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Physiognomy and structure of a caatinga with *Cordia oncocalyx* (Boraginaceae), a new type of community in Andrade-Lima's classification of caatingas

Fisionomia e estrutura de uma caatinga com Cordia oncocalix *(Boraginaceae), um novo tipo de comunidade na classificação das caatingas de Andrade-Lima*

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Abstract

Recently, the inclusion of physiognomies with *Cordia oncocalyx* Allemão (Boraginaceae) as a new type/unit within Andrade-Lima's classification of caatingas (ALFPC) has been proposed. However, no study has quantitatively analyzed this proposal so far. In order to fill this gap, a phytosociological study was conducted in a caatinga with *C. oncocalyx*, and differences in structure and physiognomy in relation to compiled caatinga studies were verified. 1795 plants from 25 species and a total basal area of 35.26 m^2 were found. *C. oncocalyx* and *Mimosa caesalpiniifolia* Benth. (Fabaceae) had 48% of total importance index (IV). The physiognomy was characterized by the predominance of individuals of intermediate height (3—4 m) and the tallest ones accounted for the highest fraction of basal area. Of the five species with highest IV, only one had high frequency among the species with highest IV in the compiled studies (16/35). Only two of these compiled studies were comparable to the present study, and only one could be classified according to ALFPC. A contrast between that study and the present one was found, as the first reports a dense community with high number of small diameter individuals accounting for most of the basal area. These findings suggest the suitability of including *C. oncocalyx* caatingas in low and medium caatinga forests as proposed in ALFPC. However, the low number of comparable studies limits generalizations.
Key-words: community structure, phytosociology, semi-arid, vegetation classification.

Resumo

Recentemente foi proposta a inclusão de fisionomias com *Cordia oncocalyx* Allemão (Boraginaceae) como um novo tipo/unidade à classificação de caatingas de Andrade-Lima (CFFAL). Porém, nenhum estudo avaliou quantitativamente essa proposta. Este estudo visou descrever a fisionomia e estrutura de uma caatinga com *C. oncocalyx* comparando-a a outros estudos para verificar diferenças estruturais e fisionômicas. Amostrou-se 1795 indivíduos de 25 espécies, somando uma área basal de 35,26 m^2. *C. oncocalyx* e *Mimosa caesalpiniifolia* Benth. (Fabaceae) representaram 48% do VI total. A fisionomia foi caracterizada pelo predomínio de indivíduos de altura intermediária (3—4 m) e concentração de área basal nos indivíduos altos (> 8 m). Dentre as cinco espécies com maior valor de importância (VI), apenas uma teve frequência alta dentre as cinco espécies de maior VI de levantamentos compilados (16/35). Desses levantamentos, apenas dois eram comparáveis a este estudo e só um pôde ser classificado conforme a CFFAL, inserindo-se dentre caatingas arbóreas abertas. Nesse caso, a comunidade era densa e dominada por indivíduos finos e baixos, em contraste à caatinga aqui estudada. Os resultados indicam a adequação da inclusão das caatingas com *C. oncocalyx* dentre caatingas florestais médias e baixas da CFFAL. Porém, o baixo número de estudos comparáveis limita o alcance de generalizações.
Palavras-chave: classificação de vegetação, estrutura de comunidades, fitossociologia, semiárido.

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Introduction

The dominant plant formation in Brazilian semi-arid region, known as caatinga, is frequently mentioned in the literature as widely variable in composition as well as in physiognomy, in response to the heterogeneity of climate, topography, types of soil and anthropic influnce (Andrade-Lima 1981; Sampaio 1995; Fernandes 1998). Such heterogeneity has motivated many proposals for classification of types of caatinga, based on physiognomic as well as on floristic-physiognomic criteria (Luetzelburg 1923; Rizzini 1979; Andrade-Lima 1981; Eiten 1983; Fernandes 1998; Veloso *et al.* 1991).

Amongst the existing systems, the floristic-physiognomic classification by Andrade-Lima (1981 – hereafter referred to as ALFPC) is regarded as one of the most important ones due to the details it presents (Sampaio 1995). Andrade-Lima (1981) divided the caatingas into 12 main vegetation types, based on what he considered to be the most "remarkable" species, and grouped them into six physiognomic units. These units include tall caatinga forests (unit I), median and low caatinga forests (units II and III), shrubby caatingas (units IV and V), and fringe caatinga forests (unit VI).

Although Andrade-Lima (1981) had emphasized the provisionality of his classification, it was only 12 years later that Prado (2003) proposed the inclusion of a new type of community. This new type was mentioned by Andrade-Lima (1981) as a *facie* within II, median and low caatinga forests, characterized by a group of major species which are uncommon to other vegetation types described, especially *Auxemma oncocalyx* Baill. (currently repositioned to *Cordia* (Boraginaceae) Gottschling & Miller 2006).

As well as Andrade-Lima (1981), Prado's proposal (2003) was also based on qualitative observations, and so far there are no quantitative descriptions explicitly dealing with the types of caatinga communities proposed in ALFPC, limiting the quantitative evaluation of scope and applicability of ALFPC, as well as of the inclusion of the new community proposed by Prado (2003). Aiming to fill that gap, the objective of this study was to describe the physiognomy and structure of a caatinga community with *Cordia oncocalyx* Allemão, and compare it to other studies in caatinga communities in order to find out if it is characterized by a unique group of major species and how much it differs from the others phytosociologically.

Material and Methods

The survey was carried out at RPPN Serra das Almas (5°7'0.01"S and 40° 52'22.79"W), municipality of Crateús, Central-western region of the state of Ceará. The reserve was created in 2000 (IBAMA Normative Act no. 51/00 of 08/09/00), and covers an area of 6,146 hectares, comprising slopes and the top of the Ibiapaba plateau and of the adjacent depression on the crystalline basement complex. 29.19% from the total area of the reserve corresponds to caatinga vegetation. Data collection was carried out in an area on crystalline depression at Grajau, at an altitude of 368 m, on Planosol. Average annual rainfall in this area is 698 mm, 84% concentrated from January to April (rainy season). In September and October, on average, rainfall accounts for less than 1 mm, and the average annual temperature is 26.8°C (Ibiapaba meteorological station, 8 km from the study site, 20-year time series, according to Fundação Cearense de Meteorologia data). The area has been protected since 1998, and in previous excursions, little evidence of selective logging was observed in the study site, as well as high occurrence of *C. oncocalyx*, species that defines the new type of community proposed by Prado (2003).

In this area, a phytosociological survey was carried out in January 2003, in a permanent plot (reference coordinates: 40º52'21''S, 5º6'59''W) subdivided in 100 sub-plots of 10 × 10 m. The height was estimated and diameter was measured for plants with up to 3 cm of diameter at ground level (DNS). Each individual was marked with a metal tag and previously identified in the field; this identification was later verified by the collection of reproductive botanical material and consultation of botanical identification keys and herbarium material. The botanical material was deposited in the EAC herbarium. The delimitation of families followed the APG III system (2009).

The collected data was tabulated on a spreadsheet (BrOfice.org 3.0.1, Sun Microsystems, Inc.), and the general phytosociological parameters were calculated: density, total basal area, mean and maximum height and diameter, richness and Shannon's diversity index (H', in natural logarithm). Frequency distributions were constructed for individuals and for the sum of the basal area by

height classes and of frequencies of individuals by diameter claasses. To make the comparisons easier, the same classes used in other studies were adopted (Alcoforado-Filho *et al.* 2003; Rodal *et al.* 2008b). Whenever possible, the Kolmogorov-Smirnov test was carried out in order to test differences among size distributions.

Articles and thesis containing phytosociological surveys carried out in caatinga vegetation areas were compiled for comparisons among general phytosociological parameters. (Tab. 1). Each area studied in the selected surveys was considered as a separate survey and classified according to ALFPC, based on genera with highest importance value and on geographical location.

For each species included in our survey, the frequency, density, and absolute and relative dominance, as well as the Importance Value (IV) were calculated. The phytosociological calculations were made with the aid of the software Fitopac 1.0 (Shepherd 1995), and the charts and statistics in R environment, version 2.10.0 (R Development Core Team 2009).

In order to verify whether the most important species of a caatinga with *C. oncocalyx* are uncommon in other types of caatinga communities, we counted the number of times each of the highest IV species in this study occured among highest IV species of the compiled studies (Tab. 1). In these comparisons, only surveys that used an inclusion criterion similar to this study were used.

Results and Discussion

The studied caatinga had a richness of 14 families and 25 species, specific Shannon diversity of 2.271. Fabaceae was the family with the highest richness, with more than a third of the species, followed by Euphorbiaceae and Apocynaceae, with three and two species, respectively (Tab. 2). The community was characterized by the high phytosociological importance of few species: *Cordia oncocalyx* Allemão and *Mimosa caesalpiniifolia* Benth. correspond to almost half the sum of IV for all sampled species (Tab. 2). The high importance of these species in the community is due to different characteristics; *C. oncocalyx* concentrates more than 50% of all the basal area of the sample, has plants with large diameters, frequency and intermediate densities (Tab. 2). *M. caesalpiniifolia*, on the other hand, has high IV associated with high density and frequency of individuals in the sample (Tab. 2).

Phytosociological surveys of 35 caatinga areas were compiled (Tab. 1). The comparison of the five species with highest IV in the studied caatinga with the caatingas in the other surveys shows that the former is characterized by an uncommon group of major species (Tab. 3). Only *Croton blanchetianus* Müll. Arg. (identified in the other surveys as *Croton sonderianus* Müll. Arg.) has significant occurrence (16 out of 35 surveys) among the five most important species in the compared surveys. The second species with greater IV in this study, *Poincianella bracteosa* (Tul.) L.P.Queiroz, occurred in only 2 out of 35 surveys cited. In the context of ALFPC, this result shows that, as Andrade-Lima (1981) and Prado (2003) had proposed, from the floristic point of view, the caatingas with *C. oncocalyx* can be considered a distinguished type of community within this classification, as they actually present a unique group of major species.

1,795 individuals.ha^{-1} were registered, which corresponds to a total basal area of 35.26 m^2. This group had median height of 4.64 m (standard deviation = 1.8 m) and maximun height of 13 m, while the mean and maximum diameters were 11.3 cm (standard deviation = 11 cm) and 85.9 cm, respectively. The community was characterized by numerical predominance of individuals 2 to 5 m tall (66%, Fig. 1a) and by high concentration of basal area in individuals taller than 6 m (65%, Fig. 1b).

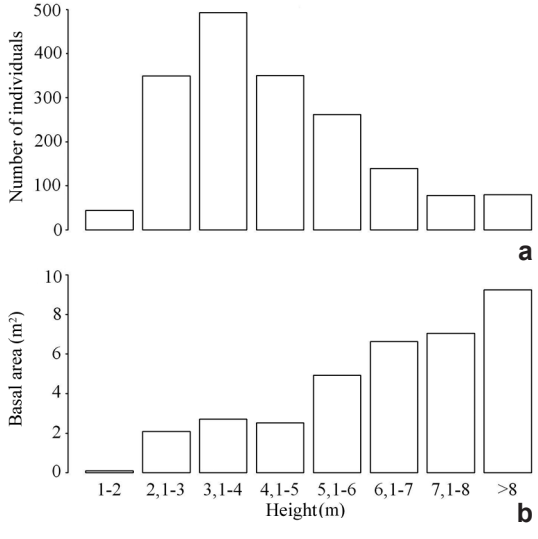

Figure 1 – Frequency distributions of the number of individuals (a) and total basal area (b) by height class in the studied plot at RPPN Serra das Almas, Crateús, Ceará.

Table 1 – Compiled phytosociological studies with respective location, sample effort (in hectares), sample method (MET), inclusion criteria (CI) and common species among the five highest IV species in this study and the five highest IV species in each compiled study. P – plot method, DNS>=3 – diameter at soil level equal to or greater than 3 cm, CAB>=10 – perimeter at soil level equal to or greater than 10 cm, CAB>=12 – perimeter at soil level equal to or greater than 12 cm.

Reference	Municipality	Location	State	Effort	MET	CI	Coincident species with highest IV
Alcoforado-Filho *et al.* (2003)	Caruarú	IPA	PE	7200	P	DNS>=3	-
Andrade *et al.* (2005)	São João do Carirí	E.E. UFPB 2	PB	2400	P	CAB>=10	*Croton sonderianus*
Andrade *et al.* (2005)	São João do Carirí	E.E. UFPB 1	PB	2400	P	CAB>=10	*Croton sonderianus*
Barbosa *et al.* (2007)	São José dos Cordeiros	RPPN Faz. Almas	PB	5000	P	DNS>=3	*Croton sonderianus*
Barbosa *et al.* (2007)	São joão do Carirí	E.E. de S.J. do Carirí	PB	1080	P	DNS>=3	*Croton sonderianus*
Fabricante & Andrade (2007)	Santa Luzia	Faz. Madalena	PB	4000	P	DNS>=3	*Croton sonderianus*
Ferraz *et al.* (2003)	Serra Talhada	Pimenteira	PE	2000	P	DNS>=3	*Croton sonderianus*
Ferraz *et al.* (2003)	Serra Talhada	Mandassaia	PE	1000	P	DNS>=3	*Croton sonderianus*
Fonseca (1991)	Canindé do São Francisco	Faz. California	SE	1500	P	DNS>=3	-
Fonseca (1991)	Canindé do São Francisco	Curituba	SE	1500	P	DNS>=3	-
Fonseca (1991)	Poço Redondo	Faz. Barra (B)	SE	1500	P	DNS>=3	-
Fonseca (1991)	Canindé do São Francisco	Estr. Brejo	SE	1500	P	DNS>=3	-
Fonseca (1991)	Poço Redondo	Faz. Barra da Onça (A)	SE	1500	P	DNS>=3	-
Freitas *et al.* (2007)	Messias Targino	Faz. Soares 2	RN	2400	P	DNS>=3	*Croton sonderianus*
Freitas *et al.* (2007)	Messias Targino	Faz. Soares 1	RN	2400	P	DNS>=3	*Croton sonderianus*
Lemos & Rodal (2002)	São Raimundo Nonato	PARNA Serra da Capivara	PI	10000	P	DNS>=3	-
Maracajá *et al.* (2003)	Serra do Mel	Vl. Sta. Catarina 1	RN	2400	P	CAB>=10	*Croton sonderianus*
Maracajá *et al.* (2003)	Serra do Mel	Vl. Sta. Catarina 2	RN	2400	P	CAB>=10	*Croton sonderianus*
Moreira *et al.* (2007)	Caraúbas	Xique-xique (Preservada)	RN	2400	P	CAB>=12	*Poincianella bracteosa*
Moreira *et al.* (2007)	Caraúbas	Xique-xique (Antropizada)	RN	2400	P	CAB>=12	*Croton sonderianus, Poincianella bracteosa*
Nascimento *et al.* (2003)	PetrolinaD+TL	EMBRAPA (D+TL)	PE	4300	P	DNS>=3	-
Nascimento *et al.* (2003)	PetrolinaDI+TL	EMBRAPA (DI+TL)	PE	7900	P	DNS>=3	-
Nascimento *et al.* (2003)	PetrolinaMR	EMBRAPA (MR)	PE	400	P	DNS>=3	-

Reference	Municipality	Location	State	Effort	MET	CI	Coincident species with highest IV
Nascimento *et al.* (2003)	PetrolinaTS	EMBRAPA (TS)	PE	400	P	DNS>=3	*Croton sonderianus*
Pegado *et al.* (2006)	Monteiro	Ambiente 2	PB	4000	P	DNS>=3	-
Pegado *et al.* (2006)	Monteiro	Ambiente 1	PB	4000	P	DNS>=3	-
Pereira *et al.* (2002)	Areia/ Remígio	Faz. São Bento	PB	6000	P	DNS>=3	*Croton sonderianus*
Queiroz *et al.* (2006)	Boqueirão	Sa. do Monte	PB	2000	P	DNS>=3	*Croton sonderianus*
Rodal *et al.* (2008a)	Custódia	Boa Vista (direita)	PE	2500	P	DNS>=3	-
Rodal *et al.* (2008a)	Custódia	Boa Vista (esquerda)	PE	2500	P	DNS>=3	-
Rodal *et al.* (2008a)	Floresta	Fasa	PE	2500	P	DNS>=3	-
Rodal *et al.* (2008a)	Floresta	Poço do Ferro	PE	2500	P	DNS>=3	-
Rodal *et al.* (2008b)	Floresta/ Betânia	RPPN Maurício Dantas	PE	10000	P	DNS>=3	-
Santana & Souto (2006)	Serra Negra do Norte	ESEC Seridó	RN	6000	P	DNS>=3	*Croton sonderianus*
Santos *et al.* (2007)	Montes Claros	Pq. Mun. da Sapucaia	MG	4000	P	CAB>=10	-

Table 2 – Phytosociological parameters of sampled species in the studied plot at RPPN Serra das Almas, Crateús, Ceará. N° ind ─ number of individuals, Fr ─ absolute frequency, AB – basal area in m^2, IV – importance value, % IV – percentage of total IV of all species.

Species	Voucher	Family	N° ind	Fr	AB	IV	%IV
Cordia oncocalyx Allemão	R.C. Costa, 404	Boraginaceae	195	59	18,301	73,13	24,38
Mimosa caesalpiniifolia Benth.	R.C. Costa, 399	Fabaceae	530	95	8,554	70,48	23,49
Croton adenocalyx Baill.	F.S. Araújo, 1346	Euphorbiaceae	250	45	2,750	29,63	9,88
Croton blanchetianus Müll. Arg.	F.S. Araújo, 1356	Euphorbiaceae	255	54	0,434	24,93	8,31
Poincianella bracteosa (Tul.) L.P.Queiroz	R.C. Costa, 401	Fabaceae	75	50	2,419	19,83	6,61
Bauhinia cheilantha (Bong.) Steud.	F.S. Araújo, 1397	Fabaceae	124	51	0,352	16,87	5,62
*Piptadenia stipulacea (*Benth.) Ducke	F.S. Araújo, 1426	Fabaceae	94	45	0,350	14,14	4,71
Combretum leprosum Mart.	F.S. Araújo, 1516	Combretaceae	45	33	0,167	8,78	2,93
Cochlospermum vitifolium (Willd.) Spreng.	S.F. Vasconcelos, 4	Bixaceae	61	13	0,232	6,34	2,11
Myracrodruon urundeuva Allemão	PROBIO, 400	Anacardiaceae	25	18	0,624	6,33	2,11
Aspidosperma pyrifolium Mart.	PROBIO, 403	Apocynaceae	22	16	0,306	4,91	1,64
Justicia sp.	F.S. Araújo, 1539	Acanthaceae	27	13	0,238	4,46	1,49
Pseudobombax marginatum (A. St.-Hil., Juss. & Cambess.) A. Robyns	F.S. Araújo, 1553	Malvaceae	21	16	0,124	4,33	1,44

Species	Voucher	Family	N° ind	Fr	AB	IV	%IV
Anadenanthera colubrina var. *cebil* (Griseb.) Reis	R.C. Costa, 562	Fabaceae	18	14	0,173	3,96	1,32
Amburana cearensis (Allemão) A. C. Sm.	M.S. Sobrinho, 202	Fabaceae	12	10	0,064	2,61	0,87
Mimosa tenuiflora (Willd.) Poir.	F.S. Araújo, 1544	Fabaceae	12	9	0,029	2,33	0,78
Libidibia ferrea (Mart. ex Tul.) L.P.Queiroz	F.S. Araújo, 1555	Fabaceae	9	9	0,052	2,23	0,74
Jatropha mollissima (Pohl) Baill.	R.C. Costa, 350	Euphorbiaceae	6	5	0,012	1,25	0,42
Aspidosperma cuspa (Kunth) S. F. Blake ex Pittier	F.S. Araújo, 1352	Apocynaceae	4	4	0,008	0,95	0,32
Lantana camara L.	R.C. Costa, 370	Verbenaceae	4	4	0,005	0,94	0,31
Guapira graciliflora (Schmidt) Lundell	J.R. Lima, 34	Nyctaginaceae	2	2	0,006	0,48	0,16
Commiphora leptophloeos (Mart.) J.B. Gillett	J.R. Lima, 48	Burseraceae	1	1	0,050	0,37	0,12
Erythrina velutina Willd.	R.C. Costa, 328	Fabaceae	1	1	0,009	0,26	0,09
Cynophalla flexuosa (L.) J. Presl.	Observada	Capparaceae	1	1	0,003	0,24	0,08
Handroanthus impetiginosus Mattos.	Observada	Bignoniaceae	1	1	0,001	0,23	0,08

Table 3 – Frequency of the five species with highest IV in this study among five species with highest IV among 35 compiled caatinga phytosociological studies. Compiled studies were from Brazilian northeastern states and Minas Gerais state and are listed in Table 1.

Species	Family	%IV	IV	Frequency
Cordia oncocalyx	Boraginaceae	24,38	73,13	0
Mimosa caesalpiniifolia	Fabaceae	23,49	70,48	0
Croton adenocalix	Euphorbiaceae	9,88	29,63	0
Croton blanchetianus	Euphorbiaceae	8,31	24,93	16/35
Poincianella bracteosa	Fabaceae	6,61	19,83	2/35

Of the 35 compiled surveys (Tab. 1), only two present method, inclusion criterion and sampling efforts similar to those in the present study (Rodal *et al.* 2008b, Lemos & Rodal 2002). Based on the genera of the major species and on geographic location, it was only possible to classify the survey by Rodal *et al.* (2008b) according to ALFPC. The caatinga described in the study by Lemos & Rodal (2002) does not fit the types of community in ALFPC, which indicates the possibility of new proposals to include types of communities in Andrade-Lima's classification (1981).

The caatinga studied by Rodal *et al.* (2008b) was classified in unit II, type six, which corresponds to "caatingas arbóreas abertas" (open arboreous caatingas). When compared to the caatinga with *C. oncocalyx* studied here, remarkable physiognomic differences are observed (the same classes were used for the size distributions). In relation to that survey, the caatinga studied here has low density (1,795 × 3,140 individuals ha^{-1}) and high basal area (35.26 × 18.5 $m^2 ha^{-1}$). High density in Rodal *et al.* (2008b) is due to short individuals (the modal height is 1 to 2 m) that concentrate most of the sampled basal area (figure 2 in Rodal *et al.* 2008b). Here, there is a predominance of individuals of intermediate height (modal height 3 to 4 m); however, the largest concentration of basal area corresponds to large individuals,

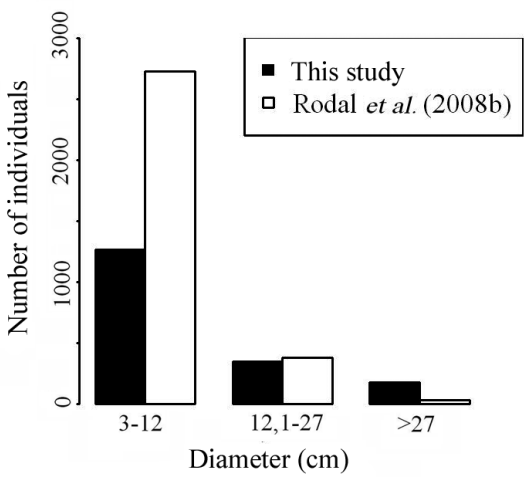

Figure 2 – Frequency distributions of individuals in diameter classes in the studied plot at RPPN Serra das Almas, Crateús, Ceará; and in Rodal *et al.* (2008).

especially of the species *C. oncocalyx,* which reaches 70% (16.1 m^2) of the basal area of individuals taller than 6 m. Although the distribution of individuals into three diameter classes had not differed (Kolmogrov-Smirnov, D = 0.33, p=1), a comparison of the absolute values shows that, in Rodal *et al.* (2008b) there are more individuals in the smaller diameter class, while in this study there is greater density of individuals in the larger diameter class (Fig. 2).

Although the caatinga studied by Rodal *et al.* (2008b) has been classified as type six (open arboreous caatingas – low density), its characteristics do not agree exactly with the physiognomic definition of this type of community, since it had high plant density. However, the characteristics of greater heights of the plants and low density placed the caatinga studied here in Andrade-Lima's description (1981) for the types of caatinga in unit II (median and low caatinga forests and open arboreous caatingas). The high concentration of basal area in larger individuals seems to be a unique characteristic of the studied caatinga, especially because this characteristic is due, in large part, to a single species, *C. oncocalyx*. This point should be better explored in posterior comparative studies aiming to define more precisely whether this is an exclusive aspect and what is the ecological importance of *C. oncocalyx* in the structuring of this type of community.

The results and comparisons obtained in this study show that, physiognomically, the new type of community proposed in ALFPC corresponds to the median and low caatinga forests of unit II, while the presence of a unique group of major species distinguishes it from the other community types in ALFPC. It should be noted that the limited number of surveys available for comparison in the literature limits a more consistent quantitative assessment of the physiognomic variation among other types of caatinga and this one, and only generalizations of primary nature are possible.

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