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Floristic diversity of two crystalline rocky outcrops in the Brazilian northeast semi-arid region[1]

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ABSTRACT – (Floristic diversity of two crystalline rocky outcrops in the Brazilian northeast semi-arid region). Floristic composition and structure of vegetation were studied in two rocky outcrop areas in the semi-arid region of northeastern Brazil. From April 2007 to September 2008, 18 monthly field trips were carried out. Vascular plants were randomly collected throughout the outcrop areas. For structural analysis, 30 plots of 1 × 1 m were set in the vegetation islands. The checklist presented combines 211 species (69 families and 168 genera), although only 56 species were collected in the plots. Fabaceae (18 spp.; 8.5%), Asteraceae (17 spp.; 8%), Orchidaceae (13 spp.; 6.1%), Euphorbiaceae (13 spp.; 6.1%), Bromeliaceae (10 spp.; 4.7%), and Poaceae (eight spp.; 3.8%) are the richest families. Overall, 1,792 shrub and herbaceous specimens were counted in the plots. The Shannon-Wiener (H) diversity index values were 2.572 and 2.547 nats individual^{-1}. The species that presented the highest absolute abundance values (number of plants) had low frequencies in the plots and vice-versa. The biological spectrum had a high proportion of phanerophytes and therophytes, followed by cryptophytes, chamaephytes, and hemicryptophytes. The studied flora shares floristic components similar to other rocky outcrop areas of the semi-arid region in northeastern Brazil, including in relation to dominant groups in the vegetation structure.

Key words - *Caatinga*, inselbergs, life-forms, saxicolous plants

RESUMO – (Diversidade florística de dois afloramentos rochosos cristalinos no semi-árido, nordeste do Brasil). Composição florística e estrutura da vegetação foram estudadas em dois afloramentos rochosos localizados no semi-árido do nordeste do Brasil. Foram realizadas 18 excursões mensais, de abril de 2007 a setembro de 2008. Plantas vasculares foram coletadas aleatoriamente, no afloramento como um todo. Para análise estrutural foram plotadas 30 parcelas de 1 × 1 m nas ilhas de vegetação. Foram encontradas 211 espécies (69 famílias e 168 gêneros), entretanto somente 56 espécies foram coletadas nas parcelas. As famílias com maior número de espécies foram Fabaceae (18 spp.; 9%), Asteraceae (17 spp.; 8,5%), Orchidaceae (13 spp.; 6,5%), Euphorbiaceae (13 spp.; 6,5%), Bromeliaceae (10 spp.; 5%) e Poaceae (oito spp.; 4%). Ao todo, foram contabilizados, nas parcelas, 1.792 indivíduos herbáceos e arbustivos. Os valores do índice de diversidade de Shannon-Wiener (H) foram de 2,572 e 2,547 nats ind.$^{-1}$. As espécies que apresentaram maiores densidade apresentaram baixa freqüência nas parcelas e vice-versa. O espectro biológico apresentou alta proporção de fanerófitos e terófitos, seguidos por criptófitos, caméfitos e hemi-criptófitos. A flora estudada compartilha conjunto florístico semelhante a outros afloramentos rochosos do Nordeste do Brasil, inclusive em termos de grupos dominantes na estrutura da vegetação.

Palavras-chave - Caatinga, formas de vida, inselbergues, plantas saxícolas

Introduction

Few vegetation formations have caught as much attention from the scientific community as the rocky outcrops. Most of such interest is due to their wide distribution and because they represent good experimental models, especially due to their easily delimitable spatial boundaries (Porembski & Barthlott 2000). However, the interests primarily turn to those environments because they shelter a peculiar biota, with several endemic species (Oosting & Anderson 1939, Porembski & Barthlott 2000).

Studies in tropical rocky outcrop areas have been intensified since the end of last century. Most of them are from Porembski and collaborators (Porembski & Barthlott 1997, Porembski *et al.* 1997, Porembski 2000, Porembski & Barthlott 2000, among others).

Despite that, there is a great knowledge gap concerning the crystalline rocky outcrops in Northeastern Brazil (Martinelli 2007). In this region, they occur mainly in the Sertaneja Depression and the Borborema Plateau, as residual massifs or mountains (Silva *et al.* 1993), differing geologically and biogeographically from *campos rupestres* of Chapada Diamantina,

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mainly in metamorphic rocks from sedimentary origin (predominantly quartzites) (Silva *et al.* 1993, Alves & Kolbek 1994, Alves *et al.* 2007).

The floristic inventories in northeastern crystalline rocky outcrop areas started with França *et al.* (1997) in the state of Bahia. Those authors also approached aspects of the vegetation's structure (França *et al.* 2005, 2006). After those initial studies, floristic checklists of rocky areas were published by Porto *et al.* (2008) for the state of Paraiba, Araújo *et al.* (2008) for the state of Ceará and finally Gomes & Alves (2009) for the state of Pernambuco (figure 1).

Nevertheless, basic aspects of the vegetation, such as which groups are dominant, are not yet clear (Martinelli 2007), especially because the already existing work covers little of the quantity and diversity of the rocky outcrops found in the semi-arid region of Brazil (Ab'Sáber 2003). Thus, this study presents the floristic diversity of two rocky outcrops from crystalline origin located in the semi-arid region of the state of Pernambuco.

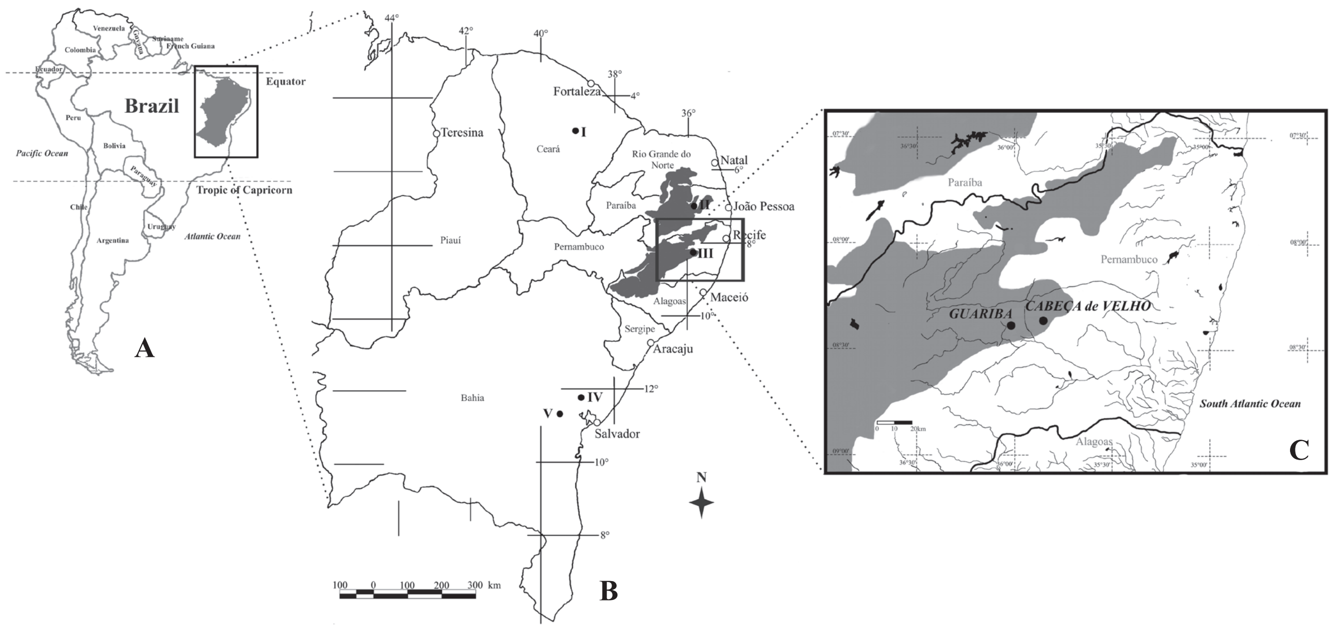


Figure 1. Location of study areas. Dark areas correspond to: A. Brazilian semi-arid; and (B and C) Borborema Plateau. B. Roman numerals are the floristic studies in northeastern crystalline rocky outcrop areas: (I) Araújo *et al.* (2008), (II) Porto *et al.* (2008), (III) Gomes & Alves (2009), (IV, V) França *et al.* (1997, 2005, 2006).

Material and methods

Study area – Most part of the Northeastern region of Brazil is characterized by a semi-arid climate, seasonally dry and with very high temperatures (Andrade-Lima 1981). Sertaneja Depression is the typical landscape unit (around 370,000 km^2) where the rainy season is limited to few months of the year and the temperature is very high (Silva *et al.* 1993). The annual pluviometry, in its core portion, is lesser than 600 mm, with annual average temperature between 25-29 °C (Ab'Saber 1974, 2003, Silva *et al.* 1993).

Amongst the other landscape entities is the Borborema Plateau (around 45,000 km^2), located in the extreme east of the semi-arid region (figure 1). It is formed from a series of strongly weathered crystalline massifs with an altitude of 600 to 1,000 m (Silva *et al.* 1993). The climate is characterized by accentuated irregularity in rain distribution and higher precipitation volume in the west than in the east (Silva *et al.* 1993). Despite having a seasonal climate as well, the climatic conditions are milder in the plateau than in the depressions between plateaus (Silva *et al.* 1993, Ab'Sáber 2003). The annual average precipitation values range from 600 to 1,000 mm, which is higher than in the surrounding area (Conti 2005, ITEP 2010). However the average temperature is similar (Conti 2005, ITEP 2010).

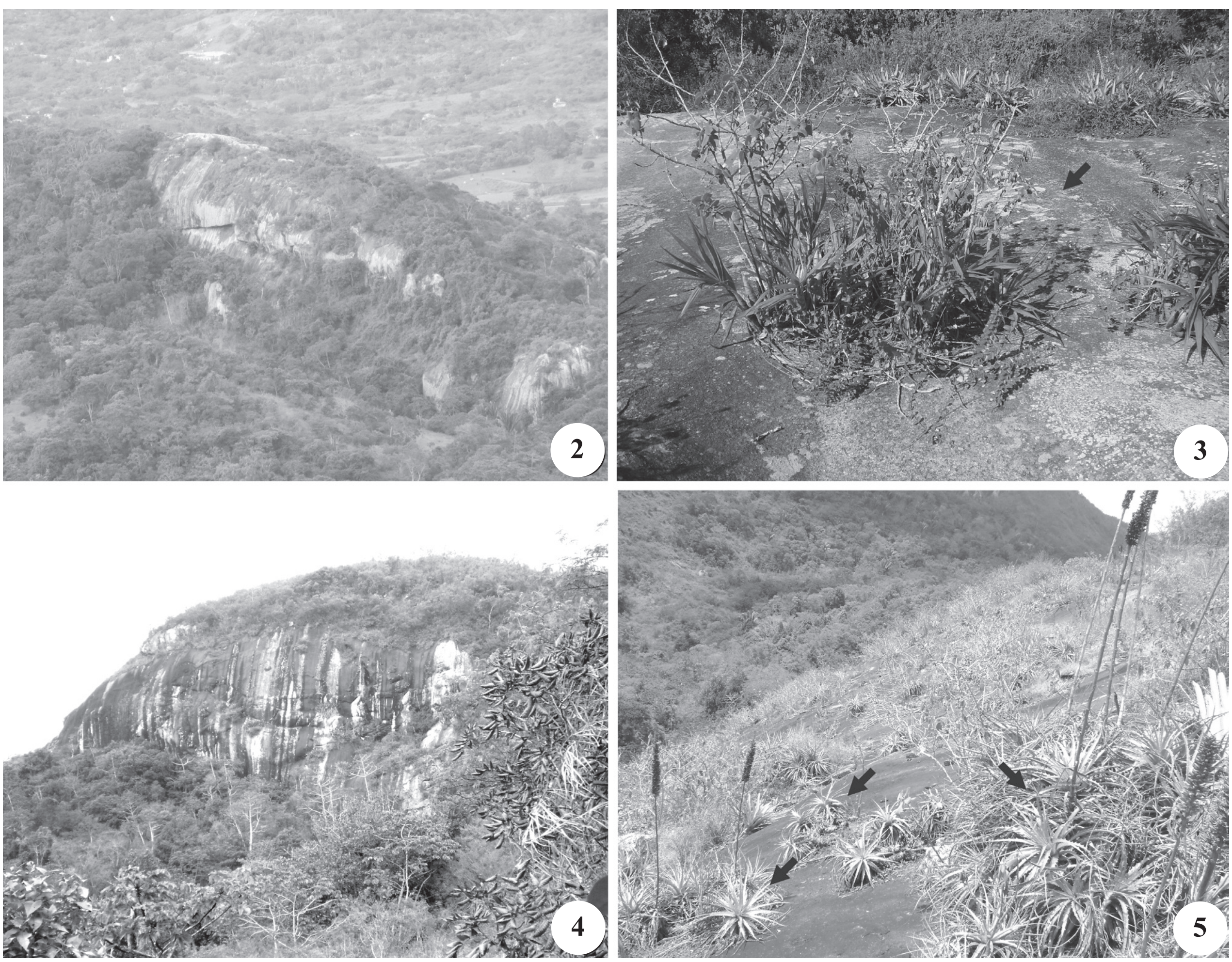
The main vegetation is the savanna-steppe – *caatinga* (Silva *et al.* 1993). However, exceptional aspects of lithology, hydrology, topography, and paleobotany explain the existence of other vegetation types, such as humid forests (Ab'Sáber 2003). These humid forest refuges occurring in the Borborema Plateau are known locally as *Brejos de Altitude* and have a peculiar climate condition generated by the relief (see Vasconcelos-Sobrinho 1949, Andrade-Lima 1982). Thus, through these barriers to the air masses, the humidity is deposited in the windward strands, grottoes and mountain valleys (Andrade-Lima 1982). The vegetation established in these areas is ombrophilous or seasonal (Rodal *et al.* 2005) and can be classified as sub-montane when located between 100 and 600 m and montane when located over 600 m (Veloso *et al.* 1991).

The two rocky outcrop areas studied in this work are mountain tops inserted in a Forest refuges, called "Brejo de Agrestina" (Vasconcelos-Sobrinho 1949). They are 2 km apart from each other and approximately 150 km away from the Atlantic coast, in the state of Pernambuco (figure 1). The first one is called "Pedra da Guariba" (08°22'55" S-35°50' 38" W; figures 2 and 3), with an altitude of 620 m and *ca.* 0.4 km^2 in size. The second one is "Pedra Cabeça de Velho" (08°23'29" S-36°00'37" W; figures 4 and 5), which has an altitude of 740 m and *ca.* 0.35 km^2 in size. Both have a granite base with some gneiss inclusions.

In the study area, the dry season extends for 6 to 8 months, with precipitation between 12-52 mm per month, while the rainy season lasts for 4 to 5 months, with precipitation between 81-98 mm per month (ITEP 2010). The annual average for precipitation is 662 mm and for temperature is 22.5 °C, with a range of 20 to 24 °C (ITEP 2010).

The surrounding areas are occupied by small and medium farms. Bovine and poultry livestock and subsistence agriculture are the main activities. The rocky outcrop areas studied are less degraded than their surroundings due to their low potential for agriculture. However, Cabeça de Velho was affected twice by accidental fires within a three-year period. There is no record of fires in Guariba, but this fragment suffers more pressure from visitors than the first one. The area is cited as of extreme importance for environment inventories and for the creation of a protection area (Martinelli 2007, MMA 2007).

Sampling – From April 2007 to September 2008, 18 monthly fieldtrips were made, totalizing *ca.* 210 h of sampling effort. Fertile specimens of vascular plants were randomly collected. The material was processed according to the usual methodology for botanical studies and was deposited in UFP herbarium, with duplicates in NY, RB, HUEFS, and IPA herbaria (see Thiers 2010).



Figures 2-5. General aspect of two crystalline rocky outcrops in the Brazilian northeast semi-arid region: (2 and 3) Pedra da Guariba and (4 and 5) Pedra Cabeça de Velho. Arrows correspond to (2 and 4) island of vegetation.

In rock outcrops there are extensive rock patches devoid of vascular vegetation (Meirelles *et al.* 1999). Due to this, in order to avoid some plots falling out on a bare surface (*e.g.* see Caiafa & Silva 2007), our sampling unity for abundance and frequency analyses of the species were the vegetation islands (figures 2 and 5). All vegetation islands that were accessible on the eastern faces (windward) were numbered. The vegetation located leeward could not be included in the analyses because these sites were inaccessible due to their high slope. In total, 178 islands were marked: 109 in Guariba and 69 in Cabeça de Velho. Then, 30 vegetation islands were randomly chosen, 15 from each outcrop, and plots of 1 × 1 m were plotted in each selected island. For the vegetation islands longer than 1 m length and/or width, the place to set the plot was randomly chosen, from left to right. In each plot the species and the number of individuals per species were counted. An individual was defined as being the whole aerial axis of a plant without any connection to another axis at or above soil level. For the plot analyses, the data were collected in July 2007 and 2008, since this is one of the months with the highest precipitation in the study locality.

Data analysis – Species identifications were made by reference to the collections available at UFP, PEUFR, IPA, HUEFS, SP and SPF, literature and taxonomists. For some taxa collected in a seedling stage in the plots, the species level identification was not possible. The floristic checklist is according to APG III (2009) and Tryon & Tryon (1982). The species were classified into Raunkiaer's life-forms (1934). With the data from the plots, the parameters of absolute dominance, relative dominance, absolute frequency, and relative frequency were calculated according to Mueller-Dombois & Ellenberg (1974). The Shannon-Wiener (H) diversity and Jaccard similarity indexes were calculated with PAST software version 1.77©.

Results

Floristic – The 211 species were found in the random sampling collected from both localities and the whole outcrop area, consisting of 205 angiosperms and 6 pteridophytes, belonging to 69 families and 168 genera (table 1). The richest families were Fabaceae (18 spp.; 8.5%), Asteraceae (17 spp.; 8%), Orchidaceae (13 spp.; 6.2%), Euphorbiaceae (12 spp.; 5.7%), Bromeliaceae (10 spp.; 4.7%), and Poaceae (eight spp.; 3.8%), representing together *ca.* 35% of the taxa. The richest genera were *Ipomoea*, with four species, followed by *Erythroxylum*, *Mandevilla*, *Tillandsia*, *Croton*, *Senna*, and *Hyptis*, with three species each.

Overall, there were 143 species exclusive to one of the two areas and 67 shared species. The richness of Guariba (154 species) was greater than that of Cabeça de Velho (125 spp.). Guariba had 86 exclusive species and 18 exclusive families. In Cabeça de Velho, there were 57 exclusive species and 12 exclusive families (table 1). The Jaccard similarity index between the studied areas was 0.347.

Table 1. Checklist of vascular plants, with localities (a), vouchers (b) and life-forms (c), collected in two rock outcrops of the semi-arid region in Brazil. (Gua = Pedra do Guariba; Cab = Pedra Cabeça de Velho; BSA = B.S. Amorim *et al.*; EC = E. Córdula *et al.*; JO = J. Oliveira *et al.*; JRM = J.R. Maciel *et al.*; KM = K. Mendes *et al.*; KP = K. Pinheiro *et al.*; PG = P. Gomes *et al.*; Cr = cryptophyte; HCr = hemicryptophyte; Ch = chamaephyte; Ph = phanerophyte; Th = therophyte. [d]Species also found in the plots.)

Family	Species	Locality[a]		Voucher[b]	Life-forms[c]
		Gua	Cab		
ACANTHACEAE	*Dyschoriste maranhonis* Kuntze	X		PG 663	Th
ALSTROEMERIACEAE	*Bomarea edulis* Herb	X	X	PG 425, JRM 505	Cr
AMARANTHACEAE	*Alternanthera brasiliana* (L.) Kuntze	X		PG 568	Th
	Gomphrena vaga Mart.	X		PG 03	Cr
AMARYLLIDACEAE	*Habranthus itaobinus* Ravenna		X	PG 732	Cr
	Hippeastrum stylosum Herb.	X	X	PG 747, 751	Cr
ANACARDIACEAE	*Myracrodruon urundeuva* M. Allemão	X		PG 737	Ph
APIACEAE	*Spananthe paniculata* Jacq.		X	PG 428	Th
APOCYNACEAE	*Ditassa oxyphylla* Turcz.	X		PG 471	Ph
	Mandevilla dardanoi M. F. Sales, Kin.-Gouv. & A. O. Simões[d]	X	X	KM15, PG 343	Ph
	Mandevilla scabra K. Schum.	X	X	PG 260, 842	Cr
	Mandevilla tenuifolia (J. C. Mikan) Woodson	X	X	KP 271, KM 19	Cr
	Marsdenia loniceroides E. Fourn.[d]	X	X	PG 716, 733	Ph
	Matelea maritima (Jacq.) Woodson	X	X	PG 312, 525	Ph

continue

continuation

Family	Species	Locality[a]		Voucher[b]	Life-forms[c]
		Gua	Cab		
	Petalostelma martianum E. Fourn.	X		PG 420	Ph
ARACEAE	*Anthurium affine* Schott[d]	X	X	PG 265, 508	Ch
	Anthurium gracile Engl.		X	PG 269	Ph
	Philodendron acutatum Schott	X		PG 461	Ph
	Philodendron leal-costae Mayo & G. M. Barroso	X		PG 763	Ph
ASPARAGACEAE	*Agave sisalana* Perrine ex Engelm.	X		PG 493	HCr
ASTERACEAE	*Achyrocline satureioides* (Lam.) DC.		X	PG 761	Th
	Ageratum sp.		X	PG 437	Th
	Bidens pilosa L.	X	X	PG 407, 505	Th
	Delilia biflora (L.) Kuntze	X		PG 460	Th
	Eclipta alba Hassk.	X		PG 573	Th
	Emilia fosbergii Nicolson	X		PG 328	Th
	Emilia sonchifolia (L.) DC.		X	PG 345	Th
	Erechtites hieraciifolius (L.) Raf. ex DC.		X	PG 430	Th
	Eupatoriopsis sp.	X		PG 259	Th
	Eupatorium sp.	X		PG 570	Ph
	Gochnatia lucida (DC. ex Mart.) Cabrera		X	PG 348	Ph
	Helichrysum indicum (L.) Grierson[d]	X	X	PG 561, 506	Th
	Pithecoseris pacourinoides Mart. *ex* DC.	X		PG 479	Th
	Platypodanthera melissifolia (DC.) R. M. King. & H. Rob.[d]	X	X	PG 409, 363	Th
	Vernonia acutangula Gardner	X		PG 408	Th
	Vernonia sp.		X	PG 514	Th
	Asteraceae 1	X		PG 378	Th
BEGONIACEAE	*Begonia lealii* Brade	X		PG 262	Ph
	Begonia saxicola A. DC.[d]	X	X	KP 270, PG 524	Ph
BIGNONIACEAE	*Jacaranda* cf. *jasminoides* (Thunb.) Sandwith	X		PG 742	Ph
	Pyrostegia venusta Miers	X		PG 670	Ph
	Tabebuia cf. *impetiginosa* (Mart. ex DC.) Standl.	X		PG 671	Ph
BORAGINACEAE	*Cordia globosa* Kunth	X		PG 834	Ph
BROMELIACEAE	*Aechmea leptantha* (Harms) Leme & J. A. Siqueira[d]	X	X	PG 255, 330	HCr
	Bromelia karatas L.	X	X	PG 256, 851	HCr
	Encholirium spectabile Mart. ex Schult. & Schult.f.	X	X	PG 725, 661	Ch
	Hohenbergia catingae Ule	X		PG 740	HCr
	Hohenbergia ridleyi Mez	X	X	PG 754, 734	HCr
	Orthophytum disjunctum L. B. Sm.[d]	X	X	PG 711, 331	HCr
	Tillandsia gardneri Lindl.	X		PG 744	Ph
	Tillandsia recurvata (L.) L.	X		PG 322	Ph
	Tillandsia stricta Sol. ex Sims.	X		PG 743	Ph
	Tillandsia usneoides (L.) L.	X		PG 317	Ph
CACTACEAE	*Cereus albicaulis* (Britton & Rose) Luetzelb.[d]	X	X	BSA 83, PG 384	Ph
	Cereus jamacaru DC.	X		PG 852	Ph
	Pilosocereus pachycladus F. Ritter	X	X	PG 753, 727	Ph
	Rhipsalis lindbergiana K. Schum.	X	X	*Image database*, PG 517	Ph
	Rhipsalis sp.	X	X	*Image database*, PG 518	Ph

continue

continuation

Family	Species	Locality[a]		Voucher[b]	Life-forms[c]
		Gua	Cab		
CANNABACEAE	*Trema micrantha* (L.) Blume	X	X	PG 382, 846	Ph
CELASTRACEAE	*Hippocratea volubilis* L.	X		PG 668	Ph
CLEOMACEAE	*Cleome* cf. *pernambucensis* Iltis & Costa, Silva		X	PG 434	Th
CLUSIACEAE	*Clusia* sp.	X	X	PG 875, PG 849	Ph
COMMELINACEAE	*Callisia repens* (Jacq.) L.	X		PG 453	Th
	Callisia sp.		X	PG 426	Th
	Commelina obliqua Vahl[d]	X	X	PG 321, 523	Th
	Dichorisandra hexandra Standl.	X		PG 323	Ch
CONVOLVULACEAE	*Ipomoea megapotamica* Choisy	X		PG 463	Ph
	Ipomoea subincana Meisn.	X		PG 324	Cr
	Ipomoea sp.		X	PG 346	Cr
	Merremia macrocalyx (Ruiz & Pav.) O'Donell	X	X	PG 451, 440	Cr
COSTACEAE	*Costus spiralis* Roscoe	X		PG 327	Ph
CUCURBITACEAE	*Cayaponia* sp.	X		PG 319	Ph
	Cyclanthera cf. *elegans* Cogn.	X		PG 370	Th
CYPERACEAE	*Bulbostylis scabra* (J. Presl & C. Presl) C. B. Clarke[d]	X	X	PG 379, 447	Th
	Cyperus cuspidatus Kunth[d]	X	X	PG 567, 542	Th
	Cyperus uncinulatus Schrad. ex Nees	X		PG 455	Th
	Lipocarpha micrantha (Vahl) G. C.Tucker		X	PG 477a	Th
	Scleria interrupta Rich.		X	PG 519	Th
DIOSCOREACEAE	*Dioscorea* cf. *coronata* Hauman		X	PG 513	Cr
	Dioscorea dodecaneura Vell.	X		PG 477	Cr
DROSERACEAE	*Drosera montana* A. St.-Hil.		X	PG 446	Th
ERIOCAULACEAE	*Paepalanthus lamarckii* Kunth		X	PG 445	Th
	Paepalanthus myocephalus Mart. ex Körn.[d]	X	X	PG 475, 441	Th
ERYTHROXYLACEAE	*Erythroxylum pulchrum* A. St.-Hil.	X		PG 476	Ph
	Erythroxylum revolutum Mart.		X	PG 361	Ph
	Erythroxylum suberosum A. St.-Hil.	X		PG 728	Ph
EUPHORBIACEAE	*Acalypha brasiliensis* Müll. Arg.	X	X	BSA 134, 97	Ph
	Acalypha sp.	X		BSA 85	Ph
	Astraea lobata (L.) Klotzsch		X	BSA 98	Th
	Cnidoscolus urens (L.) Arthur[d]	X	X	BSA 84, 101	Ph
	Croton hirtus L' Hér.		X	PG 369	Th
	Croton urticifolius Lam.	X	X	BSA 87, 99	Ph
	Dalechampia scandens L.	X		BSA 94	HCr
	Euphorbia comosa Vell.[d]	X	X	BSA 91, 102	Ph
	Euphorbia insulana Vell.[d]	X	X	BSA 88, 96	Ph
	Manihot sp.	X		PG 750	Ph
	Romanoa tamnoides (A.Juss.) Radcl.-Sm.	X		BSA 132	Ch
	Sapium argutum Huber	X		PG 253	Ph
FABACEAE	*Cajanus cajan* (L.) Millsp.	X		JO 22	Th
	Centrosema virginianum (L.) Benth.	X		PG 576	Th
	Chaetocalyx scandens (L.) Urb.		X	PG 662	Th
	Chamaecrista nictitans Moench	X	X	PG 738, 516	Th
	Crotalaria lanceolata E. Mey.	X	X	PG 309, 590	Th
	Desmodium incanum DC.		X	PG 336	Ph
	Hymenaea martiana Hayne		X	PG 660	Ph

continue

continuation

Family	Species	Locality[a]		Voucher[b]	Life-forms[c]
		Gua	Cab		
	Inga vera Willd.	X		PG 767	Ph
	Macroptilium bracteatum (Nees & C. Mart.) Maréchal & Baudet	X		PG 856	Ph
	Mimosa arenosa Poir.		X	PG 515	Ph
	Mimosa ursina Mart.		X	PG 520	Ph
	Piptadenia stipulacea (Benth.) Ducke	X		EC 311	Ph
	Senna aversiflora (Herb.) H. S. Irwin & Barneby	X	X	PG 418, 423	Ph
	Senna martiana (Benth.) H. S. Irwin & Barneby		X	PG 332	Ph
	Senna rizzini H. S. Irwin & Barneby	X		PG 470	Ph
	Stylosanthes scabra Vogel		X	PG 356	Th
	Vigna peduncularis Fawc. & Rendle	X	X	PG 488, 591	Th
	Zornia myriadena Benth.		X	PG 541	Th
GENTIANACEAE	*Schultesia guianensis* (Aubl.) Malme[d]		X	PG 436	Th
GESNERIACEAE	*Paliavana tenuiflora* Mansf.[d]	X	X	PG 264, 340	Ph
	Sinningia nordestina Chautems, Baracho & Siqueira	X	X	PG 487, 855	Th
LAMIACEAE	*Hyptis* cf. *calida* Mart. ex Benth.	X	X	PG 421, 431	Ph
	Hyptis pectinata Poit.	X		PG 571	Ch
	Hyptis sidifolia (L'Hér.) Briq.	X		PG 569	Ch
	Marsypianthes chamaedrys Kuntze[d]		X	PG 354	Th
	Vitex regnelliana Moldenke	X	X	PG 739, 731	Ph
LENTIBULARIACEAE	*Utricularia nigrescens* Sylvén[d]		X	PG 448	Th
LOASACEAE	*Aosa rupestris* (Gardner) Weigend	X		PG 325	Th
LORANTHACEAE	*Struthanthus* sp.		X	PG 667	Ph
MALVACEAE	*Corchorus orinocensis* Kunth		X	PG 367	Th
	Pavonia aschersoniana Gürke		X	PG 509	Ph
	Pavonia cancellata (L.) Cav.	X		PG 462	Ph
	Sida barclayi Baker f.		X	PG 757	Ph
	Sida linifolia Cav.		X	PG 362	Th
	Waltheria indica L.		X	PG 512	Th
MELASTOMATACEAE	*Clidemia hirta* D. Don.	X	X	JO 21, PG 845	Th
	Pterolepis polygonoides Triana[d]		X	PG 588	Th
	Pterolepis tricothoma (Rottb.) Cogn.		X	PG 439a	Th
	Tibouchina multiflora Cogn.	X	X	PG 466, 587	Ph
MENISPERMACEAE	*Cissampelos* sp.	X	X	PG 371, 854	Cr
MYRTACEAE	*Myrciaria* sp.	X	X	PG 380, 344	Ph
ONAGRACEAE	*Ludwigia* cf. *leptocarpa* (Nutt.) H. Hara	X		PG 481	Th
ORCHIDACEAE	*Acianthera ochreata* (Lindl.) Pridgeon & Chase[d]	X	X	PG 263, 339	Ph
	Campylocentrum crassirhizum Hoehne	X	X	PG 768, 765	Ch
	Catasetum barbatum (Lindl.) Lindl.	X		PG 485	Cr
	Cyrtopodium flavum (Nees) Link & Otto ex Rchb.[d]	X	X	PG 669, 666	Cr
	Epidendrum difforme Jacq.	X		PG 416	Ph
	Epidendrum rigidum Jacq.	X		PG 417	Ph
	Habenaria pratensis Rchb.f.	X	X	PG 422, 342	Cr
	Habenaria trifida Kunth		X	PG 853	Cr
	Oeceoclades maculata (Lindl.) Lindl.	X		PG 318	Cr

continue

continuation

Family	Species	Locality[a]		Voucher[b]	Life-forms[c]
		Gua	Cab		
	Oncidium barbatum Lindl.	X		PG 484	Cr
	Polystachya estrellensis Rchb. f.	X	X	PG 257, 729	Cr
	Prescottia phleoides Lindl.[d]	X	X	PG 572, 592	Cr
	Rodriguezia bahiensis Rchb. f.	X		PG 764	Cr
OROBANCHACEAE	*Alectra aspera* (Cham. & Schltdl.) L. O. Williams		X	PG 438	Th
OXALIDACEAE	*Oxalis cratensis* Hook.[d]	X		PG 320	Th
	Oxalis hedysarifolia Pohl ex Progel		X	PG 334	Th
PASSIFLORACEAE	*Passiflora foetida* L.		X	PG 760	Th
PHYLLANTHACEAE	*Flueggea flexuosa* Müll. Arg.	X		BSA 93	Ph
	Phyllanthus niruri L.	X	X	BSA 92, 100	Th
PHYTOLACCACEAE	*Microtea maypurensis* G. Don.		X	PG 360a	Th
PIPERACEAE	*Peperomia blanda* Kunth	X		PG 411	Th
	Peperomia circinnata Link	X		PG 755	Th
PLANTAGINACEAE	*Angelonia pubescens* Benth.		X	PG 844	Th
POACEAE	*Anthephora hermaphrodita* (L.) Kuntze	X		JRM 502	Th
	Eragrostis rufescens Schrad. ex Schult.	X		JRM 500	Th
	Ichnanthus bambusiflorus Döll		X	PG 848	Ph
	Ichnanthus dasycoleus Tutin		X	PG 850	Th
	Lasiacis ligulata Hitchc. & Chase	X		PG 566	Th
	Melinis minutiflora P. Beauv.		X	PG 357	Ch
	Panicum trichoides Sw.	X		PG 468	Th
	Schizachyrium brevifolium (Sw.) Nees ex Büse		X	PG 589	Th
POLYGALACEAE	*Polygala glochidiata* Kunth.		X	PG 341	Th
	Polygala paniculata L.[d]		X	PG 360	Th
	Polygala spectabilis DC.		X	PG 759	Th
	Polygala violacea Aubl.		X	PG 338	Th
	Securidaca diversifolia (L.) S. F. Blake	X		PG 745	Ph
POLYPODIACEAE	*Microgramma geminata* (Schrad.) R. M. Tryon & A. F. Tryon	X		PG 741	Ph
	Microgramma vacciniifolia (Langsd. & Fisch.) Copel.	X		PG 482	Ph
	Polypodium polypodioides (L.) Watt	X		PG 757	Ph
PORTULACACEAE	*Portulaca elatior* Mart. ex Rorhb.[d]	X	X	PG 705, 659	Th
	Talinum paniculatum (Jacq.) Gaertn.	X		PG 836	Th
PRIMULACEAE	*Anagallis minima* (L.) E. H. L. Krause[d]	X	X	PG 574, 543	Th
PTERIDACEAE	*Doryopteris pedata* (L.) Fée[d]	X	X	KP 275, PG 419	Ch
RHAMNACEAE	*Gouania colurnifolia* Reissek[d]		X	PG 377	Ph
RUBIACEAE	*Diodella apiculata* (Willd. ex Roem. & Schult.) Delprete	X	X	PG 316, 366	Th
	Emmeorhiza umbellata K. Schum.	X	X	PG 564, 511	Ph
	Manettia cordifolia Mart.	X		PG 373	Ph
	Mitracarpus frigidus K. Schum.	X	X	PG 258, 333	Ch
	Randia armata (Sw.) DC.	X		PG 837	Ph
	Spermacoce alata Aubl.	X	X	PG 491, 499	Th
	Tocoyena cf. *formosa* K. Schum.	X	X	PG 414, 746	Ph
RUTACEAE	*Esenbeckia febrifuga* A. Juss.	X	X	PG 835, 358	Ph
	Fagara rhoifolia Engl.	X		PG 416a	Ph
SALICACEAE	*Casearia sylvestris* Sw.	X		PG 839	Ph

continue

continuation

Family	Species	Locality[a]		Voucher[b]	Life-forms[c]
		Gua	Cab		
SAPINDACEAE	*Cardiospermum halicacabum* L.	X	X	PG 459, 546	Ph
	Cupania revoluta Radlk.	X	X	PG 375, 349	Ph
	Paullinia pinnata L.	X	X	KP 272, JO 07	Ph
SAPOTACEAE	*Chrysophyllum rufum* Mart.	X		PG 855	Ph
SCHIZAEACEAE	*Anemia flexuosa* (Sav.) Sw.	X	X	KP 275a, PG 442	Ch
SCROPHULARIACEAE	*Ameroglossum pernambucensis* Fischer, Vogel & Lopes[d]	X		PG 261	Ph
SELLAGINELACEAE	*Selaginella potaroensis* Jenman[d]		X	PG 449	Th
SMILACACEAE	*Smilax* sp.	X		PG 326	Cr
SOLANACEAE	*Capsicum* cf. *parvifolium* Sendtn.	X		PG 664	Ph
	Schwenckia americana L.[d]		X	PG 352	Th
	Solanum asperum Rich.	X		PG 465	Ph
TURNERACEAE	*Piriqueta* sp.		X	PG 657	Ph
URTICACEAE	*Pilea hyalina* Fenzl[d]	X	X	PG 489, 450	Th
VERBENACEAE	*Lantana camara* L.	X	X	PG 315, 510	Ph
	Lippia alba (Mill.) N.E. Br.	X		PG 577	Ph
VITACEAE	*Cissus simsiana* Schult. & Schult. f.[d]	X	X	PG 376, 368	Ph
	Cissus cf. *subrhomboidea* Planch.	X		PG 374	Th
Total	–	154	125	–	–

Amongst the species, three have distributions restricted to rocky outcrops in northeastern Brazil: *Mandevilla dardanoi* (Apocynaceae), *Ameroglossum pernambucensis* (Scrophulariaceae), and *Pithecoseris pacourinoides* (Asteraceae) (Sales *et al.* 2006, MMA 2007, *herbarium data*). Only *M. dardanoi* occured in both studied areas, being the other two exclusively found in Guariba.

Eight species are considered endemic to the *Caatinga* vegetation: *Cordia globosa*, *Encholirium spectabile*, *Hohenbergia catingae*, *Pilosocereus pachycladus*, *Piptadenia stipulacea*, *Senna martiana*, *Senna rizzini*, and *Senna aversiflora* (Giulietti *et al.* 2002).

Agave sisalana (Henderson 2004)*, Melinis minutiflora* (Arce & Sano 2001), and *Crotalaria lanceolata* (Lewis 1987) are invasive alien species. Only *C. lanceolata* occured in both areas, and *A. sisalana* and *M. minutiflora* occured only in Guariba and Cabeça de Velho, respectively.

Structure of vegetation – Overall, 1,792 shrub and herbaceous individuals were found, belonging to 56 taxons (table 2). Amongst them, 712 and 1083 were collected at Guariba and Cabeça de Velho, respectively. Another 155 species were found outside the plots, such as *Sinningia nordestina* (Gesneriaceae), *Bomarea edulis* (Alstroemeriaceae), and *Encholirium spectabile* (Bromeliaceae).

Helichrysum indicum (Asteraceae), *Cyperus cuspidatus* (Cyperaceae), *Paepalanthus* spp. (Eriocaulaceae) and *Portulaca elatior* (Portulacaceae) had the highest relative and absolute densities at Guariba. At Cabeça de Velho, on the other hand, *Paepalanthus myocephalus*, *Paepalanthus* spp. (Eriocaulaceae), *Utricularia nigrescens* Sylvén (Lentibulariaceae) and *Selaginella potaroensis* (Selaginellaceae) presented the highest relative and absolute densities (table 2, figures 6-7).

Cyrtopodium flavum (Orchidaceae), *Orthophytum disjunctum* (Bromeliaceae), *Bulbostylis scabra* (Cyperaceae), *Aechmea leptantha* (Bromeliaceae) and Poaceae 3 had the highest absolute and relative densities at Guariba. At Cabeça de Velho, *A. leptantha*, *Paliavana tenuiflora* (Gesneriaceae), *Pterolepis polygonoides* (Melastomataceae), *P. myocephalus* and *Euphorbia insulana* (Euphorbiaceae) had the highest values for these same parameters (table 2, figures 6-7). The Shannon-Wiener (H) diversity index values were 2.572 and 2.547 nats individual^{-1} for Guariba and for Cabeça de Velho, respectively.

Biological spectrum – At Guariba the phanerophytes represented 49% (76 spp.) of the total number found, and the therophytes came in second with 28% (43 spp.). They were followed by the cryptophytes (12%, 18), chamaephytes (6.5%, 10) and hemicryptophytes (4.5%, 7).

Table 2. Species collected in the plots and their structural attributes, from two crystalline rocky outcrops in the Brazilian northeast semi–arid region: Pedra da Guariba and Pedra Cabeça de Velho. (AD = absolute density; AF = absolute frequency; RD = relative density; RF = relative frequency).

Species	Pedra da Guariba				Pedra Cabeça de Velho			
	AD	AF	RD	RF	AD	AF	RD	RF
Acianthera ochreata (Lindl.) Pridgeon & Chase	1	6.67	0.15	1.67	–	–	–	–
Aechmea leptantha (Harms) Leme & J. A. Siqueira	3	20	0.42	5	13	66.67	1.2	12.35
Ameroglossum pernambucensis Fischer, Vogel & Lopes	3	6.67	0.42	1.67	–	–	–	–
Anagallis minima (L.) E. H. L. Krause	26	6.67	3.65	1.67	–	–	–	–
Anthurium affine Schott	1	6.67	0.15	1.67	–	–	–	–
Asteraceae 1	–	–	–	–	2	6.67	0.19	1.24
Asteraceae 2	–	–	–	–	4	13.33	0.37	2.47
Begonia saxicola A. DC.	–	–	–	–	5	20	0.46	3.7
Bulbostylis scabra (J. Presl & C. Presl) C. B. Clarke	17	33.33	2.39	8.33	21	20	1.94	3.7
Cereus albicaulis (Britton & Rose) Luetzelb.	1	6.67	0.15	1.67	1	6.67	0.09	1.24
Cissus simsiana Schult. & Schult. f.	1	6.67	0.15	1.67	–	–	–	–
Cnidoscolus urens (L.) Arthur	6	6.67	0.84	1.67	4	20	0.37	3.7
Commelina obliqua Vahl	12	6.67	1.68	1.67	–	–	–	–
Commelinaceae 1	6	6.67	0.84	1.67	–	–	–	–
Commelinaceae 2	1	13.33	0.15	3.33	–	–	–	–
Cyperaceae 1	3	6.67	0.42	1.67	–	–	–	–
Cyperaceae 2	3	6.67	0.42	1.67	–	–	–	–
Cyperaceae 3	2	6.67	0.28	1.67	–	–	–	–
Cyperaceae 4	1	6.67	0.15	1.67	–	–	–	–
Cyperus cuspidatus Kunth	141	6.67	19.8	1.67	–	–	–	–
Cyrtopodium flavum (Nees) Link & Otto ex Rchb.	6	6.67	0.84	1.67	–	–	–	–
Doryopteris pedata (L.) Fée	2	40	0.28	10	14	13.33	1.3	2.47
Euphorbia comosa Vell.	3	6.67	0.42	1.67	1	6.67	0.09	1.24
Euphorbia insulana Vell.	–	–	–	–	8	13.33	0.74	2.47
Gouania colurnifolia Reissek	1	6.67	0.15	1.67	–	–	–	–
Helichrysum indicum (L.) Grierson	155	13.33	21.77	3.33	–	–	–	–
Mandevilla dardanoi M. F. Sales, Kin.-Gouv. & A. O. Simões	4	6.67	0.56	1.67	–	–	–	–
Marsdenia loniceroides E. Fourn.	–	–	–	–	1	6.67	0.09	1.24
Marsypianthes chamaedrys Kuntze	–	–	–	–	2	13.33	0.19	3.33
Orthophytum disjunctum L. B. Sm.	5	33.33	0.7	8.33	1	6.67	0.09	1.24
Oxalis cratensis Hook.	1	–	0.09	–	1	6.67	0.09	1.24
Paepalanthus myocephalus Mart. ex Körn.	22	33.33	3.08	8.33	321	6.67	29.63	1.24
Paepalanthus spp.	127	–	17.83	–	171	6.67	15.79	1.24
Paliavana tenuiflora Mansf.	2	13.33	0.28	3.33	12	33.34	1.11	6.18
Pilea hyalina Fenzl	15	6.67	2.1	1.67	54	6.67	4.99	1.24
Platypodanthera melissifolia (DC.) R. M. King. & H. Rob.	1	13.33	0.09	3.33	–	–	–	–
Poaceae 1	7	6.67	0.98	1.67	76	20	7.02	3.7
Poaceae 2	3	6.67	0.42	1.67	13	6.67	1.2	1.24
Poaceae 3	2	13.33	0.28	3.33	1	6.67	0.09	1.24
Poaceae 4	–	6.67	–	1.67	1	13.33	0.09	2.47
Polygala paniculata L.	–	–	–	–	1	13.33	0.09	2.47
Portulaca elatior Mart. ex Rorhb.	107	13.33	15.02	3.33	–	–	–	–
Prescottia phleoides Lindl.	–	–	–	–	1	6.67	0.09	1.24
Pterolepis polygonoides Triana	–	13.33	–	3.33	45	–	4.15	–
Schultesia guianensis (Aubl.) Malme	–	–	–	–	3	6.67	0.28	1.24
Schwenckia americana L.	–	–	–	–	42	33.33	3.88	6.18
Seedling 1	17	6.67	2.39	1.67	9	13.33	0.83	2.47
Seedling 2	6	6.67	0.84	1.67	1	13.33	0.09	2.47
Seedling 3	–	–	–	–	1	6.67	0.09	1.24
Seedling 4	–	–	6.67	1.24	1	6.67	0.09	1.24
Seedling 5	–	–	–	–	1	6.67	0.09	1.24
Seedling 6	–	–	–	–	1	6.67	0.09	1.24
Seedling 7	–	–	–	–	16	6.67	1.48	1.24
Seedling 8	–	–	–	–	3	6.67	0.28	1.24
Selaginella potaroensis Jenman	–	–	–	–	97	6.67	8.95	1.24
Utricularia nigrescens Sylvén	–	–	–	–	133	6.67	12.29	1.24

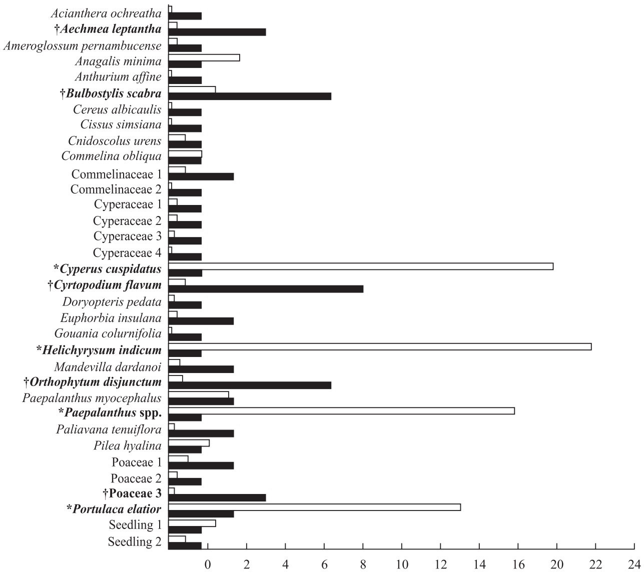


Figure 6. Relative density and relative abundance of species in Pedra da Guariba, a rocky outcrop from semi-arid region of northeastern Brazil. Symbols correspond to (*) species with highest relative densities and (†) species with highest relative frequencies. (□ = relative density; ■ = relative frequency).

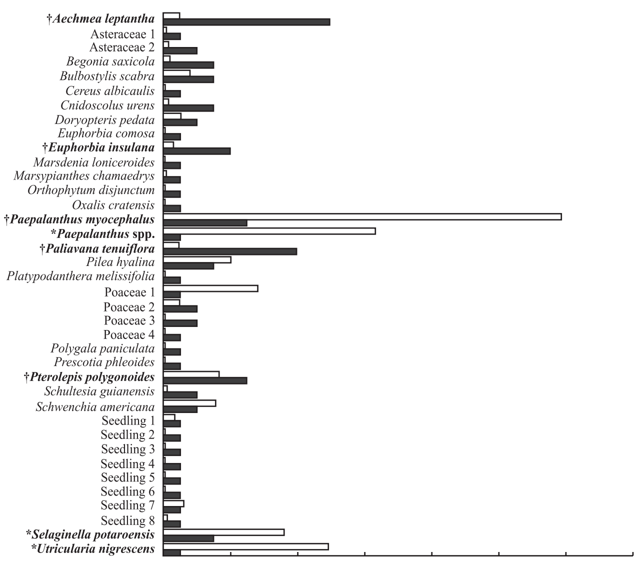


Figure 7. Relative density and relative abundance of species in Pedra Cabeça de Velho, a rocky outcrop from semi-arid region of northeastern Brazil. Symbols correspond to (*) species with highest relative densities and (†) species with highest relative frequencies. (□ = relative density; ■ = relative frequency).

At Cabeça de Velho, the same order was found, except for the smallest difference in the values for phanerophytes (43%, 90 spp.) and therophytes (38%, 79). The other life forms showed the following values: cryptophytes (11%, 22), chamaephytes (5%, 11) and hemicryptophytes (3%, 6). See figure 8.

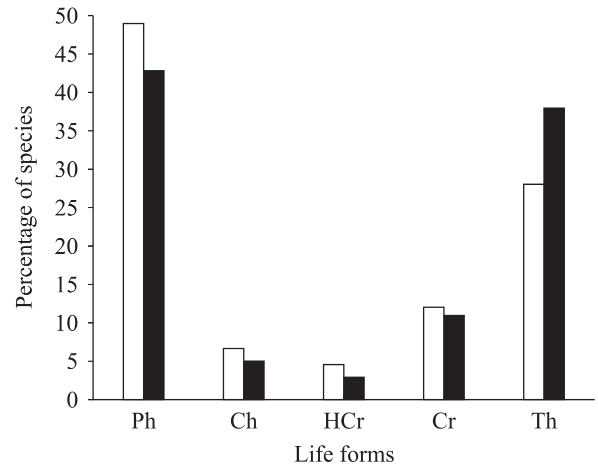


Figure 8. Biological spectrum of two rocky outcrop areas in the semi-arid region of northeastern Brazil: (Gua) Pedra da Guariba and (Cab) Pedra Cabeça de Velho. Life-forms are (Ph) phanerophytes, (Ch) chamaephytes, (HCr) hemicryptophytes (Cr) cryptophytes and (Th) therophytes. (□ = Pedra da Guariba – Gua; ■ = Pedra Cabeça de Velho – Cab).

Discussion

Floristic – The aforesaid families are very common for rocky outcrops in general (Porembski *et al.* 1997) and have been found in previous studies in the semi-arid region in Brazil (França *et al.* 1997, 2005, Araújo *et al.* 2008, Gomes & Alves 2009).

Fabaceae and Euphorbiaceae are important components of rock outcrops vegetation in semi-arid region. *Chamaecrista*, *Crotalaria*, *Senna*, *Stylosanthes*, and *Zornia* (Fabaceae) and *Croton*, *Cnidoscolus,* and *Euphorbia* (Euphorbiaceae) are also well represented in other northeastern outcrops (França *et al.* 1997, 2005, 2006, Carneiro-Torres *et al.* 2002, Araújo *et al.* 2008, Porto *et al.* 2008, Gomes & Alves 2009). These data indicate an important relationship with the *caatinga* flora, where the families are extremely diversified (Sampaio *et al.* 2002). However, the current level of knowledge is not enough to score the proportion of species shared by both vegetation types.

Asteraceae, which is the second largest group in the study area, presented low richness in outcrops from northeastern Brazil, except for data found by Araújo *et al.* (2008). Despite that, some species found in the study areas also occur in other rock outcrops of the region, such as *Delilia biflora*, *Emilia sonchifolia* and *P. pacourinoides*, in addition to different species of *Gochnatia* and *Vernonia* (França *et al.* 1997, Araújo *et al.* 2008, Porto *et al.* 2008). These taxa differ from those that colonize outcrops from the southeast region (*e.g.* Meirelles *et al.* 1999, Oliveira & Godoy 2007), with exception of widely distributed species such as *Achyrocline satureioides* (*e.g.* see Ribeiro *et al.* 2007).

Orchidaceae is well represented in almost all Brazilian rocky outcrops (*e.g.* França *et al.* 1997, 2005, Porembski *et al.* 1997, Gomes & Alves 2009) as well as in the presently studied areas. *Cyrtopodium*, *Catasetum*, and *Habenaria* are the most widespread genera of this family in the northeastern rock outcrops (França *et al.* 1997, Araújo *et al.* 2008, Porto *et al.* 2008, Gomes & Alves 2009), and they were also found here.

The richness of Bromeliaceae is also in accordance with other studies of rock outcrops in Brazil (see França *et al.* 2005, 2006, Caiafa & Silva 2007, Gomes & Alves 2009, Ribeiro *et al*. 2007). Each region is characterized by a restricted group of taxa from this family in generic or infra-generic level and only *Tillandsia* is common along Brazilian east coast (*e.g.* Meirelles *et al.* 1999, Oliveira & Godoy 2007, França *et al.* 2006). For this family, 50% of the species occurred only at Guariba. In other words, a peculiar flora for each region or a differentiated one even in geographically close areas is very common in rock outcrops (Barthlott *et al.* 1993). Finally, Poaceae, the fifth richest family within the study area, is also one of the most representative families in the outcrops, but at Pantropical scale (see Porembski & Barthlott 2000).

The two areas have distinct flora, even with elevated Jaccard similatity index (0.347), considering the values of the same similarity index (from 0.05 to 0.25) calculated (from 0.05 to 0.25) in another study comparing rock outcrops of northeastern Brazil (Gomes & Alves 2009). The differences in the richness and floristic composition could be related to several factors, such as altitude, historical devastation, and ecological succession (Begon *et al.* 2006). For example, orographic precipitation is more common in Cabeça de Velho (*personal observations*) and can help the establishment of more hydrophytic species, such as *Schultesia guianensis*. This hydrophytic group includes *U. nigrescens*, and *Drosera montana*, carnivorous plants that are exclusively found at Cabeça de Velho (table 1). They are cited as being species well adapted to rocky outcrops, indicating a dystrophic substrate (Michelangeli 2000, Saridakis *et al.* 2004). As a consequence of this nutrient limitation, combined with other edaphic and climatic factors, the plants show morphophysiological adaptations that result in high levels of endemism in these environments (Ibisch *et al.* 1995, Porembski *et al.*1996, Biedinger *et al.* 2000, Seine *et al.* 2000). Even thought the West face (leeward) of the rock outcrops was not evaluated, its composition appears to be very similar to the one at the East face (windward). However, the richness is apparently lower due to the absence of some mesophyte and hydrophytic species.

Invasive species in the study areas may cause severe damage to the native community due to their high competitiveness (Abe *et al.* 2008), and their occurrence has already been observed in other rock outcrops (Meirelles *et al.* 1999, Porembski 2000). Their impact on the rock outcrop native vegetation is still unknown. But, apparently, *A. sisalana* competes for physical space with *Hohenbergia catingae* (Bromeliaceae) because both occur in very similar edaphic conditions (*personal observations*).

Restricted species – Regarding the restrict taxa, the available information on rock outcrops in northeastern Brazil is scarce. Based on Giulliett *et al.* (2002), Sales *et al.* (2006), MMA (2007) and on herbarium data (Species Link 2010), only three species can be identified. Among them, *M. dardanoi* is very frequent in the study areas and occurs in other rock outcrops of the Borborema Plateau (Porto *et al.* 2008, Gomes & Alves 2009, *personal observations*). Other species of the genus *Mandevilla* have a close relationship with rocky substrates, and some of them, such as *M. dardanoi* generally occur associated to Bromeliaceae species (Sales *et al.* 2006).

Ameroglossum pernambucense usually occurs in small cracks. This microhabitats specificity may explain its lower frequency in nature and local herbaria. Until not so long ago, *A. pernambucense* was known only in the type locality (Fischer *et al.* 1999, Giulietti *et al.* 2004), geographically very close to the two studied areas; nowadays, it is known from other outcrops in the states of Pernambuco and Paraíba (Porto *et al.* 2008, *personal observations*). The third species, *P. pacourinoides*, known from more localities than the others, occurs only in rocky substrates, from calcareous at Chapada do Apodi (state of Ceará) to granitics at Borborema Plateau (Species Link 2010).

Structure of vegetation – The Shannon-Wiener diversity index values from both study areas are similar to the value (2.07 nats individual^{-1}) for another inselberg in the semi-arid region (França *et al.* 2006). These values are also close to the values found (2.08-2.52 nats individual^{-1}) for the herbaceous community in a nearby *caatinga* area (Araújo *et al.* 2005).

The vegetation structure analyses showed that many species are rare, because 75% of the total of 211 were not re-collected in the plots. The majority of these species registered in the plots presented low values for the structural traits in both areas, with few species being dominant or frequent. Futhermore, the species with the highest densities and frequencies were diversified between the areas.

The species with the highest density values had proportionally more individuals, yet with lower frequency. Amongst them, only *P. myocephalus* was found in more than one plot (five) in the area of Cabeça de Velho. The low occurrence of the other species is probably due to the lack of sites with adequate environment conditions. For example, the individuals of *H. indicum* occur exclusively in flooded areas and complete their life cycle in the rainy season.

Aechmea leptantha and *O. disjunctum* (Bromeliacee) are amongst the most frequent species in the plots and are in accordance with other outcrops in the semi-arid region (França *et al.* 2006). *Aechmea leptantha* is important for vegetation islands formation and seems to be the pioneer in the colonization of bare rock patches in the study areas. *Encholirium spectabile* seems to exert this role in the leeward face, apparently being the dominant species throughout this side. This shows that Bromeliaceae is a taxonomic group with a high importance to the vegetation structure of the local rock outcrops. *Paliavana tenuiflora* (Gesneriaceae) characterizes the vegetation physiognomy of these outcrops as well. It was the second most frequent species at Cabeça de Velho and one of those which had the sixth highest frequency in Guariba. None of the invasive species were relevant on the vegetation structure.

Biological spectrum – The physical structure of plant communities is also indicated by the species life forms (Philips 1982). In this aspect, the biological spectrum of both areas was similar. Both areas presented a higher proportion of phanerophytes, as well as it occurs in other rock outcrops in Brazil (Meirelles *et al.* 1999, Conceição & Giulietti 2002, Ribeiro & Medina 2002, Conceição & Pirani 2005, França *et al.* 2005, 2006, Caiafa & Silva 2005, Conceição *et al.* 2007, Ribeiro *et al.* 2007, Araújo *et al.* 2008). The phanerophytes are represented in the study areas by different growth forms, such as vines, shrubs and trees, and they occur preferentially in patches with deeper soil. Amongst the phanerophytes, only *Begonia saxicola* (Begoniaceae) was found in patches with thin humus layer.

Even though the therophytes characterize the studied vegetation, their proportion is variable between them. Therophytes are well represented in rock outcrops in Africa (Porembski *et al.* 1996, Porembski & Barthlott 1997). In Brasil, the therophyte group was the most common in only one rock outcrop in the state of Ceara, (Araújo *et al.* 2008). Climatic factors, such as seasonal water availability, are described as being the main modulators in the life forms distribution (Raunkiaer 1934). However, under the same mesoclimatic conditions, the two rock outcrops presented distinct proportions of therophytes, and Cabeça de Velho is the only one with recent fire historic. The dominance of therophytes after the fire episodes and its subsequent decrease in later stages of the community is recognized in mediterranean ecosystems (*e.g.* see Hanes 1971, Verroios & Georgiadis 2002). This may suggest that the results observed at Cabeça de Velho are a similar reaction from the vegetation to this factor.

The other life forms had a low representativity. The cryptophytes were restricted to the outcrop patches with deeper soils, due to their characteristic underground systems (see Raunkiaer 1934, Galán de Mera *et al.* 1999). The small proportion of hemicryptophytes found is not in agreement with previous studies carried out in Brazil, where this group is generally well represented (Conceição & Pirani 2005, Ribeiro & Medina 2002, França *et al.* 2005, Conceição *et al.* 2007, Ribeiro *et al.* 2007). Differently from the cryptophytes, species of this life form colonize patches of bare rock, as demonstrated by *A. leptantha*. On the other hand, the low occurrence of chamaephytes is in accordance with the data collected from other outcrops of northeastern Brazil (Araújo *et al.* 2008, Porto *et al.* 2008), although this life form is more frequent in outcrops of milder climate, in the southeast of the country. (*e.g.* Ribeiro *et al.* 2007).

In conclusion, the rock outcrops studied have a floristic relationship with other outcrops of the region and the country, but also have peculiarities in terms of flora and structure. In the biological spectrum, the high proportion of therophytes is the main difference amongst them, but more studies about the possible effects of fire in the life forms succession pattern are required. One very important characteristic is the presence of species from the surrounding vegetation, making the rock outcrops potential sources for the regeneration of this matrix, which is extensively degraded by human activities. Restricted species also aggregate value to the conservation, but more floristic and ecological studies about the semi-arid`s rock outcrops vegetation are needed to allow effective inferences about its ecological, phytogeographic and physiognomic relations.

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