Phytosociological analysis of the tree-shrub component of the Caatinga, Alagoas, Brazil

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ABSTRACT

The Brazilian semiarid region presents very heterogeneous natural conditions of climate, soil, topography and vegetation, forming a mosaic of unique ecosystems. This research aims to carry out a phytosociological analysis of the tree-shrub stratum of two Caatinga areas in the Sertão (backlands) of Alagoas. The experiment was carried out in the municipalities of Olho D 'Água do Casado (area I) and Delmiro Gouveia (area II), state of Alagoas, a quantitative evaluation of the vegetation was carried out by contiguous plots within an area of 1.0 ha. The phytosociological parameters analyzed were Density, Relative Frequency and Dominance, Importance Value, Shannon-Weaver Diversity Index and Aggregation. The families with the greatest number of species are Mimosaceae and Bignoniaceae in area I and Mimosaceae and Anacardiaceae in area II, with a higher relative density for the species Tabebuia sp. and Schinopsis brasiliensis, respectively; the species Myrcia sp., Tabebuia sp. and Pilosocereus pachycladus in area I presented a higher value of importance, standing out Schinopsis brasiliensis, Pilosocereus gounellei and Pityrocarpa moniliformis in area II. The Shannon-Weaver (H') diversity index is considered high in area I and II when compared to other areas of Caatinga; similarly, floristic richness was considered similar in both areas.

Keywords: Vegetation. Semiarid. botanical composition.

RESUMO

A região semiárida brasileira apresenta condições naturais de clima, solo, topografia e vegetação bastante heterogênea, formando um mosaico de ecossistemas únicos. Desse modo a pesquisa teve como objetivo realizar uma análise fitossociológica do estrato árboreo-arbustivo de duas áreas de caatinga no sertão de Alagoas. O experimento foi realizado nos municípios de Olho D`Água do Casado (Área I) e Delmiro Gouveia (Área II), estado de Alagoas. Em cada município foi efetivado avaliação quantitativa da vegetação pelo método de parcelas contíguas em área de 1,0 ha. Os parâmetros fitossociológicos analisados foram: Densidade, Frequência e Dominância Relativa, Valor de Importância, Índice de diversidade de Shannon e de Agregação. As famílias com maior número de espécies são: Mimosaceae e Bignoniaceae na área I e Mimosaceae e Anacardiaceae na área II, com maior densidade relativa para as espécies Tabebuia sp. e Schinopsis brasiliensis, respectivamente; As espécies Myrcia sp., Tabebuia sp. e Pilosocereus pachycladus na área I apresentaram maior Valor de Importância, destacando-se Schinopsis brasiliensis, Pilosocereus gounellei e Pityrocarpa moniliformis na área II; O índice de diversidade Shannon (H') é considerado alto na área I e II quando comparados com outras áreas de caatinga, do mesmo modo, a riqueza florística foi considerada semelhante nas duas áreas.

Palavras-chave: *Vegetação. Semiárido. Composição botânica.*

1 Introduction

The semiarid region is characterized by heterogeneity of natural conditions of climate, soil, topography and vegetation According to Ab'Sáber (1984) the diversity of environments found in the large domain of Caatinga arises from different combinations of such abiotic components, whose forms of integration condition microenvironments according to which vegetation adaptations are organized.

In this region, the rainfall regime is highly variable (PRADO, 2003). Such seasonal climatic fluctuations occurring in the semiarid zone influence the vegetation of the Caatinga, since the climate of this region subjects plants to a high water deficiency and a great evapotranspiration due to low rainfalls, among other factors. Faced with this situation, plants triggered some peculiarities of physiological and behavioral variations throughout their evolution, guaranteeing a better adaptation and acquisition of environmental resources (FREIRE *et al.*, 2003).

This biome presents a great physiognomic variation as for density and plant size, being possible to observe easily recognizable changes in local scale until a few tens of meters, as is the case of valleys that present larger plants, while in flagged areas and shallow soils there is a smaller vegetation due to a greater or less availability of water (AMORIM *et al.*, 2005).

In the state of Alagoas, the Caatinga can be found in the microregion of the São Francisco backlands formed by the municipalities of Delmiro Gouveia, Olho D`Água do Casado and Piranhas, with 20.8% of fragments of remaining vegetation. Despite its great extent and importance to the semiarid region, only 0.28% of this biome is protected, according to the Conservation Units System (MAIA, 2015).

The main threats to this biome have been the withdrawal of natural resources in an indiscriminate manner, deforestation in an accelerated way for various purposes such as illegal and unsustainable use of wood for timber, expansion of pastures and agricultural crops. According to data by the Ministry of the Environment, deforestation reaches 46% of the biome's area (MMA, 2016).

Ferraz *et al.* (2013) pointed out that, in order to carry out biodiversity conservation projects and sustainable management plans in the Caatinga, it is necessary to understand the area's vegetation, its limitations and resilience capacity. In scientific debates, some concern has led to an increase in floristic and phytosociological surveys that allow monitoring possible changes in vegetation structure, as well as provide knowledge about the biome (PEREIRA JUNIOR, ANDRADE, ARAUJO, 2012), which focuses on biology, management and species dynamics (AMARAL *et al.,* 2012; MACHADO; LOPES, 2003).

In this context, the objective is to carry out a phytosociological analysis of the tree-shrub component of two Caatinga areas in the Alagoas Sertão to subsidize a greater knowledge of this flora.

2 Materials and Methods

The research was carried out in the municipalities of Olho D`Água do Casado (Area I) and Delmiro Gouveia (Area II), both in the Mesoregion of the Alagoas Sertão and in the Alagoas Microregion of the Sertão do São Francisco. The climate of the regions is tropical semiarid, with summer rains, annual rainfall averages of 431.8 mm and rainy period from November to April (MASCARENHAS *et al.*, 2005ab). The predominant vegetation in both municipalities is hyperxerophilic Caatinga with stretches of deciduous forest (MASCARENHAS *et al.*, 2005ab).

The areas of tree-shrub vegetation selected for this study are located in the Nova Esperança II settlements (Olho D`Água do Casado), characterized by being surrounded by rocky walls favoring the formation of an island of vegetation, and Maria Bonita (Delmiro Gouveia), characterized by being a vegetative fragment inserted in a top area.

Considering the local information on the use of the area and its occupation, it has been reported that the areas are in a good state of conservation, since animals (goats) are prevented from grazing in the dry season because of the restricted access. In both areas, there are no reports of burnings or agricultural crops.

The phytosociological survey was performed by contiguous plots, according to the methodology described by Muller-Dombois e Ellemberg (1974). In each municipality, an area of 1 hectare was selected with dimensions of 50 x 200 m, divided into 100 subplots of 10 x 10 m.

All live tree-shrub individuals with a Base Height Circumference (BHC) ≥ 9.0 cm and a height ≥ 1.0 m were quantified in each plot. BHC measurements were obtained at 10 cm from the soil level using a tape measure and then converted to diameter (D = BHC/π). In cases of branched individuals, the individual base area resulted from the sum of basal areas of each

branch. The height measurements of individuals were made using a graduated ruler.

To identify the species in the field, botanical material was collected from plants in each area, selecting three specimens of each species, which were sent to the Jayme Coelho de Moraes Herbarium, at Federal University of Paraíba, where they were submitted to drying in an oven for later identification using specialized bibliography and analysis of exsiccates previously identified in the Herbarium.

Phytosociological data of horizontal structure were obtained using the Mata Nativa 2 software (CIENTEC, 2006), the parameters analyzed were Absolute and Relative Density, Absolute and Relative Frequency, Absolute and Relative Dominance, and Importance Value for each species (MULLER-DOMBOIS; ELLENBERG, 1974). To quantify the diversity of the ecosystem, the Shannon-Weaver Index and the species distribution (aggregation) was also evaluated by applying the MacGuinnes Index (IGA).

3 Results and Discussion

3.1 Floristic composition and phytosociology of the areas

In the 100 plots inventoried in area I, 1,801 individuals were sampled, represented in 18 families, 28 genera and 35 botanical species. In area II, 1,568 individuals were sampled, distributed in 22 families, 35 genera and 40 botanical species.

Considering inclusion criteria similar to those adopted in this research for the phytosociological survey, higher density studies carried out on a Caatinga fragment in Monteiro, Paraíba, by Pereira Júnior, Andrade e Araújo (2012) obtained higher values of individuals/ha upon recording 3,495 ind./ha distributed in 14 families, 26 genera and 37 species. In a survey carried out by Lemos e Meguro (2015) at the Ecological Station of Aiuaba, Ceará, 3,007 individuals were sampled divided into 47 species and 20 families. Ferraz *et al.* (2013) in a survey conducted in a Caatinga area in Canindé do São Francisco, Sergipe, considering as inclusion criterion a diameter at soil level ≥ 6 cm, found 24 species, 21 genera and 12 families with the prominence for Fabacaea, Anacardiaceae and Euphorbiaceae.

Among the families recorded in area I, it was observed that the family Mimosaceae presented the highest number of individuals (436), followed by Bignoniaceae (228), Myrtaceae (199), Cactaceae (190), Euphorbiaceae (164) and Flacourtiaceae (140). In area II, the families that stood out with the greatest number of individuals were Mimosaceae (368), Anacardiaceae (313), Cactaceae (217), Caesalpinaceae (169), and Verbenaceae (104) (Table 1).

Studie conducted in the Rio Grande do Norte state corroborate with the results obtained, pointing the Mimosacea family as having the largest species recorded (AMORIM *et al.*, 2005). According to Santana e Souto (2006) Caesalpiniaceae, Euphorbiaceae and Mimosaceae families are the most commonly found in studies of areas with Caatinga vegetation. The tree-shrub vegetation was represented in area I by 35 species, among which there was a greater emphasis on *Tabebuia* sp. (228 individuals), *Myrcia* sp. (199), *Pilosocereus pachycladus* (167), *Croton argyrophylloides* (150), *Parapiptadenia zehntneri* (149), *Laetia apetala* (140), *Pityrocarpa moniliformis* (127) and *Byrsonima gardneriana* (119), which together constituted 71.01% of the individuals sampled (Table 2).

In the area II, there was a greater number of tree-shrub individuals in relation to the area I, presenting 40 species, most notably *Schinopsis brasiliensis* (308), *Pilosocereus gounellei* (176), *Pityrocarpa moniliformis* (145), *Chamaecrista amiciella* (115), *Lantana salzmanni* (104), *Parapiptadenia zehntneri* (81) and *Byrsonima gardneriana* (74), representing 63.96% of the individuals sampled (Table 3).

As for the total basal area of the individuals classified in the tree-shrub stratum with BHC ≥ 9.0 cm, values of 21.51 m^2 were found for area I (Table 2) and 13.51 m^2 for area II (Table 3). The results obtained in area I are higher than those found by Rodal et al. (2008) who found 18.5 m^2 in the same Caatinga area of the Sertão of Pernambuco, and than that observed by Santana e Souto (2006), who found 17.5 m^2 in the Caatinga of Seridó of Rio Grande do Norte, being superior to the values of area II (13.51 m^2).

Concerning the relative frequency, which measures the regularity of the distribution of each species within a community in a number of areas of equal size (plots) there was a predominance of the species *Pilosocereus pachiycladus* (10.03%), *Tabebuia* sp. (9.47%), *Myrcia* sp. and *Byrsonima gardneriana* (7.38%) in area I (Table 2). In area II, we can highlight the following species: *Schinopsis brasiliensis* (10.96%), *Pilosocereus gounellei* (10.50%), *Parapiptadenia zehntneri* (6.85%) and *Mimosa hexandra* (6.70%) (Table 3).

Table 1 – Number of individuals per family (NI) and frequencies of individuals (%) in area I (Olho D`Água do Casado, AL) and area II (Delmiro Gouveia, AL)

Famílias	Área I		Área II		Área I+II	
	NI	%	NI	%	NI	%
Anacardiaceae	8	0,44	313	19,9	321	9,53
Apocynaceae	11	0,61	11	0,70	22	0,65
Bignoniaceae	228	12,6	46	2,93	274	8,13
Boraginaceae	3	0,17	3	0,19	6	0,18
Burseraceae	73	4,05	1	0,06	74	2,20
Caesalpinaceae	31	1,72	169	10,8	200	5,94
Cactaceae	190	10,5	217	13,8	407	12,1
Capparaceae	7	0,39	28	1,79	35	1,04
Celastraceae	0	0,00	19	1,21	19	0,56
Erythroxylaceae	19	1,05	8	0,51	27	0,80
Euphorbiaceae	164	9,11	14	0,89	178	5,28
Fabaceae	72	4,00	14	0,89	86	2,55
Flacourtiaceae	140	7,77	52	3,32	192	5,70
Malpighiaceae	119	6,61	74	4,72	193	5,73
Mimosaceae	436	24,2	368	23,5	804	23,9
Myrtaceae	199	11,5	7	0,45	206	6,11
Rhamnaceae	2	0,11	2	0,13	4	0,12
Rubiaceae	82	4,55	0	0,00	82	2,43
Rutaceae	0	0,00	63	4,02	63	1,87
Sapotaceae	0	0,00	8	0,51	8	0,24
Solanaceae	0	0,00	2	0,13	2	0,06
Sterculiaceae	0	0,00	33	2,10	33	0,98
Verbenaceae	10	0,56	104	6,63	114	3,38
Não identificada	7	0,39	12	0,77	19	0,56
Total	1.801	100	1.568	100	3.369	100

Table 2 – Phytosociological parameters of the 20 most prominent species in area I (Olho D`Água do Casado, AL)

Espécies	NI	AB	FR	DR	DoR	IVI
		m2	(%)	(%)	(%)	(%)
Myrcia sp.	199	6,24	7,38	11,0	28,9	15,8
Tabebuia sp.	228	2,05	9,47	12,6	9,53	10,5
Pilosocereus pachycladus	167	1,84	10,03	9,27	8,58	9,29
Laetia apétala	140	1,41	6,55	7,77	6,56	6,96
Tocoyena formosa	82	2,03	6,13	4,55	9,44	6,71
Byrsonima gardneriana	119	1,30	7,38	6,61	6,03	6,67
Parapiptadenia zehnteneri	149	1,00	4,74	8,27	4,66	5,89
Pityrocarpa moniliformis	127	0,97	5,29	7,05	4,50	5,61
Croton sp.	150	0,33	4,87	8,33	1,53	4,91
Commiphora leptophloeos	73	0,76	5,15	4,05	3,53	4,25
Chloroleucon foliolosum	54	0,94	5,15	3,00	4,39	4,18
Fabaceae (1)	71	0,66	4,46	3,94	3,08	3,83
Mimosa arenosa	31	0,49	3,06	1,72	2,28	2,35
Piptadenia sp.	28	0,10	2,65	1,39	0,45	1,55
Mimosa hexandra	20	0,32	1,95	1,11	1,49	1,52
Mimosa aff. Pthecolobroies	27	0,29	1,39	1,50	1,37	1,42
Libidibia férrea	19	0,15	2,37	1,05	0,70	1,38
Pilosocereus gounellei	17	0,17	2,09	0,94	0,78	1,27
Erythroxylum revolutum	19	0,07	0,97	1,11	0,33	0,79
Chamaecrista amiciella	12	0,03	1,39	0,67	0,13	0,73
Total	1.801	21,51	100	100	100	100
H'	3,07	-	-	-	-	-

NI = Number of individuals; BA = Basal area; RF = Relative Frequency; RD = Relative Density; RDo = Relative Dominance and IVI = Importance Value Index.

Table 3 – Phytosociological parameters of the 20 most prominent species in Área II (Delmiro Gouveia–AL)

Espécies	NI	AB	FR	DR	DoR	IVI
		m2	(%)	(%)	(%)	(%)
Acacia bahiensis	31	0,23	1,98	1,98	1,68	1,88
Parapiptadenia zehnteneri	81	0,61	5,17	6,85	4,51	5,51
Pityrocarpa moniliformis	144	1,52	9,18	4,26	11,25	8,23
Fabaceae (1)	13	0,08	0,83	1,22	0,56	0,87
Byrsonima gardneriana	74	0,69	4,72	5,02	5,06	4,93
Libidibia férrea	14	0,18	0,89	2,13	1,30	1,44
Caesalpinia pyramidalis	37	0,40	2,36	2,74	2,94	2,68
Capparis flexuosa	28	0,23	1,79	3,50	1,71	2,33
Laetia apétala	52	0,59	3,32	5,18	4,36	4,28
Melochia tomentosa	33	0,25	2,10	2,13	1,82	2,02
Maytenus rígida	19	0,12	1,21	2,44	0,91	1,52
Lantana salznanni	104	0,57	6,63	4,26	4,19	5,03
Chamaecrista amiciella	115	0,76	7,33	6,39	5,60	6,44
Mimosa hexandra	70	0,87	4,46	6,70	6,41	5,86
Mimosa arenosa	34	0,21	2,17	2,89	1,53	2,20
Pilosocereus gounellei	177	1,42	11,29	10,50	10,50	10,76
Pilosocereus pachiycladus	39	0,32	2,49	4,11	2,36	2,99
Schinopsis brasiliensis	308	2,34	19,64	10,96	17,26	15,95
Tabebuia P.	34	0,59	0,70	1,22	0,39	2,78
Zanthoxylum pohlianum	63	0,79	2,17	1,83	4,34	3,95
Total	1.568	13,51	100	100	100	100
H'	2,89	-	-	-	-	-

NI = Number of individuals; BA = Basal area; RF = Relative Frequency; RD = Relative Density; RDo = Relative Dominance and IVI = Importance Value Index.

It was verified that all species had a low percentage, indicating that they are not well distributed within the sample units. A species with a value of 100% indicates that it is well distributed in the community, being found in all sample units. Low values, in turn, indicate that this species is not well distributed, appearing concentrated in few sample units.

Silva et al. (2013) pointed out that the species *Schinopsis brasiliensis* belongs to the vulnerable category in the official list of endangered species of Brazilian flora, and emphasizes the importance of a greater protection of areas against anthropic pressures.

Regarding the species with a high relative density, the highlight in area I in descending order was for *Tabebuia* sp. (12.66%), *Myrcia* sp. (11.05%), *Pilosocereus pachiycladus* (9.27%), *Croton* sp. (8.33%), *Parapiptadenia zehntnri* (8.27%) and *Laetia apetala* (7.77%), totaling 57.35% of the total relative density (Table 2). The species with the highest occurrence in area II were *Schinopsis brasiliensis* (19.64%), *Pilosocereus gounellei* (11.29%), *Pityrocarpa moniliformis* (9.18%), *Chamaecrista amiciella* (7.33%), *Lantana salznanni* (6.63%) and *Parapiptadenia zehntnri* (5.17%), with 59.24% of the total sampled individuals (Table 3).

The three species with the greatest relative dominance in area I were *Myrcia* sp. (28.99%), *Tabebuia* sp. (9.53%) and *Tocoyena formosa* (9.44%) (Table 2); in area II, there was a dominance of the species *Schinopsis brasiliensis* (17.26%), *Pityrocarpa moniliformis* (11.25%) and *Pilosocereus gounellei* (10.50%) (Table 3).

It was observed that, practically, the same species that stood out in the other parameters (density and relative dominance) also stood out for Importance Value Index (IVI), as verified for *Myrcia* sp. (IVI = 15.81%), *Tabebuia* sp. (IVI = 10.55%), *Pilosocereus pachiycladus* (IVI = 9.29%), *Laetia apetala* (IVI = 6.96%), *Tocoyena formosa* (IVI = 6.71%) and *Byrsonima gardneriana* (IVI = 6.67%) in area I, which totaled 67.49% of the value of Total Importance Value Index (Table 2). In area II, the species *Schinopsis brasiliensis* (IVI = 15.95%), *Pilosocereus gounellei* (IVI = 10.76%), *Pityrocarpa moniliformis* (IVI = 8.23%), *Chamaecrista amiciella* (IVI = 6.44%), *Mimosa hexandra* (IVI = 5.86%) and *Parapiptadenia zehntneri* (IVI = 5.51%) obtained a high Importance Value, totaling 52.75% of the ecological importance of the study area (Table 3).

The value of importance of the species in both studied areas was determined, and only two species of each area presented a value of importance > 10%, demonstrating the dominance of these species among the population.

It is worth noting that the species with the highest value of importance observed in the study areas were not commonly found in the different Caatinga areas, as shown by the work conducted by Santana e Souto (2006), who determined the species *Caesalpinia pyramidalis* with the highest value of importance, followed by *Asbidosperma pyrifolium*. In the survey carried out by Queiroz *et al.* (2006) this same species, with the highest importance value, was recorded in the city of Boqueirão, PB. Alcoforado-Filho *et al.* (2003) stated that *Caesalpinia pyramidalis* is one of the most frequent species in the list of studies on the vegetation of the Caatinga.

3.2 Floristic diversity

The Shannon-Weaver (H') diversity index represents the floristic heterogeneity of an area. Thus, the greater the value of the Shannon-Weaver diversity index (H'), the greater the floristic diversity of the studied community (Ramalho, 2009). Thus, it was observed that the values found in this study (3.07, area I; and 2.89, area II) were higher than those observed in other surveys in Caatinga areas adopting the same inclusion criteria as observed by Santos *et al.* (2009) and Oliveira *et al.* (2009) and no semiárido Nordestino.

4 Conclusions

The families with the highest number of species in the tree-shrub stratum are Mimosaceae and Bignoniaceae in area I (Olho D'Água do Casado, AL) and Mimosaceae and Anacardiaceae in area II (Delmiro Gouveia, AL), with a higher relative density for the species *Tabebuia* sp. and *Schinopsis brasiliensis*, respectively.

The species *Myrcia* sp., *Tabebuia* sp. and *Pilosocereus pachycladus* had the highest value of importance in area I, and *Schinopsis brasiliensis, Pilosocereus gounellei* and *Pityrocarpa moniliformis* in area II.

The Shannon-Weaver (H') diversity index was considered high in areas I and II when compared to other areas of Caatinga, just as floristic richness was considered similar in both areas.

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