The role of local experts in the selection and use of fodder crop species: a case study in the Brazilian dry forest

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Research

Abstract

Background: Native vegetation is the primary source of animal forage in Brazil's semiarid region. However, comprehensive ethnobotanical studies are lacking, hindering understanding of local knowledge on Caatinga plants and their selection criteria for animal feed. The study aims to investigate the differential use of native Caatinga plant species for domestic animal feeding and identify factors influencing their use in a rural community in the Northeast semiarid region of Brazil.

Methods: The free-list technique was used to identify the known forage plants offered to the animals by the small livestock farmers. In order to identify the most important species and evaluate the criteria for selection of forage plants by small livestock farmers, the calculation of the Index of Cultural Significance of Forage Plants (ICSFP) was performed.

Results: The findings revealed that the selection of forage species is influenced by various factors, including considerations for animal welfare and environmental changes perceived by small livestock farmers. The most culturally significant species identified were *Portulaca oleraceae* L.*, Cereus jamacaru* DC.*, Manihot glaziovii* Müll. Arg. and some species from the Poaceae family.

Conclusions: Despite the potential of these species as forage, further research is needed to evaluate their nutritional, toxic, and medicinal properties, as well as their ecological impact. Additionally, more studies on the selection criteria for forage plants are necessary to identify potential species for inclusion in public policies aimed at sustainable livestock management, particularly in semiarid regions.

Keywords: Ethnobotany, Local knowledge, Animal feed, Caatinga, Selection criteria.

Background

In semiarid regions a wide variety of vegetation resources is extracted and used in different ways, mainly by local people who depend on it for their survival (Albuquerque & Andrade 2002, Campos & Albuquerque 2021, Lucena *et al.* 2012, Nunes *et al.* 2015, Ramos *et al.* 2008). One of the ways that local people use plant resources in the Caatinga is the use of native plants to feed domestic animals (Moura *et al.* 2024, Pereira *et al.* 2012, Santos *et al.* 2010), considering that livestock in the semiarid, in addition to being a means of family subsistence, is an alternative to make up the income (Pereira *et al.* 2012; Santos *et al.* 2010) through the sale of meat, milk, cheese (Santos 2009), skin (Pereira *et al.* 2012) and live animals.

Forage production from the Caatinga vegetation is generally the main a crucial source of animal feed in the semiarid region of northeastern Brazil (Caldas Pinto *et al.* 2006, Gonzaga-Neto *et al.* 2001). This includes flocks of sheep, cattle, mules, and especially goats. However, the availability of forage in the Caatinga vegetation varies according to the rainfall distribution (Mesquita *et al.* 1988). Thus, during the rainy season forage is generally abundant, however, during the dry season the remaining herbaceous species are drastically reduced, and often only the biomass of trees and shrubs remains available to the animals (Gonzaga-Neto *et al.* 2001). During prolonged drought periods, when native species are not abundantly available, mixing cacti with hay from forage species can be a viable alternative to feed the herds (Silva *et al.* 2011). As a result of exposure to these different scenarios, people who live in semiarid regions have accumulated over time an extensive local ecological knowledge of forage resources based on their observations and pastoral experiences, cognitive skills and worldviews, which are important for the perception of a species having potential for forage (Linstädter *et al.* 2013).

The studies perception-based, that were dedicated to recording local knowledge about the use of native plants used as forages in semiarid regions, identified as main criteria the availability and nutritional quality in meeting the needs of animals, which provide weight gain and increase in the production of milk (Nunes et al. 2015, Nunes *et al.* 2016), in addition to palatability (Badshah & Hussain 2011, Bahru *et al.* 2014, Linstädter *et al.* 2013).

Although the Caatinga plants are the main forage support for the maintenance of animals in this region, the use of these plants has been mainly through extensive breeding systems in which the animals are kept free in the vegetation both in the rainy and in the dry season (Silva 2012), which can cause potentially negative impacts to the local vegetation structure (Ribeiro *et al.* 2015).

In this context, ethnobotanical studies are increasingly using a biocultural approach, which seeks to combine the conservation of knowledge and use of natural resources to reduce the loss of biological and cultural diversity (Gavin *et al.* 2015). Ethnobotanical studies have also highlighted that only a portion of the total plant species traditionally recognized as useful is used effectively. This more effective use of certain plants over others, even though they are all part of local knowledge, is known as differential use (Albuquerque *et al.* 2019).

Livestock in the semiarid region is not only a source of family subsistence but also an alternative for supplementing income. Over the years, local knowledge about native plants has adapted in response to the edaphoclimatic challenges of the region. Therefore, it is crucial for ethnobotanists to investigate the knowledge of rural communities, especially in the semiarid Northeast, regarding the native plants of the Caatinga. This includes examining these plants as potential forages to identify which ones are best suited for animal feed and understanding the factors that drive their differential use. To fill this gap, we analyzed the differential use of plant species native to the Caatinga used to feed domestic animals and identified the factors associated with the differential use of these plants as forage based on the knowledge of local experts.

Materials and Methods

Study area

This study was carried out in the municipality of Girau do Ponciano (-09º 53' 03" S and 36º 49' 44" W), which is located in the micro-region of Arapiraca, in the Agreste region of the state of Alagoas (Santos 2009). The Brazilian Institute of Geography and Statistics characterize the municipality as having the population of 36.102, occupying an area of 513.454 km² (IBGE 2022). According to the Köppen-Geiger classification, the region's climate is tropical with winter rains (As), with an average annual rainfall of 686 mm and an average temperature of 23.9 °C. Girau do Ponciano has the fifth largest effective cattle raising in Alagoas, comprising 31.256 heads of cattle, thus constituting an important economic factor for the composition of the family income of the local population (IBGE 2022).

The Dom Hélder Câmara rural settlement, popularly known as settlement “Rendeira", was the area chosen for the study. According to data from the Colonization and Agrarian Reform National Institute (INCRA 2017) is the largest settlement in the state in territorial extension and in the capacity of families. The Dom Hélder Câmara settlement was officially created on December 27, 1999, and houses an average of 287 families, occupying a land area of 4493.24 hectares (INCRA 2017). There are Legal Reserve and Permanent Protection Areas at the site, as well as spaces that consist of the production and animal husbandry area, which is divided into 287 family productive units (lots), extending over eight to 12 hectares, intended for

performance agricultural activities (Santos 2009). Furthermore, the settlement is spatially distributed into six agro-villages, namely: Sete Casas, Maravilha, 25 de Julho, 1º de Maio, Carro Queimado and 1º de Dezembro (Santos 2009). According to the author, temporary cultivars of corn, tobacco and beans stand out as agricultural activities, for which planting is typically carried out in the rainy season. As an alternative, the settlers raise animals, from which they extract part of their family income through the sale of milk, cheese and meat, with the actual livestock consisting of cattle, goats, sheep, pigs, mules, horses and poultry (Santos 2009).

Ethical and legal aspects of research

This study is one of the actions of an umbrella project entitled: "Ethnobotanical survey and perceptions about plants as a basis for the sustainable use of forest resources, soil and pastures in the "Rendeira" settlement in Girau do Ponciano - AL", approved by the Ethics Committee in research by the Center for Higher Studies of Maceió (CESMAC), whose protocol number is 1377/12. All informants received explanations about the research objectives, and those aged 18 or older who agreed to participate were asked to sign the Free and Informed Consent Form (FICF), thus formalizing their participation. The FICF was read for the illiterate and, after agreeing with the clauses, they were given a pad/collector for fingerprinting the document. A copy with both the informant's and the responsible researcher's signatures was provided.

Selection of informants and research site

The data obtained from the free-list (see Albuquerque *et al.* 2014), generated from interviews during the census of this central project, were used to more specifically select the informants in this research, through non-probabilistic sampling (see Albuquerque *et al.* 2014). For this purpose, data referring to the names of all respondents who mentioned forage plants in the settlement were filtered. With this, it was observed that among the six agro-villages of the settlement, 138 people were interviewed, of which 48 resided in the agro-village Sete Casas. Thirty respondents cited 20 forage plants in total, which is one of the reasons for selecting this agro-village for this study. Finally, two criteria were adopted for a more accurate selection of informants from the agro-village Sete Casas: the number of forage species mentioned (considering from two species) and, in parallel, their residence time in the locality (from 11 to 15 years), making up a sample of 10 local experts (small livestock farmers). Associated with the fact that it has the largest number of experts in forage plants, the agro-village Sete Casas was selected because it is the most populous among the others, in addition to being adjacent to a remnant Caatinga vegetation that is used as a resource for the animals.

Data collection

In order to identify the plant species offered to animals as forage by small livestock farmers, the free-list technique was used. This stage of the research was conducted during the month of June 2014 and the guiding question was: What forage plants do you know and offer to your animals? Semi-structured interviews were also carried out (see Albuquerque *et al.* 2014) to obtain additional information on the criteria for choosing forage plants. The following script was used for the interviews: (1) part offered to the animal, (2) frequency of seasonal use, (3) perceived availability, (4) any processing went through before being offered to the animal, (5) if the plant had a medicinal-food role, (6) the animals to which it was offered, (7) the reason why each plant was offered to the animal, (8) the place where the animals were kept during foraging, (9) the location of perceived use (species distribution in local vegetation), and (10) whether there has been a change in the repertoire of forage plants used over time and why. Although 10 interviews were planned, only seven were carried out, because the other three experts who made up the sample no longer resided in the agro-village Sete Casas during the period of the interviews. Therefore, the results of this study are not interpreted as a pattern for the entire community, but rather as a bias for local experts.

Plant collecting

The recognition and collection of the cited species took place through the guided tour technique (see Albuquerque *et al.* 2014) with the accompaniment of a local specialist. Some plant species were identified in the field, the others were identified from specialized bibliography and/or by comparison of plant specimens from Herbarium of Arapiraca (HARA), localized in the Federal university of Alagoas, with the nomenclature revised in accordance with the list of flora species in Brazil, contained in the website of the Rio de Janeiro Botanical Garden. The exsiccates were stored in the herbarium mentioned above. However, two species were not identified as they did not present fertile samples at the time of collection.

Data analysis

The calculation of the Index of Cultural Significance of Forage Plants (ICSFP) was performed to assess the selection criteria of these plants by local experts, as well as the most important plant species. This information obtained from the free-list and semi-structured interviews. The Index of Cultural Significance (ICS) was initially proposed by Turner (1988). The index was

created with the aim of evaluating and recording the cultural significance of the role of plants in a culture and has several variables (Silva et al. 2006). Over time, some researchers have made various adaptations and modifications to this index (Stoffle *et al.* 1990; Lajones & Lemas 2001; Pieroni 2001; Silva *et al.* 2006; Colaço, 2006). Here we take as a basis the proposals of Pieroni (2001) and Colaço (2006).

Pieroni (2001) developed the index of cultural significance of food to assess the importance of the role that an edible food plant plays within a given culture. The formula considered seven indices that expressed the frequency of citation, availability, frequency of use, parts of the plant used, multifunctional food use, appreciation of flavor and food-medicinal role. One of the advantages of the method is that a plant could have low citation, low availability rates and low frequency of use, but may stand out due to another cultural factor such as its perception as healthy, in which case the use consensus analysis would underestimate the value of the species. Colaço (2006), in turn, proposed an index that makes it possible to evaluate the selection of plants with forage potential through ecological, zootechnical and geographical variables that receive pre-established values in the composition of all the indices, so that these values are assigned based on the qualification of certain characteristics by the interviewees.

In this study, it was adopted as an evaluation method, after the introduction of new elements and the reformulation of the variables, in accordance with the group of plants (forage category) and the variables to be investigated. The formula considers eight sub-indexes, and all components of the overall index are multiplied. Thus, each plant obtains a ICSFP value, which represents, within the investigated variables, its cultural importance. Each index reflects a criterion that elects the plant as the most important by the group of experts interviewed in relation to offering their animals. The index formula is as follows: **QI** x **AI** x **SUFI** x **PUI** x **MUI** x **MFRI** x **VAI** x **VI** x **10^{-2}**, where QI (Quotation Index), AI (Availability Index with application of correction factor), LU (Location of use), SUFI (Seasonal Use Frequency Index), UPI (Parts Used Index), MUI (Multifunctional Use Index), MFRI (Medicinal-Food Role Index), VAI (Value-Added Index), and VI (Versatility Index). For each index there are several categories, which have pre-established values in the composition of all indexes so that these values are attributed based on the qualification of certain characteristics by the interviewees, mostly following a ranking or counting.

To identify the most culturally important fodder species, the average of the values corresponding to the pre-established categories for each species in each sub-index was calculated. The average values for each sub-index were then incorporated into the ICSFP formula. The plants with the highest ICSFP values are the most important as fodder. The description of each index and the values of each category are specified in the Table 1. The species names were updated to the currently accepted scientific nomenclature based on consultations with the Global Biodiversity Information Facility (GBIF) (https://www.gbif.org/).

Table 1. Description of the sub-indices of ICSFP, their categories and respective values

Sub-indexes	****Categories**
QI - Quotation Index: Considers the spontaneous mention of forage plants known and used in the present and in the past by specialists.	Citation frequency of the forage plant.
AI - Availability Index: Expresses the plant's perceived availability by specialists in the local vegetation. The pre-established values ranged from 4.0 to 5.0 points	Very = 5.0, Fair = 4.5, Little = 4.0
LU - Location of use: Refers to the geographic location of the plant in the studied community and works as a correction factor that corrects the perceived availability. Considers the ubiquitous or localized use of the plant within the study area. In these cases, the AI value can be lowered by - 0.5 and - 1.0 points. The values were included in the calculation of ICSFP with the availability corrected by the LU of each plant.	Throughout the forest = does not add or decrease any value to the index, In some places in the forest = - 0.5, In a specific place in the forest = -1.0
SUFI - Seasonal Use Frequency Index: Comprises the frequency of use of each plant in relation to seasonality, using the winter/rain and summer/dry seasons representing the whole year as a reference. The pre-established values ranged from 3.5 to 5.0 points.	In two seasons, often being in both = 5.0; In one season, often in winter = 4.5; In one season, often in summer = 4.0, In an infrequent summer season = 3.5
UPI - Used Part Index: Considers whether multiple morphological parts (leaf, stem, root, flower and fruit) are	Whole plant = 4.0; Whole aerial parts = 3.5, Branches or twigs = 2.5, Leaves = 1.5.

collected and offered to animals rather than single parts. The pre-established values ranged from 1.5 to 4.0 points. The weight of these categories was assigned based on the plant structures contained in each denomination. For example, in the case of 'whole aerial parts', leaves, stems and reproductive structures (flower or fruit) can be considered, so the weight of this category is greater than that of branches or twigs.	
MUI - Multifunctional Use Index: Considers the forage use of each plant and the preparations and processes the plants go through before being offered as feed to the animal. The pre-established values ranged from 2.5 to 5.0 points.	**Plant offered directly = 5.0, Plant crushed and offered in the fodder = 4.5, Burning to remove thorns or parts that hurt the animal = 4.0, Cut into smaller pieces = 3.5, Mixed with other plants = 3.0, Mixed with other components = 2.5
MFRI - Medicinal-Food Role Index: Considers the properties of each plant perceived by experts as food and medicine for animals. The pre-established values ranged from 3.0 to 5.0 points	**Food (fodder) and medicinal (veterinary) use = 5.0, Forage use only = 4.5, Healthy use for the animal = 3.5, Sustains the animal = 3.0
VI - Versatility Index: This refers to all animal species that consume the plant. The pre-established values ranged from 2.5 to 5.0 points. The highest values were assigned according to the importance given to each species by the experts.	**Cattle = 5.0, Horse = 4.5, Donkey (**jumento**) = 4.0, Sheep = 3.5, Goat = 3.0, jackass (**burro**) = 2.5
VAI - Value-Added Index: Expresses other criteria that can jointly influence the preference by experts of certain forage plants to the detriment of others. These criteria are related to economic factors, physiological issues for the animal, palatability, abundance and resistance of the plants or even the lack of options for other plant species. The pre-established ranged from 1.5 to 5.0 points.	**Satisfies hunger = 5.0, Drought resistance (always green) = 4.5, High animal acceptance (flavor) = 4.0, Gives the animal vigor = 3.5, Easy access = 3.0, Contributes to weight gain = 2.5, Contributes to the production of a lot of milk = 2.0, Does not involve costs = 1.5, Lack of options for other plants =1.0
Legend: *Categories qualified by the experts. **When mentioning more than one category, the values were added, including the total value in the calculation of the general index.	

Results

General characterization of plants and animals

The seven experts interviewed (four men and three women) mentioned 17 forage plants native to the Caatinga, belonging to 16 genera and distributed in 12 families (Table 2). The most represented families in number of species were: Poaceae (five species), Cactaceae (three species) and Anacardiaceae (two species).

The animals that the experts owned at the time the interviews were conducted included cattle and horses (donkey, mare and horse). The places where these animals were kept included the extensive system (confined in areas enclosed by fences, known as lots) and semi-extensive rearing (both confined in lots and released into the local vegetation).

Cultural importance of forage plants for the local population

The culturally most important species with forage potential were *Portulaca oleraceae* L., **capim nativo**, *Cereus jamacaru* DC. e *Manihot glaziovii* Müll. Arg. (Table 3).

Portulaca oleraceae L. was the second most cited species (four citations) and the most culturally important as a potential forage. This species stood out specifically in the Part Used Index (PUI), being unanimous by the experts who cited it, the offering of all its parts as animal feed, demonstrating that its importance may be related to practicality, since it is offered directly to animals without any type of processing, in addition to having 100% use as forage.

In relation to the Poaceae family, the ethnocategory **capim nativo** (native grass) stood out. The name **capim nativo** was attributed to more than one species by the research informants, one of them belonging to the genus Chloris and two other species: *Eragrostis ciliaris* (L.) R. Br. and *Dactyloctenium aegyptium* (L.) Willd. This information was confirmed after a

collection carried out from the guided tour carried out with a local rancher who showed three different species for the same attribution (**capim nativo**). The **capim nativo** category was ranked second among the most important species for small livestock farmers. Among all species, the species in this ethnocategory were the most prominent in the Food-Medicinal Role Index (FMRI), demonstrating that their importance is linked to their multiple properties (forage and medicinal). The medicinal attribution by cattle breeders was related to its application in cuts and wounds of animals such as cattle and horses, as well as in the case of these animals appearing to present intestinal discomfort, when its ingestion is recommended. In addition, **capim nativo** also stood out in the Seasonal Use Frequency Index (SUFI), among the other three plants that presented the highest ICSFP values. This category was identified by experts who cited it as being used throughout the year (dry and rainy season), more frequently in winter, when it is more available.

Cereus jamacaru DC. obtained the highest quotation frequency (six) and is the third most important culturally. This species was indicated with various forms of preparation and processing before offering it to the animal (burned, cut into smaller pieces and ground in the forage) being highlighted in the Multifunctional Use Index (MUI) among the plants with the highest ICSFP values chosen by the informants. Additionally, this plant was reported by small livestock farmers only being used after having experienced in the years 2011-2012 an intense period of drought.

The fourth-ranked species in terms of cultural importance is *M. glaziovii* Müll. Arg., which stood out in three of the evaluated criteria. This plant has been reported to be offered to more animal species (cattle, goats, sheep and horses), being prominent in the Versatility Index (VI). In addition, this species stood out in the Value-Added Index (VAI), which indicates that its choice by small livestock farmers as fodder may also be influenced by several other criteria, despite having been mentioned by only two of the interviewed small livestock farmers. Among the criteria indicated for the VAI are the: satisfaction of the animal's hunger, its high acceptance (palatability), easy access and no cost involvement. Furthermore, among the three most important species, *M. glaziovii* it is the plant with the highest perceived availability, which may justify another aspect of its relevance for small livestock farmers, since it is available locally. Interestingly, the two informants who mentioned this plant, pointed out that it could harm the animal if it was consumed fresh and in large quantities, without any type of processing (for example, passing it on forage).

Table 2. List of cited species and their respective uses and ICSFP in descending order

Popular name	Scientific name	Family	Uses	ICSFP	Voucher
Beldroega	*Portulaca oleraceae* L.	Portulacaceae	F	12995288.09	*
**Capim nativo	*Chloris* sp.; *Eragrostis ciliaris* (L.) R. Br.; *Dactyloctenium aegyptium* (L.) Willd.	Poaceae	F, M	26277.6	*
Mandacaru	*Cereus jamacaru* D.C	Cactaceae	F	21866.6	ARA000029
Maniçoba	Manihot glaziovii Müll.Arg.	Euphorbiaceae	F	12533.95	*
Batatá	Undetermined	-	F	10874.53	-
Facheiro	*Pilosocereus pachycladus* F. Ritter	Cactaceae	F	10165.54	ARA000039
Capelinha	*Serjania* sp.	Sapindaceae	F	6686.3	ARA000078
Malva	*Waltheria* sp.	Malvaceae	F	5285.25	*
Carrapicho	*Bidens subalternans* DC.	Asteraceae	F	4809.3	*
Juazeiro	*Sarcomphalus joazeiro* (Mart.) Hauenschild	Rhamnaceae	F	3729.3	ARA000010
Quixabeira	*Sideroxylon obtusifolium* (Roem. & Schult.) T.D.Penn.	Sapotaceae	F	3628.13	ARA000016
Braúna	*Schinopsis brasiliensis* Engl.	Anacardiaceae	F, M	3174.6	ARA000049
Jitirana	*Ipomoea nil* (L.) Roth.	Convolvulacea e	F	3089.7	*
Grama de riacho	Undetermined	Poaceae	F	3078	-
Imburana de cheiro	*Amburana cearensis* (Allemão) A.C.Sm.	Fabaceae	F, M	2583.98	ARA000091
Coroa-de-frade	*Melocactus bahiensis* (Britton & Rose) Luetzelb.	Cactaceae	F	2551.5	ARA000018
Umbuzeiro	*Spondias tuberosa* Arruda	Anacardiaceae	F, M	2539.6	ARA000011

Legend: Uses: F = Forage, M = Medicinal. *Identified in the field. **Ethnocategory represented by three species.

Table 3. List of species with the highest ICSFP values and the indices in which they stood out

Popular name	Scientific name	ICSFP	Featured Index(s)
Beldroega	*Portulaca oleraceae* L.	12995288.09	IPU = 4
Capim nativo	*Chloris* sp., *Eragrostis ciliaris* (L.) R. Br., *Dactyloctenium aegyptium* (L.) Willd.	26277.6	IPMA = 6, IFUS= 4.5
Mandacaru	*Cereus jamacaru* DC.	21866.6	IUM = 7.33
Maniçoba	*Manihot glaziovii* Müll. Arg.	12533.95	IV = 22.5, IVA = 16.25, ID= 4.75
Legend: IPI = Used Part Index, MFRI = Medicinal-Food Role Index, SUFI = Seasonal Use Frequency Index, MUI = Multifunctional use index, VI = Versatility Index, VAI = Value Added Index, AI = Availability Index.			

Local knowledge about forage plants in the past

The knowledge of small livestock farmers about forage plants in the past (from the beginning of the settlement) and in the present time diverged among the interviewees. Most of the interviewed cattle raisers (five) claimed to have always offered their animals the same plants mentioned since the moment they started raising animals, after the occupation in the settlement. That is, there was no variation in their behavior in diversifying the plant species offered to their animals over time. However, only two informants claimed to have changed the repertoire of forage plants over time. According to them, this change had happened as a result of the great drought in 2011-2012, which forced them to use other available plant resources, such as **facheiro** (*Pilosocereus pachycladus* F. Ritter) and **mandacaru** (*C. jamacaru* DC), plant species not used in animal feed by them before this period.

Discussion

General characterization of plants and animals

The Cactaceae and Anacardiaceae families are among the most representative in terms of species number in this study. These families also have been recorded by some researchers in their studies as potential forages from the Caatinga (Lucena *et al.* 2012, Nunes *et al.* 2015).

The groups of animals bred (bovine and equine) by the small livestock farmers in this study contrasts with the logic of animals recorded in other studies in which, generally, the animals most bred in semiarid regions are goats and sheep (Linstädter *et al.* 2013), because these species are more rustic and adaptable to the edaphoclimatic conditions of the region. Although in the northeast of Brazil, the production of goats is predominant, the production of cattle has increased significantly in the country since 1974. In 2022, Brazil reached a significant increase in the number of cattle (n = 234.352.649) (IBGE 2022). Of this total, the state of Alagoas accounts for 1.335.493 heads. In the context of rural settlements, one possible explanation for this increase is the development of government programs such as the National Plan to Strengthen Family Farming, which offer credit to livestock farmers, allowing them to invest in the sector.

Cultural importance of forage plants for the local population

The species *Portulaca oleraceae* L. which was the most prominent forage has been widely studied by scientists for its nutritional, cosmetic and medicinal properties for humans and, interestingly, for its reported toxicity in sheep and cattle, due to the presence of oxalic acid in this plant (Azuka *et al.* 2014, Dweck 2001). Prolonged ingestion of the plant can cause incoordination of gait and tetanic conditions in sheep (Dweck 2001).

The Poaceae family has been recorded with ecological and economic importance highlighted for being dominant in several plant ecosystems and for its use in animal feed (Welker & Longhi-Wagner 2007). Although they have been included in a native category by small livestock farmers, the genera *Chloris*, *Eragrostis* and *Dactyloctenium*, for the most part, are disseminated in the literature as genera considered invasive (Boechat & Longhi-Wagner 2000, Viana & Filgueiras 2008). Furthermore, the differential use of **capim nativo** is related its seasonal availability. As discussed by some researchers, the use of some resources in the Caatinga is determined by climatic seasonality, as this region has well-defined seasons, with a well-determined dry period (Albuquerque & Andrade 2002). The differential use of **capim nativo** also is associated to its multiple uses (fodder and medicinal), what can be a key factor in the selection of these species. Researchers have highlighted that food plants are commonly ingested as medicinal foods and its phytochemical aspects can influence its appreciation,

overlapping its nutritional aspects (Pieroni 2001). Since then, several ethnobotanical studies have been dedicated to understanding the food-medicine continuum in socio-ecological systems in the human context (Pieroni *et al.* 2008, Pieroni & Quave 2005). However, there is still no record of studies focused on this intersection between forage plants and those for veterinary use, nor exclusively on the therapeutic efficiency of the species that make up the category **capim nativo**.

In relation to *Cereus jamacaru* DC., this species stood out over other forage species in terms of (1) quotation frequency, (2) as the second most culturally important forage and in the (3) Multifunctional Use Index (MUI), reported to have various forms of processing before being offered to the animal. Regarding this last aspect, a very common practice throughout the Northeast region is the burning of the cladodes of cacti such as **mandacaru** so that their thorns can be removed (Roque & Loiola 2013). However, the slow growth and the high cost of labor in processing by cutting, burning or removing the thorns and crushing their parts, are limiting factors for this species (Silva *et al.* 2010). In addition, the burning of these plants in the same location in which they are found makes their recovery in areas of primary and secondary vegetation unfeasible, making it an unsustainable management practice (Lucena *et al.* 2012).

Although *C. jamacaru* was mentioned requiring more manual work to serve as animal feed, it was still the most cited plant among all mentioned by small livestock farmers. One of the factors that may help explain its importance to small livestock farmers is the resistance that this cactus has to drought, as it is available as forage throughout the year, although it is often used in periods of great drought, as reported by the small livestock farmers themselves. The resistance of cacti is due to their adaptive structures and their physiological characteristics of saving and using water, which allow them to survive conditions of water scarcity, withstanding intense solar radiation and high temperatures (Andrade 2002). These plants are important forage resources of the Caatinga that are used in the composition of ruminant diets, especially in periods of prolonged drought when there is a shortage of food and water, as has been corroborated by several researchers (Andrade 2002, Cavalcanti & Resende 2006, Lucena *et al.* 2012, Roque & Loiola 2013, Silva *et al.* 2010).

The highlight of the species *Manihot glaziovii* Müll. Arg., in the Versatility Index (VI), Perceived Availability Index (AI) and in the Value-Added Index (VAI) demonstrates the multiple criteria that elect it as the fourth most important forage species among the studied small livestock farmers. Among the criteria indicated for the VAI are the satisfaction of the animal's hunger, its high acceptance (palatability), easy access and non-involvement of costs. Some researchers also reported in an investigation conducted in the semiarid region of Pakistan that two of the criteria frequently mentioned by farmers for selecting the best forage species were palatability and the forage's ability to satisfy the animal's hunger (Badshah & Hussain 2011, Bahru *et al.* 2014). In fact, researchers commonly report *M. glaziovii* as a potential fodder in the Caatinga due to its nutritional value and high palatability (Barros *et al*. 1990, Salviano & Soares 2000, Santos 2013). Regarding the criterion of non-involvement of costs, the use of forage species as the main source of food for ruminants is proven to be the cheapest alternative for feeding the herds, which represent one of the main sources of livelihood for many families in semiarid regions (Maia & Gurgel 2013). With regard to its prominence in terms of its perceived availability by small livestock farmers, some authors found that the availability of plant species is an important factor influencing the selection of species by local people, as recorded in a survey carried out in five indigenous communities of Chiapas in Mexico on the potential of woody plants in animal diets (Nahed *et al.* 1997). This result is in line with the assumptions of the availability hypothesis proposed in ethnobotanical studies, according to which local availability can explain the importance of useful plants for local communities, because people tend to use more plants that are readily available (Phillips & Gentry 1993).

Although it has stood out in several aspects that reinforce its importance for the local population, *M. glaziovii* has been recorded with emphasis in the literature as having a toxic property, related to cyanogenic glycosides that can cause the death of animals such as cattle, sheep and goats (Amorim *et al.* 2006, Riet-Corrêa *et al.* 2012). Furthermore, some studies show that even when crushed or wilted, the toxic components are still preserved for a period of up to three days (Riet-Corrêa *et al.* 2012). An experimental study identified that even plant hay or silage remains toxic for up to 30 days after its preparation (Amorim *et al.* 2006). Thus, it is necessary to be careful in its use as forage to avoid the risk of intoxication and even death by farm animals, which would result in great damage to small farmers. There were also records on the toxicity of this species in a survey carried out with the Pankararé indigenous peoples of the Raso da Catarina, in Bahia, in which the indigenous people reported that the **maniçoba** (*M. glaziovii*) could kill any type of creation, mainly in the wilted form or in the case of ingestion of water after its consumption (Colaço 2006).

Local knowledge about forage plants in the past

The divergence in the use of plants by small livestock farmers over time can be understood from the concept of local botanical knowledge. This knowledge is understood as a system composed of different wisdoms and beliefs about the plant

environment that guide different patterns of behavior and selective action strategies (Pochettino *et al.* 2012). Therefore, local knowledge is not static, and changes as human groups adjust to the changing circumstances of their biocultural environment (Hurrell 2014). Furthermore, some researchers assume that in the same population, different individuals may have different strategies for dealing with natural resources (Albuquerque & Medeiros 2013).

Additionally, the periodic occurrence of droughts is a difficulty that the population of the semiarid Northeast has faced for several decades (Baptista & Campos 2013, Martins *et al.* 2015). According to these authors, some of these great droughts occurred in the 70s, 79-80s, 98-99 and in 2012, the last being considered one of the worst in the last 50 years. The practice of using *Cereus jamacaru* DC. by small livestock farmers in this study from the drought that occurred between 2011 and 2012 may have led to the development of knowledge about plant use strategies, thus allowing the practice of its current use, as for the sharpened memory in their minds, even though during the period of the interviews it was not being used as a forage resource. Memory has been highlighted as the most important resource of the rural producer, as it is where all the experiences accumulated throughout his life are stored, expressing both personal and collective wisdom and being slowly enriched by variations and unpredictable conditions associated with it (Toledo 1992). This idea is reinforced by the fact that the cultural significance of a plant can change over time, varying in terms of quality, intensity and exclusivity of use (Turner 1988). Furthermore, some scientists have pointed out three adaptive mechanisms that emerged in our ancestral past and that are responsible for guiding the functioning of the naturalistic mind today: attention to natural challenges that most regularly affect nature, the ability to remember information about natural challenges of importance are survival (adaptive memory) and the ability to adapt to different threats in the environment (phenotypic plasticity) (Albuquerque *et al.* 2020). Unstable environments such as the Caatinga, influenced by climatic seasonality, can help us to better empirically understand these adaptive components that guide people's behavior in relation to the use of natural resources, such as the use of forage plants native to the Caatinga under an evolutionary perspective.

Limitations of this study

We assume some limitations in this study that need to be addressed in future research.

This study was conducted with local experts, which may limit the generalization of its results to other contexts. To overcome this limitation, future research could be carried out in different socio-environmental contexts, using representative samples of the population, to identify possible patterns in the selection of forage species in semiarid regions.

Furthermore, there is a 10-year gap between the conclusion of this study and the publication of its results. Although this gap does not invalidate our findings, it is crucial to recognize that local knowledge is dynamic, as evidenced by several studies. Therefore, factors such as the accelerated effects of climate change in semiarid areas and changes in land use may have influenced changes in the repertoire of forage plants and even their local importance. It is important to take these factors into account in future studies.

Finally, the use of the Index Cultural Significance has a solid basis in previous studies. Although we believe that the use of the ICSFP allowed us to effectively capture relevant cultural nuances, considering the experience and knowledge of the interviewees, the possibilities for statistical analysis have been significantly expanded in the last decade. We therefore encourage the use of more refined analyses to assess the importance of forage plants, especially for future studies supported by scientific hypotheses.

Conclusions

Our findings indicated that species are selected for forage from a multifactorial perspective related not only to animal welfare but also to environmental changes perceived by livestock farmers. We identified species from the Caatinga with great potential for foraging. The dependence of the local population on these plants only reinforces the idea that specific studies on forage resources constitute an important record for the selection of potential species, especially in the northeastern semiarid.

In addition to forage potential, the medicinal properties of grasses within the ethnocategory capim nativo (*Chloris* sp., *E. ciliaris*, and *D. aegyptium*) should also be investigated. Although animal husbandry occurs on a small scale, it is necessary to assess the ecological impact of using these species in the region to ensure that their populations are not being significantly reduced. Furthermore, more studies on the selection criteria for forage plants are needed to identify species suitable for inclusion in public policies aimed at sustainable livestock management, particularly in semiarid regions.

Declarations

List of abbreviations: AI - Availability Index with application of correction factor; CESMAC - Centro de Estudos Superiores de Maceió (Center for Higher Studies of Maceió); FICF - Free and Informed Consent Form; GBIF - Global Biodiversity Information Facility; HARA - Herbarium of Arapiraca; IBGE - Instituto Brasileiro de Geografia e Estatística (Brazilian Institute of Geography and Statistics); ICS - Index of Cultural Significance; ICSFP - Index of Cultural Significance of Forage Plants; INCRA - Instituto Nacional de Colonização e Reforma Agrária (Colonization and Agrarian Reform National Institute); LU - Location of use; MFRI - Medicinal-Food Role Index; MUI - Multifunctional Use Index; QI - Quotation Index; SUFI - Seasonal Use Frequency Index; UFAL - Universidade Federal de Alagoas (Brazilian Federal University of the state of Alagoas); UPI - Parts Used Index; VAI - Value-Added Index; VI - Versatility Index.

Ethics approval and consent to participate: This study was approved by the Ethics Committee in research by the Center for Higher Studies of Maceió (CESMAC), whose protocol number is 1377/12. Furthermore, all participants previously signed the Free and Informed Consent Form (FICF).

Consent for publication: Not applicable.

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