Acta Botanica Brasilica - 33(2): 350-359. April-June 2019.
doi: 10.1590/0102-33062019abb0166

Ethnobotany of native cacti in the northeast region of Brazil: can traditional use influence availability?

Ailza Maria de Lima-Nascimento[1*], José Severino Bento-Silva[2], Camilla Marques de Lucena[1] and Reinaldo Farias Paiva de Lucena[1, 3]

Received: May 11, 2019
Accepted: June 11, 2019

ABSTRACT

Documenting the uses of native species of Cactaceae in Northeast Brazil contributes to understanding how the inhabitants of this seasonally dry and low-rainfall region have used these resources, considering that some species of this family of Cactaceae are among the most endangered in the world. The aim of this research was to determine which species of Cactaceae occur in the study area and investigate the knowledge and recurrent uses associated with them, as well as the local availability of the species most used by residents. Ethnobotanical data were collected through semi-structured interviews with 59 heads of households. Guided tours were conducted for data collection and subsequent taxonomic identification of species. Use value and availability were determined for the most-used species in two predefined areas. Six native species were recorded and classified into eight categories. Columnar species had higher use values, while fodder and construction were the most cited use categories. *Cereus jamacaru* DC was the most-used species, with consequent interference in its availability due to significant reduction in the number of cladodes as a result of their constant removal from plants in areas of direct use for the purpose of fodder.

Keywords: caatinga, conservation, dry forests, knowledge on the use of natural resources, management

Introduction

It is estimated that Cactaceae species began to appear in arid and semi-arid environments around 35 million years ago (Arakaki *et al*. 2011), and ethnobotanical and archaeological studies on these plants indicate varied ancient uses by different human populations (Castillo & Trujillo 1991; Wallace & Gibson 2002; Mario & Angélica 2014). There is a richness of diversity and endemism for these species in eastern Brazil, which is considered the third largest center of diversity and importance for the Cactaceae in the world, after areas in Mexico and the United States (Taylor & Zappi 2004; Casas *et al*. 2014). However, these plants have become popular worldwide, causing the dissemination of several species outside their native regions for ornamental use and other purposes (Novoa *et al*. 2015).

In the northeast region of Brazil, which is mostly characterized by vegetation typical of the Caatinga (Queiroz *et al*. 2017), the diversity of Cactaceae is low when compared to the southeast region (Zappi *et al*. 2011). Nevertheless, cacti are a symbol of resistance to limiting climatic conditions, with a rich diversity and abundance of species, represented by about 90 native species, 34 of which are endemic (Zappi *et al*. 2011). In the last few years, ethnobotanical surveys conducted in the region have recorded the use of these plants by residents of rural communities, citing such functions as timber, medicine, ornamental plants, fodder and food

1 Programa de Pós-Graduação em Desenvolvimento e Meio Ambiente, Centro de Ciências Exatas e da Natureza, Universidade Federal da Paraíba, 58051-9000, João Pessoa, PB, Brazil
2 Departamento Acadêmico de Ambiente, Saúde e Segurança, Instituto Federal de Educação, Ciência e Tecnologia de Pernambuco, 50740-540, Recife, PE, Brazil
3 Departamento de Sistemática e Ecologia, Universidade Federal da Paraíba, 58051-9000, João Pessoa, PB, Brazil

* Corresponding author: ailzamlima@gmail.com

(Lucena *et al.* 2012; 2013; 2014; 2015a; Chaves & Barros 2015; Nunes *et al.* 2015). Such potential places these species among the most used native plants in the semi-arid region of northeast Brazil, with food for ruminant domestic animals representing the major function. Even so, some cacti have a high economic potential, both in the culinary field, for the production of sweets, and in landscaping, for their rustic ornamentation (Zappi *et al.* 2011; Lucena *et al.* 2013; 2015a).

As found in other diversity centers for these plants around the world (Goettsch *et al.* 2015), in addition to being impacted by commercial exploitation (Taylor & Zappi 2004; Zappi *et al.* 2011), in Brazil, the Cactaceae are also constantly affected by anthropic activities related to use and occupation of land (Janzen 1988; Goettsch *et al.* 2015; Berriozabal-Islas *et al.* 2017). These are the main factors that make them the most endangered species in the world (Goettsch *et al.* 2015; Lucy 2015), and their loss could potentially compromise the life dynamics of those who use them as essential resources for survival (Valiente-Banuet & Godínez-Alvarez 2002; Leal *et al.* 2007). No studies on the availability of these species have been carried out in the northeast region, despite their usefulness to residents of rural communities in semi-arid regions, who use them as a subsistence resource.

Extraction rates of plant resources may be low in relation to their spatial availability and may not endanger plant populations (Pérez-Negrón & Casas 2007). However, when there is dependence on a specific part of the plant, the extraction rates may also be high, making implementation of conservation strategies difficult (Campos *et al.* 2018).

In this context, the present study investigated and recorded, through an ethnobotanical survey, native species belonging to the Cactaceae in the semi-arid region located in Pernambuco, Brazil, including uses associated with such species (current or not) by local members of two rural communities. The local availability of the most used species was also analyzed. In this region, *Cereus jamacaru* had the most prominent use compared to the other species mentioned in the same use category (Lima-Nascimento *et al.* 2017). Based on this information, the effect on the population of this species of continuous extraction of this resource was evaluated. This analysis was performed in the knowledge that when plants were taken from their natural habitats the population might be affected by several factors, such as retrogression and high mortality in all size classes, coupled with low seed production (Mandujano *et al.* 2015).

Materials and methods

Study area

This research was carried out in a region of vegetation typical of the Caatinga (Giulietti *et al.* 2004), located on the Borborema Plateau, which is the main terrain unit in north-eastern Brazil (Corrêa *et al.* 2010), covering the Agreste mesoregion of Central Pernambuco (CONDEPE/FIDEM 2017). It had a dry climate, with rainfall ranging from 400 to 650 mm annually, or higher in the mountainous areas, in the Brejos de Altitude (humid areas at high altitude; Velloso *et al.* 2002). The survey was conducted in the rural communities of Marimbas (8º34'06.81"S 36º39'44.45"W) and Papagaio do Meio (8º33'26.01"S 36º39'37.81"W), both located in the Microregion of the Ipojuca River Valley, and separated by one of its tributaries, called the Parrot Stream. The communities belong to the municipality of Pesqueira (Fig. 1), which was located approximately 209 km from Recife, the state capital of Pernambuco. The resident population was about 219 individuals, distributed in 72 residences, according to data from the Municipal Health Department. In addition to family-based agriculture, the livelihood of the population was based on small-scale livestock and handicraft of Renaissance lace.

Legal and ethical aspects

This research was approved by the Ethics Committee (5188) of the Health Sciences Center of the Federal University of Paraíba (judgment Nº. 2,507,332). All those interviewed agreed to participate in the research and signed an informed consent form (TCLE), allowing the subsequent use of the information from the study (Resolution Nº. 466).

Ethnobotanical data

Ethnobotanical data were obtained through interviews, using semi-structured questionnaires (Martin 1995), conducted with the primary income-earner for the family (men or women). The interviews took place between December 2016 and June 2017. All the residences in the two communities studied were visited in the style of a census, and the informant was interviewed privately in order to avoid the influence of other residents. Fifty-nine families in total participated in the interviews. Of the 13 residences where the interviews were not performed, six were due to specific health problems, such as Alzheimer's disease, hearing impairment, mental disability and speech difficulties. In the other seven residences, the residents were not at home at the time of the visits.

The residents were interviewed based on the premise that they would cite the local species of Cactaceae known to them, and also describe the uses of the plants. Then they were asked whether they had used any of the plants during or prior to the period of the research, and for what purpose. In addition, they were asked how often and in what manner the plants were collected. The information obtained from the interviews was stored in a database in Microsoft Excel 2010. In order to discover the most prominent species, the use value (UV) was calculated after the completion of the ethnobotanical survey, as the sum of the uses of each species cited by each informant divided by the total

number of informants (UV = ∑U/Total Informants; Silva *et al.* 2010).To verify the correct taxonomic identification, cited plants were collected during guided tours (Martin 1995). The information obtained was recorded according to the method of Rotta *et al.* (2008), and species were identified by a specialist. All the plants were deposited in the IPA Dárdano de Andrade Lima Herbarium, located in Recife, Pernambuco.

Characteristics analyzed to investigate the availability of the species that had the highest use value in the ethnobotanical survey

To investigate the availability of the species with the highest UV, the following method was used, based on some parameters used by Casas *et al.* (1999) in a study that analyzed morphological variation in columnar cacti in Mesoamerica. The current study compared the structure of the plants in terms of the number of branches produced by those that were more and less frequently used in different areas. Two different types of area were selected for data collection. The first one, defined as an 'area of direct use', corresponded to areas of land use in the immediate surroundings of the residences of those interviewed and who mentioned using a plant species. This included all places they indicated that could be used for agriculture, pasture land, and to maintain some remnants of native vegetation for the extraction of wood and/or raising domestic animals (livestock). The second type, were 'areas of indirect use', and referred to two previously selected private areas, which were defined based on no land use in these areas in the last 50 years. Both areas were owned by members of the research team, who provided them for this study, and each one had the dimensions of 50 m x 50 m, totaling 5,000 m² for the two plots. These areas comprised remnants of native vegetation at the stage of advanced succession, and according to the owners, had no history of land use for pasture and/or planting, although they might have been used to collect firewood for domestic use. In both areas, all cacti with a diameter at ground level (DGL) ≥ 7 cm were analyzed, because no extraction of cladodes from plants with a lower diameter was recorded. For these plants, DGL, diameter at breast height (DBH) and height was recorded. All branches of each plant were counted individually for each branch category (Fig. 2), and the total number of cuts per individual plant was recorded, considering only those where the cladode was completely removed. Cladode availability was measured by comparing the number of the plant branches in the two different areas. The data were analyzed using BioEstat 5.0 software, and Pearson's linear correlation test was performed to ascertain the relationship between branch removal and resource availability.

Results

Socioeconomic characteristics of the informants

The 59 primary income-earners for the families who were interviewed were 40 men and 19 women, aged 22–91 years. The majority of the people interviewed were between 40 and 50 years old, and 83 % were married. Fifty-one percent of the interviews were carried out in the community of Marimbas, and the other 49 % in Papagaio do Meio. All respondents were farmers, and 90 % of them had been living in the area for over 30 years. The participants had a low schooling level; 73 % of them had not finish primary education. Fifty-eight percent of the residents surveyed earned less than minimum wage (R$ 937.00 per month), 20 % earned the minimum wage, and 22 % earned more than the minimum wage.

Ethnobotanical survey of Cactaceae species

The occurrence of six native cacti was recorded as 320 citations (Fig. 3): *Cereus jamacaru*, *Pilosocereus pachycladus*,

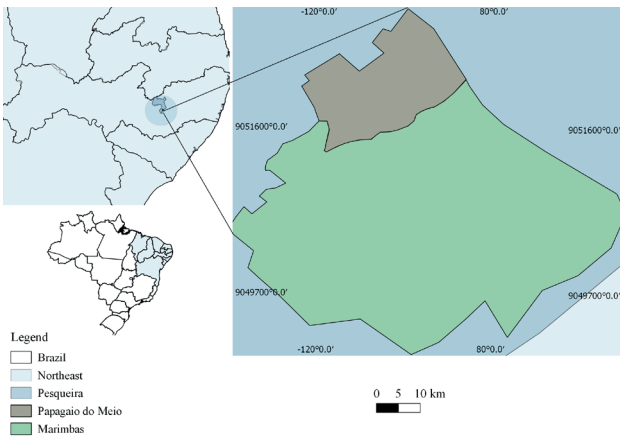

Figure 1. Location map of the rural communities of Marimbas and Papagaio do Meio, Pesqueira, Pernambuco, Brazil.

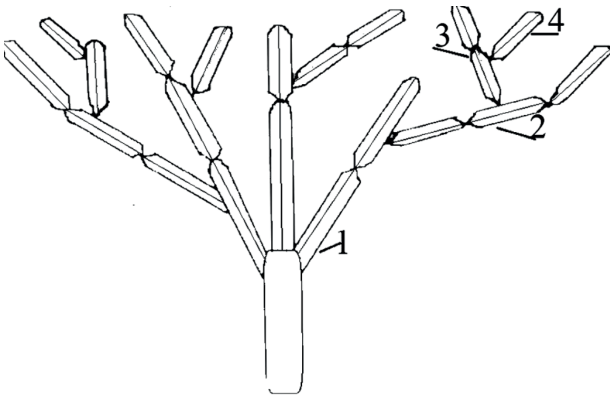

Figure 2. Illustration showing the order number of the analyzed branches. 1, first order; 2, second order; 3, third order; 4, fourth order.

Tacinga palmadora, *Melocactus zehntneri*, *Pilosocereus gounellei*, and *Arrojadoa rhodantha*. The columnar cacti *C. jamacaru* (Fig. 3A) and *P. pachycladus* (Fig. 3B) had the highest UVs (Tab. 1).

Table 1. Cacti species known and used by residents of the rural communities of Marimbas and Papagaio do Meio, Pesqueira, Pernambuco, Brazil. HRN, herbarium registration number; UV - use value.

HRN	Scientific name	Vernacular name	UV
91603	*Cereus jamacaru* DC.	Mandacaru	2.27
91607	*Pilosocereus pachycladus f.* Ritter	Facheiro	1.38
91608	*Arrojadoa rhodantha* (Gürke) Britton & Rose	Rabo de Raposa	0.67
91604	*Pilosocereus gounellei* (F.A.C. Weber) Byles & G.D. Rowley	Alastrado	0.38
91605	*Melocactus zehntneri* (Britton & Rose) Luetzelb	Coroa de Frade	0.37
91606	*Tacinga palmadora* (Britton & Rose) N.P.Taylor & Stuppy	Palmatória	0.32

The use citations were classified into eight categories: fodder, construction, human food, animal food, medicinal, ornamental, fuel and magic/religious. The fodder and construction categories had the highest number of citations (Fig. 4). In both categories, *C. jamacaru* was the most cited, accounting for 37 % of the total citations in the fodder category and 71 % of the citations in the construction category.

All species had a low number of citations for non-timber uses, relating to the use of fruit, pulp, sprouts, and roots (Tab. 2). The estimations of variation between use citations could have been improved by comparing the use citations for cladodes, which were normally used for fodder, with those for whole plants, which were normally used as living fences.

Acquisition, purpose and current use

For the construction of living fences and as fodder, the current use, means of collection, processing and/or their ultimate destination, as mentioned by those interviewed and confirmed in loco, was recorded for *C. jamacaru*, *A. rhodantha*, *T. palmadora* and *P. pachycladus*. For fodder, the cladodes were cut from the plants and burned to remove the thorns, before being ground in a machine (Fig. 5A, B). By contrast, *T. palmador* and *P. pachycladus* were only used as fences. The uses of *P. pachycladus* for energetic purposes and *M. zehntneri* for magic/religious purposes were also recorded (Fig. 5C, D).

Frequency of use

Thirty-three percent of use citations recorded for all plants referred to species that had not been used for fodder or fence construction in the last five years, and 43 % of the citations referred to plants in categories that had never been used by the respondents. The other 24 % represented current use.

Cereus jamacaru stood out in terms of frequency of use, ranging from daily to monthly (Tab. 3). According to the respondents, this variation in frequency of use was justified by the conditions of resource availability and by the number of animals that needed to be fed, since the higher the demand for food, the higher the need for its use, and the lower the resource availability, the lower the frequency of use.

Availability of ***Cereus jamacaru*** DC columnar species

Cereus jamacaru columnar species had the most prominent UV, compared to the other species mentioned in the ethnobotanical survey. For this reason, it was chosen to have its availability analyzed. In the areas of direct use, 130 cacti with a DGL = 7 ± 32.2 cm, DBH = 7 ± 38.5 cm and total height = 2 ± 6.94 m were analyzed. Signs of branch removal were found on 120 of them, totaling 594 cuts. In the areas of indirect use, 37 individuals with a DGL = 7 ± 31 cm, DBH = 6 ± 36 cm and total height = 2 ± 8.75 m were analyzed. Signs of branch removal were found on 20 of them, totaling 63 cuts. The plants in the areas of direct use had a higher number of branches in category 1 of branching order, which are those that originate from the main stem (Fig. 6A), than those in the areas of indirect use, which had a higher number of branches in categories 2, 3 and 4 (Fig. 6B). Therefore, it could be concluded that the most used plants were those in the areas of direct use, i.e., on land near the residences, which was easily accessible to the residents. Pearson's linear correlation analysis confirmed a positive relationship between the total number of branches in the category 1 of branching order and the total number of cuts on the cacti in the areas of direct use (Pearson, R = 0.5103, p = 0.0001; Fig. 7). This showed a positive relationship between cost and benefit, in which the higher the number of branches produced by a plant, the higher the number of cuts.

Discussion

The six cacti species recorded in the study region, popularly known as mandacaru (*C. jamacaru*), facheiro (*P. pachycladus*), rabo de raposa (*A. rhodantha*), coroa de frade (*M. zehntneri*), alastrado (*P. gounellei*) and palmatória (*T. palmador)*, are endemic to Brazil. They are commonly found in savanna formations, rocky outcrops, meadows and in the 'Sertão', due to their low environmental requirements; however, *C. jamacaru* and *P. gounellei* have been recorded in all geographic domains in north-eastern Brazil (Menezes *et al.* 2013). The species recorded in the present study have tree (*C. jamacaru and P. pachycladus*), shrub (*T. palmador, A. rhodantha, P. gounellei*) and rounded

Table 2. Cacti species classified in category, subcategory, plant part used, and number of citations of associated use, as recorded from interviewing residents of the rural communities of Marimbas and Papagaio do Meio, Pesqueira, Pernambuco, Brazil.

Species	Category	Subcategory	Part used	No. of citations
Cereus jamacaru DC.	Construction	Fence	Whole plant	47
		Plank	Stem	8
		Lath	Stem	5
		Door	Stem	1
	Fodder		Cladode	57
	Human food		Fruit	1
			Pulp	2
	Animal food		Fruit	4
	Medicinal		Pulp	2
			Root	6
			Sprout	1
Melocactus zehntneri (Britton & Rose) Luetzelb	Animal food		Pulp	3
			Fruit	1
	Human food		Pulp	1
			Fruit	1
	Fodder		Whole plant	2
	Magic religious		Whole plant	4
	Medicinal		Root	1
			Pulp	4
	Ornamental		Whole plant	5
Pilosocereus gounellei (F.A.C. Weber) Byles & G.D. Rowley	Animal food		Fruit	1
			Cladode	1
	Construction	Fence	Whole plant	5
	Fodder		Cladode	15
	Ornamental		Whole plant	1
Arrojadoa rhodantha (Gürke) Britton & Rose	Animal food		Fruit	1
	Construction	Fence	Whole plant	9
	Fodder		Cladode	30
Pilosocereus pachycladus f. Ritter	Fodder		Cladode	34
	Animal food		Fruit	2
	Human food		Pulp	17
	Magic religious		Whole plant	1
	Fuel		Whole plant	2
	Construction	Rafter	Stem	3
		Fence	Whole plant	11
		Roof beam	Stem	6
		Lath	Stem	6
Tacinga palmadora (Britton & Rose) N.P.Taylor & Stuppy	Construction	Fence	Whole plant	2
	Animal food		Fruit	1
	Fodder		Cladode	16

(*M. zehntneri*) physiognomies, though some of them show high morphological variability (Taylor & Zappi 2004).

Recent ethnobotanical studies have illustrated the usefulness and versatility of cacti, which are commonly valued by residents of rural communities in the semi-arid region of Brazil (Taylor & Zappi 2004; Menezes *et al.* 2013; Coelho *et al.* 2015; Lucena *et al.* 2015a; Santos & Meiado 2015). In the region of study, uses were recorded for most of the cacti species encountered. However, effective use was only recorded for two purposes, fodder and fence construction, especially in the case of *C. jamacaru*. Although knowledge of the main uses commonly attributed to these plants had been documented, their potential full utility was not harnessed. This was particularly true of non-timber uses, which could occur by using plant parts, such as fruit and pulp, which have been commonly mentioned as a basis for therapeutic treatments (Lucena *et al.* 2015a), and for human consumption (Chaves & Barros 2015). The exploitation of the potential offered by cacti through locally planned practices might contribute to the socioeconomic development of families. Casas (2002) and Pérez-Negrón *et al.* (2014) have shown how harvesting the potential of other plants from the same family can favourably affect economic and food spheres in regions of Mesoamerica. However, in the Brazilian semi-arid region, the residents of rural communities do not use cacti in their diet, since they associate these plants only with fodder; thus, avoiding them for cultural reasons.

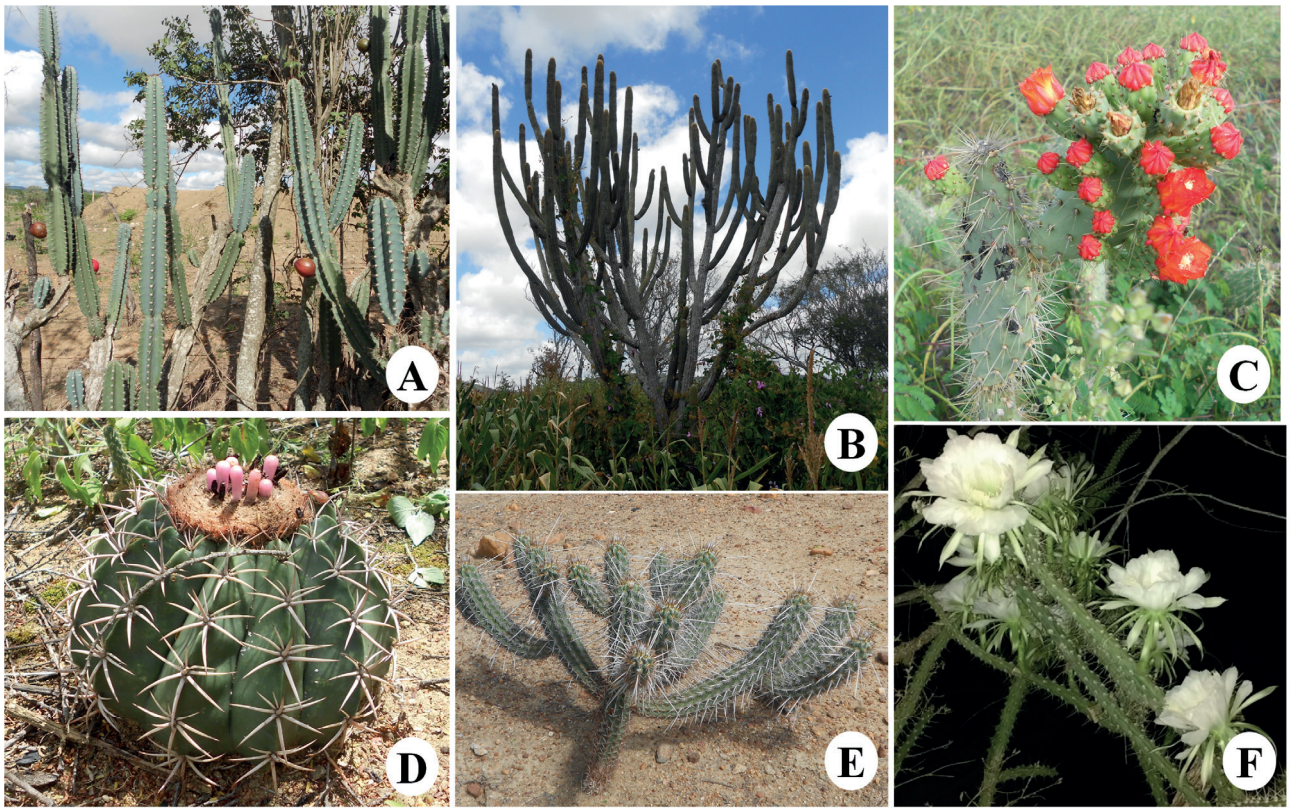

Figure 3. Species occurring in the rural communities of Marimbas and Papagaio do Meio, Pesqueira, Pernambuco, Brazil. **A.** *Cereus jamacaru* DC; **B.** *Pilosocereus pachycladus* f. Ritter; **C.** *Tacinga palmadora* (Britton & Rose) N.P.Taylor & Stuppy; **D.** *Melocactus zehntneri* (Britton & Rose) Luetzelb; **E.** *Pilosocereus gounellei* (F.A.C. Weber) Byles & G.D. Rowley; and **F.** *Arrojadoa rhodantha* (Gürke) Britton & Rose. Photographs taken by Ailza Maria Lima-Nascimento in 2017.

Table 3. Frequency of use of Cactaceae species, classified by purpose and the total number of people using the species for such a purpose in the rural communities of Marimbas and Papagaio do Meio, Pesqueira, Pernambuco, Brazil. [1] It is not possible to determine the frequency for this type of use; [2] frequency dependent on the availability of the plant in a suitable condition; [3] frequency conditioned by the need for therapeutic treatment.

Species	Purpose	Frequency of use	No. of people using the plant
Cereus jamacaru DC	Fence construction	[1]	17
	Used as fodder	Daily	7
		Weekly	11
		Biweekly	1
		Monthly	2
Pilosocereus gounellei (F.A.C. Weber) Byles & G.D Rowley	Used as fodder	Daily	1
		Weekly	2
	Fence construction	[1]	2
Pilosocereus pachycladus F. Ritter	Used as fodder	Daily	4
		Weekly	6
		Monthly	2
	Fence construction	[1]	5
	Fuel	[2]	1
Arrojadoa rhodantha (Gürke) Britton & Rose	Used as fodder	Daily	5
		Weekly	3
		Monthly	2
	Fence construction	[1]	3
Tacinga palmadora (Britton & Rose) N.P.Taylor & Stuppy	Used as fodder	Weekly	1
Melocactus zehntneri (Britton & Rose) Luetzelb	Ward off evil eye	[1]	1
	Tea for inflammation	[3]	1
	Ornamental use	[1]	1

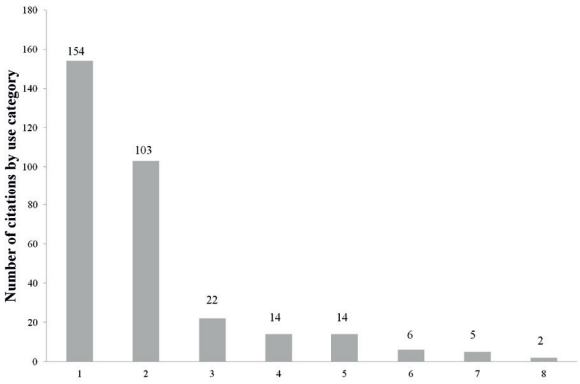

Figure 4. Number of use citations in each category recorded in the 59 interviews conducted with the residents of the rural communities of Marimbas and Papagaio do Meio, Pesqueira, Pernambuco, Brazil. Categories: 1) fodder; 2) construction; 3) human food 4) animal food; 5) medicinal 6) ornamental; 7) magic/religious; and 8) fuel.

The high number of citations for fodder is related to water and pasture scarcity, due to the lack of regular rainfall in the study region for the past six years (2011–2017). A similar situation was reported by Lucena *et al.* (2015a) in a rural community in the semi-arid region of Paraíba. The use of cacti as fodder has been reported in other Brazilian states (Lucena *et al.* 2012; 2015a; Nunes *et al.* 2015), as well as in in other regions, such as Mesoamerica (Casas 2002) and the drylands of Argentina. This dissemination of cacti use in other regions of the world also occurs for rural construction, which is a common practice, such as in Cuba (Fuentes 2005) and Mexico (Casas 2002; Rodríguez-Arévalo *et al.* 2006).

In the communities for the current study, the only type of construction the cacti were used for was living fences. According to the participants, these plants were used to fill in empty spaces in conventional fences made of wood and

Figure 5. Photographic documentation of cacti uses in the communities of Marimbas and Papagaio do Meio, Pesqueira, Pernambuco, Brazil. **A.** Burning of thorns from *Arrojadoa rhodantha* so it can be used as fodder; **B.** Preparation for burning the thorns from *Cereus jamacaru* so it can be used as fodder; **C.** *Pilosocereus pachycladus* wood being used for energy purposes; **D.** *Melocactus zehntneri* being used as an amulet (lower right corner of the image); **E.** Use of *Pilosocereus pachycladus*, *Arrojadoa rhodantha*, and *Tacinga palmadora* as a living fence; **F.** Use of *Cereus jamacaru* in a spaced wire fence; **G.** Use of *Cereus jamacaru* in a living fence, termed a "faxina". Photographs taken by Ailza Maria Lima-Nascimento in 2017.

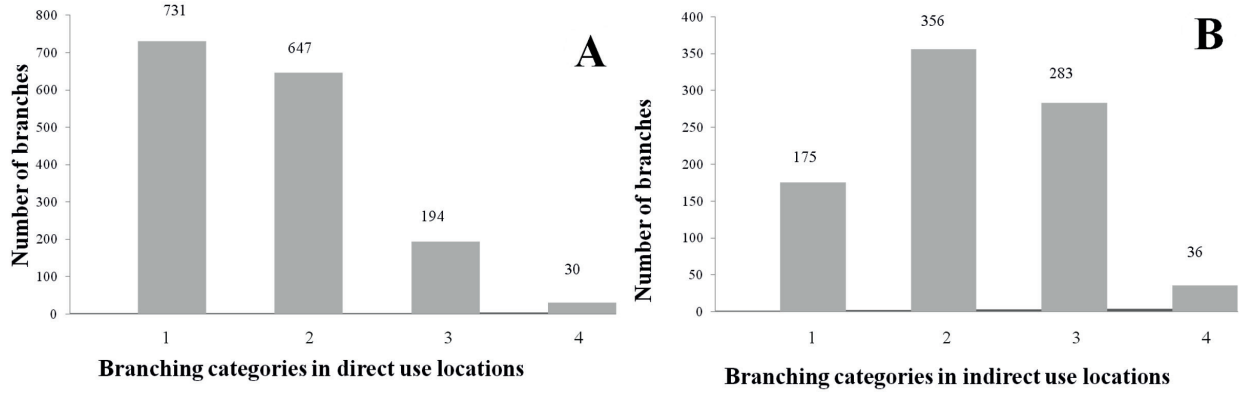

Figure 6. Sum of branches in each category of branching order for cacti analyzed in the rural communities of Marimbas and Papagaio do Meio, Pesqueira, Pernambuco, Brazil. **A.** Plants in areas of direct use. **B.** Plants in areas of indirect use.

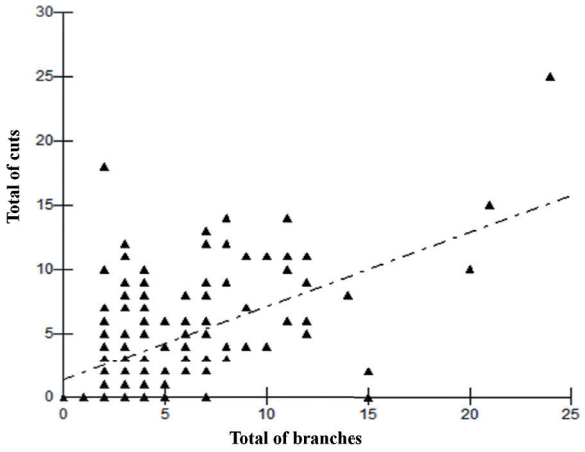

Figure 7. Correlation between the total number of branches of category 1 branching order and the total number of cuts on the plants, for areas of direct use in the rural communities of Marimbas and Papagaio do Meio, Pesqueira, Pernambuco, Brazil.

barbed wire, which delimited their pastures, plantations, and residences. In addition, this technique offered better sealing and protection against animal invasion due to the presence of cactus thorns. The structure of the fences built in the study areas was similar to those described by Lima *et al*. (2015) in their research on the management of fences containing species from the Caatinga in Paraíba. The way the fences were built was also similar to that described by Rodríguez-Arévalo *et al.* (2006), in a study on the use of *Pachycereus hollianus*, which is widely distributed in regions of the Tehuacán-Cuicatlán Valley in Mexico, and is used to build living fences and other rural construction that requires timber resources. Lucena *et al.* (2012; 2015a; b) also reported the use of columnar cacti for construction in Paraíba; however, *P. gounellei* was the main species used. It is worth noting that, regardless of the species used, propagation of living fences is recommended for the conservation of native species, as shown by Nascimento *et al.* (2009), who identified a lack of use of cacti in the construction of live fences in a study area in Pernambuco.

Therefore, the use of columnar cacti to build living fences may be a sustainable management strategy for these species. In addition to maintaining their ecological importance and dynamics, this approach also provides benefits for the farmers in semi-arid regions, as well as keeping alive the tradition of use and the knowledge of these plants in local populations.

Acquisition and use of cacti, and availability of ***Cereus jamacaru*** *DC*

The frequency and intensity of obtaining and using cacti varies according to the need and purpose for which each of them is used. Those used in routine and dynamic activities are affected in their natural processes of development, unlike cacti that are used on a conditional basis, such as those used in the treatment of diseases, for magical/religious purposes, and as fodder for domestic animals. The intensity of use also depends on the availability and applicability of the resource, which may influence the dynamics of its collection (Albuquerque & Andrade 2002; Andrade *et al.* 2015).

Cereus jamacaru had the highest UV and was the cactus most frequently collected by the residents in the current study, as confirmed by the analysis of the plants in the areas of direct anthropogenic use, where agricultural and livestock activities were carried out near the residences. It was important to emphasize that, although the cut cladodes could regenerate by regrowth, the number of cuts in the branching order No. 1, which were those originating from the main stem, affected the order of the next branches, resulting in a much lower number of branches of order 2, 3 and 4. This reduction was reported by the respondents, who described a situation of vulnerability due to the unavailability of this resource in a usable condition. Therefore, comparing the condition of the plants in these areas to those in the areas of indirect use, which were subject to less interference, it was possible to perceive a different pattern of development. Where plants are used less, they had more branches in the higher branching categories.

The current study showed that there was a pressure of use on *C. jamacaru* in the land use areas, from the standpoint of cost-benefit ratio. This condition can result in specific ecological problems, not only for this species, but also for those that interact with it. Removal of cladodes may interfere with processes such as flowering, fruiting, and reproduction, which may be linked to the dynamics of survival of other interacting species, e.g., mammals, birds, insects, and reptiles that eat the flowers, fruits, and seeds of this cactus (Valiente-Banuet & Godínez-Alvarez 2002; Leal *et al.* 2007).

When considering the form of use and intensity under which cladodes are removed, limited odds need to be applied for the physiological capacity of regeneration, , which can be influenced by external conditions such as temperature, humidity and soil type (Godínez–Álvarez *et al.* 2003; Arruda *et al.* 2005; Luz-Freire *et al.* 2014; Bárbara *et al.* 2015; Medeiros *et al.* 2015). Adverse environmental conditions can affect the natural regeneration of these plants and compromise their use by local residents, leading to searching for these resources in more distant areas, and thus increasing their exploitation.

Conclusions

The ethnobotanical survey showed a low number of current uses for Cactaceae species with far greater potential cited by the participants. All the species had utility; however, cladodes of *C. jamacaru* were the most frequently harvested in the area of direct use, affecting local availability by reducing the number of branches. This finding showed that, although the method of acquisition allowed for regeneration, there was a need to plan and control the collection of this species so that it could maintain its basic physiological processes. This would maintain the resource and ensure its availability. However, we recognize that the absence of ecological data could limit our conclusions about availability. In addition, we recommend population dynamics studies to evaluate the current status of *C. jamacaru,* and to determine stage-dependent life tables and demographic data. Such information would make it possible to more precisely manage local use and conservation.

Acknowledgements

The authors thank the Higher Education Personnel Improvement Coordination – CAPES for providing the incentive grant. We also express our sincere gratitude to the residents of the rural communities of Marimbas and Papagaio do Meio for participating and contributing to the research.

References

Albuquerque UP, Andrade LDHC. 2002. Conhecimento botânico tradicional e conservação em uma área de caatinga no estado de Pernambuco, Nordeste do Brasil. Acta Botanica Brasilica 16: 273-285.

Andrade WM, Ramos MA, Souto WMS, Bento-Silva J, Albuquerque UP, Araújo EL. 2015. Knowledge, uses and practices of the licuri palm (*Syagrus coronata* (Mart.) Becc.) around protected areas in northeastern Brazil holding the endangered species Lear´s Macaw (Anodorhynchus leari). Tropical Conservation Science 8: 893-911.

Arakaki M, Christina PA, Nyffeler R, *et al.* 2011. Contemporaneous and recent radiations of the world's major succulent plant lineages. Proceedings of the National Academy of Sciences of the United States of America 108: 8379-8384.

Arruda E, Melo-de-Pinna GF, Alves M. 2005. Anatomia dos órgãos vegetativos de Cactaceae da caatinga pernambucana. Revista Brasileira de Botânica 28: 589-601.

Bárbara EPS, Silva AA, Souza MMOR, Gurgel ZER, Marchi MNG, Bellintani MC. 2015. Germinação e criopreservação de sementes de cactos nativos da Bahia. Gaia Scientia 9: 91-96.

Berriozabal-Islas C, Badillo-Saldaña LM, Ramírez-Bautista A, Moreno CE. 2017. Effects of habitat disturbance on lizard functional diversity in a tropical dry forest of the Pacific Coast of Mexico. Tropical Conservation Science 10: 194008291770497. doi: 10.1177/1940082917704972

Campos JLA, Araújo EL, Gaoue OG, Albuquerque UP. 2018. How can local representations of changes of the availability in natural resources assist in targeting conservation? Science of the Total Environment 628-629: 642-649.

Casas A. 2002. Uso y Manejo de cactáceas Columnares Mesoamericanas. CONABIO, Biodiversitas 40: 18-23.

Casas A, Caballero J, Valiente-Banuet A, Soriano JA, Davila P. 1999. Morphological variation and the process of domestication of *Stenocereus stellatus* (Cactaceae) in central Mexico. American Journal of Botany 86: 522-533.

Casas A, Blancas JJ, Negrón EP, *et al.* 2014. Manejo sustentable de recursos naturales: naturaleza y cultura. In: Hernández GA, Heredia BF, Huacuz JCC, *et al.* (coords.) Sustentabilidad e interculturalidad paradigmas entre la relación cultura y naturaleza. Pátzcuaro, Universidad Intercultural Indígena de Michoacán. p. 10-19.

Castillo RF, Trujillo S. 1991. Ethnobotany of *Ferocactus histrix* and *Echinocactus platyacanthus* (Cactaceae) in the semiarid Central Mexico: Past, presente and future. Economic Botany 45: 495-502.

Chaves EMF, Barros RFM. 2015. Cactáceas: recurso alimentar emergencial no semiárido, Nordeste do Brasil. Gaia Scientia 9: 129-135.

Coelho PJA, Junior SCFF, Nascimento E. 2015. Coleta e conservação ex situ de cactáceas nativas do Estado do Ceará. Gaia Scientia 9: 183-192.

CONDEPE/FIDEM – Agência Estadual de Planejamento e Pesquisas de Pernambuco. 2017. Pernambuco em Mapas. Recife, CONDEPE/FIDEM. http://www2.condepefidem.pe.gov.br/web/condepe-fidem/publicacoes. 13 Dec. 2017.

Corrêa ACB, Tavares BAC, Monteiro KA, Cavalcanti LCS, Lira DR. 2010. Megageomorfologia e morfoestrutura do Planalto Da Borborema. Revista do Instituto Geológico 31: 35-52.

Fuentes FVR. 2005. Etnobotánica de Cactaceae en Cuba. In: Torres LRG, Palmadora A, Rodríguez A. (eds.) Memorias del taller conservación de cactus Cubanos. La Habana, Jardim Botánico Nacional, Universidad de La Habana. p.15-24.

Giulietti AM, Bocage Neta ALB, Castro AAJF, *et al.* 2004. Diagnóstico da vegetação nativa do bioma Caatinga. In: Silva JMC, Tabarelli M, Fonseca MF, Lins LV. (Orgs.) Biodiversidade da caatinga: áreas e ações prioritárias. Brasília, MMA. p. 49-78

Godínez-Álvarez H, Valverde T, Ortega-Baes P. 2003. Demographic trends in the Cactaceae. The Botanical Review 69: 173-203.

Goettsch B, Hilton-Taylor C, Cruz-Pinon G, *et al.* 2015. High proportion of cactus species threatened with extinction. Nature Plants 1: 7. doi: 10.1038/nplants.2015.142

Janzen DH. 1988. Biodiversity. In: Wilson EO, Perer FM. (eds.) The national academies advisers to the national on science, engineering and medicine. Washington, Academy Press. p. 130-538.

Leal IR, Wirth RN, Tabarelli M. 2007. Seed dispersal by ants in the semi-arid caatinga of north-east Brazil. Annals of Botany 99: 885-894.

Lima JRF, Nascimento-Filho AH, Alves CAB, *et al.* 2015. Uso y manejo de cercas en una comunidad rural del semiárido de Paraíba, Nordeste de Brasil. Interciencia 40: 618-625.

Lima-Nascimento AM, Bento-Silva JS, Ferraz EMN. 2017. Conhecimento e uso das plantas da Caatinga por agricultores locais moradores de uma comunidade rural do município de Pesqueira Estado de Pernambuco. Cientec 9:10-23.

Lucena CM, Costa GGSC, Carvalho TKNC, Guerra NM, Quirino ZGM, Lucena RFP. 2012. Uso e conhecimento de cactáceas no município de São Mamede (Paraíba, Nordeste do Brasil). BioFar Volume Especial: 121-134.

Lucena CM, Paiva-Lucena RF, Costa GM, *et al.* 2013. Use and knowledge of Cactaceae in Northeastern Brazil. Journal of Ethnobiology and Ethnomedicine 9: 62. doi: 10.1186/1746-4269-9-62

Lucena CM, Carvalho TKN, Marín EA, *et al.* 2014. Potencial medicinal de cactáceas en la región semiárida del Nordeste de Brasil. Gaia Scientia Volume Especial Populações Tradicionais: 36-50.

Lucena CM, Carvalho TKN, Ribeiro JES, Quirino ZGM, Casas A, Lucena RFP. 2015a. Conhecimento botânico tradicional sobre cactáceas no semiárido do Brasil. Gaia Scientia 9: 77-90.

Lucena CM, Ribeiro JES, Nunes EM, *et al.* 2015b. Distribuição local de *Cereus jamacaru* DC. subsp. *jamacaru* e *Pilosocereus pachycladus* F. Ritter subsp. *pernambucoensis* (F. Ritter) Zappi (Cactaceae) e sua relação com uma comunidade rural do Município do Congo, Paraíba. Gaia Scientia 9: 97-103.

Lucy SS. 2015. Nearly one third of all cactus species are threatened by extinction. Christian Science Monitor. https://www.nature.com/articles/nplants2015142. 20 Dec. 2017.

Luz-Freire HP, Trindade DPF, Sá-Neto RJ, Corrêa MM. 2014. Survival dynamics of *Melocactus conoideus* Buining & Brederoo (Cactaceae), a threatened species endemic to northeastern Brazil. Acta Botanica Brasilica 28: 293-297.

Mandujano MC, Bravo Y, Verhulst J, Carrillo-Angeles I, Golubov J. 2015. The population dynamics of an endemic collectible cactus. Acta Oecologica 63: 1-7.

Mario M, Angélica M. 2014. El cactus San Pedro ayer y hoy . Un enfoque etnobotánico. Cactáceas y Suculentas Mexicanas 59: 121-135.

Martin GJ. 1995. Ethnobotany: a methods manual. London, Chapman Hall.

Medeiros RLS, Souza VC, Azeredo GA, *et al.* 2015. Germinação e vigor de sementes de *Pilosocereus catingicola* (Gürke) Byles & Rowley subsp. *salvadorensis* (Werderm.) Zappi (cactaceae) da caatinga paraibana. Gaia Scientia 9: 61-66.

Menezes MOT, Taylor NP, Loiola MIB. 2013. Flora do Ceará, Brasil: Cactaceae. Rodriguésia 64: 757-774.

Nascimento VT, Sousa LG, Alves AGC, Araújo EL, Albuquerque UP. 2009. Rural fences in agricultural landscapes and their conservation role in an area of caatinga (dryland vegetation) in northeast Brazil. Environment, Development and Sustainability 11: 1005-1029.

Novoa A, Roux JJ, Robertson MP, Wilson JRU, Richardson DM. 2015. Introduced and invasive cactus species: A global review. AoB Plants 7: 1-14.

Nunes AT, Lucena RFP, Ferreira-Santos MV, Albuquerque UP. 2015. Local knowledge about fodder plants in the semi-arid region of Northeastern Brazil. Journal of Ethnobiology and Ethnomedicine 11: 12. doi: 10.1186/1746-4269-11-12

Pérez-Negrón E, Dávila P, Casas A. 2014. Use of columnar cacti in the Tehuacán Valley, Mexico: perspectives for sustainable management of non-timber forest products. Journal of Ethnobiology and Ethnomedicine 10: 79. doi: 10.1186/1746-4269-10-79

Pérez-Negrón E, Casas A. 2007. Use, extraction rates and spatial availability of plant resources in the Tehuacán-Cuicatlán Valley, Mexico: The case of Santiago Quiotepec, Oaxaca. Journal of Arid Environments 70: 356-379.

Queiroz LP, Cardoso D, Fernandes MF, Moro MF. 2017. Diversity and evolution of flowering plants of the Caatinga domain. In: Silva MC, Leal IR, Tabarelli M. (eds.) Caatinga the largest tropical dry forest region in South America. Gewerbestrasse, Springer. p. 23-63.

Rodríguez-Arévalo I, Casas A, Lira R, Campos J. 2006. Uso, Manejo y procesos de domesticación de *Pachycereus hollianus* (F.A.C. Weber) Buxb. (Cactaceae), em El Valle de Tehuacán-Cuicatlán, México. Interciencia 31: 677-685.

Rotta E, Carvalho LC, Beltrami MZ. 2008. Manual de prática de coleta e herborização de material botânico. Vol. 173. Colombo, Empresa Brasileira de Pesquisa Agropecuária.

Santos CS, Meiado MV. 2015. Levantamento florístico e status de conservação dos cactos do estado de Sergipe Nordeste do Brasil. Gaia Scientia 9: 136-146.

Silva VA, Nascimento viviany T, Soldati GT, Medeiros MFT, Albuquerque UP. 2010. Técnicas para análise de dados etnobiológicos. In: Albuquerque UP, Lucena RFP, Cunha LVFC. (eds.) Métodos e técnicas na pesquisa etnobiológica e etnoecológica. 1st. ed. Recife, Nuppea. p. 189-206.

Taylor N, Zappi D. 2004. Cacti of Eastern Brazil. Kew, Botanic Gardens.

Valiente-Banuet A, Godínez-Alvarez H. 2002. Population and community ecology. In: Nobel SP. (ed.) Cacti: biology and uses. Berkeley/ Los Angeles, University of California Press. p. 1-281

Velloso AL, Sampaio EVSB, Pareyn FGC. 2002. Ecorregiões: propostas para o bioma caatinga. Vol. 2. Recife, Associação Plantas do Nordeste/ Instituto de Conservação Ambiental do Brasil.

Wallace RS, Gibson AC. 2002. Evolution and systematics. In: Nobel SP. (ed.) Cacti: biology and uses. Berkeley/ Los Angeles, University of California Press. p. 211-234.

Zappi D, Taylor N, Ribeiro-Silva S. 2011. Plano de ação nacional para a conservação das Cactáceas. Brasília, ICMBIO.