Traditional management of Cactaceae: *Cereus jamacaru* DC as the native cactus most managed by rural communities in areas of Caatinga in Brazil

Ailza Maria de Lima-Nascimento, José Severino Bento da Silva, Alejandro Casas, Camilla Marques de Lucena and Reinaldo Farias Paiva de Lucena

Research

Abstract

Background: Studies on management practices reflect the quality of the actions regarding the managed resource by people and allow us to identify possible selective pressures over time.

Methods: Was investigated how have been carrying out management practices using native cacti species in two communities. Data collection was through the ethnobotanical (semi-structured interviews) and morphometric approach (botanical measurements). It was aimed to interview residents who used and/or cultivated some native species. For morphometric analysis were recorded total height from the highest branch and the maximum number of stem ribs per plant, ground-level and chest level diameter. Managed and unmanaged plants were comparatively analyzed. Was created a distribution map with gathering and cultivation areas indicated by the residents through QGIS software. The Kruskal-Wallis test was applied to investigate the differences between the specimens managed and unmanaged, and the Pearson linear correlation test to test the correlation between the diameter x height.

Results: People mentioned the management of six native species, through the collection, non-selective incipient management, and *ex situ* cultivation. Low complexity activities were the most frequent; also, there was little variation between the forms of management. *Cereus jamacaru* DC. was the most locally managed species and by a higher number of people, and it was observed that specimens from the Area of Direct Use (ADU) had greater variation.

Conclusions: Intra-specific variants were identified by people and they said to prefer the larger and healthier branches and younger (green) cladodes, suggesting human selection that can favor particular phenotypes where these plants are propagated.

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Background

Although management of some Cactaceae species is apparently common and has been frequently documented in Mesoamerica (Blancas *et al.* 2013, Casas *et al.* 1999b, Pérez-Negrón *et al.* 2014), in the Northeast Region of Brazil was identified that rural residents use a relatively small number of species of this plant family (Cruz et *al*. 2013; Lucena *et al*. 2013; Pedrosa *et al*. 2020b). The consumption of fruits as human food has greater prominence in Mesoamerica (Parra *et al*. 2012). But, Brazilian species have different cultural values for the local communities that implement animal fodder as their main use. Thus, as a result, the cacti parts more used are cladodes instead of fruits (Lucena *et al*. 2015a, 2014; Nunes *et al*. 2015; Pedrosa *et al*. 2020a).

Based on plant management in the Mesoamerica, investigations have been evidenced the potential of transformation of human activities on both the landscape and the phenotypic and genetic variation and structure of the species (Barbosa *et al.* 2017, Casas & Caballero 1996, Casas *et al.* 2007, Castro-Felix *et al.* 2014, Rodríguez-Arévalo *et al.* 2006, Ruán-Tejeda *et al.* 2014), and these changes may occur gradually based on the different management regimes used, which may be unconscious and with low intensity, or conscious, systematic and highly intense (Abbo *et al.* 2014, Heiser 1988). The intentional choice of a particular species or phenotype of interest and its protection, promotion, and tolerance are known practices that can cause changes in composition and dynamics of populations and communities and, eventually morphological, physiological, and genetic differentiation with respect to the original populations and communities of the organisms subjected to management (Casas & Caballero 1996). The tolerance of a plant occurs when it is kept in an area before and after the land preparation for agricultural or livestock purposes. It is protected when competing factors are eliminated and it is promoted when practices lead to an increase in its population density by pruning, fertilizing, among other practices (González-insuasti & Caballero 2007). And these practices may vary in intensity according to the interest of people on the particular resource, and according to its scarcity or difficult access to it (Rangel-Landa *et al.* 2016, 2017).

In northeastern Brazil, studies on management practices of Cactaceae species have started based on results from ethnobotanical surveys showing the use of these species for different purposes (Lucena *et al*. 2015a, 2014; Nunes *et al*. 2015; Pedrosa *et al*. 2020a), evidencing the high ecological and economic importance for residents of rural communities in semi-arid regions (Sales *et al.* 2014). Therefore, understanding how the management of these plant resources has been carried out is relevant and can contribute to understanding their current conditions of management and conservation (Casas *et al.* 2007). This is a topic particularly important considering that plants of this family, distributed in the northeast region of Brazil, are under chronic and/or acute anthropogenic impacts, which compromise their living conditions in the semi-arid environment (Zappi *et al*. 2011).

In this context, this study aimed to investigate how the residents of two semi-arid rural communities have been performing management practices on native Cactaceae species used by the local populations, as well as to highlight the possible implications of the development of these practices for the managed species. Was hypothesized that management occurs intentionally through gathering, tolerance, protection or promotion, similarly as documented in research regarding the forms of management practiced by local populations in the Tehuacán Valley, Mexico (Blancas *et al*. 2010). These types of management may be more intense (involving cultivation and selection of phenotypes, and/or specific sites of gathering) in those more valued species, than in less valued species (which would be occasionally gathered, with low selectivity). Following previous studies of cacti in Mexico, was expected that the *in situ* managed populations of cacti would produce more robust individual plants and more robust stems or branches with more ribs as on as significant differences in height because species that have an arboreal size normally the diameter growth maintains relationships with its canopy that can increase or decrease according to the vitality of its stem (Sumida *et al.* 2013). Characteristics of the fruits were not considered because they are not consumed by local people (Lima-Nascimento *et al*. 2019). In addition, was expected to find the practice of methods of choosing from desirable traits for *ex situ* managed plants. Thus, was selected the most managed species by the local population and compared their morphological characteristics.

Material and Methods

Area Characterization

The study area is located in the Agreste region of the State of Pernambuco (Corrêa *et al.* 2010), inserted in the Caatinga, a seasonal tropical dry forest, an ecosystem that makes up a large portion of the Northeast region of Brazil (Giulietti *et al.* 2004; Queiroz *et al*. 2017). The climate is dry, classified as BShs' according to Köppen-Geiger classification with semi-arid characteristics, and evaporation rates exceeding the annual rainfall means (Velloso *et al.*

2002). The annual precipitation means is 550-700 mm, and the temperature 21º-22ºC (CPRH 2016). The studied communities, Marimbas (8º34'06.81''S 36º39'44.45''W) and Papagaio do Meio (8º33'26.01''S 36º39'37.81''W), belonging to the municipality of Pesqueira, are located in the Ipojuca River basin (CPRH 2016). The municipality population estimated in 2017 was 66,881 inhabitants, 17,805 of them living in rural areas (IBGE 2015). The resident population of the studied communities is approximately 219 individuals, in 72 residences. The altitudes range between 720 m to 800 m above sea level, and the soils consist of solodizado planosols, litholic soils, regosols, and quartz sands, red and yellow podzolic soils, and rock outcrops (EMBRAPA 2000). The local economy is based on subsistence activities such as family agriculture and small-scale livestock, in addition to the renaissance cotton-based lace handicraft, which is made by women (called "rendeiras") to contribute to family income.

Legal and Ethical Aspects

This research was submitted to the Ethics Committee (5188) of the Health Sciences Center of the Federal University of Paraíba and approved under number 2.507.332. All the respondents agreed to participate in the research and signed the Informed Consent Term (TCLE), allowing the subsequent use of the information (RESOLUTION Nº. 466).

Ethnobotanical Data

Data collection was initiated through semi-structured interviews (Martin 1995). Seventy-two residences were visited in the two communities based on the method described by Lima-Nascimento *et al.* (2019), Fifty-nine families in total participated in the interviews that were performed in the style of a census. It was aimed to interview all residents who used and/or cultivated some native species occurring in the area. In the case of gathering, the participants were asked about the preference for choosing the collected species and the gathering areas, the criteria used to select the plants, and about the gathering and management methods. In the case of cultivation, the questionnaire addressed questions on the reasons for choosing the planted species, preferred planting areas, and cultivation methods. Three different management regimes were classified as follows: *in situ* management, incipient management, and *ex situ* cultivation, according to González-Insuasti and Caballero (2007), and Sousa Júnior *et al.* (2018). The intentional (non-selective) and non-opportunistic practice of gathering branches from native vegetation remnant areas in which individuals that spontaneously occur are found was considered in situ management. Incipient management is related to the practice of tolerance, protection, and promotion of individuals that spontaneously occur in areas of direct use. The *ex situ* cultivation when vegetative parts are grown in interest areas. At the end of each interview, all the gathering and cultivation areas were indicated by the informants on a map of the community extracted from Google Earth Pro, printed on colored satellite images of 90 x 120 with a sight point of 1 km, referring to the year 2016. All the areas indicated on the map were visited with the assistance and monitoring of a local resident and the geographical location was made using a GPS device. The maps were produced through SIRGAS 2000/UTM zone 25S coordinate system at QGIS software version 2.6.0. All the species mentioned in the interviews were collected, identified by a specialist, and deposited in the Dárdano de Andrade Lima (IPA) Herbarium, Recife, in the State of Pernambuco. Socioeconomic data were collected and analyzed and are available at Lima-Nascimento *et al.* (2019).

Morphological Data

Surveys based on the method described by Casas *et al.* (1999b), were carried out to investigate differences in the physical structure of the plants belonging to the species most incipiently managed in different areas and intensities. For this purpose, three areas with different profiles of use and occupation were defined within the study area (Fig. 1). In each area, all specimens with a ground level diameter (GLD) ≥7 cm (because no management of plants with a lower diameter was recorded) were analyzed and the following records were made: GLD; chest level diameter (CLD); total height from the highest branch; and the maximum number of unsegmented stem ribs per plant. *Profile 1 (Area of Direct Use)*. It corresponds to the anthropogenic land use areas around the residences, areas used for agriculture, pasture formation, or where some remnant of native vegetation is maintained for the collection of firewood or the release of domestic animals (livestock). Area coverage: All places informed by residents who collect plants in their lands. *Profile 2 (Control Area 1)*. Remnant of native vegetation in a place 1 km away from the residences, at an advanced succession stage with no history of land use for pasture and/or planting (in the last 50 years), but where firewood or wood can be collected for domestic use. Altitude of 766 m; area coverage: 4 plots of 50 x 50 m, totaling 10,000.00 m². *Profile 3 (Control Area 2).* Places with the remnant of native vegetation at an advanced succession stage with no history of land use for pasture and/or planting (in the last 50 years), near the residences, where firewood and/or wood is collected for domestic use. Altitude of 742 m; area coverage: 4 plots of 50 x 50 m, totaling 10,000.00 m².

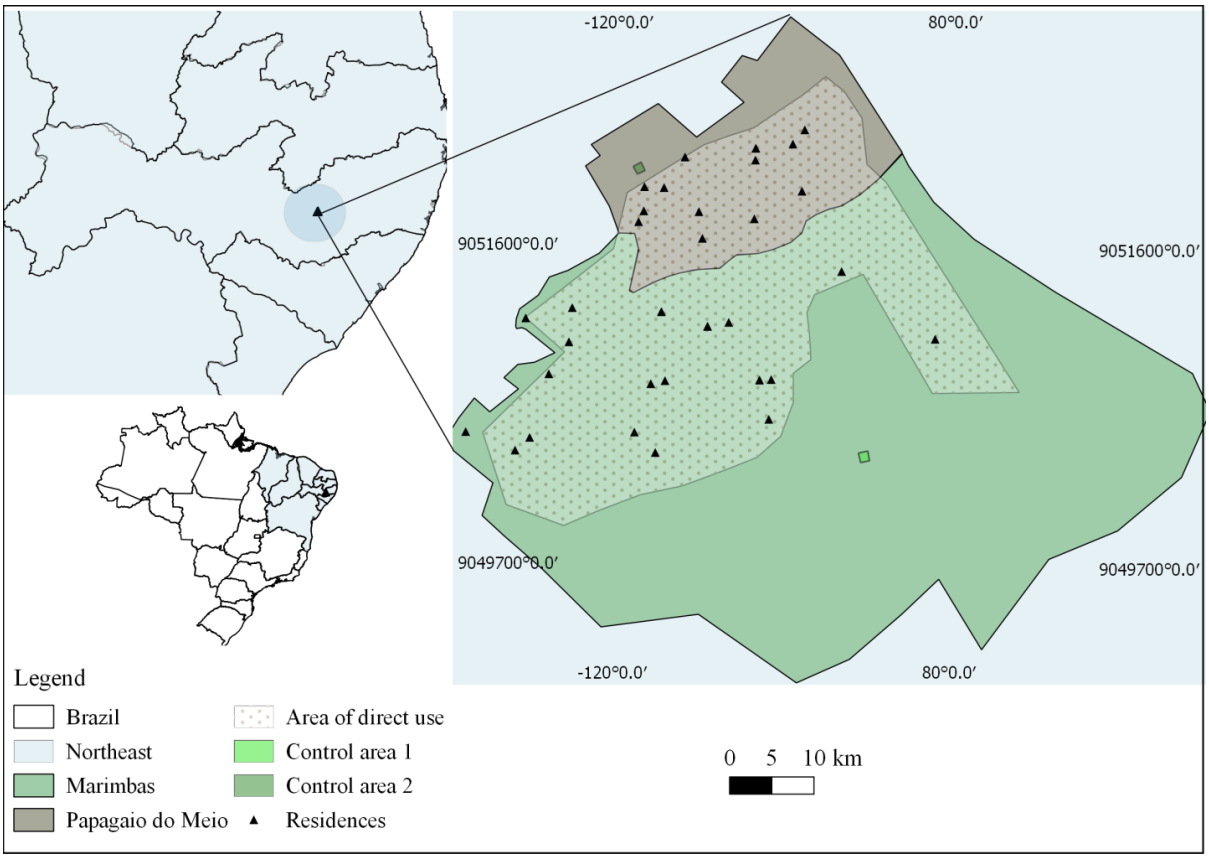

Figure 1. Location map of the study area showing the three profiles of the areas investigating the differences in the structure of the specimens belonging to the most incipiently managed species of *Cereus jamacaru* DC, in the rural communities of Marimbas and Papagaio do Meio, in the municipality of Pesqueira, Pernambuco State, Brazil.

Data Analysis

The equation used by González-Insuasti and Caballero (2007) was applied to measure the species management intensity and choose the most managed for further morphological analysis.

$$MI = \sum MF\ x\ \frac{n}{N}$$

For this, it is considered the number of people who carry out any form of management, plus the complexity of each form, in addition to the total number of different practices performed simultaneously. Where MI is the management intensity; MF is the sum of the management forms considering the following complexity levels: 1 for non-selective gathering (simple gathering); 2 for non-selective incipient management (non-selective practices of tolerance, protection, or promotion); 3 for selective incipient management (practices of tolerance, protection, or promotion involving selective favoring of phenotypes with desirable features including selective gathering); and 4 for ex situ cultivation (including seed sowing and vegetative propagation of plants in crop fields). The “n” is the number of respondents interviewed who practice any form of management and “N” is the total number of respondents interviewed (González-insuasti & Caballero 2007). The Kruskal-Wallis test was applied to investigate the differences of diameter and height between the specimens managed and unmanaged analyzed in the different profiles of areas, and the Pearson linear correlation test was used to test the correlation between the diameter at ground-level and total height, both of them performed in the Bioestat 5.0 statistical analysis software.

Results

Native Species and Management Intensity

Thirty-two residents perform some form of management for one of the six cited native species present in the study area. Three of these species have been subjected to simultaneous forms of non-agricultural management: gathering, non-selective incipient management, and *ex situ* cultivation (*Cereus jamacaru* DC, *Pilosocereus pachycladus* F. Ritter and *Arrojadoa rhodantha* (Gürke) Britton & Rose). No form of selective management was recorded for these species (Table 1). There are no specific criteria for choosing gathering places, preference is only given to the places closest to the residences regardless of the area characteristic. The planting is mostly performed near the residences and in the areas where family agriculture is carried out.

C. jamacaru was the most managed species (5.45). The indexes values obtained for *A. rodantha* (2.37) and *P. pachycladus* (3.38) can be explained by the non-selective gathering, since the promotion and cultivation by using plant parts were performed only by one inhabitant (Fig. 2). The same is observed for *M. zehntneri* (0.67), which suffer no incipient management. No practice of protection was recorded for the species.

Table 1. Identification of management methods for all Cactaceae species investigated in the rural communities of Marimbas and Papagaio do Meio, municipality of Pesqueira, Pernambuco State, Brazil. TL = Tolerance; PT = Protection; PM = Promotion.

Species	In Situ gathering	Non-selective incipient management			Ex Situ cultivation
		TL	PT	PM	
1. *Cereus jamacaru* DC. (91603).	x	x		x	x
2. *Pilosocereus pachycladus* F. Ritter. (91607).	x			x	x
3. *Arrojadoa rhodantha* (Gürke) Britton & Rose. (91608).	x			x	x
4. *Melocactus zehntneri* (Britton & Rose) Luetzelb. (91605).	x				x
5. *Pilosocereus gounellei (F.A.C. Weber) Byles & G.D. Rowley.* (91604).	x				
6. *Tacinga palmadora* (Britton & Rose) N.P.Taylor & Stuppy. (91606).	x				

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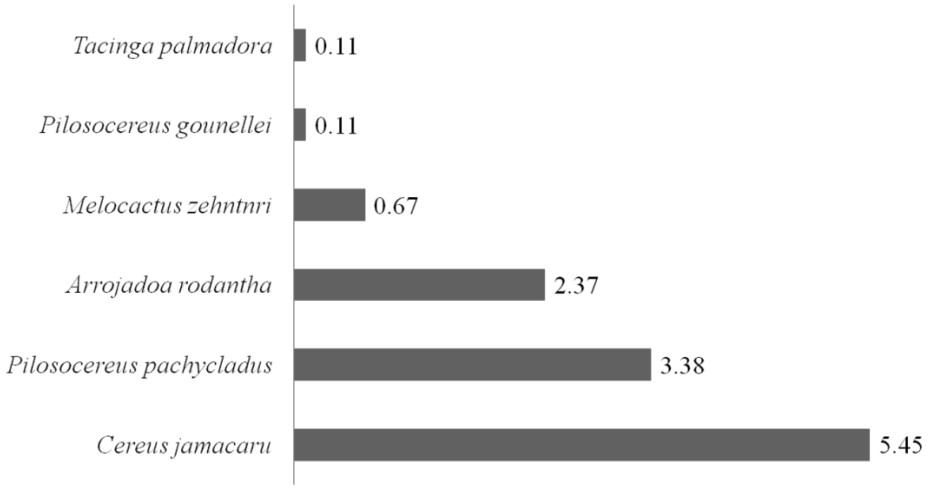

Figure 2 Management intensity gradient for the native cactus species (*Pilosocereus pachycladus* F. Ritter; *Arrojadoa. rhodantha* (Gürke) Britton & Rose; *Melocactus zehntneri* (Britton & Rose) Luetzelb; *Pilosocereus gounellei* (F.A.C. Weber) Byles & G.D. Rowley; *Tacinga palmadora* (Britton & Rose) N.P. Taylor & Stuppy), found in the rural communities of Marimbas and Papagaio do Meio, in the municipality of Pesqueira, Pernambuco State, Brazil.

Diversified Species Management

Different management systems were observed for Cactaceae species investigated in the rural communities. However, the management techniques employed are not differing as a function of species. The management of these species has been performed by the interviewed residents in the following ways:

(1) Gathering (Fig. 3ab). It is performed in a non-selective way directly from the wild populations or from the areas where the plants were planted. Only the cladodes are gathered, for two distinct purposes: for the propagation of propagules and for fodder. The

larger (mature) and healthier branches are collected for the propagation via cladodes because they have a higher chance of rooting and survival in the cultivated environment. As for the gathering for fodder, the preference is for younger cladodes (green) because they are more malleable and still have no wood in their interior, moreover, branches with fewer thorns are preferred. These characteristics facilitate the plant gathering and its processing for fodder preparation. For both purposes, the gathering of cladodes is performed by using cutting tools such as sickle or machete, preferentially removing one branch at a time through a single cut, made in the diagonal direction of the branch, preserving the place where the cladodes are divided. According to the informants, this method of cutting makes it possible to fix the seedling at the planting area, making it more successful.

(2) Promotion. In order to favor the existence of the species, the gathering is done by pruning without hitting the stem of the plant, making possible the regrowth of cladodes. In the specific case of *C. jamacaru* the fertilization of the specimens kept in the cultivation areas may be occurring indirectly since the fertilizer used for crop production can favor the growth of the plants maintained in those areas.

(3) Ex situ cultivation (Fig. 3cdef). It is performed by planting vegetative parts and also by the transplantation of young saplings which are removed from their natural environment and planted in places of interest. In general, it is done on the edges of the fences, since in addition to clearing the land for agriculture planting and/or confinement of animals, it promotes the building of live fences that effectively contribute to closing and protecting the areas.

Weeding is usually done before planting, but in some cases, it also occurs after planting for the maintenance of the plants. The use of pesticides and fertilizer was also cited in the interviews, but as an exception, since the cladodes are mostly planted and left to develop naturally.

(4) Tolerance (Fig. 3g). In all gathering places, *C. jamacaru* is kept in the cultivation and pasture areas, as well as in yards of residences and on roadsides.

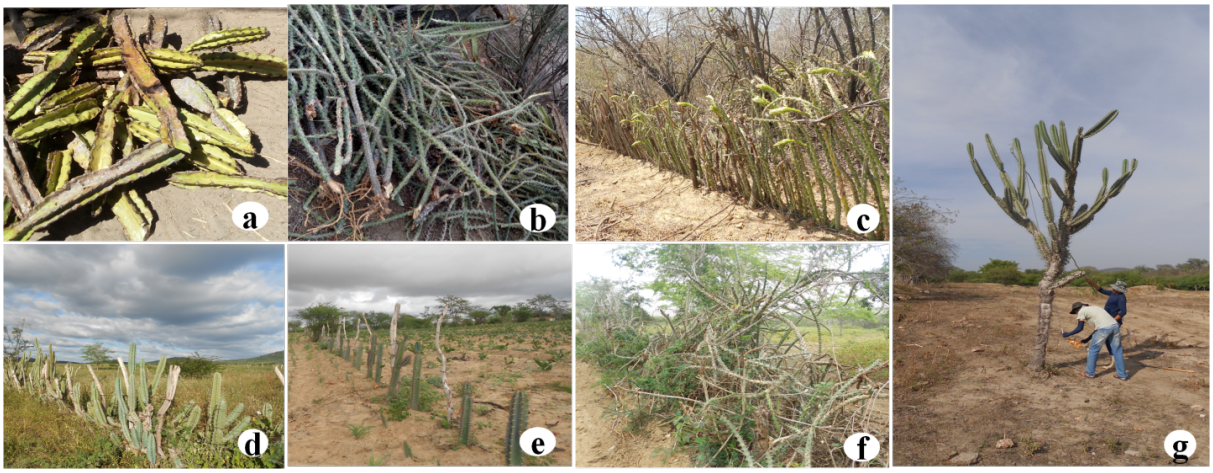

Figure 3. *C. jamacaru*, *A. rhodantha* and *P. pachycladus* simultaneously managed by farmers in the communities of Marimbas and Papagaio do Meio, municipality of Pesqueira, Pernambuco State, Brazil. **a)** Non-selective gathering of *C. jamacaru* cladodes; **b)** Non-selective gathering of *A. rhodantha* cladodes; **c)** Ex situ cultivation of *A. rhodantha* and *P. pachycladus;* **d)** and **e)** Ex situ cultivation of *C. jamacaru* ; **f)** Ex situ cultivation of *A. rhodantha*; **g)** *C. jamacaru* tolerated in the area of anthropogenic use. Pictures taken by Ailza Maria de Lima-Nascimento, 2017.

C. jamacaru stood out because it is managed in different ways and simultaneously by a higher number of people. This management intensity can also be explained due to its high use value and current use executed by the local residents, mainly as fodder and live fences (Fig. 4).

From the management method of *ex situ* cultivation it was observed an increased local distribution of *C. jamacaru* as a result of the propagation of this management practice which was intensified due to the real need of obtaining this species for fodder purposes (Fig. 5).

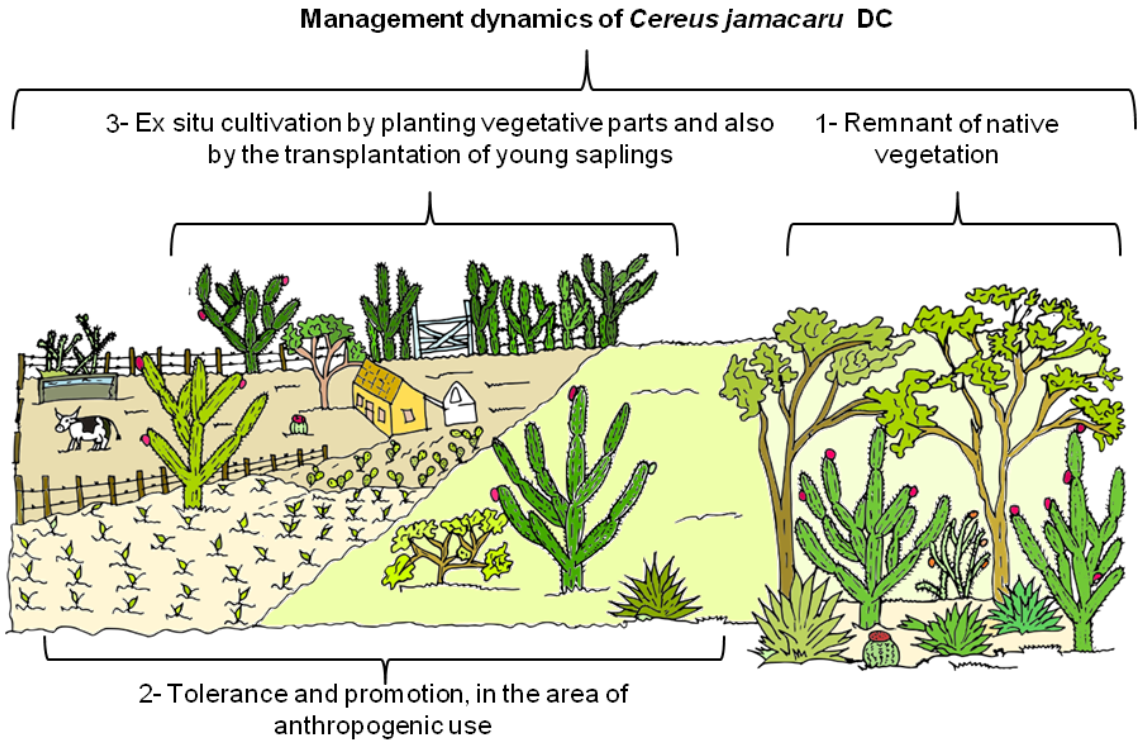

Figure 4. Management dynamics of *Cereus jamacaru* DC made by residents in the rural communities of Marimbas and Papagaio do Meio, in the municipality of Pesqueira, Pernambuco State, Brazil.

Figure 5. Spatial distribution map of *C. jamacaru* gathering and planting areas in the rural communities of Marimbas and Papagaio do Meio, in the municipality of Pesqueira, Pernambuco State, Brazil.

Physical Structure Verified on *C. jamacaru* in Three Areas with Different Profiles of Use

From the investigation of the differences in the physical structure of the plants belonging to the most managed species, a total of 256 specimens of *Cereus jamacaru,* present and/or maintained in the three different area profiles, were analyzed as follow: 97 in the Area of Direct Use (ADU), 77 in the Control Area-1 (CA-1), and 82 in Control Area-2 (CA-2). No significant differences were found by comparing the variation of diameters between the three areas, where (p) = 0.3. However, there was a difference in the data relating to the height of the plants in the ADU (Fig. 6a), which had the lowest mean height (ADU = 3.3, CA-1 = 5, and CA-2 = 4.4). The mean values for number of ribs verified were higher in the Area of Direct Use (ADU= 6) and Control Area-2 (CA-2 = 6), the Control Area-1 presented lower mean (CA-1 = 5).

Based on the significant difference previously found, when the Pearson linear correlation test was performed between height and GLD, in the control areas (CAs) and in areas of direct use, separately, a positive correlation was found: the higher the plant height the higher its diameter (Fig. 6 bc)

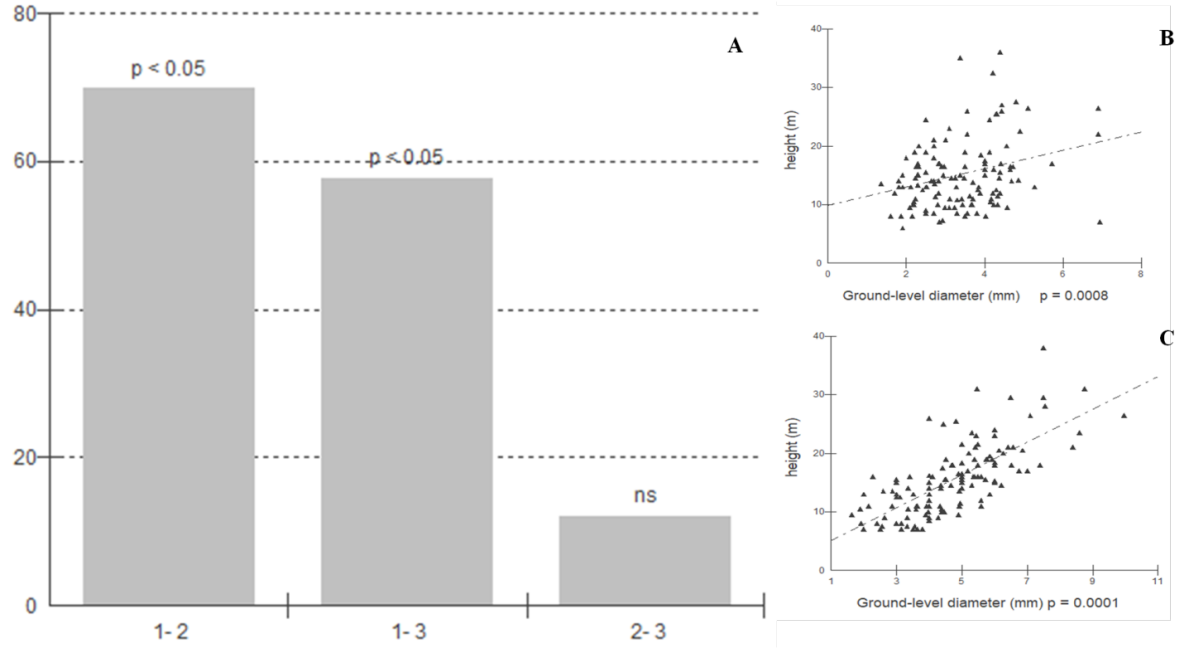

Figure 6. **a)** Analysis of variance of the height of *C. jamacaru* in different area profiles. **1 =** Area of Direct Use, **2 =** Control Area-1, and **3 =** Control Area-2. **b)** Linear correlation analysis between total height and ground level diameter of *C. jamacaru*. Plants in the Area of Direct Use; **c)** Plants in Control Areas1 and 2.

Discussion

Management Practices and Implications for Managed Species

Different management systems were observed for Cactaceae given by rural communities in Caatinga areas as documented by Blancas *et al.* (2010), in the Tehuacán Valley, Mexico, and by Pedrosa *et al.* (2020b), in state of Paraíba, northeastern Brazil. But, in this research, in all cases, the plants are subjected to simple non-selective collections. In both communities, most of the species have been subjected to two or more simultaneous forms of management. However, the management practices are of low complexity, as there is neither intentional modification of the environment in which they develop nor measures focused exclusively on each managed specimen to obtain specific benefits. According to González-insuasti and Caballero (2007), these conditions, over time, are responsible for differences between managed and wild specimens. *P. pachycladus*, *A. rodantha*, *P. gounellei*, and *T. palmadora*, although they are also managed for the same purpose as *C. jamacaru* they do not have the same local importance.

However, in the case of *C. jamacaru*, in addition to being subjected to more types of interventions in comparison with the other species, the number of people utilizing this species shows not only that it has greater importance in the local socio-ecological system, but also that it may be subject to changes in structural characteristics caused by human interventions (González-insuasti & Caballero 2007). Thus, the results show that the management intensity is not the same for all species in the study communities, as well as low complexity activities are the most frequent and there is little variation in the forms of use.

Nevertheless, considering the potential changes from management, *ex situ* cultivation was one of the most important forms recorded. This form of

management may have resulted in morphological variations between wild, managed *in situ*, and cultivated populations. In the case of *Stenocereus stellatus*, cultivation caused the highest level of divergence in the specimens (Casas *et al.* 1999c). In addition to *ex situ* cultivation, specifically, *C. jamacaru* is also managed *in situ* through the collection, tolerance, and promotion. When this practice is intense, involving the selection of desirable phenotypes, people can also modify the phenotypic structure of plant populations (Casas & Caballero 1996), and cause differences in morphology, germination patterns, and genetic variation between wild, managed *in situ*, and cultivated populations (Casas *et al.* 2007). The phenology of specimens exposed to different levels of exploitation over time is also subject to change (Alcântara *et al*. 2020).

Thus, based on the results obtained in the interviews, it was observed that the current forms of management in the two communities were determined by at least two active factors: (1) momentary need for resources, which led to intense exploitation, reducing the local availability of plants, especially *C. jamacaru* (Lima-Nascimento *et al.* 2019) and (2) local cultural importance (Lima-Nascimento *et al.* 2017), because of which the species of greatest importance to the local socio-ecological system was affected by management practices of greater complexity and performed by more people simultaneously. In this case, *C. jamacaru* was also the most prominent species because it is a plant that can supply momentary needs for fodder with greater efficiency in preparation, in addition to promoting other important uses such as medicinal and rural construction (Lima-Nascimento *et al.* 2019). According to González-Insuasti e Caballero (2007), culturally very important species, but less abundant in wild environments and with shorter periods of production of collectable structures, are prone to more intense management. The cultural importance of *C. jamacaru* has also been recorded in the state of Paraíba, northeastern Brazil, where specimens were possibly subjected to some type of incipient management, as they were often maintained close to residences, roadside, and courtyards (Lucena *et al.* 2015b). Moreover, *ex situ* management through vegetative propagation was also recorded as a mean of obtaining resources from this species (Pedrosa *et al.* 2020b).

Variations of Physical Characteristics of *C. jamacaru* in the Different Study Areas

Regarding differences in the physical structure of *C. jamacaru*, resulting from the incipient management, it was observed that specimens from the ADU had greater physical variation. There was a significant difference in the specimens' total height. This fact can be explained by the constant collection of cladodes by residents (Lima-Nascimento *et al.* 2019) because these plants had the lowest mean height.

However, the non-significant difference between the stem diameters recorded in the ADU and those in the other areas where the plants had a higher mean height, indicates that specimens in the ADU have been managed in an incipient manner for 50 years, which was the time estimated by residents for the selected control areas.

According to Sumida *et al.* (2013), the number of leaves on a tree can increase or decrease depending on the intensity in the stem diameter growth. Thus, long-term changes in the number of leaves would also likely accompany an increase or decrease in the crown and stem length (Sumida *et al.* 2013). However, even so, it is necessary to be cautious when trying to explain the nature of the divergence patterns observed in the managed specimen height, since abiotic environmental factors and morphology were not assessed. Nevertheless, it is noteworthy that studies on plant management and domestication often record changes in functional characteristics of specimens managed in areas of direct management in comparison with those available and managed in wild areas, such as increased size and number of fruits and flowers (Baldauf *et al.* 2014, Casas *et al.* 1999b, Rodríguez-Arévalo *et al.* 2006).

Ecological Implications of the *Ex Situ* Cultivation Method Practiced in Communities

With regards to the *ex situ* management of *C. jamacaru*, which has been highlighted for its simultaneous forms of management, from the ecological point of view it is important to emphasize that its vegetative propagation may result in different implications, positive and/or negative.

The planting technique can rapidly supply the resource needs of the community residents (Correia *et al*. 2012), favoring the current need, and differing as for the planting time from the direct sowing, which requires more control due to demands such as types of soil and temperature appropriate for seed germination (Guedes *et al.* 2009). This replantation made by the residents strengthen ecological response time necessary to the plants that were exploited in their natural environment, considering that the species will be decentralized and directed also at cultivated plants. Furthermore, because this process has been developed in a semi-arid region, with limited climatic conditions and recurrent land quality degradation, the planting of xerophytic cacti species should be encouraged since it helps to restore eroded soils as the root system of these plants improves the soil, and moreover, they are also adapted to high-temperature conditions, becoming

the best option to revegetate arid lands (Nefzaoui *et al.* 2014).

With the adoption of *ex situ* cultivation in the studied communities, the distribution of *C. jamacaru* is noticeably higher than that recorded by Barbosa *et al.* (2017) (77 individuals in 20.000m²), and Lucena *et al.* (2015b) (170 individuals totaling all areas visited), both in the state of Paraíba in places without areas of cultivation. However, from the genetics and reproduction point of view, it is important to emphasize that the asexual reproduction developed in the study areas, promotes low gene flow between the species (Rodríguez-Arévalo *et al.* 2006), and the changes in the forms of dispersion may considerably affect this dynamics which is essential for the maintenance of life, as reported by Bustamante *et al.* (2016), in northeastern Mexico. Thus, although the planting contributes to a higher density, it does not ensure a high genetic diversity (Santos *et al.* 2008). However, it is still positive since it avoids the loss of variability due to population decline, such as in the case of *Ferocactus histrix* (DC) Lindsay, a barrel cactus diffused in Mexico, which is losing its genetic variability due to the high decline in the number of individuals and is at a high risk of extinction (Castro-Felix *et al.* 2014).

The complexity of management of *C. jamacaru* requires more specific investigations from the genetic point of view, considering that these ecological changes and management practices have been responsible for the domestication of cacti and other plant resources in Mesoamerica (Blancas *et al.* 2010, Casas *et al.* 1996, 1999a, Rodríguez-Arévalo *et al.* 2006). In this context, we may wonder if incipient domestication processes are occurring in Cactaceae species in Brazil, as occurring in Mexico. This perspective can guide specific studies in the rural communities and areas of Caatinga vegetation in the semi-arid region of Brazil.

Conclusions

The management of most of the studied species (*Pilosocereus pachycladus* F. Ritter; *Arrojadoa rhodantha* (Gürke) Britton & Rose; *Melocactus zehntneri* (Britton & Rose) Luetzelb; *Pilosocereus gounellei* (F.A.C. Weber) Byles & G.D. Rowley; *Tacinga palmadora* (Britton & Rose) N.P.Taylor & Stuppy), can be considered of low complexity, mainly gathered to low selection of areas and intra-specific variants. But, *C. jamacaru* was recorded to be gathered, cultivated, transplanted, promoted and tolerated. Intra-specific variants were identified by people and they said to prefer the larger (mature) and healthier branches and younger (green) cladodes, both for each specific type of use, suggesting human selection that can favor particular phenotypes where these plants are propagated. Thus, morphological and genetic studies are necessary to evaluate the consequences of these selection processes in *C. jamacaru* populations and possible processes of incipient domestication as well as variations resulted from the asexual propagation.

Declarations

List of abbreviations: Area of Direct Use (ADU); Agronomic Institute of Pernambuco (IPA); Control Area (CA); Diameter at Ground Level (DGL); Diameter at Chest Level (DCL); Informed Consent Term (TCLE);

Ethical approval and consent to participate in the research: This research was approved by the Ethics Committee (5188) of the Federal University of Paraíba – Health Sciences Center – under protocol No. 2,507,332. All interviewed people agreed to participate by signing the consent form.

Consent for publication: All participants were informed about the research objectives and were invited to sign the Informed Consent Form and allowed the subsequent use of the information (RESOLUTION No. 466).

Availability of data and material : The authors do not wish to provide data from their studies, because some bases charge fees and there is no appropriate Brazilian database. The collected plants were identified and deposited in the herbarium, as described in the methodology. The identification number is found in the tables.

Competitive interests: The authors declare no competing interests.

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Authors' contributions: AMLN carried out fieldwork, data analysis and drafted the manuscript. JSBS and RFPL configured the research project, supervised the work and improved the manuscript. AC and CML read and perfected the drafted manuscript. All authors read, reviewed and approved the final version of the manuscript.

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