and converting the few remaining patches of native vegetation into islands within anthropogenic landscapes. Such a scenario inevitably causes changes in microhabitats from the edge to the interior of these fragments. At the edge, there is greater light intensity, temperature and ventilation as well as lower humidity. These differences influence the establishment and maintenance of species populations.

Species occurring at the forest edge must tolerate, or at least adapt to, these harsh conditions. The increase of climbing plants is common. These plants affect the growth of woody plants by using them as supports and breaking their branches (Araújo 2005; Araújo *et al.* 2005). In addition, the forest edge is highly vulnerable to invasion by exotic and ruderal species, increasing the risk of competitive displacement of native species (Andrade and Fabricante 2009). It has also been reported that natural enemies or stronger competitors frequently do not affect these exotic species, likely increasing the probability of invasion (Andrade *et al.* 2009, 2010). Furthermore, the role of these useful exotic and ruderal plants in human communities is poorly understood (Saltos *et al*. 2009).

Exotic species can also carry diseases not experienced previously by native species (Primack and Rodrigues 2001), increasing mortality rates for the native organisms and reducing their population sizes. Thus, the deforestation associated with changes in habitat causes the following problems for native plant communities: loss of genetic variability and evolutionary flexibility; an increased risk of local extinction; limited potential for dispersal and colonization and a decrease in resources for animals as well as for people (Araújo *et al.* 2007).

Depending on the population size of the exploited plants and the intensity of exploitation, the resource may become increasingly scarce, or even locally extinct, inevitably affecting the people who use it. This scenario occurs because the exploited population becomes unviable when it is reduced to a critical size. Conservation biologists have discussed the need to maintain a minimum population size in natural habitats (termed the minimum viable population, MVP). This parameter is "the smallest size at which an isolated population has a 99% chance to continue to exist for 1,000 years" (Primack and Rodrigues 2001).

ETHNOBOTANY AND POPULATION ECOLOGY

Ethnobotany has a strong relationship with plant population ecology because both are concerned with sustainable development, which should be guided by a balanced view of conservation (Albuquerque *et al.* 2007; Lucena *et al.* 2007; Albuquerque *et al.* 2009, 2011). A frequently asked research question with respect to sustainability of resource use is "how much can we take from a resource while still ensuring that it can be renewed naturally by the growth and reproduction of its population?" The practices of applied ethnobotany and ecology are facing a race against time. Unfortunately, in northeastern Brazil (as in other parts of the world), plant resource use and conservation are moving in opposite directions. Today, there are two important questions that ethnobotany and population ecology seek to answer: "how can we manage a given resource without threatening the well-being and quality of life of the people who use it?" and "how can we restore a resource that has already been lost?"

In management and restoration, it is necessary to identify limiting factors for population growth. These factors can be grouped into at least four levels, namely, 1) absence of seed production, 2) absence of seed germination and 3) absence of growth of seedlings and saplings. Problems surrounding the absence of seeds produced may be due to insufficient pollination, inbreeding (which leads to the formation of unviable seeds), excessive predation, climatic and edaphic stresses (which affect plant reproduction and seed production) and disease. Absence of germination may be due to lack of dispersers, an unsuitable environment for germination, excessive predation and disease. Growth of seedlings and saplings may inhibited by elevated competition for some limiting resource, an inadequate environment for growth, excess predation, climatic and physical stresses, disease and, 4) finally, the extraction of resources beyond the self-renewing capacity of plant populations. Obviously, this last aspect may be also be influenced by the other factors mentioned.

How has ethnobotany contributed to these ecological studies? Ethnobotany enables the identification of useful species in a region (and those with future potential uses) (Lucero *et al.* 2007; Cartaxo *et al.* 2010; Albuquerque *et al.* 2011a, 2011b), determines how local communities use each species (Lucena *et al.* 2008; Almeida *et al.* 2010), identifies preferred sites for resource collection, characterizes the ways in which a resource is exploited (Albuquerque and Andrade 2002; Albuquerque *et al.* 2005), indicates the intensity of resource exploitation (Albuquerque *et al.* 2007; Monteiro *et al*. 2010), identifies alternative management strategies from the perspective of local communities (Florentino *et al.* 2007; Nascimento *et al.* 2009), identifies conservation priorities (Oliveira *et al.* 2007; Melo *et al.* 2009; Albuquerque *et al.* 2009) and identifies demands that should be addressed through public policies (Florentino *et al.* 2007; Nascimento *et al.* 2009).

For example, let us consider the use of plants as timber, which is common in northeastern Brazil. This type of use is generally destructive and, therefore, causes a substantial impact on the dynamics of the native population that is exploited (Ramos and Albuquerque 2007; Ramos *et al.* 2008). We know that timber in the northeast is used and/or sold as firewood, as charcoal and as material for building houses and other objects (Figueroa *et al.* 2005). The questions that must be complicated the management of plant resources include: Which species are used for each purpose? How are plants collected? How much is collected? What factors affect or determine the collection of a certain plant? Can a plant survive the cutting process? In a seasonal environment, such as the Caatinga, are certain times more favorable for cutting than others?

Ethnobotanical studies have addressed some of these questions. For example, the survival of plants after cutting and the cutting season have been studied by researchers from the "Plants of the Northeast" (PNE) association, in partnership with the Key Botanical Garden. Figueroa *et al.* (2006) selected four Caatinga species, *Caesalpinia pyramidalis* Tul. (catingueira), *Mimosa tenuiflora* (Willd.) Poir (jurema preta), *Mimosa ophthalmocentra* Mart. ex Benth. (jurema branca) and *Croton sonderianus* Muell. Arg. (marmeleiro), for an experiment replicating the types of cutting methods used by local communities, including clearcutting, branch pruning and crown thinning. The authors aimed to evaluate the effect of these cutting treatments on the survival of these species. They found that there were no differences in the ability of species to survive the different cutting methods.

Figueroa *et al.* (2006) have experimentally reproduced these types of cuts with consideration of the seasonality of the region to identify whether cutting at certain times of year reduced the impact on the survival and regrowth of plants. They found that some species demonstrate reduced survival if they are cut during the rainy season; this reduced survival was evident for jurema branca and jurema preta (*M. tenuiflora* and *M. ophthalmocentra*), which showed higher survival rates after clearcutting in the dry season. Regardless of the type of cut, all four species showed the capacity to regrow, especially when subjected to clearcutting. Regrowth is important for habitat restoration (Sampaio *et al.* 1998; Figueroa *et al.* 2008), a fact that has been confirmed in other dry environments around the world (Negreros-Castillo and Hall 2000; McLaren and McDonald 2003; Luoga *et al.* 2004; Tewari *et al.* 2004). This type of information will allow for better planning for the use of vegetation as firewood.

Another important use of wood in the northeast is for constructing fences to define property boundaries, confine animals and protect crops (Nascimento *et al.* 2007). Ethnobotanical research has shown that the practice of constructing fences is essential to biodiversity conservation. For example, an ethnobotanical study conducted by Nascimento *et al.* (2009) in Caruaru, Pernambuco state, Brazil, showed that three types of fences are used in the region: 1) dead fences (formed with dead plants); 2) live fences (formed with live stakes that take root and remain alive in the fence) and 3) mixed fences (with some parts of the fence composed of live plants and some parts composed of dead plants).

Among these types of fences, the mixed fences were the most frequently used in the studied community (53.65%). This preference occurs because people recognize that fences have ecological functions (e.g., as wind barriers, as resources for wildlife or for facilitation of landscape connectivity) and productive functions (e.g., the production of fruit and food for livestock and as sources of medicine and stakes for new fences) as well as ornamental and aesthetic functions. Additionally, fences serve as a source of fuel (it is possible to use twigs for firewood) and of shade for cattle. Thus, this type of fence is best suited to meet the needs and dynamics of the lives of the inhabitants of rural environments (Nascimento *et al.* 2007).

Many Caatinga species can be used in fences, but the most commonly used species are not always the most preferred by the community. Nascimento *et al.* (2009) found that just three out of the ten species most frequently found were indicated as preferred by the community. In addition, the most common species used in wood fences were of low wood density, which facilitates rooting. The authors concluded that the use of mixed fences in the studied community is an interesting practice because it meets subsistence needs and also aids in nature conservation by reducing the demand for stakes that do not sprout. Such stakes usually need to be replaced by others that are taken from the native vegetation. Furthermore, mixed fences provide useful products, decreasing the need to gather these products in native fragments.

Another practice adopted by the community, and one that ethnobotany has shown to be helpful in conservation, is the cultivation of home-gardens. Homegardens are an agricultural unit with the primary purpose of providing food to supplement a family's diet (Albuquerque *et al.* 2005). However, Florentino *et al.* (2007) showed that home-gardens have other uses in addition to food production, because they can also provide shade and medicinal uses of plants, ornamental and timber. Home gardens are generally comprised of exotic and native plants, the latter obtained from fragments of native vegetation near the community. The authors demonstrated that home-gardens are important for biodiversity conservation because they reduce the use of destructive methods of collecting plant products on the remaining native fragments. This reduction is due to the fact that some native species such as *Piptadenia stipulacea* (Benth) Ducke (calumbi) and *Acacia paniculata* Willd. (unha de gato) are maintained in home-gardens for use as firewood.

Despite the contributions made by ethnobotanical studies to understanding the uses and management of Caatinga species (Monteiro *et al.* 2005; Almeida *et al.* 2010; Monteiro *et al.* 2010), we know that plant populations in natural habitats are subject to considerable variation in their demographic features. Interannual variations in plant reproduction may cause plants to reproduce at above- or below-average rates. In addition, unpredictable environmental disturbances (e.g., fires or storms) may still occur. These variations introduce stochasticity into the growth and renewal rates of the population.

FINAL REMARKS

The contribution of ethnobotany to sustainable resource use (that is, knowledge of how much of a resource can be removed from the habitat while still allowing plant populations to be replaced by natural growth) must be complemented with demographic studies. These studies should include the following aims: to determine the proportion of seedling, juvenile, immature, adult and senile individuals in a population; to determine the growth, reproduction and survival rates of plants both under natural conditions and under conditions of frequent use by human populations; to identify key ecological factors for the self-renewal of populations and the maintenance of communities; to describe numerical changes in populations over time and when under exploitation pressure; to distinguish short- and long-term fluctuations and to determine the stability of populations over space and time (Begon *et al.* 2007; Gotelli 2007).

Unfortunately, such studies have not been performed in northeastern Brazil. Most demographic studies conducted in the Caatinga have attempted to describe natural populations without taking into account the susceptibility of these resources to exploitation (even when such exploitation has recently begun). Most studies are designed to show the influence of seasonality and microhabitat conditions on the natural reproduction and survival rates of plants (e.g., Araújo *et al.* 2005; Lima *et al.* 2007; Santos *et al.* 2007; Silva *et al.* 2008; Santos *et al.* 2009; Fabricante *et al.* 2010; Lima *et al.* 2010). Very recently, some studies (which are still in progress) were designed with the goal of integrating ethnobotanical information with demographic features of the exploited plant populations.

Undoubtedly, habitat management and conservation are scientific issues linking applied ethnobotany to plant population ecology. Currently, the number of demographic studies directed toward species that face high exploitation pressures in the Caatinga is small, despite the importance of them to guide the management of the resource and identify strategies that promote habitat conservation. This gap occurs firstly because demographic studies require long monitoring times. Secondly, it occurs because the commercial exploitation of plant resources occurs mainly on private property, where it is often impossible to monitor the response of plants to a given pressure.

Finally, based on existing studies, we present two proposals for advancing ethnobotanical studies. These proposals focus on plant demography and on finding alternatives for resource management and conservation, while involving the participation of people:

1. To identify trends in plant resource use in communities and to formulate proposals that might be considered by decision makers and included in social and biodiversity conservation programs. An example would be to make a list of community members who maintain live fences and homegardens and to create incentives for the use of mixed fences and homegardens. Such incentives could favor higher species diversity, accommodation of community demands and more regionally marketable products that could be obtained from fences and home gardens.
2. To expand the incentives for integrated research (as is done for various biological sciences) that addresses social and economic aspects; such research could combine ethnobotany, population ecology, plant physiological ecology and plant reproduction studies. Such incentives should include financial support that can be used to compensate the landowner, so that a portion of the property can be designated for monitoring the effects of plant resource use on the demographic features of a given resource. In other words, such incentives should be used to transform landowners into partners in research development by providing socio-environmental support or other mechanisms to financially compensate them for not using part of their land.

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