



Original Paper

Flora and physiognomy of *Caatinga* vegetation over crystalline bedrock in the northern *Caatinga* domain, Brazil

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Abstract

The Seasonally Dry Tropical Forests and Woodlands biome (SDTFW) has its largest nucleus in the *Caatinga* domain. We characterized the flora and physiognomy of the vegetation in the Pedra da Andorinha Wildlife Refuge (RPA), in Ceará, Brazil. Plant collections were made between March/2015 and May/2021, applying usual botanical methods. All material was deposited in HUVA herbarium. The phytosociological studies covered five 50 m x 50 m plots established (1.25 ha) in which all individuals with diameters at soil level ≥ 3 cm were inventoried. We identified 266 vascular plants species distributed among 185 genera and 67 families, including one fern (*Marsilea deflexa* - Marsileaceae). Fabaceae had the greatest species richness (38 spp.), while *Ipomoea* was the richest genus (9 spp.). 43.6% of all plant species were herbaceous, with a predominance of therophytes (57.5% of all herbaceous plants). The phytosociological study sampled 1,988 individuals distributed among 24 species of 13 families. The species with the greatest important value were *Cordia oncocalyx* (Boraginaceae) and *Croton blanchetianus* (Euphorbiaceae). We classify the local physiognomy as typical *caatinga sensu stricto* vegetation and rocky vegetation on inselbergs and outcrops. We highlight the richness of herbaceous plants in the local community, which surpass the richness of the woody component.

Key words: floristics, life forms, phytosociology, SDTFW, semiarid.

Resumo

O bioma das Florestas e Arbustais Tropicais Sazonalmente Secos tem na *Caatinga* sua mais extensa área, possuindo elevada diversidade florística e ambiental. Caracterizamos a composição florística e a fisionomia da vegetação no Refúgio da Vida Silvestre Pedra da Andorinha (RPA), área de conservação no noroeste do estado do Ceará, Brasil. Realizamos coletas botânicas entre março de 2015 e maio de 2021, aplicando os métodos tradicionais de coleta e herborização. Todo o material foi depositado no herbário HUVA. A fitossociologia foi feita em cinco parcelas de 50 x 50 m (1,25 ha), onde os indivíduos lenhosos com diâmetro ao nível do solo ≥ 3 cm foram inventariados. Avaliamos os parâmetros fitossociológicos de estrutura da vegetação e sua diversidade florística. Identificamos 266 plantas vasculares, distribuídas em 185 gêneros e 67 famílias,

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incluindo uma pteridófita (*Marsilea deflexa* - Marsileaceae). A família Fabaceae teve a maior riqueza (38 spp.), enquanto *Ipomoea* foi o gênero mais rico (9 spp.). O componente herbáceo foi o componente mais rico (43,6%), com uma predominância de herbáceas terófitas (57,5% de todas as plantas herbáceas). O estudo fitossociológico amostrou 1.988 indivíduos, distribuídos em 24 espécies de 13 famílias. As espécies com maior valor de importância foram *Cordia oncocalyx* e *Croton blanchetianus*, responsáveis por 63% dos indivíduos amostrados. Classificamos a área como Caatinga *sensu stricto* e em vegetação rupícola de inselbergues e afloramentos rochosos, chamando a atenção para a elevada riqueza de espécies no componente herbáceo, que, como em outras áreas de Caatinga *sensu stricto*, supera a riqueza de espécies lenhosas.

Palavras-chave: fitossociologia, florestas tropicais sazonalmente secas, florística, formas de vida, semiárido.

Introduction

The *Caatinga* domain is currently considered the largest and most diverse nucleus of the Seasonally Dry Tropical Forests and Woodlands biome (SDTFW), in which 3,347 different species, 962 genera, and 153 families of angiosperms have been identified, with 526 species and 29 genera being considered endemic (Fernandes *et al.* 2020).

One hundred and thirty-five geo-environments, composing at least eight ecoregions, exist in that extensive ecological region, demonstrating a significant heterogeneity of *Caatinga* environments (Velloso *et al.* 2002). A number of different proposals of biogeographic subdivisions for the *Caatinga* have been suggested over the years. Silva *et al.* (2017) recently proposed modifying the delimitation of what is normally considered the *Caatinga* phytogeographic domain to include the dry forests along the midcourse of the São Francisco River and to exclude the Campo Maior ecoregion in Piauí state (whose phytophysiology and flora are more closely related to the *Cerrado*).

The floristic heterogeneity observed among the diverse *caatinga* phytophysionomies has been examined based on the hypothesis of the influence of geological strata on the floristic composition of those different areas. Current research indicates that there are at least two large floristic subgroups within the flora of the *Caatinga* domain: sedimentary *caatinga*, on the sandy terrains of the sedimentary basins, and *caatinga* over crystalline bedrock (crystalline *caatinga*). Each subgroup occupies approximately 30% and 70% of the inland semiarid surface respectively (Cardoso & Queiroz 2007; Costa *et al.* 2015; Moro *et al.* 2016; Silva *et al.* 2017). The crystalline *caatinga*, established over shallow soils with moderate to high fertility, constitutes a typical vegetation type of the semiarid region, with the predominance of herbaceous therophytic elements

that represent approximately 60% of all species. Sedimentary *caatinga* (also called Sandy *Caatinga* or *Carrasco*) vegetation, on the other hand, is established on sedimentary basins associated with deep sandy soils of low fertility, with its vegetation predominantly composed of low, shrubby plants (Moro *et al.* 2016; Fernandes & Queiroz 2018).

The diversification of botanical components as a function of geological strata, landscape, and soils under the influence of a semiarid climate has resulted, over time, in a high environmental diversity within the *Caatinga* phytogeographic domain (Silva *et al.* 2004, 2017) and, consequently, a high diversity of phytophysionomies, as the *Caatinga* can be classified into at least 13 different typologies (Andrade-Lima 1981; Prado 2003).

In contrast to the wide phytophysionomic and floristic diversity encountered in the *Caatinga*, there are insufficient numbers of established conservation areas there, with only 7.96% of the *Caatinga* domain being included within preservation areas, and only 1.3% of those areas are full protection sites (Silva *et al.* 2017; Teixeira *et al.* 2021).

Ceará state, in northeastern Brazil, is included within the *Caatinga* domain, with 70% of its territory over crystalline peneplains. The landscape is largely flat, and is known as the *Sertaneja* depression or the *interplanalto* depression (Moro *et al.* 2015). The extensive planar surface of that region, with elevations generally less than 400 meters above sea level, is notably deficient in water resources and is associated with thin soils covering ancient crystalline bedrock (Moro *et al.* 2015).

The crystalline *caatinga* therefore represents the principal phytoecological region in Ceará state, although it has been largely ignored in terms of floristic studies (which have largely focused on more exceptional phytoecological areas such as cerrado enclaves and humid altitudinal forests known as *brejos*). Many questions are therefore still

open concerning the floristic relationships between the crystalline *caatinga* and crystalline dry forests (Moro *et al.* 2015).

Considering the wide extension of crystalline *caatinga* and the diverse mesoregions of Ceará state with probable floristic variations, previous surveys have not filled in the gaps in our current knowledge concerning floristic variations within that vegetation type (Costa *et al.* 2007; Araújo *et al.* 2011; Costa & Araújo 2012; Duarte *et al.* 2013; Pereira *et al.* 2018). Additionally, SDTFW generally have locally abundant but geographically restricted species, with low similarities between areas and high beta diversity - even over relatively short distances (Apgaua *et al.* 2014).

Considering the need for more data concerning the crystalline *caatinga*, especially in Ceará state, the present study sought to characterize the flora and the phytosociology of the *Caatinga* vegetation in the Pedra da Andorinha Wildlife Refuge (RPA), a conservation area located in the northwestern region of that state.

Materials and Methods

Study area

The Pedra da Andorinha Wildlife Refuge (or “Refúgio de Vida Silvestre Pedra da Andorinha”, designated here as RPA), covers approximately 600 ha within the Tapera District (04°03’51”S, 39°59’51”W), in the municipality of Sobral, in northwestern Ceará state, Brazil (Fig. 1). The RPA was created in 2010 to protect the natural environment of the resident and migratory fauna and flora of the region. The refuge has, as its principal objective, the conservation of biological diversity through research and scientific studies. In addition to protecting *caatinga* vegetation, the RPA serves as a natural refuge for millions of swallows that nest in natural cavities (*tafonis*) in the inselberg that gives the refuge its name (Fig. 1a,b,c).

The borders of the RPA enclose the Pedra da Andorinha inselberg, on the northern slope of the Correntes range (Rodrigues 2018), as well as the lowlands around it. From a geological point of view, the study area is included within the geologic shields and ancient massifs domain (Claudino-Sales & Peulvast 2007), which is composed of predominantly crystalline bedrock of the Tamboril-Santa Quitéria Group (principally granites and migmatites of neoproterozoic origin [630–600 my]) (FUNCME 2015). The regional landscape is dominated by the Pedra da Andorinha

inselberg, which is surrounded by planar erosive surfaces (Claudino-Sales 2016). Elevations within the RPA vary from 200 to 500 masl, with most of the area below 300 m.

The predominant climate in the region of the RPA is characterized as tropical hot and semiarid, with rainfall between January and June and a mean annual precipitation of 539.7 mm (1999–2008), with high mean temperatures, varying between 25 and 27° C (type Bsw’h’ by the Köppen climatic classification). Accentuated droughts occur periodically, lasting between seven to eight months, with elevated hydric deficiencies (Rodrigues 2018; Rodrigues *et al.* 2020).

The drainage system within the RPA consists of two small creeks: the Bilheira and the Tamanduá. The former runs from east to northwest, and the latter south to north. The drainage basins are of the dendritic type, and belong to the Aracatiaçu River basin.

The predominant soil types in the RPA are Chromic Luvisols, which occupy approximately 90% of its area. Poorly developed Fluvisols Neosols can be found along streams and small fluvial canals, with a superficial covering having a sandy to clayey texture.

Floristic survey

The floristic survey involved 21 sporadic collecting expeditions between March/2015 and May/2021, using random walks through the study area during both the dry and rainy seasons. Collecting efforts were mainly concentrated in flat lowland areas near the Pedra da Andorinha inselberg (up to an elevation of 430 m). That search area comprised most of the RPA, where three environments were identified in terms of collecting sites: (i) rock outcrops and associated habitats, (ii) the margins of temporary watercourses, and (iii) level interfluvial surfaces (Fig. 2).

The collections were made using traditional botanical procedures (Mori *et al.* 1989), taking into consideration the diverse vegetation layers and different substrates within the three environments indicated above. The collected material was deposited in the Prof. Francisco José de Abreu Matos herbarium (HUVA) at the Vale do Acaraú State University; duplicates were sent to other herbaria (EAC, HUEFS, and HDELTA - acronyms according to Thiers, continuously updated).

All of the specimens were photographed, geo-referenced, and subsequently identified based on the technical literature (Lorenzi 2008a,b, 2009a,b;

Souza & Lorenzi 2008), specialized databases (CRIA 2021, Flora do Brasil 2020, REFLORA 2021), comparisons with herbarium material, and consultations with specialists.

The species list was organized alphabetically by family, based on the APG IV (2016), with the

exception of Turneraceae, which is considered a different family from Passifloraceae. The spelling of the scientific names and synonyms follow the Flora do Brasil 2020 (constinuously updated). Exotic invasive species were recorded, following the recommendations of Moro *et al.* (2012).

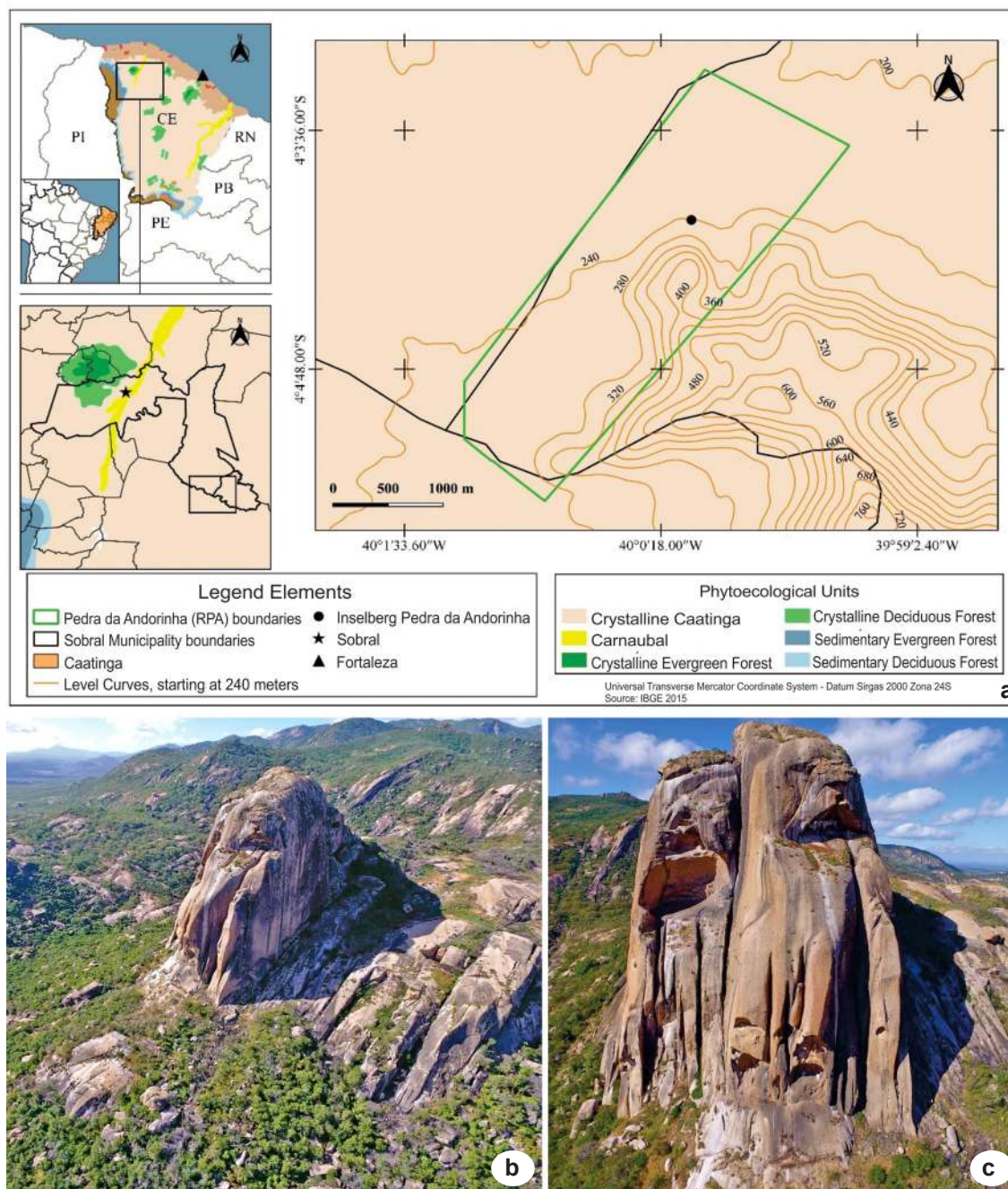


Figure 1 – a. Map locating the Pedra da Andorinha Wildlife Refuge (Refúgio de Vida Silvestre Pedra da Andorinha), in Tapera, Sobral municipality, Ceará state, Brazil, within the context of phytocological areas of Ceará state; **b.** side view of the Andorinha Inselberg; **c.** frontal view of the Andorinha Inselberg. (b-c. D. Gomes).

Each species was classified in terms of its habit, following Gonçalves & Lorenzi (2011), and their life forms noted following the system of Raunkiaer (1934) (Braun-Blanquet 1979; Martins & Batalha 2011), classifying them into five categories: phanerophytes, chamaephytes, hemicryptophytes, cryptophytes/geophytes and therophytes. Woody climbers (lianas) and shrub and arboreal cacti were considered phanerophytes, while vines or herbaceous climbing plants were classified according to the degree of reduction of their aerial portions during the dry period, and if they had (or not) underground storage organs (França *et al.* 2005; Araújo *et al.* 2008, 2011; IBGE 2012; Queiroz *et al.* 2015).

Geographic distributions of the species

The distributions of the species among the four major tropical Brazilian phytogeographic domains contiguous to *Caatinga* (*Caatinga*, *Cerrado*, Amazon and Atlantic rainforests) were verified using the Flora do Brasil 2020 (continuously updated), and compared in a Venn diagram, using Venny 2.1 software (Oliveros 2007-2015).

Comparing the biological spectra of *Caatinga* areas

A matrix was elaborated with the different spectra of life forms in the different environments encountered in the Pedra da Andorinha Wildlife Refuge (based on data available in the literature) to compare them with other areas within the *Caatinga* phytogeographic domain (Tab. 1). We included within that matrix studies undertaken in areas of crystalline *caatinga*, sedimentary *caatinga*, and on inselbergs. The relationships among the biological spectra were inferred based on non-metric multidimensional scaling (NMDS) analyses, using Euclidean distances (Faith *et al.* 1987; Gotelli & Ellison 2011) and implemented in the R environment with the Vegan package (Oksanen *et al.* 2018).

Phytosociological survey

The sampling technique used was based on five 50 × 50 m (2,500 m²) plots, each subdivided into twenty-five 10 × 10 m subplots, yielding a total sampling area of 12,500 m² (1.25 ha). Data collection followed the protocol of plots in areas of seasonally dry vegetation as proposed by Moonlight *et al.* (2020), with adaptations. All living woody individuals within the sampling

areas with diameters at ground level greater than or equal to 3 cm (DGL ≥ 3 cm) were measured and identified following the standard protocol used in *Caatinga*, as proposed by Rodal *et al.* (1992). The variables measured were: Diameter at Ground Level (DGL, in centimeters), and total height of each individual (HT, in meters). Raw



Figure 2 – a-c. Natural environments in the Pedra da Andorinha Wildlife Refuge where the floristic survey was undertaken – a. rock outcrops and associated habitats; b. margins of intermittent watercourses; c. planar and interfluvial surfaces. (a-c. E.B. Souza).

Table 1 – Areas considered in the matrix of biological spectra for NMDS analysis. The = Therophyte; Cry = Cryptophyte; Hem = Hemicryptophyte; Pha = Phanerophyte.

Site	Life forms (%)					Reference
	The	Cry	Hem	Cha	Pha	
Crystalline Caatinga						
Revis Pedra da Andorinha, Sobral, CE	57.52	2.63	1.50	5.26	33.08	This study
Estação ecológica do Seridó, Serra Negra do Norte, RN	79.25	2.72	1.36	3.40	13.27	Queiroz <i>et al.</i> (2015)
Reserva Natural Serra das Almas, Crateús, CE	45.26	1.46	6.57	18.98	27.74	Araújo <i>et al.</i> (2011)
Reserva Particular do Patrimônio Natural Maurício Dantas, Betânia e Floresta, PE	40.45	1.12	14.61	17.98	25.84	Costa <i>et al.</i> (2009)
Reserva Particular do Patrimônio Natural Maurício Dantas, Betânia e Floresta, PE	38.14	1.69	16.10	17.80	26.27	Rodal <i>et al.</i> (2005)
Serrote dos Picos, Santa Quitéria, CE	40	0	12	28	20	Pereira <i>et al.</i> (2018)
Serrote dos Picos, Santa Quitéria, CE	30	0	13.33	30	26.67	Pereira <i>et al.</i> (2018)
Sítio Galinha de Angola, Santa Quitéria, CE	35.5	0	8.82	32.35	23.53	Pereira <i>et al.</i> (2018)
Lagoa do Peixe, Groaíras, CE	41.67	0	22.22	19.44	16.67	Pereira <i>et al.</i> (2018)
Sedimentary Caatinga						
Reserva Natural Serra das Almas, Crateús, CE	16.91	2.94	3.68	19.12	57.35	Araújo <i>et al.</i> (2011)
Reserva Natural Serra das Almas, Crateús, CE	13.20	3.20	2.40	23.20	58	Araújo <i>et al.</i> (2011)
São José do Piauí, PI	4.4	3.7	8.1	12.5	71.3	Mendes & Castro (2010)
Inselbergs						
Sítio Santa Luíza, Quixadá, CE	44.74	2.63	13.16	14.47	25	Araújo <i>et al.</i> (2008)
Distrito de Lagoa de Pedra, Esperança, PB	42.5	0.78	4.72	12.59	39.37	Porto <i>et al.</i> (2008)
Pedra da Guariba, Platô da Borborema, PE	28	8	4.5	6.5	31	Gomes & Alves (2010)
Pedra Cabeça de Velho, Platô da Borberma, PE	38	11	3	5	49	Gomes & Alves (2010)
Pedra do trevo, Catende, PE	33	10	18	16	23	Gomes & Sobral-leite, (2013)
Lajedo do Uruçui, Maraial, PE	27	8	15	19	31	Gomes & Sobral-leite (2013)
Monumento Nacional Monólitos de Quixada, Quixadá, CE	23.36	4.67	5.61	6.54	59.81	Paulino <i>et al.</i> (2018)

data available on supplementary material <<https://figshare.com/s/9e7be11ce771eb9740a1>>

The characterization of the horizontal structures of the sampled species were determined using FITOPAC 2.1 software (Shepherd 2010): Numbers of Individuals (NI), Absolute Density (AD), Relative Density (RD), Absolute Frequency (AF), Relative Frequency (RF), Absolute Dominance (ADo), Relative Dominance (RDo), Importance Value Index (IVI), Coverage Value Index (CVI), and Shannon-Wiener Diversity Index (H').

Rarefaction, extrapolation, and estimates of total richness

The methods of rarefaction (interpolation), extrapolation, and estimates of total richness (asymptotic) were used to evaluate the sampled richness in the phytosociological survey. To that end, we calculated species rarefaction per plot to evaluate the accumulation curves of the species using 1,000 randomizations. As any sampling of biodiversity is typically an underestimation of the total richness of an area, we used a set of non-parametric statistical estimators based on the numbers of rare species and the distributions of species in the sampling plots to estimate the total number of species in the study area. The estimators used were: ICE (an estimator of cover based on incidence), Chao 2, and Jackknife 1 (Gotelli & Colwell 2011). Those algorithms estimate the total numbers of species in a given area based on data from sampling plots (Gotelli & Colwell 2011). After that step, the sampling was extrapolated to a larger area than the true sampling space to evaluate if a considerable increase in the richness recorded in the study areas would be an expected if greater sampling efforts were made. We prepared collection curves for the numbers of species observed in the present study and for the numbers of extrapolated species (Colwell *et al.* 2012). Those analyses were performed using EstimateS 9.1.0 software (Colwell & Elsensohn 2014)

Results

Floristics and geographic distribution

We cataloged 266 vascular plant species in the RPA (Tab. 2; Fig. 3), distributed among 185 genera and 67 families of angiosperms, as well as one fern species (*Marsilea deflexa* - Marsileaceae). The families with the greatest species richness were Fabaceae (38 spp.), Convolvulaceae (19 spp.), Malvaceae (17 spp.), Poaceae and Euphorbiaceae

(16 spp. each), Asteraceae (11 spp.), Boraginaceae (9 spp.), Apocynaceae and Solanaceae (7 spp. each), corresponding to 52.6% of all of the species inventoried; 24 families were represented by a single species, and 17 families by two species.

The families with the largest numbers of genera were Fabaceae (22 genera), Poaceae (13), Asteraceae and Malvaceae (11 each), Euphorbiaceae (9), Apocynaceae (7), Commelinaceae (6), Boraginaceae and Rubiaceae (5 each), Bignoniaceae, Cactaceae, and Solanaceae (4 each), and Acanthaceae, Convolvulaceae, Cyperaceae, Lamiaceae, Plantaginaceae, and Verbenaceae (3 each); 34 families (50.7%) were represented by only a single genus. The genera with the largest numbers of species were *Ipomoea* (9), *Croton* (7), *Chamaechrista*, *Jacquemontia*, *Mimosa*, *Senna*, and *Sida* (5 spp. each), *Combretum*, *Portulaca*, and *Solanum* (4 each), *Alternanthera*, *Evolvulus*, *Stachytarpheta*, *Turnera*, and *Varronia* (3 each). Together, those 16 genera comprised 26.7% of the species of the flora of the RPA.

Of the total number (266) of species, 249 (93.6%) were classified as native and 17 (6.4%) as exotic. Among the exotic species, two (*Calotropis procera* and *Cryptostegia madagascariensis*) stood out as being large and vigorous shrubs. Most of the exotic species, however, were part of the herbaceous component, with Poaceae being the family with the greatest number of exotic species (8) (Tab. 2).

The herbaceous component had the largest species richness in the sampling areas, with 116 species of herbs (43.6%), followed by 41 species of shrubs (15.4%), 40 species of vines (15%), 38 species of subshrubs (14.3%), and 28 species of trees (10.5%); there was one holoparasite species (*Cuscuta racemosa*) and one hemiparasite (*Passovia pedunculata*) (0.4% each), and one palm (0.3%) (*Copernicia prunifera*).

As noted above, climbing plants demonstrated significant diversity, and could be classified as herbaceous (9.8%) or woody (5.3%). Four families comprised 70% of the climbing species richness: Convolvulaceae (12 spp.), Fabaceae (6 spp.), Apocynaceae and Bignoniaceae (4 spp. each). Among climbing mechanisms, 28 species (70%) were twiners, followed by 11 species with tendrils (27.5%), and one species with adhesive roots (2.5%) (*Philodendron acutatum*).

Comparisons with the known geographic distributions of the taxa surveyed indicated that most of the species are not endemic to Brazil

Table 2 – List of species identified in the RPA. Environments: I = rock outcrops and associated habitats; II = riverine vegetation on the margins of intermittent watercourses; III = Caatinga *sensu stricto* in planar and interfluvial surfaces. OR: origin (Nat = native; Exn = exotic naturalized; Exi = exotic aggressive invader). GF: growth form (Shr = shrub; Tre = tree; Her = herbaceous; Pal = palm; Par = parasite; Sub = subshrub; Var = vines with adhesive roots; Vtw = twiner vines; Vte = vines with tendrils; Lite = liana with tendrils; Ltw = twiner lianas). LF: life form (The = therophyte; Cry = cryptophyte; Pha = phanerophyte; Hem = hemicryptophyte). DB: distribution (*Ad = ample distribution; Ca = Caatinga; Ce = Cerrado; AF = Atlantic Forest; Am = Amazonian; Pa = Pampa; Pt = Pantanal). VC: voucher (EBS = E.B. Souza *et al.*; FFA = Francisco Fernandes de Araújo; ASFC = Antônio Sérgio Farias de Castro; EAC = acronym according to Thiers, continuously updated). * > three phytogeographic domains. Ob = Observed, but not collected.

Family / species	Common name	Environment			GF	LF	DB	VC
		I	II	III				
1. Marsileaceae+								
<i>Marsilea deflexa</i> A. Braun	Trevo-d'água	X			Nat	Her	Am Ce	EBS 4656
2. Acanthaceae								
<i>Dicliptera ciliaris</i> Juss.	Melosa-de-boi		X		Nat	Her	Ad	EBS 4057
<i>Elytraria imbricata</i> (Vahl.) Pers.	-	X			Nat	Her	Am Ca Ce	EBS 4058
<i>Ruellia asperula</i> (Mart. ex Nees) Lindau	Melosa-vermelha		X		Nat	Sub	Ca	EBS 4750
<i>Ruellia paniculata</i> L.	Melosa		X		Nat	Sub	Ca Ce AF	EBS 5716
3. Alismataceae								
<i>Echinodorus subulatus</i> (Mart.) Griseb.	Língua-de-vaca		X		Nat	Her	Am Ca Ce	EBS 4627
4. Amaranthaceae								
<i>Alternanthera brasiliana</i> (L.) Kuntze	Cabeça-branca		X		Nat	Her	Ad	EBS 3849
<i>Alternanthera marii</i> (Moq.) R.E.Fr.	-	X			Nat	Her	Am Ce	EBS 4506
<i>Alternanthera tenella</i> Colla	Quebra-panela		X		Nat	Her	Ad	EBS 3829
<i>Amaranthus viridis</i> L.	Bredo		X		Exn	Her	Ad	EBS 5370
<i>Froelichia humboldiana</i> (Roem. & Schult.) Seub.	ervanço		X		Nat	Her	Ca Ce	EBS 4413
5. Anacardiaceae								
<i>Astronium urundeuva</i> (M. Allemão) Engl.	Aroeira		X		Nat	Tre	Ad	EBS 5348
6. Apocynaceae								
<i>Aspidosperma pyrifolium</i> Mart. & Zucc.	Pereiro		X		Nat	Tre	Ca Ce	EBS 5294

Family / species	Common name	Environment			GF	LF	DB	VC
		I	II	III				
<i>Calotropis procera</i> (Aiton) W.T.Aiton	Ciúme		X	Exi	Shr	Pha	Ad	EBS 5371
<i>Cryptostegia madagascariensis</i> Bojer	Unha-de-bruxa		X	Exi	Shr	Pha	Am Ca	EBS 5272
<i>Ditassa hastata</i> Decne	-			Nat	Ltw	Pha	Am Ca Ce	EBS 4627
<i>Forsteronia pubescens</i> A.DC.	-			Nat	Ltw	Pha	Ca Ce AF	FFA 98
<i>Ibatia nigra</i> (Decne.) Morillo	-			Nat	Vtw	Pha	Ca	EBS 3856
<i>Petalostelma martianum</i> (Decne.) E. Fourn.	-			Nat	Vtw	Pha	Ad	EBS 4955
7. Araceae								
<i>Philodendron acutatum</i> Schott	Imbé	X		Nat	Var	Cha	Ad	EBS 4845
<i>Taccarum ulei</i> Eng. & K. Krause	Milho-de-cobra	X		Nat	Her	Cry	Ca Ce AF	EBS 4971
8. Arecaceae								
<i>Copernicia prunifera</i> (Mill.) H.E. Moore	Carnaúba		X	Nat	Pal	Pha	Ca Ce	Ob
9. Asteraceae								
<i>Baltimora geminata</i> (Brandegee) Stuessy	-	X		Nat	Her	The	Ca Ce AF	EBS 4653
<i>Bidens bipinnata</i> L.	Picão		X	Exn	Sub	The	Ca AF Pa	EBS 5284
<i>Blainvillea acmella</i> (L.) Philipson	Erva-palha		X	Nat	Her	The	Ca Ce AF	EBS 4098
<i>Centratherum punctatum</i> Cass.	Perpétua-do-mato		X	Nat	Her	The	Ad	EBS 5219
<i>Chresta pacourinoides</i> (Mart. ex DC.) Siniscalchi & Loeuille	-	X		Nat	Her	The	Ca	EBS 5278
<i>Delilia biflora</i> (L.) Kuntze	Espoleta		X	Nat	Her	The	Ca Ce AF	EBS 5281
<i>Lagascea mollis</i> Cav.	-		X	Nat	Her	The	Ca AF Pt	EBS 5282
<i>Lepidaploa chalybaea</i> (Mart. ex DC.) H. Rob. (Mart. ex DC.) H. Rob.	-	X		Nat	Sub	The	Ca Ce	EBS 3853
<i>Melanthera latifolia</i> (Gardner) Cabrera	-		X	Nat	Her	The	Ad	EBS 3819
<i>Stilpnopappus trichospiroides</i> Mart. ex DC.	-		X	Nat	Her	The	Ca Ce	EBS 4078
<i>Tridax procumbens</i> L.	Dente-de-leão		X	Nat	Her	The	Ad	EBS 3824

Family / species	Common name	Environment			OR	GF	LF	DB	VC
		I	II	III					
10. Bignoniaceae									
<i>Cuspidaria argentea</i> (Wawra) Sandwith	-	X			Nat	Lte	Pha	Ca	EBS 5020
<i>Dolichandra quadrivalvis</i> (Jacq.) L.G.Lohmann	Unha-de-gato		X		Nat	Lte	Pha	Ad	EBS 4835
<i>Handroanthus impetiginosus</i> (Mart. ex DC.) Mattos	Ipê-roxo			X	Nat	Tre	Pha	Ad	EBS 4969
<i>Tanaecium dichotomum</i> (Jacq.) Kaehler & L.G.Lohmann	-		X		Nat	Lte	Pha	Ad	EBS 5474
<i>Tanaecium parviflorum</i> (Mart. ex DC.) Kaehler & L.G.Lohmann	-		X		Nat	Lte	Pha	Ca Ce	F 96
11. Bixaceae									
<i>Cochlospermum vitifolium</i> (Willd.) Spreng.	Pacotê		X		Nat	Tre	Pha	Ad	EBS 5387
12. Boraginaceae									
<i>Cordia glabrata</i> (Mart.) A. DC.	Pau-branco-louro	X			Nat	Tre	Pha	Ca Ce	EBS 4084
<i>Cordia oncocalyx</i> Allemão	Pau-branco		X		Nat	Tre	Pha	Ca	EBS 4426
<i>Euploca lagoensis</i> (Warm.) Diane & Hilger	-		X		Nat	Her	The	Am Ca Ce	EBS 4822
<i>Euploca procumbens</i> (Mill.) Diane & Hilger	-		X		Nat	Her	The	Ad	EBS 4825
<i>Heliotropium indicum</i> L.	Fedegoso			X	Nat	Her	The	Ad	EBS 4824
<i>Myriopus rubicundus</i> (Salzm. ex DC.) Lueber	-		X		Nat	Shr	Pha	Ca Ce AF	EBS 3844
<i>Varronia dardani</i> (Taroda) J.S.Mill.	-		X		Nat	Shr	Pha	Ca	EBS 4430
<i>Varronia globosa</i> Jacq.	Maria-preta		X		Nat	Shr	Pha	Ca AF	EBS 4423
<i>Varronia multispicata</i> (Cham.) Borhidi	-	X			Nat	Shr	Pha	Ad	EBS 3855
13. Bromeliaceae									
<i>Encholirium spectabile</i> Mart. ex Schult. & Schult.f.	Macambira-de-flecha	X			Nat	Her	Hem	Ca AF	EBS 4850
14. Burseraceae									
<i>Commiphora leptophloeos</i> (Mart.) J.B.Gillett	Amburana-de-espinho	X		X	Nat	Tre	Pha	Am Ca Ce	FFA 92
15. Cactaceae									
<i>Cereus jamacaru</i> DC.	Mandacaru	X		X	Nat	Tre	Pha	Ca Ce	EBS 4848

Family / species	Common name	Environment			OR	GF	LF	DB	VC
		I	II	III					
<i>Pilosocereus chrysostele</i> (Vaupel) Byles & G.D.Rowley	Facheiro, Chico-grilo	X	X	X	Nat	Tre	Pha	Ca	EBS 4846
<i>Xiquexique gounellei</i> (F.A.C.Weber) Lavor & Calvente	Xique-Xique	X			Nat	Shr	Pha	Ca Ce	EBS 4847
<i>Tacinga palmadora</i> (Britton & Rose) N.P.Taylor & Stuppy	Palma	X			Nat	Shr	Cha	Ca	EBS 4755
16. Capparaceae									
<i>Cynophalla flexuosa</i> (L.) J. Presl.	Feijão-bravo		X		Nat	Shr	Pha	Ad	EBS 4840
<i>Crateva tapia</i> L.	Trapiá		X		Nat	Tre	Pha	Ad	EBS 4445
17. Cleomaceae									
<i>Physostemon guianense</i> (Aubl.) Malme	-			X	Nat	Her	The	Am Ca Ce	EBS 4411
<i>Physostemon lanceolatum</i> Mart. & Zucc.	-			X	Nat	Her	The	Ca AF	EBS 5204
<i>Tarenaya diffusa</i> (Banks ex DC.) Ilts	-	X			Nat	Her	The	Ca AF	EBS 4450
<i>Tarenaya longicarpa</i> Soares Neto & Roalson	Mussambê		X		Nat	Sub	Cha	Ad	EBS 4826
18. Combretaceae									
<i>Combretum duarteianum</i> Cambess.	Mofumbo		X		Nat	Shr	Pha	Ad	EBS 5386
<i>Combretum glaucocarpum</i> Mart.	Cipaúba		X		Nat	Shr	Pha	Ad	EBS 5221
<i>Combretum leprosum</i> Mart.	Mofumbo		X	X	Nat	Shr	Pha	Ad	EBS 4754
<i>Combretum</i> sp.1	Mofumbo		X		Nat	Shr	Pha	-	EBS 4067
19. Commelinaceae									
<i>Aneilema brasiliense</i> C.B.Clarke	-	X			Nat	Her	The	Ca Ce AF	EBS 5291
<i>Callisia filiformis</i> (M.Martens & Galeotti) D.R.Hunt	-			X	Nat	Her	The	Ca Ce	EBS 5191
<i>Commelina obliqua</i> Vahl.	Marianinha			X	Nat	Her	The	Ad	EBS 4403
<i>Dichorisandra perforans</i> C.B.Clarke	-	X		X	Nat	Her	Hem	Ca Ce	EBS 3822
<i>Tinantia sprucei</i> C.B.Clarke	-		X		Nat	Her	The	Am Ca Ce	EBS 5198
<i>Tradescantia ambigua</i> Mart. ex Schult. & Schult.f.	-	X			Nat	Her	The	Ca Ce	EBS 5019

Family / species	Common name	Environment			OR	GF	LF	DB	VC
		I	II	III					
20. Convolvulaceae									
<i>Cuscuta racemosa</i> Mart.	Cipó-dourado		X	Nat	Par	The	Ce AF Pa	EBS 5287	
<i>Distimake aegyptius</i> (L.) A.R.Simões & Staples	Jitirana cabeluda		X	Nat	Vtw	The	Ca Ce AF	EBS 4093	
<i>Evolvulus alsinoides</i> L.	-		X	Nat	Her	The	Am Ce	EBS 5189	
<i>Evolvulus filipes</i> Mart.	-		X	Nat	Her	The	Ad	EBS 4081	
<i>Evolvulus ovatus</i> Fernald	-		X	Nat	Her	The	Am Ca Ce	EBS 4082	
<i>Ipomoea acanthocarpa</i> (Choisy) Aschers. & Schweinf.	-		X	Nat	Vtw	The	Am Ca AF	EBS 4628	
<i>Ipomoea asarifolia</i> (Desr.) Roem. & Schult.	Salsa		X	Nat	Vtw	The	Am Ca AF	EBS 5271	
<i>Ipomoea bahiensis</i> Willd. ex Roem. & Schult.	Jitirana		X	Nat	Vtw	The	Ad	EBS 4094	
<i>Ipomoea carnea</i> Jacq.	Mata-cabra		X	Nat	Shr	Pha	Ad	EBS 4629	
<i>Ipomoea hederifolia</i> L.	Corda-de-violã		X	Nat	Vtw	The	Ad	EBS 4074	
<i>Ipomoea longeramosa</i> Choisy	-		X	Nat	Vtw	The	Ca Ce	EBS 4095	
<i>Ipomoea nil</i> (L.) Roth (L.) Roth	Jitirana		X	Exn	Vtw	The	Ad	EBS 4092	
<i>Ipomoea parasitica</i> (Kunth) G.Don	-		X	Exn	Vtw	The	Ca Ce AF	EBS 5249	
<i>Ipomoea rosea</i> Choisy	-		X	Nat	Vtw	Hem	Ca Ce AF	EBS 4631	
<i>Jacquemontia corymbulosa</i> Benth.	-		X	Nat	Vtw	The	Ca Ce	EBS 4963	
<i>Jacquemontia evolvuloides</i> (Moric.) Meisn.	-		X	Nat	Vtw	The	Ad	EBS 4406	
<i>Jacquemontia ferruginea</i> Choisy	-		X	Nat	Sub	The	AF	EBS 4066	
<i>Jacquemontia gracillima</i> (Choisy) Hallier	-		X	Nat	Her	The	Ca Ce AF	EBS 4090	
<i>Jacquemontia pentanthos</i> (Jacq.) G. Don	-		X	Nat	Vtw	The	Am Ca Ce	EBS 5210	
21. Cucurbitaceae									
<i>Momordica charantia</i> L.	Melão-de-São-Caetano		X	Exn	Vte	The	Ad	EBS 4830	
<i>Sicyos martii</i> Cogn.	-			Nat	Vte	The	Ca Ce AF	EBS 5268	

Family / species	Common name	Environment			GF	LF	DB	VC
		I	II	III				
22. Cyperaceae								
<i>Bulbostylis capillaris</i> C.B.Clarke	-			X	Nat	Her	Ad	EBS 5216
<i>Cyperus cuspidatus</i> Kunth.	Barba-de-bode			X	Nat	Her	Am Ca	EBS 4953
<i>Scleria reticularis</i> Michx. ex Willd.	-			X	Nat	Her	Ad	EBS 5220
23. Dioscoreaceae								
<i>Dioscorea campestris</i> Griseb.	Cará-casco-cavalo			X	Nat	Vtw	Ad	EBS 4956
<i>Dioscorea ovata</i> Vell.	Inhame-bravo			X	Nat	Vtw	Ca Ce AF	EBS 4421
24. Eriocaulaceae								
<i>Paepalanthus tortilis</i> (Bong.) Mart.	-		X		Nat	Her	Ad	EBS 4657
25. Erythroxylaceae								
<i>Erythroxylum revolutum</i> Mart.	Oitizinho			X	Nat	Shr	Ca AF	EBS 4429
<i>Erythroxylum subtrotundum</i> A. St.-Hil.	-			X	Nat	Shr	Ca Ce AF	EBS 5029
26. Euphorbiaceae								
<i>Acalypha communis</i> Müll. Arg.	Algodãozinho			X	Nat	Sub	Ad	EBS 4443
<i>Astraea lobata</i> (L.) Klotzsch	Café-bravo			X	Nat	Sub	Ce Pa Pt	EBS 4439
<i>Cnidoscolus urens</i> (L.) Arthur.	Cansanção			X	Nat	Sub	Ad	EBS 5273
<i>Croton adenocalyx</i> Baill.	Marneleiro-cravim			X	Nat	Shr	Ca	EBS 4947
<i>Croton anisodontus</i> Müll. Arg.	Marneleiro			X	Nat	Shr	AF	EBS 4436
<i>Croton blanchetianus</i> Baill.	Marneleiro			X	Nat	Shr	Ca	EBS 4412
<i>Croton hirtus</i> L'Hér.	-			X	Nat	Sub	Ad	EBS 5184
<i>Croton japirensis</i> Müll.Arg.	Velame			X	Nat	Shr	Ca	EBS 4954
<i>Croton rudolphianus</i> Müll. Arg.	-			X	Nat	Shr	Ca	EBS 4437
<i>Croton triangularis</i> Müll. Arg.	-			X	Nat	Shr	Ca Ce	EBS 5025
<i>Dalechampia scandens</i> L.	Cipó-urtiga			X	Nat	Vtw	Ad	EBS 4949

Family / species	Common name	Environment			OR	GF	LF	DB	VC
		I	II	III					
<i>Euphorbia heterophylla</i> L.	Amendoim-bravo	X		X	Nat	Her	The	Am Ca	EBS 5277
<i>Euphorbia hyssopifolia</i> L.	Burra-leitera	X		X	Nat	Her	The	Ad	EBS 4972
<i>Jatropha mollissima</i> (Pohl.) Baill.	Pinhão-bravo	X		X	Nat	Shr	Pha	Am Ca Ce	EBS 3841
<i>Manihot carthagenensis</i> (Jacq.) Müll. Arg.	-	X			Nat	Tre	Pha	Am Ca Ce	EBS 4427
<i>Tragia cearensis</i> Pax & K. Hoffm.	-			X	Nat	Her	The	Ca	EBS 5286
27. Fabaceae									
<i>Aeschynomene evenia</i> C. Wrigth & Sauvalle	-		X		Nat	Sub	The	Ad	EBS 4643
<i>Ancistrotropis peduncularis</i> (Kunth) A. Delgado	-			X	Nat	Vtw	The	Ad	EBS 4088
<i>Anadenanthera colubrina</i> (Vell.) Brenan	Angico			X	Nat	Tre	Pha	Ca Ce AF	EBS 4839
<i>Arachis dardani</i> Krapov. & W.C. Greg.	Amendoim-de-carcará			X	Nat	Her	The	Ca Ce AF	EBS 4422
<i>Bauhinia cheilantha</i> (Bong.) Steud.	Mororó			X	Nat	Shr	Pha	Ca Ce	EBS 4424
<i>Bauhinia pentandra</i> (Bong.) D. Dietr.	Pata-de-vaca			X	Nat	Shr	Pha	Ca Ce	EBS 4428
<i>Canavalia brasiliensis</i> Mart. ex Benth.	Feijão-de-porco		X	X	Nat	Ltw	Pha	Ad	EBS 5217
<i>Centrosema brasiliense</i> (L.) Benth.	-			X	Nat	Vtw	The	Ad	EBS 5218
<i>Centrosema pascuorum</i> Mart. ex Benth.	-			X	Nat	Vtw	The	Ad	EBS 5251
<i>Cenostigma nordestinum</i> Gagnon & G.P. Lewis	Catingueira			X	Nat	Tre	Pha	Ca	EBS 4448
<i>Chamaecrista calycioides</i> (DC. ex Collad.) Greene	-			X	Nat	Sub	The	Ad	EBS 5258
<i>Chamaecrista pilosa</i> (L.) Greene	-			X	Nat	Her	The	Ca Ce AF	EBS 3827
<i>Chamaecrista repens</i> (Vogel) H.S. Irwin & Barneby	-			X	Nat	Sub	The	Ad	EBS 5193
<i>Chamaecrista rotundifolia</i> (Pers.) Greene	Erva-coração			X	Nat	Her	The	Ad	EBS 5196
<i>Chamaecrista zygophylloides</i> (Taub.) H.S. Irwin & Barneby	-	X		X	Nat	Her	Pha	Ca Ce AF	EBS 5016
<i>Crotalaria incana</i> L.	Guiso-de-cascavel			X	Nat	Sub	The	Ad	EBS 5280
<i>Ctenodon paniculatus</i> (Willd. ex Vogel) D.B.O.S. Cardoso, P.L.R. Moraes & H.C. Lima	Vassoura-de-pasto			X	Nat	Sub	The	Ad	EBS 5185
<i>Desmodium glabrum</i> (Mill.) DC.	Rapadura-de-cavalo			X	Nat	Sub	The	Ca Ce AF	EBS 4073

Family / species	Common name	Environment			OR	GF	LF	DB	VC
		I	II	III					
<i>Galactia jussiaeana</i> Kunth	-		X		Nat	Sub	Cha	Ad	EBS 5255
<i>Hymenaea courbaril</i> L.	Jatobá		X		Nat	Tre	Pha	Ad	EBS 5382
<i>Indigofera suffruticosa</i> Mill.	Anil			X	Nat	Shr	Pha	Ad	EBS 4976
<i>Libidibia ferrea</i> (Mart. ex Tul.) L.P.Queiroz	Pau-ferro, Jucá			X	Nat	Tre	Pha	Ca Ce AF	EBS 4063
<i>Macropitilium gracile</i> (Poepp. ex Benth.) Urb.	-			X	Nat	Vtw	The	Ad	EBS 5263
<i>Macropitilium lathyroides</i> (L.) Urb.	Feijão-de-rolinha			X	Nat	Sub	The	Ad	EAC 2239
<i>Macropsychanthus grandiflorus</i> (Mart. ex Benth.) L.P.Queiroz & Snak	Mucunã	X			Nat	Ltw	Pha	Ca	EBS 4503
<i>Mimosa caesalpinhiifolia</i> Benth.	Sabiá			X	Nat	Tre	Pha	Ca	EBS 4501
<i>Mimosa niomarlei</i> Afr. Fern.	-			X	Nat	Her	The	Ca	EAC 17591
<i>Mimosa paraibana</i> Barneby	Cerrador			X	Nat	Shr	Pha	Ca AF	EBS 4641
<i>Mimosa somnians</i> Humb. & Bonpl. ex Willd.	-				Nat	Sub	The	Ad	EBS 5250
<i>Mimosa tenuiflora</i> (Willd.) Poir.	Jurema-preta			X	Nat	Tre	Pha	Ca Ce	EBS 4753
<i>Piptadenia retusa</i> P.G.Ribeiro, Seigler & Ebinger	Jurema-branca			X	Nat	Shr	Pha	Ca	EBS 4752
<i>Senna macranthera</i> (DC. ex Collad.) H.S. Irwin & Barneby	Aleluia			X	Nat	Shr	Pha	Ca Ce AF	EBS 4633
<i>Senna obtusifolia</i> (L.) H.S. Irwin & Barneby	Mata-pasto-liso			X	Nat	Sub	The	Ad	EBS 4823
<i>Senna occidentalis</i> (L.) Link	Manjerioba			X	Nat	Sub	The	Ad	EBS 5276
<i>Senna trachypus</i> (Benth.) H.S. Irwin & Barneby	Pau-de-besouro			X	Nat	Shr	Pha	Ca Ce	EBS 4642
<i>Senna uniiflora</i> (Mill.) H.S. Irwin & Barneby	Mata-pasto-peludo			X	Nat	Her	The	Am Ca Ce	EBS 5264
<i>Stylosanthes humilis</i> Kunth	-			X	Nat	Her	The	Ad	EBS 5252
<i>Zornia brasiliensis</i> Vogel	-		X		Nat	Her	The	Ca Ce	EBS 3843
28. Hydroleaceae									
<i>Hydrolea spinosa</i> L.	Carqueja-do-pântano		X		Nat	Her	The	Ad	EBS 4827
29. Iridaceae									
<i>Cipura paludosa</i> Aubl.	-			X	Nat	Her	Cry	Ad	EBS 4493
<i>Trimezia martinicensis</i> (Jacq.) Herb.	-			X	Nat	Her	Cry	Ad	EBS 4494

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		I	II	III					
30. Lamiaceae									
<i>Marsipianthes chamaedrys</i> (Vahl) Kuntze	-			X	Nat	Her	The	Ad	EBS 4502
<i>Mesosphaerum suaveolens</i> (L.) Kuntze	Bamburral			X	Nat	Sub	The	Ad	EBS 4635
<i>Vitex gardneriana</i> Schauer	Jaramataia		X		Nat	Tre	Pha	Ca	EBS 4446
31. Loasaceae									
<i>Mentzelia aspera</i> L.	Prega-prega			X	Nat	Her	The	Ad	EBS 4056
32. Loganiaceae									
<i>Spigelia anthelmia</i> L.	Lombrigueira			X	Nat	Her	The	Ad	EBS 5195
33. Loranthaceae									
<i>Passovia pedunculata</i> (Jacq.) Kuijt	Erva-de-passarinho			X	Nat	Par	Pha	Ad	EBS 4435
34. Lythraceae									
<i>Cuphea campestris</i> Koehne	-			X	Nat	Her	The	Ca	EBS 5208
35. Malpighiaceae									
<i>Diplopterys lutea</i> (Griseb.) W.R.Anderson & C.C.Davis	-		X		Nat	Ltw	Pha	Ad	EBS 4833
<i>Heteropterys</i> sp.1	-		X		Nat	Ltw	Pha	-	EBS 4849
<i>Heteropterys</i> sp.2	-		X		Nat	Ltw	Pha	-	EBS 4832
36. Malvaceae									
<i>Briqueiatrum spicatum</i> (Kunth in H.B.K.) Bovini	Paco-paco			X	Nat	Sub	The	Ad	EBS 4640
<i>Ceiba glaziovii</i> (Kuntze) K. Schum.	Barriguda	X			Nat	Tre	Pha	Ca	Ob
<i>Corchorus hirtus</i> L.	-			X	Nat	Her	The	Ad	EBS 5192
<i>Helicteres velutina</i> K. Schum.	Saca-rolha			X	Nat	Shr	Pha	Ca Ce	EBS 4965
<i>Herissantia tiubae</i> (K. Schum.) Brizicky	Mela-bode			X	Nat	Sub	Pha	Ca Ce	EBS 4650
<i>Melochia pyramidata</i> L.	Guaxuma			X	Nat	Sub	The	Ad	EBS 3823
<i>Melochia tomentosa</i> L.	-			X	Nat	Sub	Cha	Ca Ce AF	EBS 4420
<i>Pavonia cancellata</i> (L.) Cav.	Malva-rasteira			X	Nat	Her	The	Ad	EBS 4097

Family / species	Common name	Environment			OR	GF	LF	DB	VC
		I	II	III					
<i>Pseudobombax marginatum</i> (A.St.-Hil., Juss. & Cambess.) A. Robyns	Embiratanha			X	Nat	Tre	Pha	Ca Ce Pt	ASFC 1205
<i>Sida ciliaris</i> L.	-			X	Nat	Her	The	Ca AF	EBS 4410
<i>Sida cordifolia</i> L.	Malva-branca			X	Nat	Sub	The	Ad	EBS 4059
<i>Sida galheirensis</i> Ulb.	Canela-de-siriema			X	Nat	Sub	The	Ca Ce AF	EBS 3830
<i>Sida limifolia</i> Cav.	Malva-fina			X	Nat	Her	The	Ad	EBS 4649
<i>Sida spinosa</i> L.	Guaxuma-de-spinho			X	Nat	Sub	The	Ca Ce AF	EBS 3848
<i>Sidastrum micranthum</i> (A.St.-Hil.) Fryxell	Malva-preta			X	Nat	Sub	The	Ad	EBS 3821
<i>Waltheria operculata</i> Rose	-		X		Nat	Her	The	Ca Ce Pt	EBS 4080
<i>Wissadula contracta</i> (Link) R.E.Fr.	-			X	Nat	Sub	Cha	Ad	EBS 5266
37. Microteaceae									
<i>Microtea celostoides</i> Moq. ex Sennikov & Sukhor.	Capim-névoa		X		Nat	Her	The	Ad	EBS 3851
38. Molluginaceae									
<i>Mollugo verticillata</i> L.	Molugo, vassourinha			X	Nat	Her	The	Ad	EBS 3840
39. Moraceae									
<i>Brosimum gaudichaudii</i> Trécul	Conduru, Inharé		X		Nat	Tre	Pha	Ad	EBS 4838
<i>Ficus gomelleira</i> Kunth	Gameléria		X		Nat	Tre	Pha	Ad	EBS 4843
40. Myrtaceae									
<i>Eugenia stictopetala</i> Mart. ex DC.	Pitanga-do-mato		X		Nat	Tre	Pha	Ad	EBS 4087
41. Nyctaginaceae									
<i>Boerhavia diffusa</i> L.	Pega-pinto			X	Exn	Her	Hem	Ad	EBS 3850
<i>Guapira laxa</i> (Netto) Furlan	João-mole		X		Nat	Shr	Pha	Ca	EBS 4854
42. Onagraceae									
<i>Ludwigia erecta</i> (L.) H.Hara.	Cruz-de-malta		X		Nat	Her	The	Ad	EBS 4061
<i>Ludwigia octovalvis</i> (Jacq.) P.H. Raven	Cruz-de-malta		X		Nat	Sub	The	Ad	EBS 4648

Family / species	Common name	Environment			OR	GF	LF	DB	VC
		I	II	III					
43. Oxalidaceae									
<i>Oxalis divaricata</i> Mart.ex Zucc.	Azedinha			X	Nat	Her	The	Ad	EBS 4075
<i>Oxalis frutescens</i> L.	-			X	Nat	Her	The	Ad	EBS 4405
44. Passifloraceae <i>sensu stricto</i>									
<i>Passiflora foetida</i> L.	Maracujá-do-mato			X	Nat	Vte	Cha	Ad	EBS 4968
<i>Passiflora cincinnata</i> Mast.	-			X	Nat	Lte	Pha	Ad	Ob
45. Phyllanthaceae									
<i>Phyllanthus niruri</i> L.	Quebra-pedra			X	Nat	Her	The	Ad	EBS 3820
<i>Phyllanthus orbiculatus</i> Rich.	-			X	Nat	Her	The	Ad	EBS 5018
46. Phytollacaceae									
<i>Petiveria alliacea</i> L.	Tipi		X		Exn	Sub	Cha	Ad	EBS 4634
47. Piperaceae									
<i>Peperomia pellucida</i> (L.) Kunth	Erva-de-jaboti	X			Nat	Her	The	Ad	EBS 5295
48. Plantaginaceae									
<i>Angelonia pubescens</i> Benth.	-			X	Nat	Her	The	Ca Ce	EBS 5283
<i>Scoparia dulcis</i> L.	Vassourinha			X	Nat	Sub	The	Ad	EBS 4831
<i>Stemodia durantifolia</i> (L.) Sw.	-		X		Nat	Her	The	Ad	EBS 4821
49. Plumbaginaceae									
<i>Plumbago scandens</i> L.	-		X		Nat	Sub	Cha	Am Ca AF	EBS 5376
50. Poaceae									
<i>Aristida adscensionis</i> L.	-			X	Exn	Her	The	Ad	EBS 5201
<i>Aristida setifolia</i> Kunth.	-			X	Nat	Her	The	Ca Ce AF	EBS 4089
<i>Cenchrus ciliaris</i> L.	Capim-búfalo			X	Exn	Her	The	Am Ca Ce	EBS 4064
<i>Cenchrus echinatus</i> L.	Capim-carrapicho			X	Nat	Her	The	Ad	EBS 3836
<i>Chloris barbata</i> (L.) Sw.	-			X	Nat	Her	The	Ca Ce AF	EBS 3838

Family / species	Common name	Environment			GF	LF	DB	VC
		I	II	III				
<i>Cynodon dactylon</i> (L.) Pers.	-		X	Exn	Her	The	Ad	EBS 5190
<i>Dactyloctenium aegyptium</i> (L.) Willd.	Pé-de-galinha		X	Exn	Her	The	Ad	EBS 3834
<i>Digitaria horizontalis</i> Willd.	Capim-de-roça		X	Exn	Her	The	Ad	EBS 5205
<i>Eleusine indica</i> (L.) Gaertn	Pé-de-galinha		X	Exn	Her	The	Ad	EBS 5265
<i>Eragrostis ciliaris</i> (L.) R. Br.	Capim-mimoso	X	X	Exn	Her	The	Ad	EBS 4654
<i>Hyparrhenia bracteata</i> (Hum. & Bonpl. ex Willd.) Stapf	-	X	X	Nat	Her	The	Ce AF Pt	EBS 4655
<i>Melinis repens</i> (Willd.) Zizka	-	X	X	Exn	Her	The	Ad	EBS 4065
<i>Panicum trichoides</i> Sw.	-		X	Nat	Her	The	Ad	EBS 4060
<i>Paspalum arenarium</i> Schrad.	-		X	Nat	Her	The	Ad	EBS 5256
<i>Paspalum scutatum</i> Nees ex Trin.	-		X	Nat	Her	The	Ca	EBS 5203
<i>Setaria parviflora</i> (Poir.) Kerguelén	Capim-rabo-de-gato		X	Nat	Her	The	Ad	EBS 5595
51. Polygalaceae								
<i>Asemeta violacea</i> (Aubl.) J.F.B.Pastore & J.R.Abbott	Roxinha		X	Nat	Her	The	Ad	EBS 5211
<i>Polygala boliviensis</i> A.W. Benn.	-		X	Nat	Her	The	Ca AF	EBS 5213
<i>Polygala trichosperma</i> Jacq.	-		X	Nat	Her	The	Ad	EBS 5253
52. Polygonaceae								
<i>Triplaris gardneriana</i> Wedd.	Pajeú		X	Nat	Tre	Pha	Ad	EBS 4837
53. Portulacaceae								
<i>Portulaca elatior</i> Mart.	-	X	X	Nat	Her	The	Ca Ce AF	EBS 4418
<i>Portulaca halimoides</i> L.	-	X	X	Nat	Her	The	Ad	EBS 3825
<i>Portulaca mucronata</i> Link	-	X	X	Nat	Her	The	Ad	EBS 4076
<i>Portulaca umbraticola</i> Kunth	-	X	X	Nat	Her	The	Ad	EBS 4400
54. Rhamnaceae								
<i>Crumenaria decumbens</i> Mart.	-		X	Nat	Her	The	Ca	EBS 5197
<i>Sarcophalus joazeiro</i> (Mart.) Hauenschild	Juazeiro		X	Nat	Tre	Pha	Ca	EBS 4844

Family / species	Common name	Environment			OR	GF	LF	DB	VC
		I	II	III					
55. Rubiaceae									
<i>Borreria scabiosoides</i> Cham. & Schltdl.	Cabeça-branca		X		Nat	Her	The	Ad	EBS 4499
<i>Hexasepalum apiculatum</i> (Willd.) Delprete & J.H. Kirkbr.	-			X	Nat	Sub	The	Ad	EBS 3837
<i>Mitracarpus baturitensis</i> Sucre	Ervância-do-mato		X		Nat	Her	The	Ca Ce	EBS 4086
<i>Mitracarpus strigosus</i> (Thunb.) P.L.R. Moraes, De Smedt & Hjertson	-			X	Nat	Her	The	Ad	EBS 4079
<i>Staelia virgata</i> (Link ex Roem. & Schult.) K. Schum.	-		X		Nat	Her	The	Ad	EBS 4651
<i>Tocoyena sellowiana</i> (Cham. & Schltdl.) K. Schum.	Jeniparana		X		Nat	Shr	Pha	Am Ca AF	EBS 4842
56. Salicaceae									
<i>Prockia crucis</i> P.Browne ex L.	-		X		Nat	Shr	Pha	Ad	EBS 4442
57. Sapindaceae									
<i>Cardiospermum corindum</i> L.	Balãozinho			X	Nat	Vte	The	Ca Ce AF	EBS 4630
58. Simaroubaceae									
<i>Simarouba versicolor</i> A.St.-Hil.	Paraíba		X		Nat	Tre	Pha	Am Ca Ce	EBS 4447
59. Solanaceae									
<i>Capsicum parvifolium</i> Sendtn.	-			X	Nat	Shr	Pha	Ca AF	EBS 5030
<i>Physalis pubescens</i> L.	Juá-de-capote			X	Nat	Her	The	Ad	EBS 3828
<i>Schwenckia americana</i> L.	-		X		Nat	Her	The	Ad	EBS 3857
<i>Solanum agrarium</i> Sendtn.	-			X	Nat	Her	The	Ca Ce AF	EBS 5270
<i>Solanum americanum</i> Mill.	Pimenta-de-galinha			X	Nat	Her	The	Ad	EBS 4828
<i>Solanum graniicola</i> V.S. Sampaio & Gouvêa	-		X		Nat	Shr	Pha	Ca	EBS 4070
<i>Solanum paludosum</i> Moric.	-		X		Nat	Shr	Pha	Am Ca AF	EBS 5027
60. Talinaceae									
<i>Talinum fruticosum</i> (L.) Juss.	Bredo			X	Nat	Her	The	Ad	EBS 5477
61. Turneraceae (Passifloraceae <i>sensu lato</i>)									
<i>Piriqueta guianensis</i> N.E.Br.	-			X	Nat	Her	The	Ad	EBS 5219

Family / species	Common name	Environment			GF	LF	DB	VC
		I	II	III				
<i>Piriqueta viscosa</i> Griseb.	-		X	Nat	Her	The	Ad	EBS 4407
<i>Turnera chamaedrifolia</i> Cambess.	Chanana		X	Nat	Sub	The	Ca Ce AF	EBS 3854
<i>Turnera pumilea</i> L.	Arranca-estrepo		X	Nat	Her	The	Ca Ce AF	EBS 4401
<i>Turnera subulata</i> Sm.	Chanana		X	Nat	Her	Cha	Ad	EBS 3831
62. Urticaceae								
<i>Laportea aestuans</i> (L.) Chew	Urtiga-vermelha		X	Nat	Her	The	Ad	EBS 5279
63. Verbenaceae								
<i>Lantana camara</i> L.	Cambara-chumbinho		X	Exn	Shr	Pha	Ad	EBS 5207
<i>Lantana fucata</i> Lindl.	Cambará		X	Nat	Shr	Pha	Ad	EBS 4957
<i>Lippia origanoides</i> Kunth	-		X	Nat	Shr	Pha	Ad	EBS 5293
<i>Stachytarpheta angustifolia</i> (Mill.) Vahl	Gervão-do-alagadiço		X	Nat	Her	The	Ad	EBS 5187
<i>Stachytarpheta macedoi</i> Moldenke	-		X	Nat	Her	The	Ca Ce	EBS 5259
<i>Stachytarpheta sessilis</i> Moldenke	Rabo-de-tatu		X	Nat	Her	The	Ca	EBS 4083
64. Vitaceae								
<i>Cissus tinctoria</i> Mart.	-	X		Nat	Lte	Pha	Ad	EBS 4085
<i>Cissus verticillata</i> (L.) Nicolson & C.E.Jarvis	Uva-do-mato	X		Nat	Lte	Pha	Ad	EBS 3847
65. Violaceae								
<i>Pombalia calceolaria</i> (L.) Paula-Souza	Ipapeconha		X	Nat	Her	The	Ad	EBS 4507
<i>Pombalia communis</i> (A.St.-Hil.) Paula-Souza	Bandeira-branca		X	Nat	Sub	The	Ad	EBS 4416
66. Vochysiaceae								
<i>Callisthene fasciculata</i> Mart.	Capitão-do-mato	X		Nat	Tre	Pha	Ad	EBS 4434
<i>Callisthene minor</i> Mart.	Pau-de-pilão	X		Nat	Tre	Pha	Ca Ce AF	EBS 5269
67. Ximeniaceae								
<i>Ximenia americana</i> L.	Ameixa-de-espinho		X	Nat	Shr	Pha	Ad	EBS 4431

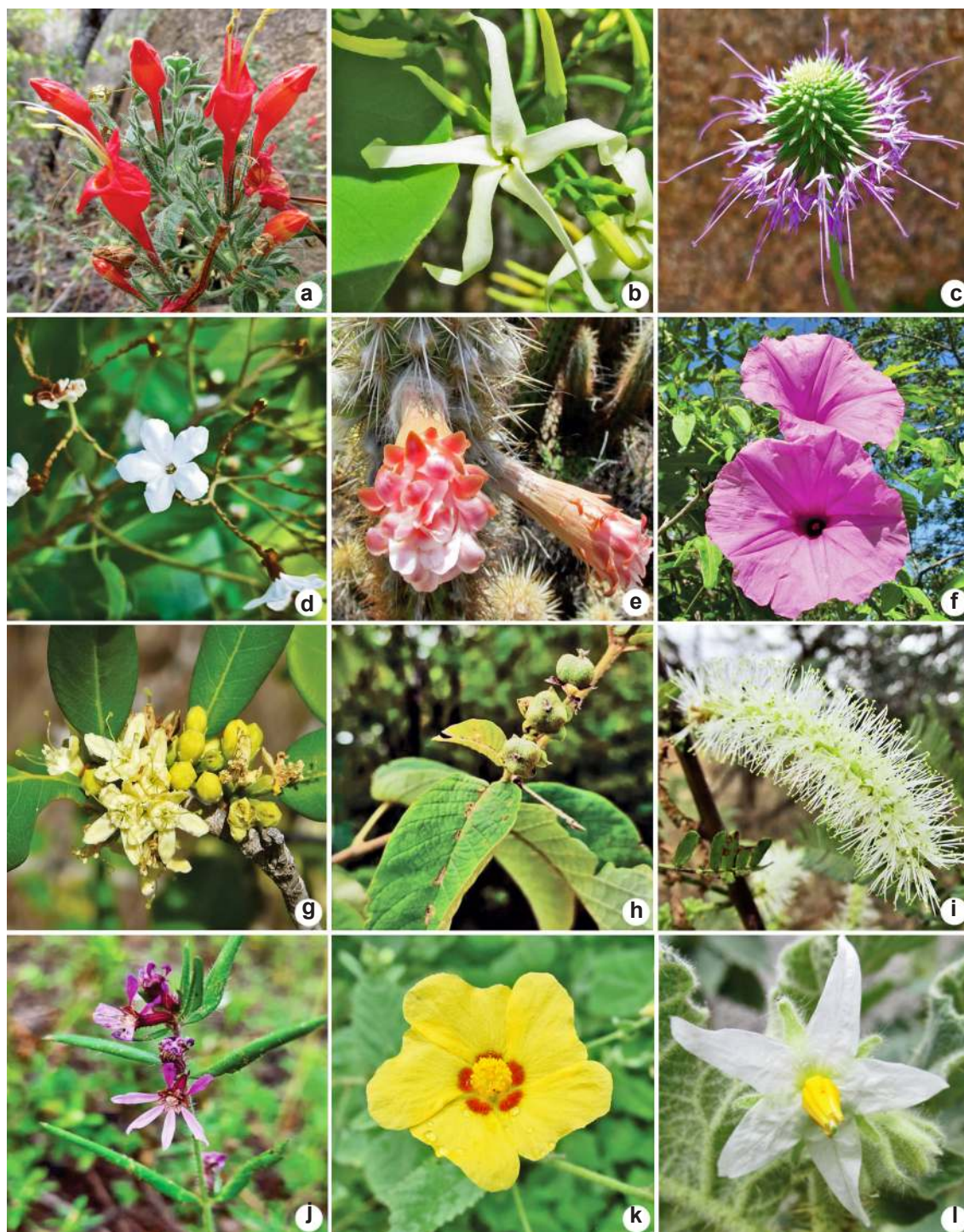


Figure 3 – a-l. Representatives of the flora of the Pedra da Andorinha Wildlife Refuge – a. *Ruellia asperula* (Acanthaceae); b. *Aspidosperma pyrifolium* (Apocynaceae); c. *Chresta pacourinoides* (Asteraceae); d. *Cordia oncocalyx* (Boraginaceae); e. *Xiquexique gounellei* (Cactaceae); f. *Ipomoea rosea* (Convolvulaceae); g. *Erythroxylum revolutum* (Erythroxylaceae); h. *Croton blanchetianus* (Euphorbiaceae); i. *Mimosa tenuiflora* (Fabaceae); j. *Cuphea campestris* (Lythraceae); k. *Sida galheirensis* (Malvaceae); l. *Solanum graniticola* (Solanaceae). (a, b, e, f, g, h, i, k, l. E.B. Souza; c, d, h, j. V.O. Amorim).

(73,3%) (Fig. 4a), especially the family Poaceae, whose species were classified as either exotic or native with ample geographic distribution (Tab. 2). The only exception was *Paspalum scutatum*, a grass species endemic to the *Caatinga* domain.

In relation to the phytogeographic domains of Brazil, 10.2% of the species surveyed are exclusive to the *Caatinga* domain (Fig. 4b), followed by three major distribution patterns: (i) *Caatinga* | *Cerrado* | Atlantic Forest; (ii) *Caatinga* | *Cerrado*; (iii) *Caatinga* | *Cerrado* | Amazonian. Most of the species are widely distributed, occurring in more than three phytogeographic domains (44.4%) (Tab. 2).

Among the 23 species endemic to the *Caatinga* phytogeographic domain, four species belong to the family Euphorbiaceae (*Croton adenocalyx*, *C. blanchetianus*, *C. japiensis* and *C. rudolphianus*), three to the family Fabaceae (*Cenostigma nordestinum*, *Mimosa niomarlei* and *Macropsyчанthus grandiflorus*), with two species each belonging to Cactaceae (*Pilosocereus chrysostele* and *Tacinga palmadora*) and Boraginaceae (*Cordia oncocalyx* and *Varronia dardani*).

New occurrences for Ceará state were encountered in the survey area (the species *Marsilea deflexa*, *Cuscuta racemosa*, *Evolvulus alsinoides*, and *Petiveria alliacea*), as well as new occurrences for Northeastern Brazil (*Hyparrhenia bracteata*).

Some species occupied restricted environments in the RPA, such as the fern *Marsilea*

deflexa, which has an amphibious habit and produces floating fronds in the shape of four-leaf-clovers that appear in small pools formed during the rainy period on the slopes of the inselberg. Their sporocarps are found buried in the substrate when those pools completely evaporate during the dry period. Species growing on rocky substrates include: the phanerophytes *Callisthene fasciculata*, *C. minor*, *Pilosocereus chrysostele*, *Solanum graniticola*, *Tacinga palmadora*, *Xiquexique gounellei*, and the chamaephyte *Philodendron acutatum*; the hemicryptophyte *Encholirium spectabile*; and the therophytes *Alternanthera martii*, *Chresta pacourinoides*, *Dichorisandra perforans*, *Mitracarpus baturitensis*, *Portulaca* spp., *Tradescantia ambigua*, and *Waltheria operculata*. From a phytogeographic point of view, some of the species growing on rock outcrops are listed as endemic to the *Caatinga* (5 spp.), or are species shared by both the *Caatinga* and *Cerrado* (5 spp.).

Species including *Cordia oncocalyx*, *Croton blanchetianus*, *Mimosa caesalpinifolia*, and *Mimosa tenuiflora*, can be found in areas that had been burned but are currently in the process of recuperation. Species including *Amburana cearensis*, *Anadenanthera colubrina*, *Handroanthus impetiginosus*, and *Astronium urundeua* were encountered immediately at the base of the Pedra da Andorinha inselberg where the vegetation is taller.

Life forms

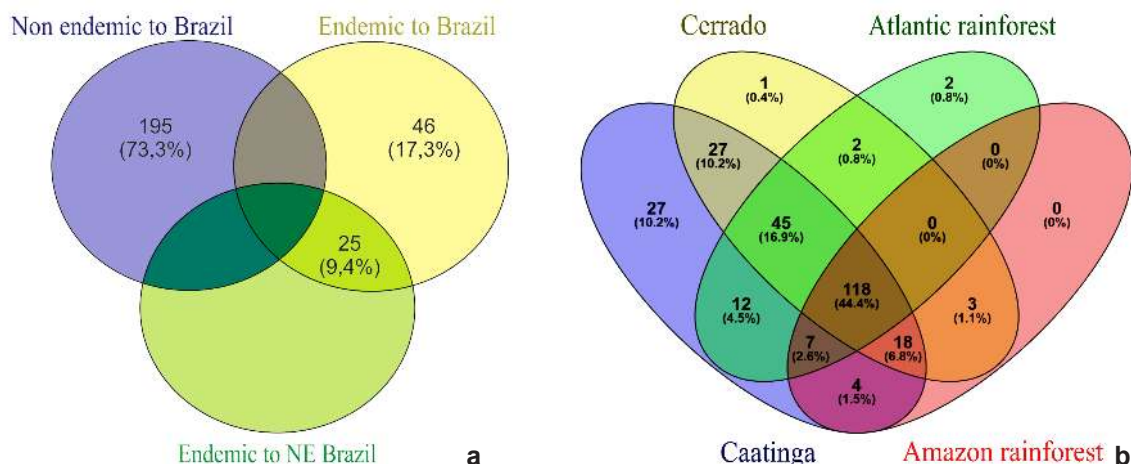


Figure 4 – a-b. Venn diagram demonstrating the overlapping and exclusive taxa of the 266 species surveyed in the RPA – a. Brazil and northeastern Brazil; b. Brazilian phytogeographic domains.

The spectrum of life forms (as defined by Raunkiaer) for the RPA (CE-Cry-And1) include 153 therophytes (57.5% of the flora), 88 phanerophytes (33.1%), 14 chamaephytes (5.3%), seven cryptophytes (2.6%), and four hemicryptophytes (1.5%) (Tab. 2).

We observed the dominance of therophyte species within the general biological spectrum in areas of crystalline *caatinga* (Fig. 5). Therophytes likewise showed elevated proportions in four areas of the inselbergs, while the other three areas had a majority of phanerophytes. Evaluating a *Caatinga* wide analysis of life form spectra, we observe that phanerophytes are predominant in all of the areas of sedimentary *caatinga* with sandy soils. Chamaephytes are well-represented in the two types of *caatinga*, with proportions comparable to the phanerophytes. Hemicryptophytes and cryptophytes have lower levels of occurrence, although they are present in practically all areas.

The NMDS analysis (stress: 0.109) of life forms in each area indicated the formation of three groups (Fig. 6): one was formed by all of the sedimentary *caatinga* areas, which have phanerophytes as the principal life form; another group was formed by areas of crystalline *caatinga* (in close proximity to each other due) with the dominance of therophyte species; the third group was formed by inselberg areas, apparently grouped

due to their higher proportions of cryptophytes on sediments accumulating in depressions in the rocks.

Phytosociology survey

We recorded 1988 woody individuals belonging to 24 species distributed among 13 families (Tab. 3; Fig. 7). The species with the largest numbers of individuals were: *Croton blanchetianus* (681), *Cordia oncocalyx* (558), *Combretum leprosum* (164), and *Mimosa caesalpinifolia* (127). Those woody individuals in the survey area had a total basal area of 45.31 m² and a mean height of 4.68 m. The tallest plant measured was a specimen of *Cordia oncocalyx* (12 m tall).

The total density of the survey area was 1,590.4 individuals/ha. Within that total, two species corresponded to 62.33% of the individuals surveyed: *Croton blanchetianus*, the species with the greatest absolute (544.8) and relative (34.26) densities; and *Cordia oncocalyx*. *Cordia oncocalyx* had the second greatest absolute density (446.4), as well as the greatest absolute dominance (22.16), the greatest relative dominance (61.12), the greatest importance value index (111.48), and the greatest cover value index (89.19).

In relation to the structural parameters of frequency, *Cordia oncocalyx* had the greatest absolute (90.40) and relative (22.29) frequencies,

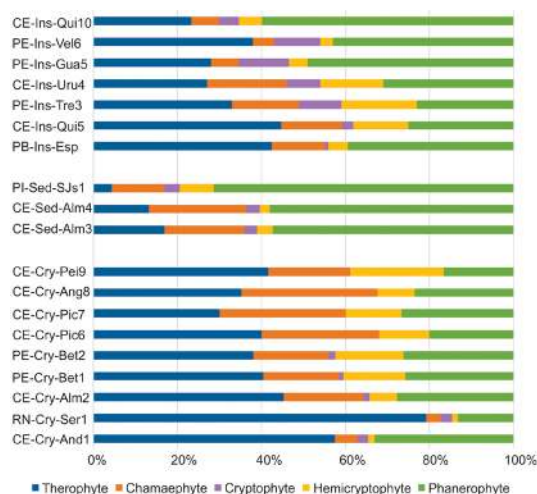


Figure 5 – Life form spectra of areas with different types of bedrock within the Caatinga phytogeographic domain. CE = Ceará state; PB = Paraíba; PE = Pernambuco; PI = Piauí; RN = Rio Grande do Norte; Cry = Crystalline Caatinga; Ins = Inselbergs; Sed = Sedimentary Caatinga.

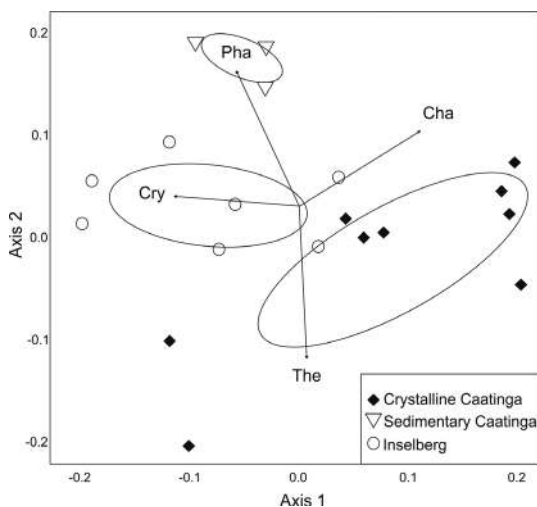


Figure 6 – Non-metric multidimensional scaling (NMDS) analysis of the Raunkiaer life forms for Crystalline Caatinga, Sedimentary Caatinga, and Inselbergs.

Table 3 – Structural parameters of the species, ordered according to their IVI indices (Importance Value Index). NI = number of individuals; AD = absolute density; RD = relative density; AF = absolute frequency; RF = relative frequency; ADo = absolute dominance; RDo = relative dominance; IVI = importance value Index; CVI = cover value index.

Species	NI	AD	RD	AF	RF	ADo	RDo	IVI	IVC
<i>Cordia oncocalyx</i>	558	446,4	28,07	90,4	22,29	22,16	61,12	111,48	89,19
<i>Croton blanchetianus</i>	681	544,8	34,26	35,2	8,68	3,18	8,78	51,71	43,03
<i>Mimosa tenuiflora</i>	104	83,2	5,23	45,6	11,24	3,14	8,66	25,13	13,89
<i>Mimosa caesalpinhiifolia</i>	127	101,6	6,39	37,6	9,27	2,83	7,8	23,46	14,19
<i>Combretum leprosum</i>	164	131,2	8,25	47,2	11,64	1,19	3,3	23,18	11,55
<i>Piptadenia retusa</i>	123	98,4	6,19	38,4	9,47	0,65	1,79	17,44	7,97
<i>Cenostigma nordesitum</i>	70	56	3,52	30,4	7,5	1,65	4,56	15,58	8,08
<i>Bauhinia cheilantha</i>	50	40	2,52	14,4	3,55	0,28	0,78	6,85	3,3
<i>Aspidosperma pyrifolium</i>	25	20	1,26	10,4	2,56	0,16	0,44	4,26	1,69
<i>Libidibia ferrea</i>	13	10,4	0,65	8,8	2,17	0,16	0,45	3,27	1,1
<i>Sarcomphalus joazeiro</i>	10	8	0,5	7,2	1,78	0,19	0,52	2,8	1,03
<i>XiqueXique gounellei</i>	13	10,4	0,65	7,2	1,78	0,08	0,22	2,65	0,88
<i>Cardiospermum corindum</i>	7	5,6	0,35	4,8	1,18	0,08	0,23	1,76	0,58
<i>Cereus jamacaru</i>	6	4,8	0,3	4,8	1,18	0,02	0,06	1,55	0,36
<i>Luetzelburgia auriculata</i>	10	8	0,5	2,4	0,59	0,1	0,29	1,38	0,79
<i>Commiphora leptophloeos</i>	5	4	0,25	4	0,99	0,03	0,08	1,32	0,33
<i>Cynophalla flexuosa</i>	5	4	0,25	3,2	0,79	0,05	0,13	1,17	0,38
<i>Varronia globosa</i>	4	3,2	0,2	3,2	0,79	0,02	0,05	1,04	0,25
<i>Cordia glabrata</i>	4	3,2	0,2	3,2	0,79	0,02	0,05	1,04	0,25
<i>Anadenanthera colubrina</i>	2	1,6	0,1	1,6	0,39	0,19	0,54	1,03	0,64
<i>Astronium urundeua</i>	2	1,6	0,1	1,6	0,39	0,03	0,09	0,59	0,19
<i>Cochlospermum vitifolium</i>	2	1,6	0,1	1,6	0,39	0,01	0,03	0,53	0,13
<i>Jatropha mollissima</i>	2	1,6	0,1	1,6	0,39	0	0,01	0,5	0,11
<i>Pseudobombax marginatum</i>	1	0,8	0,05	0,8	0,2	0,01	0,03	0,28	0,08

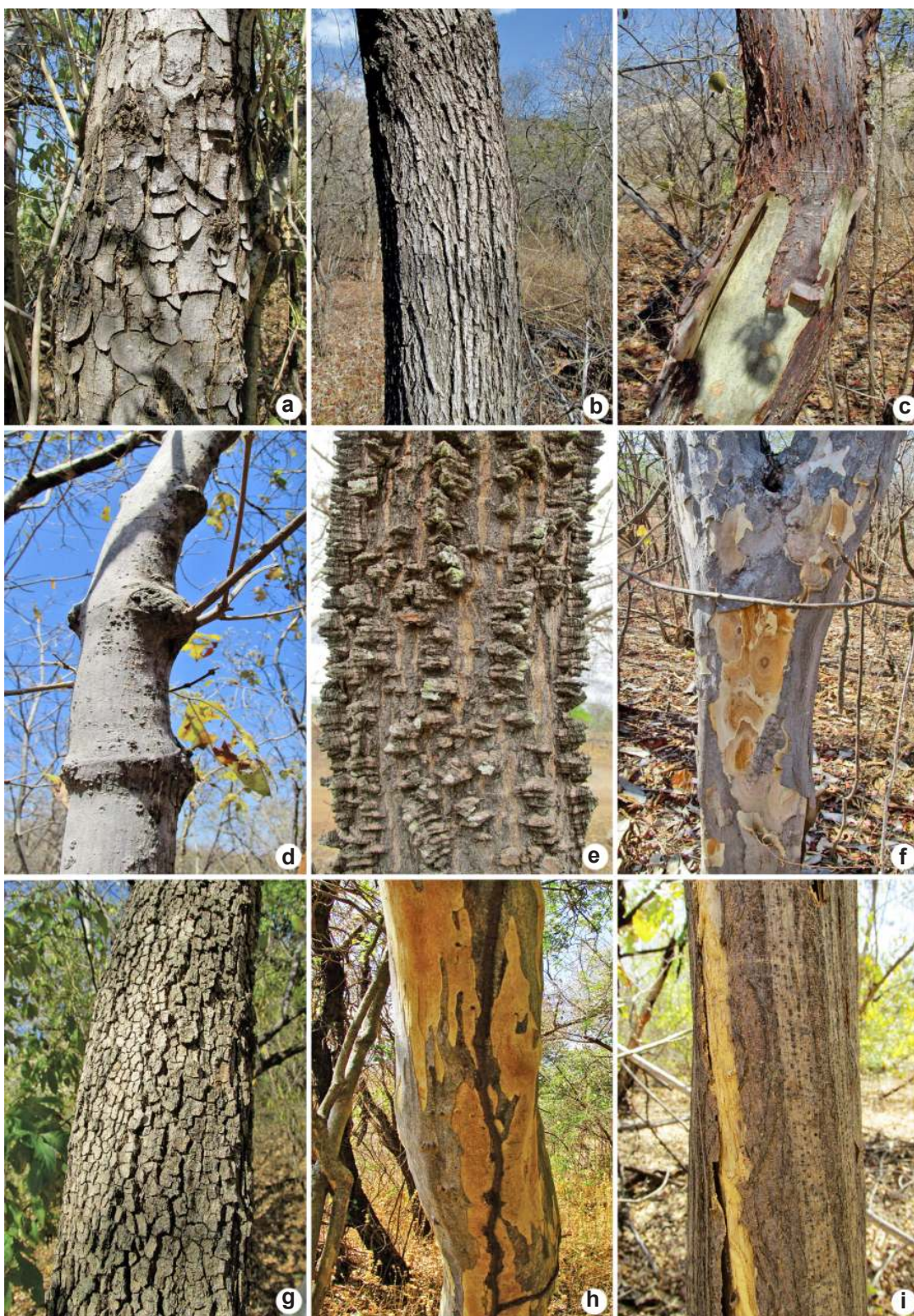


Figure 7 – a-i. Demonstration of the diversity of tree trunks of species catalogued within the Pedra da Andorinha Wildlife Refuge – a. *Astronium urundeuva*; b. *Handroanthus impetiginosus*; c. *Commiphora leptophloeos*; d. *Combretum leprosum*; e. *Anadenanthera colubrina*; f. *Cenostigma nordestinum*; g. *Cynophalla flexuosa*; h. *Libidibia ferrea*; i. *Piptadenia retusa*. (a-i. E.B. Souza).

followed by *Combretum leprosum* (47.20; 11.64), and then *Mimosa tenuiflora* (45.60; 11.24). The floristic diversity analyzed by the Shannon-Wiener diversity index (H') was 1.94.

Rarefaction, extrapolation, and estimation of total richness

All three asymptotic richness estimators used indicated similar richness values for the study area [ICE (24.4 spp.), Chao 2 (24 spp.), and Jack 1 (24.99 spp.)] (Fig. 8) - indicating that the numbers of plots used was satisfactory for sampling local woody species richness. The extrapolation method estimated that even if the number of plots was tripled, the numbers of species encountered would not be altered (Fig. 9). As such, the richness sampled in the present study appears very close to the true richness of the locality.

Discussion

Floristics and distribution

The family Fabaceae had the greatest species richness, appearing as the principal family composing the flora of the RPA, a position that family frequently holds in studies of the *Caatinga* flora. What is interesting, however, is that Convolvulaceae ranks as the second most important family in terms of species diversity (usually occupying approximately a fifth level ranking), although its genus *Ipomoea* is usually among the richest in *Caatinga* areas (a pattern that was repeated in the present study) (Costa *et al.* 2007; Araújo *et al.* 2008; Queiroz 2009; Gomes *et al.* 2011; Duarte *et al.* 2013; Ferreira *et*

al. 2013; Moro *et al.* 2014; Queiroz *et al.* 2015; Pereira *et al.* 2018).

The absence and low richness of Orchidaceae and Bromeliaceae families in inselbergs, respectively, may be related to the dry climate of the studied area and its surroundings. The few studies carried out in inselbergs in Ceará also have similar results, suggesting that these families are richer in more humid climates (Araújo *et al.* 2008; Paulino *et al.* 2018; Pereira *et al.* 2018) than in the *Caatinga* domain.

The genera having the greatest species richness in the present study area were the same as the most well-represented genera in a composite list of 131 floristic and phytosociological studies of the *Caatinga* compiled by Moro *et al.* (2014), as for example *Croton*, *Ipomoea* and *Mimosa*. Based on the recent checklist of angiosperms in Ceará state (Loiola *et al.* 2020), six new records can now be added to the Flora of Ceará, totaling 2,590 species.

The proportions of different habits within the RPA were very similar to those reported for other *Caatinga* areas (Costa *et al.* 2009; Araújo *et al.* 2011; Silva *et al.* 2013), with herbaceous plants, especially those with therophytic life forms, being the most species rich. Herbaceous plants, largely therophytes, are the predominant component of the flora in the RPA, as was observed in similar surveys in crystalline *caatinga* (Costa *et al.* 2007; Araújo *et al.* 2008, 2011; Gomes *et al.* 2011; Duarte *et al.* 2013; Ferreira *et al.* 2013; Queiroz *et al.* 2015; Pereira *et al.* 2018). The woody component, represented by phanerophytes,

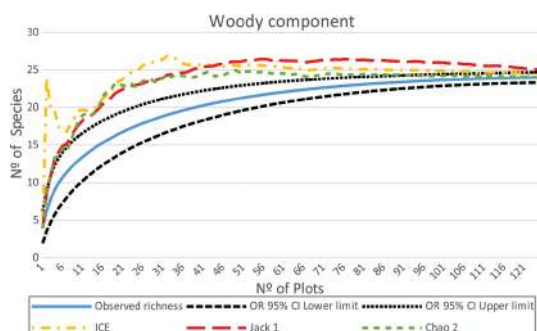


Figure 8 – Interpolated accumulation curve of the species sampled demonstrating the numbers of woody species observed in the study area (solid blue line) and the numbers of species estimated by three different richness estimators. OR = Observed richness; CI = Confidence interval.

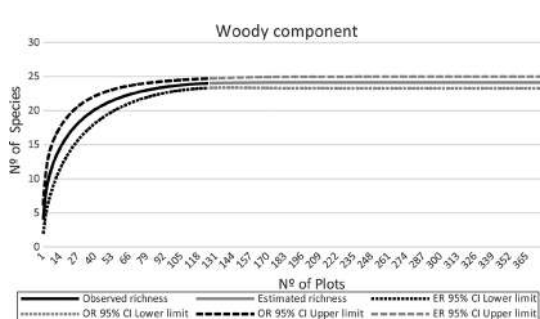


Figure 9 – Interpolated species accumulation curve to determine the richness of woody plants sampled within the study area, and the interpolated curve calculated for three times the sampling effort. ER = estimated richness; OR = observed richness; CI = confidence interval.

constitutes a third of the floristic composition of the RPA, and their presence is fundamental to defining the structure and physiognomy of *caatinga* vegetation.

The present survey area included a higher proportion of herbaceous species than reported for another area of crystalline *caatinga* at Quixadá, also in Ceará (Costa *et al.* 2007), although a smaller proportion than reported in Seridó in Rio Grande do Norte state (Queiroz *et al.* 2015).

The proportion of species found in the RPA having climbing mechanisms as opposed to tendrils was equivalent to the value (67%) reported by Araújo (2014) for the *Caatinga* domain. Other recent studies have corroborated those findings and identified climbing vines as important components in many *Caatinga* areas, presumably representing a successful adaptation related to competition in that environment. Those plants are associated with initial successional phases and occurring principally in clearings and along forest edges (Araújo 2014; Lucena *et al.* 2017, 2020).

In relation to endemism, we found numerous species endemic to the *Caatinga* domain in the RPA, such as *Solanum graniticola* (Sampaio *et al.* 2019), as well as others considered typical of (or frequent in) Cerrado *sensu lato* vegetation, such as *Callisthene minor*, *C. fasciculata*, and *Simarouba versicolor* (Fina & Monteiro 2013) - indicating that northwestern Ceará state shares floristic elements associated with both the *Caatinga* and Cerrado phytophysiognomies. Additionally, our survey evidenced high species richness and a significant number of endemic species growing on rock outcrops, in agreement with the observation that Brazil is among three global hot spots of inselberg plant diversity (Porembski 2007).

The single fern collected in the area (*Marsilea deflexa*) is widely distributed, occurring into Mexico, Guatemala, Honduras, Costa Rica, Colombia, Venezuela, Brazil, Peru, and Paraguay (Stefano *et al.* 2005). Although there have been very few records from Brazil (Xavier *et al.* 2012; Windisch 2015).

Life forms

The proportion of therophytes encountered in the RPA study area was in agreement with the proportion projected for crystalline *caatinga* based on Moro *et al.* (2016) and Fernandes & Queiroz (2018). Therophytes generally show high richness in *Caatinga* vegetation established on crystalline

bedrock regions (Araújo *et al.* 2005, 2008; Rodal *et al.* 2005; Costa *et al.* 2007, 2015; Mamede & Araújo 2008; Queiroz *et al.* 2015) and generally appear as the dominant life form in arid and semiarid vegetations (Kovács-Lang *et al.* 2000; Costa *et al.* 2015; Queiroz *et al.* 2015; Moro *et al.* 2016). In areas of sandy sedimentary *caatinga*, however, phanerophytes tend to demonstrate the greatest species richness (Moro *et al.* 2016), as was found in the three areas considered in the biological spectrum matrix (Fig. 3) - a pattern observed in other studies in the *Caatinga* domain (Araújo *et al.* 2011; Moro *et al.* 2016).

Therophytes and phanerophytes tend to predominate on inselbergs in *Caatinga*, with little difference between their observed richness. Comparing the biological spectra of inselbergs with that of the crystalline *caatinga*, similarities can be seen in terms of the proportions of each life form, with therophytes and phanerophytes demonstrating the greatest numbers of species, followed by chamaephytes and hemicryptophytes. The areas of both environments shared very similar climatic characteristics - with the exception of the inselbergs designated as PE-Ins-Uru4 and PE-Ins-Tre3, which are located in the *caatinga-agreste* transition zone and receive more rainfall and experience lower temperatures. Those areas are also located over crystalline bedrock formations, where greater richness of therophytes is usually observed (Araújo *et al.* 2005, 2008; Rodal *et al.* 2005; Costa *et al.* 2007, 2015; Mamede & Araújo 2008; Queiroz *et al.* 2015).

Comparing the observed biological spectrum with the results of the NMDS, it was notable to observe that cryptophyte species constitute an important element for grouping inselberg areas. Taking into consideration the environmental conditions of crystalline bedrock areas as having low rainfall rates, high temperatures, and shallow soils (Nimer 1972; Santos *et al.* 2018; IPECE 2020), it would be expected that the plants growing there would have developed survival strategies adequate for inselberg environments. Cryptophytes are characterized as plants having subterranean reserve structures (such as bulbs) that allow their survival through the dry season (Martins & Batalha 2011), and those plants normally occur on inselbergs in crevices or depressions with accumulations of substrate.

Phytosociology

The study area evidenced a density of plant

individuals ($1,590.4 \text{ ind.ha}^{-1}$) smaller than has been reported in most phytosociological surveys undertaken in crystalline *caatinga* sites: $2,448 \text{ ind.ha}^{-1}$ by Santana & Souto (2006); $2,448 \text{ ind.ha}^{-1}$ by Pereira-Júnior *et al.* (2012); and $4,822 \text{ ind.ha}^{-1}$ by Lima *et al.* (2019). Similar surveys undertaken by Rodal *et al.* (1992) ($1,076 \text{ ind.ha}^{-1}$) and Lacerda & Barbosa (2018) ($1,623 \text{ ind.ha}^{-1}$), however, likewise reported low plant densities in that habitat.

The sum of the basal area of the individuals found in the RPA ($36.25 \text{ m}^2 \cdot \text{ha}^{-1}$) was similar to what Lima *et al.* (2019) reported ($38.85 \text{ m}^2 \cdot \text{ha}^{-1}$) and greater than Pereira-Júnior *et al.* (2012) ($28.77 \text{ m}^2 \cdot \text{ha}^{-1}$) described, although those authors reported greater values of absolute abundance. That contrast is probably due to the high frequency and dominance of *Cordia oncocalyx* in the area surveyed here, as that species is relatively tall and develops relatively large diameter stems.

The notable presence of *Cordia oncocalyx* in the study area is crucial for identifying the vegetation type now known as Median *Caatinga* Forest according to the classification system of Prado (2003), Unit VII/Type 13 - a phytophysiology marked by the presence of *C. oncocalyx*. A phytosociological study undertaken in RRPN Serra das Almas in Ceará state (Costa & Araújo 2012) likewise reported *Caatinga* vegetation with *C. oncocalyx* as a distinct floristic subtype community within the *Caatinga* domain.

The Pedra da Andorinha Wildlife Refuge was established only 11 years ago, and its vegetation still retains marks of previous degradation, with areas in different successional stages - a heterogeneity that was sampled in the study plots. Additionally, local residents have commented on the occurrence of anthropic fires along the boundaries of the Refuge that have penetrated into its interior, generating severe environmental impacts.

The plots evidencing some type of recent degradation contained elevated numbers of individuals of *Croton blanchetianus*, adding to its overall high absolute density; that same species was also reported as occurring at high densities by Lacerda & Barbosa (2018). A number of different authors have reported *Croton* species as occurring with high abundances in phytosociological surveys undertaken in crystalline *caatinga* sites (Pereira-Júnior 2012; Lemos *et al.* 2019), reflecting its habit and developmental characteristics, including its shrub form and facility for sprouting, which makes it, like many representatives of the Euphorbiaceae

family, well adapted to the dry *Caatinga* climate (Oliveira 2013; Barros *et al.* 2021).

The Shannon-Wiener diversity index (H') of 1.94 is comparatively low in relation to reports from other crystalline *caatinga* areas: 3.466 by Lemos *et al.* 2019; 2.35 by Santana & Souto 2006; 2.29 by Pereira-Júnior 2012; and 2.18 by Lacerda & Barbosa 2018. That result reflects, in part, the high abundances of *Cordia oncocalyx* and *Croton blanchetianus* (62.33 % of all individuals) as compared to the total richness of the 24 woody species identified in the area.

Our results indicate that the flora of the RPA is composed of a large proportion of herbaceous plants, with the predominance of therophytes, a pattern frequently encountered in crystalline *caatinga*. The biological spectrum indicated a significant diversity of life and growth forms, especially of vine species, reflecting the heterogeneity of habitats and the different states of conservation of the individual plots. Most of the species encountered in this study have ample geographic distributions within Brazil, although endemic species are also present. The horizontal structure of the vegetation is principally marked by an abundance of *Croton blanchetianus* in areas with histories of recent degradation, and an abundance of *Cordia oncocalyx* in more highly conserved sites. Based on floristic and physiognomic data, the vegetation in the RPA was identified as Median *Caatinga* Forest. The existence of plant species endemic to Brazil, and to the *Caatinga*, within the Refuge boundaries reinforces its importance to conservation efforts - not only in terms of the plants themselves and the resident native fauna, but also the migratory birds that depend on it for their reproduction and survival.

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