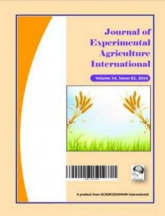

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Floristic and Phytoosociological Survey in a Caatinga Fragment under Extensive Grazing in Patos-PB Municipality

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: The caatinga is a typical Brazilian semi-arid vegetation, where dominant shrub species and some dispersed arboreal individuals are found, in addition to the marked presence of cacti
Aims: The aim of the present study was to evaluate the arboreal-shrub component, analyzing the floristic composition and phytosociology in caatinga area under extensive grazing in the Paraíba hinterland
Methodology: The study area extends over 60 ha, and presents vegetation of the caatinga type with the presence of extensive cattle grazing. The vegetation data were obtained using the simple

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random sampling method, with plots with a standard size of 20 x 20 m, and randomly arranged 15 sample units. In each sample unit were measured all living or dead individuals, with Chest Height Circumference (CAP) ≥ 6 cm as well as total height of each individual. Phytosociological parameters were analyzed and floristic diversity was determined using the Shannon-Weaver index (H '), Simpson dominance (S), Pielou equability (J').
Results and Discussion: There were 1285 individuals belonging to 9 families, 16 species, 15 genera. The Fabaceae family obtained the largest number of individuals and species, with the *Poincianella pyramidalis* species being the most important, with 650 individuals. The first class of diameter, concentrated the largest number of individuals with 627 individuals (48.8%), followed by the second class with 464 individuals (36%) confirming a tendency to reverse in the diameters classes. Regarding height distribution, it was observed that 1154 individuals (89%) are grouped in the first three classes. In relation to floristic diversity, the shannon-wienner index was 3,094 nats / ind, while the furrow index was 0.995, simpson 0.999.
Conclusion: The species *Poincianella pyramidalis* presented the highest parameters of horizontal structure, whereas indexes indicated that the study area presents a low diversity, proving that the extensive grazing has been changing the floristic composition of the area.

Keywords: Anthropisation; phytosociology; semi-arid; exploration.

1. INTRODUCTION

The semi-arid region covers an area of 982,563.3 km², covering 89.5% of the northeastern region of Brazil. Occupying a good part of this territorial space, is the Caatinga Biome with 844,453 km², corresponding to 11% of the Brazilian territory extending through the states of Paraíba, Pernambuco, Bahia, Piauí, Ceará, Alagoas, Rio Grande do Norte, Sergipe, and part of Minas Gerais [1].

The typical vegetation of semi-arid is of the type estapean savannah, and is known in Brazil like Caatinga, where are dominant shrub species and some dispersed arboreal individuals, besides the marked presence of cactáceas. The climatic and hydrological conditions and singularities present in this biome give rise to species highly adapted to the hostile environment of the region. Other characteristics such as rainfall irregularity, and two well-defined climatic seasons in the year, rainy season, and dry season, are considered typical and unique peculiarities of this Biome [2].

The caatinga is the only ecoregion of dry forest, surrounded by humid forests, thus making it rich both in diversity and complexity [3]. Therefore, studies on the composition and structure of this biome, offer tools for understanding the ecological aspects of the region, and promote the construction of bases and strategies for its sustainable conservation [4].

Due to population growth in the semi-arid region, there has been an increase in the exploitation of the caatinga, and one of the factors that contributes most to the degradation of the biome is extensive grazing, especially cattle [5]. In the medium term, the excess of support capacity by area by the animals, can cause strong pressure on the floristic composition of the native vegetation, because they are palatable species, and in the long term, generate areas susceptible to desertification processes [6]

The management used in livestock production systems, in the semi-arid region, turns the caatinga into the only food source for the animals, not giving importance to the productive cycles of the vegetation, increasing the capacity of fixed stocking by area, which often entails higher grazing in the dry season, and lower in the rainy season [7].

Among the tools to study the state of vegetation is phytosociology, which becomes essential, since it provides important data, such as hierarchy levels among species, as well as to analyze the best measures to be taken for the preservation and forest conservation [8,9], through quantitative and qualitative parameters on the structure and behavior of a plant population. For ecological management, it provides data on potential use of forest species, based on wealth and abundance information, their importance in the environment [10,11].

Studies in grazing areas are essential, since they can direct the appropriate practices for both correction and maintenance of capacity by area, based on sustainable management, which include minimum conditions for the survival of

biomes, and the capacity of regeneration of anthropized environments [12].

Aiming at this, the objective of this study was to evaluate the arboreal-shrub component and analyzing the floristic and phytosociological composition in the caatinga area under extensive grazing in the Paraíba hinterland.

2. MATERIALS AND METHODS

The study was carried out at the Research Nucleus for the development of the semi-arid Tropic (NUPEÁRIDO), belonging to the Federal University of Campina Grande (UFCG), located at the geographic coordinates 7°4'58" S and 37°15'37" W, in the municipality of Patos-PB (Fig. 1), inserted in the immediate geographic region of Patos [13].

The climate of the region, according to the classification of Alvares et al. [14], is BSh type, semi-arid, with two well defined seasons, one rainy (January to May) and one dry season (June to December) annual rainfall is 600 mm. The average annual temperature is 28°C, minimum 24°C and maximum 35°C. According to EMBRAPA [15], the predominant soil in the study area is Neosol Litólico and Luvissolos Crômico, which is characterized by its high stoniness and small depth.

The study area extends over 60 ha, and shows open-season shrub (CAAA) vegetation, with the presence of specimens of aroeira (*Myracrodruon urundeuva* M. Allemão), Angico (*Anadenanthera colubrina* (Vell.) Brenan), faveleira (*Hyptis suaveolens* (L.) Poit.), and in the herbaceous stratum (*Brachiaria brava*) (*Hyptis suaveolens* (L.) Poit). This area has been maintained with native vegetation cover for about 40 years, however, it has extensive cattle grazing.

The vegetation data were obtained using the simple random sampling method, with plots with a standard size of 20 x 20 m (400 m²), following the Protocol of Measurements of Permanent Parcels (CAATINGA FOREST MANAGEMENT NETWORK - RMFC, [16], being randomly arranged 15 sample units, totaling a sampled area of 6000 m² In each sample unit were measured all living or dead individuals, with Chest Height Circumference (CAP) equal to or greater than six centimeters, measured with a tape measure at 1.30 m from the soil level and total height of each individual was measured with graduated ruler.

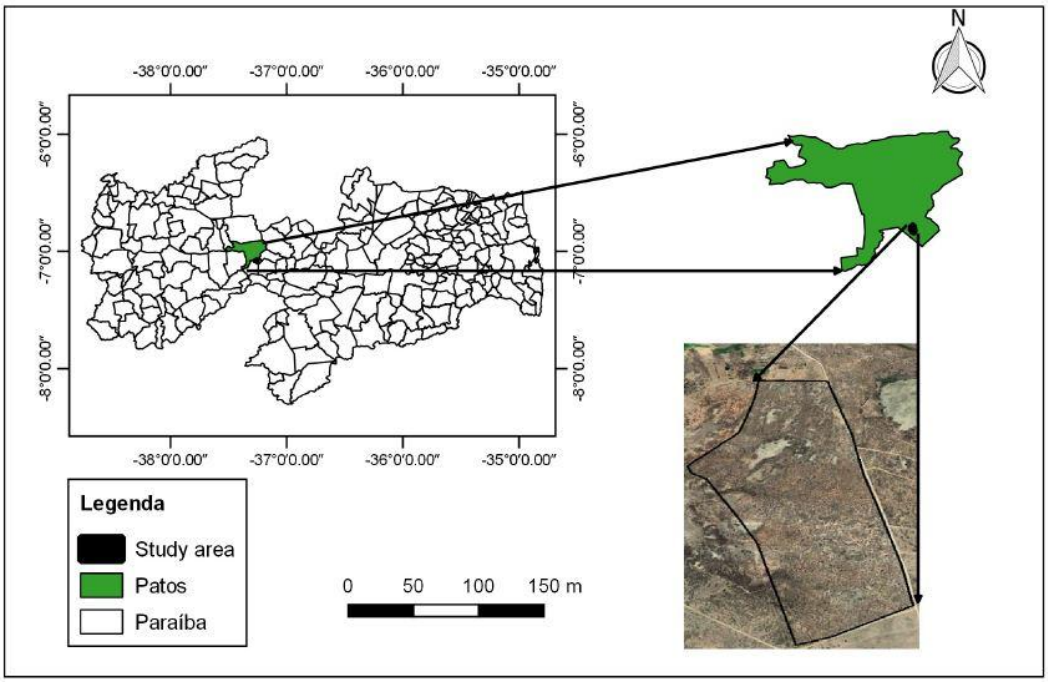

Fig. 1. Map of location, highlighting the municipality of Patos-PB and of study area

The identification of the botanical material was carried out by classical standards used by the taxonomy, based on floral and vegetative morphological characters, using botanical collections, by comparing exsicates collected with material cataloged in the Herbarium of the Federal University of Campina Grande (Campus Patos), and also by consulting the literature and specialists. The species were organized according to the families recognized by the classification of the Angiosperm Philogeny Group [17].

Sampling adequacy was obtained based on the analysis of the collector curve constructed using the nonparametric estimator Jackknife, which is based on the occurrence of species and the number of plots to estimate the total of species in the community.

The phytosociological parameters analyzed were relative frequency, absolute frequency; relative dominance, absolute dominance and importance value (VI). Floristic diversity was determined using the Shannon-Weaver index (H '), Simpson dominance (S), Pielou equability (J'). The calculations were performed using the Past program (statistical software) [18].

The classes of diameters were established using class intervals of 3 cm, following the Calixto methodology; Drumond [19], Guedes et al. [4], and height classes, were established using classes of 1 m height [19].

The floristic and phytosociological analyzes were performed with the help of Mata Native Software 3.11 [20] and the charts were elaborated in Microsoft Excel 2013.

3. RESULTS AND DISCUSSION

Sampling sufficiency, demonstrated by the species accumulation curve (Fig. 2), shows that from the 11th plot the number of species stabilized or from that point on, there was a stagnation in the number of species, showing that 100% of the species number of species inventoried had been recorded, indicating that the 15th plots sampled are sufficient to characterize the floristic composition of the fragment studied.

A total of 1,285 individuals belonging to 9 families, 16 species, 15 genera were collected. The Fabaceae family obtained the highest number of individuals and species, with *Poincianella pyramidalis* (650) and *Mimosa tenuiflora* (132) being the most abundant among the species, followed by the Euphorbiaceae family, with 162 individuals distributed in 3 species, *Jatropha mollissima* (76), *Croton blanchetianus* (66), *Cnidoscolus quercifolius* (20) (Table 1), thus totaling 89.18% of the species sampled in the community.

Catingueira (*Poincianella pyramidalis*) species with the highest values in all the parameters studied with absolute frequency (93.3) and relative (13.158%), Absolute density (1083.33) were the most representative values for the species) and relative (50.58%), absolute dominance (42,770) and relative (7.886%); and Importance value index (106.51) respectively, followed by Pereiro (*Aspidosperma pyrifolium*) with absolute frequency (93,33) and relative (12,58%), absolute (248,333) and relative (11,082%) density, and (12) and (12,28%), absolute density (220,000) and relative density

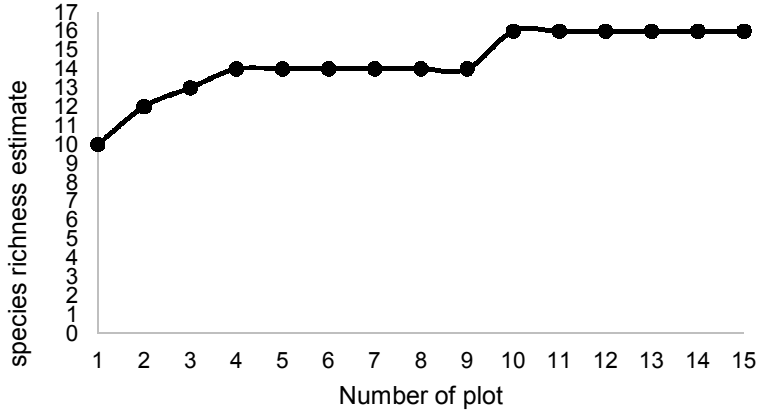

Fig. 2. Accumulation curve obtained by the non-parametric Jackknife estimator in relation to the sampled area, in the anthropic caatinga, in the municipality of Patos-PB

Table 1. Phytosociological parameters of the woody species sampled in an anthropic caatinga area in the municipality of Patos-PB

Nome cientifico/ família	NI	FA	FR (%)	DA	DR (%)	DoA	DoR (%)	IVI
Anarcadiaceae								
Myracrodruon urundeuva Allemão	3	13,33	1,754	5,00	0,234	1,346	0,248	3,334
Apocynaceae								
Aspidosperma pyrifolium Mart	149	93,33	12,281	248,333	11,595	11,082	2,043	34,958
Burseraceae								
Commiphora leptophloeos (Mart.) J. *B. Gillett*	11	40	5,263	18,333	0,856	3,958	0,730	10,077
Capparaceae								
Cynophalla flexuosa (L.) J. Presl	2	13,33	1,754	3,333	0,156	0,123	0,023	2,033
Combretaceae								
Combretum leprosum Mart	60	86,67	11,403	100	4,669	1,546	0,285	17,619
Euphorbiaceae								
Cnidoscolus quercifolius Pohl	20	33,33	4,386	33,333	1,556	13,122	2,419	19,064
Croton blanchetianus Baill.	66	66,67	8,772	110,00	5,136	1,580	0,291	15,489
Jatropha mollissima (Pohl) Baill	76	86,67	11,403	126,667	5,914	3,110	0,573	20,428
Fabaceae								
Bauhinia sp	94	60	7,895	156,667	7,315	3,666	0,676	18,876
Poincianella pyramidalis (Tul.) L. P. Queiroz var	650	100	13,158	1083,333	50,584	42,770	7,886	106,512
Libidibia ferrea (Mart. ex Tul.) L. P. Queiroz*	1	6,67	0,877	1,667	0,078	0,037	0,007	0,992
Anadenanthera colubrina (Vell.) Brenan	7	13,33	1,754	11,667	0,545	4,975	0,917	7,247
Mimosa ophthalmocentra Mart. ex Benth.	6	20	2,632	10,00	0,467	0,175	0,032	3,274
Mimosa tenuiflora (Willd.) Poir	132	93,33	12,281	220,00	10,272	10,733	1,979	33,286
Malvaceae								
Pseudobombax marginatum (A. St.-Hil.) *A. Robyns*	3	20	2,632	5,000	0,234	0,341	0,063	3,207
Rhamnaceae								
Ziziphus joazeiro Mart	5	13,33	1,754	8,333	0,389	1,437	0,265	3,580
Total	1285	760	100	2141,67	100	18,44	100	300

Ni; number of individuals FA: absolute frequency; FR: relative frequency; DA: absolute density; DR: relative density; DoA: absolute dominance; Pain; relative dominance; I SAW; Index of importance valu

(10,272%), and value of importance value (34,958) and black jurema (*Mimosa tenuiflora*) with absolute frequency (93,33) and relative frequency (33,28). The highest results for IVI of the species *Poincianella pyramidalis, Aspidosperma pyrifolium* and *Mimosa tenuiflor*a were mainly contributed by the high number of individuals, frequency, and density, since they together obtained 72.45% of the total trees sampled.

However, for absolute (13,122) and relative (2,419) dominance the favela species (*Cnidoscolus quercifolius*) obtained the highest results only of the species *P. pyramidalis*. This fact shows that although the species obtained few individuals (29) in the survey in relation to other species, its occupation in the environment per unit area was larger in relation to the area occupied by the other species, which can be explained by the larger size of the same individuals present in the area.

In a similar study, Sabino et al. [21] found similar results, where the species *P. pyramidalis* had the highest number of individuals (678), relative density (30.45%), relative dominance (43,58), relative frequency 13,158) and IVI (29,066), making it clear that the species does not have higher environmental requirements. Guedes et al. [4] , also in a study of caatinga fragment in the municipality of Santa Terezinha, PB, showed high IVI values (21.58%), frequency (8.55%), density (387.5), dominance 32.30%) for *P. pyramidalis*. The abundance of the species can be observed in surveys in the caatinga area in different states of the northeast region [22, 23].

As for the superiority of these species in the phytosociological parameters studied in the area can be explained by the fact that they have beneficial characteristics to the communities of secondary succession preparing the environment, especially in areas that had anthropic intervention [24].

This is corroborated by the majority of the Caatinga studies, where the Fabaceae and Euphorbiaceae families cover most of the tree species collected in the Caatinga biome according to the majority of the studies [25,11].

In a study in the Seridó, Rio Grande do Norte, Santana [26], observe the species *P. pyramidalis* and *A. pyrifolium*, together with the species *C. sonderianus* obtained 58.66% of the total sampled individuals.

Santana et al. [27] observed that the species *Poincianella pyramidalis, Aspidosperma pyrifolium* and *Croton blanchetianus*, obtained the highest values in all phytosociological parameters. The same author reports that the predominance of this species in some areas of the caatinga is related to anthropization, such as extensive grazing of animals and logging, preferentially eliminating the species that present larger individuals to be used for firewood, coal and construction rural, thus leading to the absence of individuals of secondary species such as *Myracrodruon urundeuva* and *Schinopsis brasiliensis*.

Barbosa et al. [28], in a floristic survey of arboreal and shrub species in a caatinga area in the municipality of Arcoverde-PE, under semi-extensive bovine grazing, found that the species *P. pyramidalis* and *C. sonderianus*, number of individuals raised with 22.38%.

Already in the cerrado-caatinga transition area in Piauí, Amaral et al [29] surveyed the species *Campomanesia xanthocarpa* Berg (616) *Bauhinia. ungulata* L. (507), *Mimosa caesalpinifolia* Benth. (457), as the largest number of individuals, with higher IVI for *B. ungulata* (31.91%) differing from the results of this study.

In relation to the dead individuals, 352 were identified, totaling 27.39% of the species sampled in the study area. Souza [30], in a floristic survey in the same study area, found a mortality of 7.11% of the individuals. In a survey in 2013 Sabino et al. [21] observed 10.69% of individuals dead. According to the AESA [31], the average annual precipitation of the last seven years was below the average for the municipality of Patos, PB. Some factors may explain this behavior in the six-year period that contributed to the increase of this index, such as the prolonged periods of drought, in addition the edaphoclimatic factors also contribute to the high mortality, since the existing soils in the region are shallow and stony, not favoring the conservation of the humidity in the same damaging the survival of the species. The similar result was found by Araújo [32], in a survey in a municipality near the study area, also observed a high mortality rate (24%).

The first diameter class (Fig. 3), concentrated the largest number with 627 individuals (48.8%), followed by the second class with 464 individuals (36%). These two classes represent 84% of the individuals raised in the study. It is observed a tendency to reverse J in the diameters classes, with a larger number of individuals in the classes with smaller diameters, thus showing a typical characteristic of unequal forest. Apparently this pattern was basically due to the behavior of three species of highest value (*Poincianella pyramidalis, Aspidosperma pyrifolium, Mimosa tenuiflora*), both of which presented high numbers of individuals in the lowest classes.

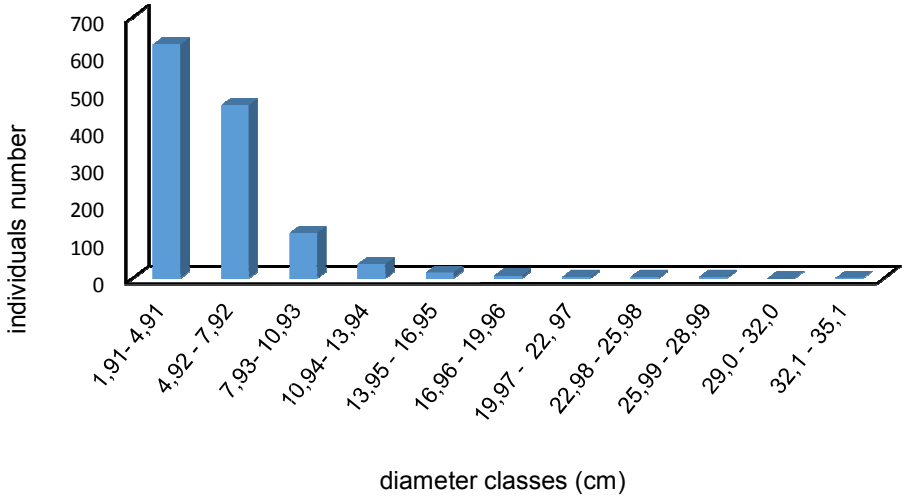

Fig. 3. Distribution of the number of individuals in diameter classes (cm) in a fragment of anthropic caatinga, at the Research Center for the development of the semi-arid Tropics in Patos, PB

According to Machado et al. [33], most of the forest tree-shrub component inventories of secondary forests have a larger distribution in smaller diameter classes, following the reverse or exponential negative J model.

Calixto Junior and Drumond [25], studying the phytosociological survey of a caatinga area in the municipality of Petrolina-PE, around 30 years without anthropic intervention, observed that 53.7% of individuals surveyed presented a diameter in the class between 3.0-6.0 cm, this result being similar to this study. Marangor et al. [34], in a phytosociological survey in a caatinga area with a history of disturbance, with logging and pasture of goats in the municipality of Floresta-PE, found a diametric distribution represented in inverted form of J, in which 84% of the individuals were distributed in the first two classes up to 6.4 cm in diameter and then with a sharp drop for the other classes, corroborating the results of this work.

Regarding height distribution (Fig. 4), it was observed that 1154 individuals (89%) are grouped in the first three height classes. The maximum height was 8.5 meters, in an individual of *Anandenathera columbrina*. However, the second class presented the highest number of individuals with 496 (38%) of the total sampled individuals. There was a small decrease of individuals in the other height classes, since the majority of the individuals present in the survey are pioneer species of low size. According to Souza and Soares [35], the study of the vertical structure is of paramount importance for the evaluation of the sociological position of each species in relation to its height, because from this it classifies the forest fragment in the upper, middle and lower vertical strata and forest.

The average height of the individuals inventoried was 3.5 meters, and this value was similar to those verified by Medeiros et al.[36], studying the vertical structure of the caatinga fragment in the municipality of São Mamede-PB, verified an average height of 3.6 meters. Alves et al. [37], analyzing the vegetative structure in an area of Caatinga in the municipality of Bom Jesus, PI and obtained the mean value of 3.44 meters in height, corroborating these results for this study. According to the previous author, the types of anthropic disturbances such as cattle trapping, partial cutting of trees, directly influence the low height of this species. So the cattle grazing in the area of the present study is a preponderant factor for the low average height for this community.

In relation to floristic diversity, the Shannon-Wienner index was 3,094 nats / ind, while the Pielou index was 0.995, Simpson 0.999.

In other works carried out in caatinga, low diversity indexes were found. Holanda et al.[38] studying floristic diversity in two areas of caatinga under grazing of sheep, cattle and cuttings, observed a variation in the Shannon-

Wienner index of 0.23 to 1.50 nats / ind. The same author explains that the low floristic diversity is associated to the different histories of anthropic disturbances, mainly the animal component that interferes in a significant way in the structure and diversity of the vegetation.

Barbosa et al. [28], in a survey of the floristic diversity in a caatinga area submitted to semiextensive cattle breeding in the municipality of Arcoverde-PE, found that the Shannon-Weaver index was 2.05 nats / ind. and Pielou, of 0.57

Guedes et al. [4], studying the remnant component of shrub-tree caatinga that has been maintained with its native vegetation cover for at least 30 years, we found a Shannon index of 2.54 nats / ind, Pielou of 0, 96 and Simpsom of 0.82. It is observed that the index of Shannon and Simpsom of the present study was superior to the work of Guedes et al. [4].

Leite et al. [39], in a quantitative analysis of the Caatinga woody vegetation in the city of Teixeira, PB, presented a diversity index of Shannon-Weaver (H ') for the studied area of 2.69; the Simpson dominance index, 0.99; Pielou equability (J), 0.70.

According to Felfili and Resende [40], the shannon-wienner index assumes that individuals are randomly sampled from an infinitely large set, and that all species are represented in the sample, thus basing themselves on the higher the value of Shannon, the greater the diversity of the area, however the values can reach 4.5 but generally are generally between 1.3 and 3.5.

The same author reports that the Simpson index indicates the probability that any two individuals, randomly taken from a community, belong to different species, giving more weight to species abundance and being less sensitive to wealth. The values of the index vary in the scale of 0 to 1, values close to 1 indicate lower diversity. In this study, the Simpson index (0.99), indicates that the area where this study was performed presents less diversity.

The Pielou Index represents the distribution of individuals among existing species and the scale ranges from 0 to 1, where the values close to 0 represent a minimum uniformity and the value 1 represents the maximum diversity, that is, all species are equally abundant [41].

The three indices of floristic diversity studied in this study indicate that the area presents little richness and diversity, since the values are inferior when compared to environments of high diversity.

It is observed a great variation in the diversity indexes, within the same phytogeographic region, this is related mainly to the different stages of succession, floristic heterogeneity caused by the different types of soil and the anthropic activities that are carried out in an unsustainable way.

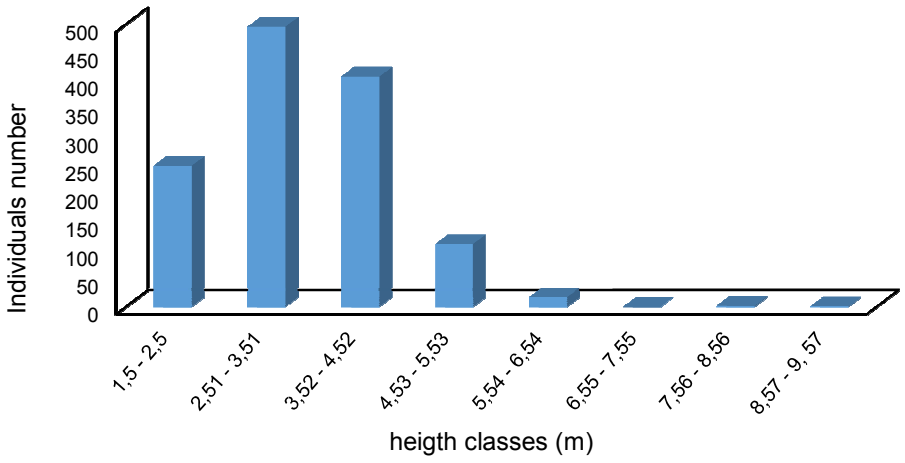

Fig. 4. Distribution of the number of individuals in height classes (m) in a fragment of anthropic caatinga, at the Research Center for the development of the semi-arid Tropics in Patos, PB

The results found in this study show that anthropic actions and unfavorable environmental conditions lead to a decrease in floristic diversity indexes. According to Pereira [42], the low rates in certain areas of the caatinga are associated with rainfall irregularities in the region, high annual average temperatures and anthropogenic actions such as logging and extensive grazing.

Luna et al. [43], in a study carried out in four caatinga areas under different pasture densities of goats in Cariri Paraibano, observed low diversity indexes. The same author reports that these low indices are related to a high degree of degradation by grazing as well as the limitations of soil, and rainfall irregularity.

In view of the above, the results presented in this work are extremely important, since it opens the way for further research in order to determine measures to reduce degradation in this area. It also confirms that cattle grazing and the unmanageable environmental conditions that the area has undergone over the years accelerates the degradation process, making mitigation measures necessary to recover the environment.

4. CONCLUSION

The results confirmed that the families Fabaceae and Euphorbiaceae are the most representative floristically, with 7 species and 3 species, respectively.

The species *Poincianella pyramidalis*, presented the highest parameters of horizontal structure, making it clear that it does not have higher environmental demands and it has a great regrowth power after periods of human disturbance.

The first three diameter classes presented the largest numbers of individuals, thus showing a trend of reverse J, which is characteristic of unequal forests and absence of individuals in the last large ones due to anthropic actions.

The average height of the individuals inventoried was 3.5 meters, thus demonstrating that the types of anthropic disturbances such as cattle grazing, partial cutting of trees, directly influence the low height of this species.

In relation to diversity, the indexes indicated that the study area presents a low diversity, proving that the extensive grazing has been changing the floristic composition of the area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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