

Ethnobotanical and phytosociological studies of forage plants in the Lisboa settlement in a sedimentary caatinga area

Estudos etnobotânico e fitossociológico de plantas forrageiras no assentamento Lisboa em área de caatinga sedimentar

Estudios etnobotánicos y fitossociológicos de plantas forrajeras en el asentamiento Lisboa en una zona de caatinga sedimentaria

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Abstract

Caatinga rangelands are multifunctional ecosystems that contribute to the conservation of natural resources, biodiversity, animal production and income generation. Goats are widely distributed in these pastures, and the identification of the botanical composition of their diet is essential for maintaining the richness and abundance of forage plants. The objective of this study was to describe the diet of goats and the phytosociology of forage plants in a Caatinga rangeland. The list of species was elaborated in an ethnobotanical survey with goat breeders; the phytosociological study was carried out in rangeland grazed by goats for over thirty years. Participants cited thirty-four forage species with a predominance of trees and shrubs. In the phytosociological survey, the most relevant families were *Fabaceae* and *Euphorbiaceae*, and sixteen forage plants were identified. Arboreal species succeed shrubs with increased diversity in the forage plant community. The dominant species are *Senna macranthera*, *Caesalpinia pyramidalis*, *Piptadenia moniliformis* and *Mimosa tenuiflora*.

Keywords: Biodiversity, diet of goats, local knowledge, rangeland, semiarid.

Resumo

As pastagens nativas da Caatinga são ecossistemas multifuncionais que contribuem para a conservação de recursos naturais, biodiversidade, produção animal e geração de renda. Os caprinos são amplamente distribuídos nessas pastagens, logo a identificação da composição botânica da sua dieta é essencial para a conservação da riqueza e abundância de plantas forrageiras. Objetivou-se descrever a dieta de caprinos e a fitossociologia de plantas forrageiras em pastagem nativa em área de caatinga. A lista de espécies foi elaborada em levantamento etnobotânico com criadores de caprinos; o estudo fitossociológico foi realizado em pastagem nativa manejada com caprinos há mais de 30 anos. Os criadores citaram 34 espécies forrageiras, com predominância de árvores e arbustos. No levantamento fitossociológico as famílias mais relevantes foram Fabaceae e Euphorbiaceae, identificaram-se 16 plantas forrageiras. As espécies arbóreas sucedem as arbustivas com aumento da diversidade na comunidade das plantas forrageiras. As espécies dominantes são *Senna macranthera*, *Caesalpinia pyramidalis*, *Piptadenia moniliformis* e *Mimosa tenuiflora*.

Palavras-chave: Biodiversidade, dieta de caprino, pastagem nativa, saber popular, semiárido.

Resumen

Los pastos nativos de la Caatinga son ecosistemas multifuncionales que contribuyen a la conservación de los recursos naturales, la biodiversidad, la producción animal y la generación de ingresos. Las cabras se encuentran ampliamente distribuidas en estos pastizales, por lo que identificar la composición botánica de su dieta es fundamental para conservar la riqueza y abundancia de plantas forrajeras. El objetivo fue describir la dieta de cabras y la fitosociología de plantas

forrajeras en pastos nativos en una zona de caatinga. La lista de especies fue elaborada en un estudio etnobotánico con criadores de caprinos; el estudio fitosociológico se realizó en pastos nativos manejados con cabras durante más de 30 años. Los criadores citaron 34 especies forrajeras, con predominio de árboles y arbustos. En el estudio fitosociológico las familias más relevantes fueron Fabaceae y Euphorbiaceae, se identificaron 16 plantas forrajeras. Las especies de árboles siguen a las especies de arbustos con un aumento en la diversidad en la comunidad de plantas forrajeras. Las especies dominantes son *Senna macranthera*, *Caesalpinia Pyramidalis*, *Piptadenia moniliformis* y *Mimosa tenuiflora*.
Palabras-clave: Biodiversidad, dieta de caprinos, pastos nativos, conocimiento popular, semiárido.

INTRODUCTION

Rangelands are multifunctional ecosystems that contribute to the conservation of natural resources, biodiversity, animal production and income generation. This importance is increasing significantly as natural resource depletion and climate change intensify (Holecheck *et al.*, 2020). Rangelands in the Caatinga region have been a source of feed for domestic ruminants since the colonization of Brazil, when these animals arrived in the semi-arid region of Northeast (Prado Jr., 1962). Located in this region, the state of Piauí has approximately 63% of its area covered by Caatinga vegetation, including 140 towns (IBGE, 2019), in which 67% of cattle, 74% of goats and 85% of sheep are concentrated (IBGE, 2021).

Among ruminants in the Caatinga areas of Piauí, goats are managed predominantly on rangelands, where forage plants provide the necessary nutrients for the animals in their different productive phases and thus guarantee the production of milk, meat, leather and other products. They contribute as a source of income and food for farmers, especially in the family farming sector (Monteiro *et al.*, 2021).

The management of these animals by farmers over time has resulted in an accumulation of knowledge obtained through practical interrelationships with the pastoral ecosystem. The knowledge of traditional communities, passed down from generation to generation, regarding the local flora, has become a valuable contribution to science (Albuquerque Andrade; Silva, 2005), which has been accessed through ethnobotanical surveys (Linstädter *et al.*, 2013; Nampanzira *et al.*, 2015; Nunes *et al.*, 2015).

Farmers' knowledge on ruminant diets includes not only identifying the forage species selected by the animals and classifying them according to their order of preferences, but also the structures of the plants ingested and the spatial and temporal variability in the

availability of these plants in the pastoral ecosystem (Leal; Vicente; Tabarelli, 2003; Kgosikoma; Mojeremane; Harvie, *et al.*, 2013). This knowledge can help to develop indicators of the condition of the pasture, in terms of the presence of forage plants, identifying key species and the current situation of the pastoral ecosystem (Abusuwar; Ahmed, 2010).

Therefore, ethnobotanical surveys associated with phytosociological studies will help to assess the state of the rangeland. Species richness can be defined as the number of species in a given area, while diversity is a combination of richness and abundance. These two biodiversity metrics are used as indicators of rangeland ecosystems in phytosociological studies (Smystad *et al.*, 2011). This information helps to increase the understanding of forage resources and their dynamics in pastoral ecosystems and serves as a basis for defining management strategies for rangelands (Linstädter *et al.*, 2013).

This study focused on a pastoral ecosystem in a Caatinga area that has been managed with grazing goats for more than three decades. The objective was to identify and document traditional knowledge on forage species in the diet of goats and to carry out a phytosociological survey of two grazing sites in a sedimentary Caatinga area.

METHODOLOGY

The study was conducted in the Lisboa settlement, which is located on the south bank of Piauí River, in the towns São João do Piauí (08°21'29" S, 42°14'48" W and 222 m of altitude), predominantly, and Pedro Laurentino (08°04'06" S, 42°17'06" W and 200 m of altitude), in the Serra da Capivara development territory, within the semi-arid region of the state of Piauí, Brazil. The local climate is classified as BSh, characterized as Hot Semi-arid, with rainfall instability mainly in summer (CLIMATE, 2018), with average annual rainfall ranging from 800 to 1000 mm. The towns are located in the sedimentary basin, which is characterized by the existence of deep, low-fertility soils. The local caatinga vegetation is characterized by the predominance of arboreal and shrub strata and a small occurrence of herbaceous vegetation (Lemos; Rodal, 2002; Farias, 2003; Emperaire, 1989).

The Lisboa settlement was created from an area occupied by farmers from the Landless Rural Workers' Movement (MST) in 1983, with an estimated area of 9,976 ha, and was recognized by the National Institute for Colonization and Agrarian Reform (INCRA). Currently, 265 families live in the settlement.

The main activities practiced by most of the settlers are dryland farming, corn (*Zea mays* L.), beans (*Phaseolus* spp.), cassava (*Manihot esculenta* Crantz), and animal husbandry, mainly sheep, goats and cattle, managed in rangeland areas. Goats and sheep make up the largest herds and are sources of income throughout the year.

Initially, meetings were held with goat farmers and visits were made to the places where these animals are kept, in an attempt to get closer to the community. To choose the participants in the ethnobotanical survey, it was considered informants over the age of 18, who had lived in the settlement for more than 15 years, which is a period that was enough to experience the changes in the area and absorb knowledge on the local flora. Of the 21 goat farmers in the settlement, 17 participated in the study, 14 men and three women, aged between 33 and 77. All participants who agreed to collaborate voluntarily with this study signed a Free and Informed Consent Form, authorizing the study to be carried out, which is a condition laid down by the Genetic Heritage Management Council (CGEN), that disciplines and supervises all research carried out with animals and plants, including research involving the knowledge of traditional communities, and by the National Research Ethics Commission (CONEP) (Resolution 510/16). The semi-structured interviews were conducted individually (Phillips; Gentry, 1993), and the survey also included questions about the structures of the plants preferentially consumed by the goats (leaf, flower, fruit), and at what time of year they are most consumed, as well as about the areas in the settlement frequently grazed by these animals.

The information collected during the interviews served as the basis for generating a list of the forage species found in the settlement. After the interviews, guided tours were carried out (Albuquerque; Lucena; Alencar, 2010), which is a technique adopted with the help of a key informant with high level of knowledge about local plants. During the guided tours, botanical material was collected from the forage species mentioned in the interviews and found on the sites studied.

The phytosociological study was carried out in December/2015 and February, March, April, May and July/2016. The plots and subplots method proposed by Müeller-Dombois; Ellenberg (1974) was adopted in a rangeland managed with grazing goats for over 30 years. Two ecological sites were selected in this area, considering this term to describe areas of rangeland with phyto-physiognomic differences (Stoddart; Smith; Box, 1975). Site I, called shrub site, due to the occurrence of vegetation with a predominantly shrubby physiognomy; and Site II, called arboreal site, due to the predominance of tree-type vegetation. These areas had a history of mechanical deforestation for planting buffel grass (*Cenchrus ciliaris* L.). On the first site, the native vegetation was cleared twice, the first time in 1985 and the second time in 2004; on the second site, clearing was carried out in 1985, also to plant cultivated pasture. In all these attempts, the grass did not establish itself, and the area was opened up to animal grazing. To collect samples at each site, an area of 0.76 ha was dimensioned, totaling 1.52 ha. Three 190-m-long parallel transects were established 20 m apart at each site. Ten experimental plots measuring 10 x 10 m (100 m²) were marked out 10 m apart on each transect. Thus, 30 plots were sampled, totaling a sampling area of 3,000 m² per site.

In the 10 x 10 m plots, arboreal forage species were assessed and, within these plots, a 4 x 4 m sub-plot was delimited to assess shrub plants and those of other life habits. In each plot and sub-plot, the living forage plants mentioned in the ethnobotanical survey and found in the phytosociological survey during the guided tours were counted. Individuals with breast height circumference ≥ 6 cm (Ferraz *et al.*, 2013) and height greater than 2 m were considered to be arboreal forage specimens; shrubby individuals were those between 0.5 and 2 m in height, with a stem base diameter of less than 6 cm and excessive branch emission from the base (Albuquerque; Soares; Araujo Filho, *et al.*, 1982).

The soil in the area is classified as Quartzzerenic neosol with the following characteristics: pH in CaCl₂: between 3.0 and 4.0; organic matter: 12 - 13g/dm³; available P: 3.0 - 5.0 mg dm³; Al: 2.0 - 5.0 mmolc dm³; and Ca: 2.0 - 4.0 mmolc dm³. During the months when the botanical material was collected (December/2015 and February, March, April, May and July/2016), the accumulated rainfall was 217.5 mm. The maximum rainfall occurred in January and March, with 276.5 and 95.5 mm, respectively.

The botanical material was identified using the usual bibliographies and comparison with materials deposited in the Graziela Barroso Herbarium (TEPB) of the Federal University of Piauí (UFPI). The species were organized by family according to Angiosperm Phylogeny Group IV (APG IV, 2016). Consultations were made with the database of the List of Species of the Flora of Brazil for the spelling of names of the taxa and correct identification (Flora e Funga do Brasil, 2017).

The phytosociological analysis of the forage species found at the two sites was carried out by evaluating the parameters: AD - absolute density; RD - relative density; RF - relative frequency; RDo - relative dominance and IVI - importance value index, according to Müeller-Dombois e Ellenberg (1974), and also, N - number of individuals sampled; and NP - number of plots in which the species was sampled.

The diversity and similarity of species at the two sites was determined. The Shannon-Weaver index (H') was used to determine floristic diversity. This allows the diversity of plants to be obtained by considering the relative abundance of citations (Begossi, 1996).

The Jaccard and Pielou indices were used to determine floristic similarity and evenness. The Jaccard Similarity Index or Jaccard Coefficient (J) was calculated using Equation 1.

Equation 1:
$$J = \frac{a}{a+b+c}$$

Where: J = Similarity index or Jaccard's Similarity Coefficient; a = number of species common to both sites; b = number of species exclusive to site I; c = number of species exclusive to site II.

Pielou's evenness index (J') derives from Shannon's diversity index and represents the uniformity of the distribution of individuals among the existing species (Pielou, 1966).

The species sampled were organized in a Microsoft® Excel spreadsheet, and a floristic list was drawn up with the families and species occurring in the two sites evaluated. The phytosociological parameters were calculated using the *Mata Nativa 2* software (CIENITEC, 2006).

RESULTS AND DISCUSSION

The Lisboa Settlement's goat herd is made up mainly of crossbred animals and mixed Anglonubian, totaling 581 animals, divided between 21 breeders. The goats are fed on rangeland throughout the year, and at the end of each day, they are gathered into pens. The source of water in the rainy season is a dam, and in the dry season, a tank supplied by an artesian well. The goats' diet consisted of 34 species of forage plants, distributed among 10 families and 26 genera (Table 1).

Table 1. Forage plants present in the diet of the goats according to the traditional knowledge of farmers in the town of São João do Piauí, PI.

Families	Scientific name	Vernacular name	Growth habit	Consumed parts
Fabaceae	<i>Albizia inundata</i> (Mart.) Barneby & J.W. Grimes	Muquém	Arboreal	Leaf
	<i>Albizia polycephala</i> (Benth.) Killip ex Record	Maracaíba	Arboreal	Leaf
	<i>Amburana cearensis</i> (Allemão.) A.C. Smith	Imburana	Arboreal	Leaf
	<i>Bauhinia cheilantha</i> (Bong.) Steud.	Mororó	Shrubby	Leaf, Fruit
	<i>Caesalpinia pyramidalis</i> Tul.	Catingueira	Arboreal	Leaf, Fruit
	<i>Cenostigma macrophyllum</i> Tul.	Canela de velho	Arboreal	Leaf
	<i>Cratylia mollis</i> Mart. ex Benth.	Camaratuba	Climber	Leaf, Fruit
	<i>Desmanthus virgatus</i> (L.) Willd.	Jureminha	Shrubby	Leaf, Fruit
	<i>Libidibia ferrea</i> (Mart. ex Tul.) L.P. Queiroz	Pau-ferro	Arboreal	Leaf
	<i>Mimosa tenuiflora</i> (Willd) Poir	Jurema	Arboreal	Leaf, Fruit
	<i>Piptadenia moniliformis</i> Benth.	Angico-de-bezerro	Arboreal	Leaf, Flower, Fruit
	<i>Prosopis juliflora</i> (Sw.) DC.	Algaroba	Arboreal	Fruit
	<i>Senna spectabilis</i> var. <i>excelsa</i> (Schrad.) H.S. Irwin & Barneby	Canafistula	Arboreal	Leaf, Flower
	<i>Senna macranthera</i> var. <i>pubibunda</i> (Mart.) H.S. Irwin & Barneby	Besouro	Shrubby	Leaf, Flower, Fruit
	<i>Senna obtusifolia</i> (L.) H.S. Irwin & Barneby	Mata-pasto	Shrubby	Leaf
<i>Senegalia bahiensis</i> (Benth.) Seigler & Ebinger	Jurema-branca	Arboreal	Leaf	
Euphorbiaceae	<i>Croton blanchetianus</i> Baill	Marmeleiro	Shrubby	Leaf
	<i>Croton grewoides</i> Baill	Canelinha	Shrubby	Leaf, Fruit

Families	Scientific name	Vernacular name	Growth habit	Consumed parts
<i>Rhamnaceae</i>	<i>Sarcomphalus joazeiro</i> (Mart.) Hauenschild	Juazeiro	Arboreal	Leaf
	<i>Jatropha mollissima</i> (Pohl) Baill.	Pinhão	Shrubby	Leaf
Families	Scientific name	Vernacular name	Growth habit	Consumed parts
<i>Rhamnaceae</i>	<i>Manihot pseudoglaziovii</i> Pax & K. Hoffm.	Maniçoba	Arboreal	Leaf
Combretaceae	<i>Combretum leprosum</i> Mart.	Mofumbo	Shrubby	Leaf, Fruit
	<i>Thiloa glaucocarpa</i> Mart. Eichler	Sipaúba	Arboreal	Leaf, Flower, Fruit
Bignoniaceae	<i>Arrabidaea ateramnantha</i> Bur. et K. Schm.	Cipó de chapada	Climber	Leaf, Flower
Anacardiaceae	<i>Myracrodruon urundeuva</i> Allemão	Aroeira	Arboreal	Leaf
	<i>Spondias tuberosa</i> Arruda	Umbuzeiro	Arboreal	Leaf, Fruit
<i>Apocynaceae</i>	<i>Aspidosperma discolor</i> A.DC.	Pitiá	Arboreal	Leaf
	<i>Calotropis procera</i> (Aiton) W.T. Aiton	Botão-de-seda	Shrubby	Leaf, Fruit
<i>Bromeliaceae</i>	<i>Bromelia laciniosa</i> Mart. ex Schult. & Schult.f.	Macambira	Herbaceous	Leaf, Flower
<i>Convolvulaceae</i>	<i>Ipomoea asarifolia</i> (Desr.) Roem. & Schult.	Salsa	Climber	Leaf
	<i>Ipomoea cairica</i> (L.) Sweet	Jitirana	Climber	Leaf, Fruit
<i>Solanaceae</i>	<i>Solanum paniculatum</i> L.	Jurubeba	Shrubby	Leaf, Fruit
NI		Jacurutu	Arboreal	Leaf
NI		Triadim	Arboreal	Leaf

NI - Not-identified

Source: Authors (2024).

Among the forage species, the algaroba, which in the Lisboa settlement occurs mainly in alluvial soils, was also mentioned by the breeders. It is an exotic species introduced to the semi-arid region of the Northeast in 1946 (Santos; Diodato, 2017).

During the rainy season, most species are part of the goats' diet, except for canela-de-velho, macambira and jurubeba, whose leaves are only eaten during the dry season. Leaves, flowers and fruit make up the diet of goats in the rainy and dry seasons. In the

rainy season, when green forage is available, the animals access plant structures up to 2.0m high, thanks to their bipedal grazing habit.

As the rainy season ends, leaves, fine branches, bark, flowers and fruits are deposited in the litter (material deposited on the ground as a result of the deciduous process). Animals in Caatinga areas select their diet from this litter (Lima *et al.*, 2015). Among the forage plants, 44% of them have only the leaves eaten, and 56% have the flowers and fruit as well as the leaves eaten. Cipó de chapada, canafistula and camaratuba are forage plants from which goats consume leaves and flowers, while angico-de-bezerro, besouro and sipaúba have leaves, flowers and fruit consumed.

The five species most cited by the breeders, between 65 and 95% of them, were: jurema, marmeleiro, catingueira, mofumbo and angico-de-bezerro; nine species were cited by the breeders in the range between 20 and 50% and 20 species in the range between 6 and 18% (Figure 1).

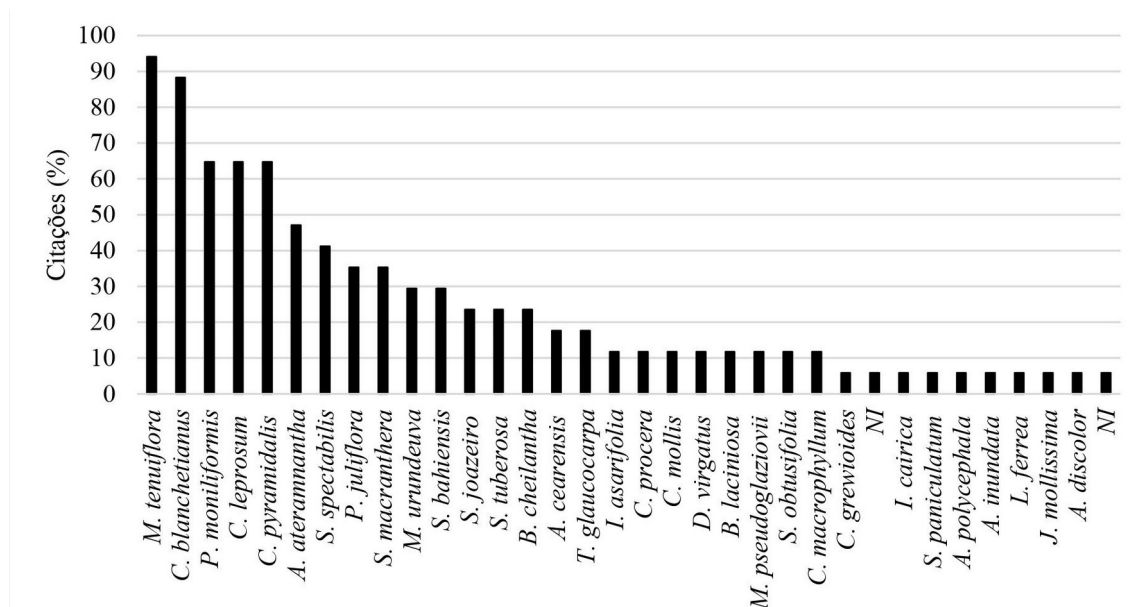


Figure 1. Percentage of forage plants listed in the goat diet cited in the Lisbon Settlement, municipality of São João do Piauí, PI.

Source: Authors (2024)

Among the species with the lowest percentage of citations are aroeira, amburana, juazeiro, mororó, pau-ferro and muquem. Although these plants are considered to be of high forage value by the farmers, they have a low occurrence in the rangeland areas of the Lisboa Settlement.

These species have been identified in the sedimentary caatinga of Piauí, in areas with lower levels or absent anthropic activities (Lemos; Rodal, 2002; Farias, 2003, Emperaire, 1989; Carvalho, 2014).

The two most cited species, jurema and marmeleiro, are classified as dominant pioneer plants in successional caatinga vegetation, subjected to deforestation for agricultural cultivation, timber harvesting and grazing (Pereira; Bake, 2010), and these practices were recorded in the Lisboa settlement. Both species are considered to be of low forage value for ruminants, in terms of their chemical composition and nutrient digestibility (Santos *et al.*, 2010). In this scenario, the high citation of these forage plants by farmers is probably related to their availability, since goats have plasticity in their diet and change it according to, among other factors, the availability of forage in the pasture (Pisani; Distel; Bontli, 2000; Papacristhou ; Dziba; Provenza, 2005).

In other ethnobotanical surveys carried out in caatinga areas, this pattern of ingestive behavior by goats has also been recorded (Leal; Vicente; Tabarelli, 2003; Nunes *et al.*, 2015), which reveals the need for planning in the management of these animals to minimize the impact on the conservation of forage plants. Goat farming development projects in caatinga areas should be based on knowledge of the status of rangelands in terms of its botanical composition.

In the phytosociological survey, it was possible to observe the population dynamics of the forage species present in the goats' diet. A total of 923 individuals were recorded: 436 in the shrub site and 487 in the arboreal site (Table 2).

At the shrub site, three botanical families were found containing four genera and four species; at the arboreal site, five botanical families were found containing 12 genera and 13 species, and one unidentified species. In both sites, the Fabaceae family was the richest, with nine species, followed by Euphorbiaceae with two species, and these two

represent 84% of the forage species. The Combretaceae, Bignoniaceae and Apocynaceae families had only one species. Of the 13 genera recorded at the two sites, 85% were represented by only one species; *Senna* and *Croton* were represented by two species each.

The difference between the ecological sites resulted from the greater intensity of deforestation: the shrub site was cleared twice in a 19-year period, while the arboreal site was cleared once. At the time of this floristic survey, the shrub site was 12 years old and the arboreal site was 31 years old since the last deforestation.

Table 2. Relative density (RD), relative frequency (RF), relative dominance (Rdo) and importance value index (IVI), in two grazing sites in a caatinga area, São João do Piauí, PI.

Family	Species	N	N P	Shrub Site			
				RD (%)	RF (%)	Rdo (%)	IVI
Fabaceae	<i>Caesalpinia pyramidalis</i>	38	10	8,72	18,26	12,31	39,29
	<i>Senna macranthera</i>	240	24	55,05	41,74	56,80	153,59
Euphorbiaceae	<i>Croton blanchetianus</i>	143	24	32,80	36,52	26,15	95,46
Combretaceae	<i>Combretum</i>	15	2	3,44	3,48	4,74	11,66
	<i>Leprosium</i>						
Total		436		100,00	100,00	100,00	
Arboreal Site							
Fabaceae	<i>A. discolor</i>	24	13	4,93	6,84	4,89	16,66
	<i>A. polycephala</i>	6	5	1,23	2,63	2,16	6,02
	<i>B. cheilantha</i>	11	7	2,26	3,68	1,01	6,96
	<i>C. pyramidalis</i>	41	11	8,42	11,05	37,85	57,32
	<i>C. macrophyllum</i>	12	3	2,46	1,58	4,07	8,11
	<i>M. tenuiflora</i>	36	24	7,39	12,63	12,02	32,04
	<i>P. moniliformis</i>	120	25	24,64	13,16	19,39	57,18
	<i>S. bahiensis</i>	12	10	2,46	5,26	2,16	9,89
	<i>S. spectabilis</i>	50	12	10,27	6,32	7,48	24,06
Euphorbiaceae	<i>C. blanchetianus</i>	80	18	16,43	22,11	5,10	43,64
	<i>C. grewioides</i>	2	1	0,41	0,53	0,31	1,24
Combretaceae	<i>T. glaucocarpa</i>	9	5	1,85	2,63	2,33	6,81
Bignoniaceae	<i>A. ateramnantha</i>	83	21	17,04	11,05	0,96	29,06
Not identified		1	1	0,21	0,53	0,28	1,01
Total		487		100,00	100,00	100,00	

N = number of individuals; NP = number of plots in which the species was inventoried.

Source: Authors (2024).

These species are classified as pioneers and are abundant in caatinga areas with different levels of degradation (Carvalho *et al.*, 2001; Pereira, 2010). Floristic surveys in areas of conserved caatinga, located in the sedimentary basin of the state of Piauí, have identified the Fabaceae family with the highest number of species (Mendes, 2003; Lemos; Rodal,

2002), meaning that in plant succession with grazing, this family continues to be the most representative.

Comparing the list of forage plants in this study with those of vegetation identified in a sedimentary caatinga area in the state of Piauí, it was found that 25% of the species present in the two ecological sites were common to the caatinga, considering vegetation at different stages of succession (Empeiraire, 1989) and in a cerrado-caatinga transition area (Oliveira *et al.*, 2010). However, only 13% were of common occurrence with a survey carried out in a conservation unit – Serra da Capivara National Park (Lemos; Rodal, 2002). The total density was 1,453.34 (shrub site) and 1,623.35 indices ha⁻¹ (arboreal site), which corresponded to 24% and 28% of that recorded in an area of preserved sedimentary Caatinga, which was 5,827 indices/ha (Lemos; Rodal, 2002). As for the importance value index (IVI), in the shrub site, the Fabaceae family obtained the highest percentage (64.29%), with *S. macranthera* having a relative dominance of over 50%. This species also recorded the highest values for the relative parameters of density (55.05%), frequency (41.74%) and dominance (56.80%) (Table 2). These results indicate the ecological importance of the species in terms of horizontal distribution of species per area, and its importance from a forage point of view, since goats graze the leaves and flowers of this shrub species in the rainy season and at the beginning of the transition between this season and the dry season, based on information from producers and on-site observation.

In the arboreal site, the Fabaceae family obtained the highest percentage of IVI (67.2%), with 56% relative dominance of *C. pyramidalis* and *P. moniliformis* species. The second highest IVI was from the Euphorbiaceae family (15%), followed by Bignoniaceae (9.69%), Apocynaceae (5.55%) and Combretaceae (2.27%). The third highest IVI value and the fifth highest RDo of the arboreal site was that of *C. blanchetianus* species. The most mentioned forage species in the ethnobotanical survey were the ones with the highest IVI in both ecological sites.

Grazing associated with the frequency of deforestation resulted in differences in floristic diversity. The Shannon-Weaver diversity indices (H') were 1.02 and 2.16 nats ind⁻¹, for the shrub and arboreal sites, respectively. Since the animals had access to both sites in the year following deforestation, the difference between them was the time after

deforestation, around 12 and 31 years for the shrub and arboreal sites, respectively. It can therefore be assumed that the greater floristic diversity in the arboreal site may be associated with a reduction in the impact of grazing over time, due to factors such as structural and chemical defense and compensatory growth of the forage plants (Sebata, 2013). Studies carried out in caatinga environments in the semi-arid region of Piauí, in places with no recent history of grazing by domestic ruminants or deforestation, the Shannon-Weaver diversity indices (H') varied between 2.7 and 3.0 nats ind⁻¹ (Lemos; Rodal, 2002; Souza *et al.*, 2017).

The analysis based on the floristic similarity index or Jaccard coefficient (J) indicated low floristic homogeneity between the two sites, with a Jaccard index of 0.13, even though they were located close to each other, at a distance of less than 1 km. According to Müeller-Dombois e Ellenberg (1974), two areas are considered similar when the Jaccard index between them is greater than 0.25. The difference in the number of clearings was probably a determining factor in this low floristic similarity, since the presence of animals is constant at both sites.

The values for Pielou's index of evenness (J') were 0.37 and 0.78, respectively, for the shrub and arboreal sites. The higher value for this index in the arboreal site indicates the absence of a marked predominance of one or a few species over the others. In situations where a few species contain many individuals, diversity is low (Pielou, 1966). In the shrub site, the low evenness was influenced by the high density of *S. macranthera*, which was present in 80% of the plots, indicating low floristic heterogeneity and the progressive stage of ecological succession in this site. This pattern of behavior has also been observed in caatinga areas in the early stages of plant succession (Calixto Junior: Drumond, 2014). Combining the information from the phytosociological and ethnobotanical surveys, it was possible to observe that the botanical composition of the goats' diet changes over the months, considering the different times of the rainy season (Figure 2).

The species *A. ateramnantha*, *C. grewoides* and *C. blanchetianus* are only present as green forage during the period of greatest rainfall concentration. The species that are present in the diet throughout the rainy season provide green leaves and thin branches, mature leaves and fruit, and those present between the middle and end of the rainy season

provide mature leaves, flowers and fruit. Even in the shrub site, where only five species were identified, forage is available until the beginning of the dry season.

In rangelands where there is a greater richness of forage plants, the goats have a diet with more options at different times of the year, which means greater food security and guarantees the productive performance of the flocks. As observed in the sedimentary caatinga area, the species catingueira, jurema and marmeleiro are also the dominant forage in the diet of goats and other ruminants in the caatinga area in the cristalino region (Carvalho *et al.*, 2021). Leaf litter, a source of forage for goats in the dry season, was not identified by forage species by the informants, but research in other areas of the caatinga shows that leaves, thin branches and fruits are the main components of the diet of these animals (Pfister *et al.*, 1986; Formiga *et al.*, 2020; Saraiva, 2020).

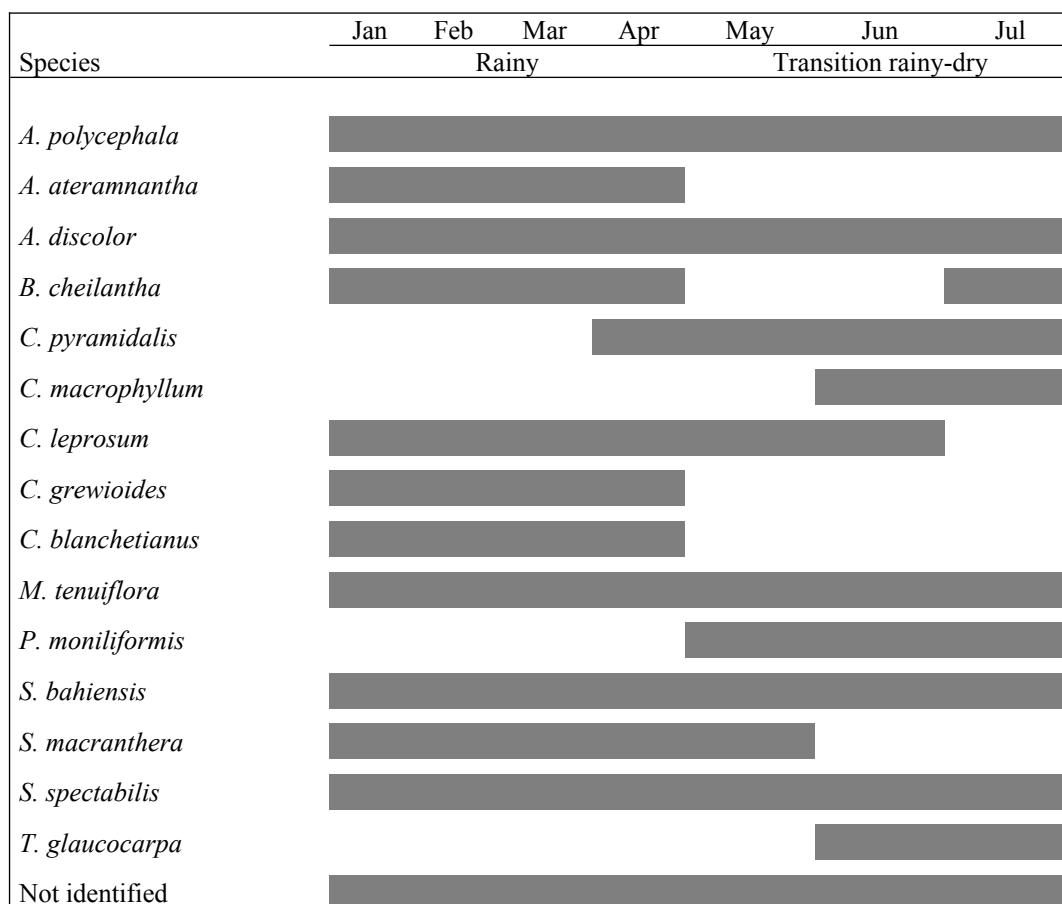


Figure 2. Distribution of forage plants during the rainy season in a caatinga area, São João do Piauí, PI.
Source: Authors (2024).

The results of this study indicate the impact of mechanical deforestation associated with goat grazing on the IVI of forage species, in this case the deforestation was performed for the establishment of cultivated buffel grass pasture (*Cenchrus ciliaris* L.), meaning that the replacement of rangeland in the caatinga with cultivated pasture needs to be well planned, considering not only environmental factors but also the cultural factors of goat farmers. Studies on forage plants in the sedimentary caatinga region need to be carried out, based initially on ethnobotany, in order to identify those plants with the best nutritional value, so that they can be conserved or reintroduced into rangeland ecosystems.

The species jureminha, camarautuba, muquem, and angico-de-bezerro mentioned in the survey are indicated in the literature as promising forage plants for feeding goats and other domestic ruminants (Nascimento *et al.*, 1996; Riestra; Valencia; Carias, 2005; Castro-Montoya; Dickhoefer, 2020). The lower frequency of occurrences of these species, or even their absence, in shrub and arboreal sites, may be associated with grazing, as they are species that are highly acceptable by goats. According to Lins (2022), the greatest impact of goat grazing in caatinga areas is due to increased seedling mortality, which modifies the conservation of botanical composition in pastoral ecosystems in this phyto-physiognomy.

CONCLUSIONS

Goat farmers in a sedimentary caatinga area identified 34 forage species, with predominance of trees and shrubs. Leaves, flowers and fruits make up the goats' diet during the rainy season and the transition between rain and dry seasons.

Arboreal forage plants succeed shrubs over time, with an increase in diversity in the forage plant community of rangelands in sedimentary caatinga. The dominant species in the shrub site is *S. machrantera* and in the arboreal site are *C. pyramidalis*, *P. moniliformis* and *M. tenuiflora*.

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