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FLORISTIC AND VEGETATIONAL ASPECTS OF AN INSELBERG IN THE SEMI-ARID REGION OF NORTHEAST BRAZIL

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Inselbergs are rocky environments that support a unique flora distinct from that of the surrounding area. The objectives of this work were to conduct a floristic inventory of an inselberg in the semi-arid region of Northeast Brazil, and to investigate the relationship between its flora and the flora of the surrounding area. The following questions were addressed: is the species richness comparable to other inselbergs in northeastern Brazil; is the floristic composition of the inselberg more similar to other inselbergs or to the surrounding *Caatinga* vegetation; and do the similarities in the floristic composition of inselbergs depend on the distance between them? This work documents 201 species in 62 families. *Cyperaceae* (28 spp.), *Euphorbiaceae* (19), *Poaceae* (15), *Orchidaceae* (11) and *Bromeliaceae* (9) are the most species-rich families. On the inselberg the plants are distributed in islands found on exposed rock, in fissures and in depressions in the rock. Variations in species richness in the region were assessed by comparison of floristic inventories conducted in other inselbergs of the semi-arid region with those of this study. The flora of the inselberg under investigation is more similar to the flora of other nearby inselbergs than to the vegetation of the surrounding semi-arid region.

Keywords. Brazil, *Caatinga* vegetation, inselbergs, rock outcrops.

Introduction

Inselbergs (from the German, *insel* = island, *berg* = mountain) are crystalline rock outcrops found mainly in tropical and subtropical regions (Barthlott *et al.*, 1993). In Brazil, they are common along the tropical Atlantic coast (Safford & Martinelli, 2000) and in the *Caatinga* domain (Ab' Sáber, 2003).

Inselberg floras have been studied in several parts of the world, especially in Africa (Porembski *et al.*, 1997) and in the United States (Wyatt & Alisson, 2000). In Brazil, botanical studies have most often been carried out in the Southeast (e.g. Meirelles *et al.*, 1999; Safford & Martinelli, 2000; Oliveira *et al.*, 2004; Medina *et al.*, 2006; Caiafa & Silva, 2007; Ribeiro *et al.*, 2007). They are still ongoing in the Northeast (França *et al.*, 1997, 2005, 2006; Costa, 2000; Carneiro-Torres *et al.*, 2002; Almeida, 2004; Pitrez, 2006; Porto *et al.*, 2008).

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The environmental conditions in these areas, such as high temperatures, low humidity and low nutrient availability, give rise to important ecological processes which determine the structure and composition of the vegetation (Porembski, 2007). The vegetation is extremely well adapted to these conditions and distinct from the surrounding flora (Barthlott *et al.*, 1993; Ribeiro *et al.*, 2007).

The aim of this study was to characterise an inselberg in northeastern Brazil and carry out a floristic survey of its angiosperms. An investigation was also carried out into the relationship of its flora to that of the surrounding area. The following questions were asked: (i) is the species richness comparable to other inselbergs in northeastern Brazil; (ii) is the floristic composition of the inselberg more similar to other inselbergs or to the surrounding *Caatinga* vegetation; and (iii) do the similarities in the floristic composition of inselbergs depend on the distance between them?

Methodology

The inselberg selected for this study, Pedra Antônio Bezerra (08°20′S, 35°50′W), is a crystalline rock outcrop composed predominantly of granite. It has an altitude of 713 m at the base and 835 m at the top, with a total area of approximately 70,000 m^2. It is located on private property in Bezerros county in the semi-arid region of the State of Pernambuco, Brazil, 115 km from the Atlantic coast. The native vegetation of the surrounding area has been greatly impacted by agricultural and grazing activities.

The study site is situated on the Borborema Plateau (Jatobá, 2003). This highland plain is formed from a series of strongly weathered massifs dating from the Pre-Cambrian, which extend across the eastern portion of the Northeast region (Morais-Neto & Alkmim, 2001; Jatobá, 2003).

The area has a semi-arid climate, with an irregular and limited rainy season (Velloso *et al.*, 2002). The annual mean precipitation is 896 mm and is generally concentrated between the months of May and August (130–249 mm). There is an accentuated hydric deficit (0–70 mm) between four and eight months of the year (ITEP, 2008). The annual mean temperature is 21.2°C and ranges from 19.4 to 27.3°C (ITEP, 2008).

Eight field trips (from April 2005 to April 2006) were carried out, five during the rainy season and three in the dry season. Each expedition lasted six hours on average, for a total of 48 hours of field work. Fertile angiosperm specimens were collected randomly and processed according to Mori *et al.* (1985).

The specimens are deposited in the herbarium at UFP, with duplicates in IPA and PEUFR (for explanation of herbarium codes see *Index Herbariorum* at http://sweetgum.nybg.org/ih/). Identifications were carried out with the aid of the literature and advice from specialists, and by matching to collections in local herbaria. Family delimitation follows APG II (Angiosperm Phylogeny Group, 2003).

In order to assess the relationship between the flora of the Pedra Antônio Bezerra inselberg and the floras of other parts of northeastern Brazil, the floristic richness (at the specific level) was compared with that known for other semi-arid areas (Table 1; Fig. 1). These included inselbergs in Pedra Furada Municipal Park (Costa, 2000) in Pernambuco State; Esperança (Pitrez, 2006; Porto *et al.*, 2008), Pocinhos, Serraria and Fagundes (Pitrez, 2006) in Paraíba State; and Feira de Santana (França *et al.*, 1997, 2005) in Bahia State. Other types of *Caatinga* formation were also used in this comparison: shrub and subshrub, dense semi-deciduous vegetation, without thorns (Andrade *et al.*, 2004), in Buíque municipality of Pernambuco State; caducifolious shrub vegetation (Rodal *et al.*, 1999) in Ibimirim municipality of Pernambuco State; rock outcrops with *brejo de altitude*, a humid forest vegetation type in high altitude areas in *Caatinga* (Agra *et al.*, 2004) in Maturéia municipality of Paraíba State; and a *campo rupestre*, a shrubby vegetation on rocky soil (Conceição & Giulietti, 2002), in Palmeiras municipality of Bahia State.

The last area is a vegetation type that, in the State of Bahia, is found mainly surrounded by *Caatinga* vegetation (Conceição *et al.*, 2005), while in other areas of the country it is frequently surrounded by *Cerrados* (Oliveira-Filho & Ratter, 2002).

In all studies selected for comparison (Table 1) the collections were made randomly. Based on the species lists for each area, an area dendrogram was produced using the Jaccard similarity index (S_j) and the clustering method UPGMA calculated using PAST software, version 1.77 (Hammer *et al.*, 2001). Only taxa identified to species level were included and all synonymies were included only under the actual species.

TABLE 1. Floristic studies in the semi-arid region of northeastern Brazil used in the analysis of similarity

Reference	Municipality	Abbreviation	Collection period	Collection frequency	Area (m^2)
This study	Bezerros – PE	AB	13 months	8 excursions	70,000
Rodal *et al.* (1999)	Ibimirim – PE	IB	33 months	Monthly	100,000
Costa (2000)	Venturosa – PE	PF	12 months	Monthly	30,000
Conceição & Giulietti (2002)	Palmeiras – BA	PA	12 months	N/A	N/A
Agra *et al.* (2004)	Maturéia – PB	MA	12 months	Monthly	N/A
Andrade *et al.* (2004)	Buíque – PE	BQ	24 months	Monthly	25,000
França *et al.* (2005)	Feira de Santana – BA	FS	3 months	4 excursions	50,000
Pitrez (2006)	Serraria – PB	SE	33 months	N/A	20,000
Pitrez (2006)	Esperança – PB	ES2	33 months	N/A	100,000
Pitrez (2006)	Fagundes – PB	FA	33 months	N/A	N/A
Pitrez (2006)	Pocinhos – PB	PO	33 months	N/A	200,000
Porto *et al.* (2008)	Esperança – PB	ES1	13 months	Monthly	30,000

N/A, not available.

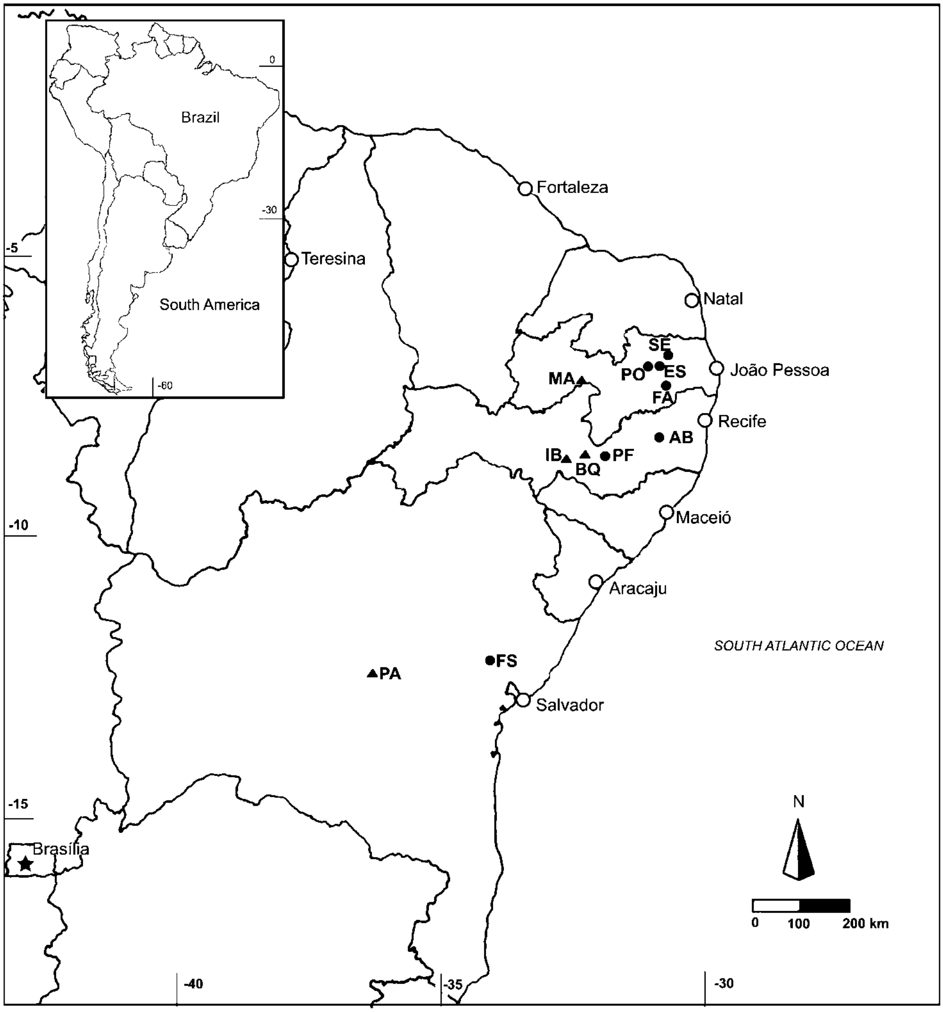

FIG. 1. Floristic studies used in the analysis of similarity and the studied area (●, inselbergs; ▲, other types of vegetation in the *Dominium Caatinga*). AB – Pedra Antônio Bezerra, Bezerros (study area), BQ – Buíque (Andrade *et al.*, 2004), IB – Ibimirim (Rodal *et al.*, 1999) and PF – Pedra Furada Municipal Park, Venturosa (Costa, 2000), in Pernambuco; MA – Maturéia (Agra *et al.*, 2004), PO – Pocinhos (Pitrez, 2006), ES – Esperança (ES1 – Porto *et al.*, 2008; ES2 – Pitrez, 2006), SE – Serraria (Pitrez, 2006) and FA – Fagundes (Pitrez, 2006), in Paraíba; PA – Palmeiras (Conceição & Giulietti, 2002) and FS – Feira de Santana (França *et al.*, 2005), in Bahia.

RESULTS AND DISCUSSION

Floristics

A total of 201 angiosperm species in 62 families were identified from the Pedra Antônio Bezerra inselberg. *Cyperaceae* (28 spp.), *Euphorbiaceae* (19), *Poaceae* (15), *Orchidaceae* (11) and *Bromeliaceae* (9) were the richest families and accounted for approximately 40% of the total (Table 2).

Richness was higher than that found by Costa (2000) in the Pedra Furada Municipal Park in Venturosa (88 spp.), where *Fabaceae*, *Euphorbiaceae* and

TABLE 2. List of families and species collected on the Pedra Antônio Bezerra inselberg, Pernambuco, Brazil

Family	Species	Voucher
Acanthaceae	*Dyschoriste maranhonis* Kuntze	*P. Gomes et al.* 142
Alstroemeriaceae	*Alstroemeria longistaminea* Mart.	*Y. Melo et al.* 24
	Bomarea edulis (Tussac) Herb.	*Y. Melo et al.* 48
Amaranthaceae	*Alternanthera brasiliana* (L.) Kuntze	*P. Gomes et al.* 08
Amaryllidaceae	*Habranthus itaobinus* Ravenna	*A. Alves-Araújo et al.* 50
	Hippeastrum stylosum Herb.	*A. Alves-Araújo et al.* 51
Anacardiaceae	*Anacardium occidentale* L.	*P. Gomes et al.* 200
Apocynaceae	*Blepharodon manicatum* (Decne.) Fontella	*P. Gomes et al.* 26
	Ditassa oxyphylla Turcz.	*P. Gomes et al.* 50
	Mandevilla dardanoi M.F.Sales, Kin.-Gouv. & A.O.Simões	*P. Gomes et al.* 177
	Mandevilla scabra (Hoffmanns. ex Roem. & Schult.) K.Schum.	*P. Gomes et al.* 58
	Mandevilla tenuifolia (J.C.Mikan) Woodson	*S. Martins et al.* 45
	Marsdenia loniceroides (Hook.) E.Fourn.	*P. Gomes et al.* 23
Araceae	*Anthurium affine* Schott	*P. Gomes et al.* 206
	Philodendron sp.	*P. Gomes et al.* 164
Arecaceae	*Syagrus coronata* (Mart.) Becc.	Not collected*
Asteraceae	*Bidens pilosa* L.	*P. Gomes et al.* 86
	Conocliniopsis prasiifolia (DC.) R.M.King & H.Rob.	*P. Gomes et al.* 146
	Delilia biflora (L.) Kuntze	*P. Gomes et al.* 106
	Gochnatia lucida (Baker) Cabrera	*P. Gomes et al.* 32
	Pithecoseris pacourinoides Mart. ex DC.	*P. Gomes et al.* 146[a]
	Platypodanthera melissifolia (DC.) R.M.King. & H.Rob.	*P. Gomes et al.* 122
	Vernonia chalybaea Mart. ex DC.	*P. Gomes et al.* 126
	Vernonia cotoneaster (Willd. ex Spreng.) Less.	*P. Gomes et al.* 156

TABLE 2. (*Cont'd*)

Family	Species	Voucher
Begoniaceae	*Begonia saxicola* A.DC.	*K. Pinheiro et al.* 23
Bignoniaceae	*Jacaranda rugosa* A.H.Gentry	*P. Gomes et al.* 203
Bixaceae	*Cochlospermum insigne* A.St.-Hil.	*P. Gomes et al.* 31
Boraginaceae	*Cordia verbenacea* DC.	*P. Gomes et al.* 201
	Heliotropium angiospermum Murray	*P. Gomes et al.* 34
Brassicaceae	*Cleome lanceolata* (Mart. & Zucc.) Iltis	*P. Gomes et al.* 16
Bromeliaceae	*Bromelia* sp.	Not collected*
	Encholirium spectabile Mart. ex Schult. & Schult.f.	*P. Gomes et al.* 161
	Orthophytum disjunctum L.B.Sm.	*P. Gomes et al.* 59
	Portea leptantha Harms	*P. Gomes et al.* 215
	Tillandsia polystachia (L.) L.	*P. Gomes et al.* 195
	Tillandsia recurvata (L.) L.	*P. Gomes et al.* 220
	Tillandsia stricta Sol. ex Ker Gawl.	*P. Gomes et al.* 162
	Tillandsia tenuifolia L.	*P. Gomes et al.* 163
	Vriesia sp.	Not collected*
Cactaceae	*Cereus jamacaru* DC.	Not collected*
	Melocactus bahiensis (Britton & Rose) Luetzelb.	*P. Gomes et al.* 193
	Pilosocereus pachycladus F.Ritter	*P. Gomes et al.* 216
Celastraceae	*Hippocratea volubilis* L.	*P. Gomes et al.* 173
Chrysobalanaceae	*Hirtella racemosa* Lam.	*P. Gomes et al.* 47
Clusiaceae	*Clusia intermedia* G.Mariz	*P. Gomes et al.* 147
	Clusia nemorosa G.Mey.	*P. Gomes et al.* 65
Commelinaceae	*Callisia repens* (Jacq.) L.	*P. Gomes et al.* 145
	Commelina obliqua Vahl	*P. Gomes et al.* 90
	Dichorisandra hexandra (Aubl.) Standl.	*P. Gomes et al.* 116
	Tradescantia sp.	*P. Gomes et al.* 72
Convolvulaceae	*Evolvulus filipes* Mart.	*P. Gomes et al.* 69
	Ipomoea bahiensis Willd. ex Roem. & Schult.	*P. Gomes et al.* 207
	Jacquemontia densiflora (Meisn.) Hallier f.	*M.T. Vital et al.* 14
	Merremia cissoides (Lam.) Hallier f.	*M.T. Vital et al.* 24
	Merremia dissecta (Jacq.) Hallier f.	*P. Gomes et al.* 89
	Merremia macrocalyx (Ruiz & Pav.) O'Donell	*P. Gomes et al.* 140

TABLE 2. (*Cont'd*)

Family	Species	Voucher
Cyperaceae	*Bulbostylis scabra* (J.Presl & C.Presl) C.B.Clarke	*S. Martins et al.* 66
	Cyperus alternifolius subsp. *flabelliformis* Kük.	*S. Martins et al.* 149
	Cyperus betafensis Cherm.	*S. Martins et al.* 68
	Cyperus eragrostis Lam.	*S. Martins et al.* 133
	Cyperus laxus Lam.	*S. Martins et al.* 130
	Cyperus odoratus L.	*S. Martins et al.* 132
	Cyperus rotundus L.	*S. Martins et al.* 96
	Cyperus surinamensis Rottb.	*S. Martins et al.* 94
	Cyperus uncinulatus Schrad. ex Nees	*S. Martins et al.* 91
	Cyperus sp.	*S. Martins et al.* 141
	Eleocharis flavescens (Poir.) Urb.	*S. Martins et al.* 67
	Eleocharis interstincta (Vahl) Roem. & Schult.	*S. Martins et al.* 47
	Fimbristylis dichotoma (L.) Vahl	*S. Martins et al.* 92
	Fuirena umbellata Rottb.	*S. Martins et al.* 46
	Kyllinga brevifolia Rottb.	*S. Martins et al.* 95
	Kyllinga odorata Vahl	*S. Martins et al.* 111
	Kyllinga squamulata Vahl	*S. Martins et al.* 135
	Lipocarpha micrantha (Vahl) G.C.Tucker	*S. Martins et al.* 153
	Lipocarpha salzmanniana Steud.	*S. Martins et al.* 134
	Pycreus capillifolius (A.Rich.) C.B.Clarke	*S. Martins et al.* 110
	Pycreus flavescens (L.) P.Beauv. ex Rchb.	*S. Martins et al.* 138
	Pycreus piceus (Liebm.) C.B.Clarke	*S. Martins et al.* 139
	Pycreus polystachyos (Rottb.) P.Beauv.	*S. Martins et al.* 109
	Rhynchospora cephalotes (L.) Vahl	*S. Martins et al.* 97
	Rhynchospora holoschoenoides (Rich.) Herter	*S. Martins et al.* 65
	Rhynchospora riparia (Nees) Boeck.	*S. Martins et al.* 143
	Scleria reticularis Michx.	*S. Martins et al.* 91
	Scleria secans (L.) Urb.	*S. Martins et al.* 69
Dioscoreaceae	*Dioscorea* cf. *coronata* Hauman	*P. Gomes et al.* 53
Eriocaulaceae	*Paepalanthus bifidus* (Schrad. ex Schult.) Kunth	*P. Gomes et al.* 93
	Paepalanthus parvus Ruhland	*P. Gomes et al.* 93[a]

TABLE 2. (*Cont'd*)

Family	Species	Voucher
Erythroxylaceae	*Erythroxylum flaccidum* Salzm. ex Peyr.	*J. Oliveira et al.* 06
	Erythroxylum ochranthum Mart.	*K. Pinheiro et al.* 26
	Erythroxylum revolutum Mart.	*J. Oliveira et al.* 08
	Erythroxylum suberosum A.St.-Hil.	*J. Oliveira et al.* 15
	Erythroxylum vacciniifolium Mart.	*J. Oliveira et al.* 10
	Erythroxylum sp.	Not collected*
Euphorbiaceae	*Acalypha* sp.	*P. Gomes et al.* 155
	Astraea lobata (L.) Klotzsch	*P. Gomes et al.* 38
	Cnidoscolus urens (L.) Arthur	*P. Gomes et al.* 184
	Croton adamantinus Müll.Arg.	*P. Gomes et al.* 87
	Croton glandulosus L.	*M.F. Lucena et al.* 1043
	Croton grewioides Baill.	*M.F. Lucena et al.* 1085
	Croton heliotropiifolius Kunth	*P. Gomes et al.* 192
	Croton hirtus L'Hér.	*P. Gomes et al.* 37
	Croton jacobinensis Baill.	*M.F. Lucena et al.* 1044
	Croton pulegioides Müll.Arg.	*P. Gomes et al.* 39
	Croton urticifolius Lam.	*M.F. Lucena et al.* 1047
	Dalechampia sp.	*P. Gomes et al.* 64
	Euphorbia comosa Vell.	*M.F. Lucena et al.* 1058
	Euphorbia insulana Vell.	*P. Gomes et al.* 40
	Euphorbia thymifolia L.	*P. Gomes et al.* 36
	Microstachys corniculata (Vahl) Griseb.	*P. Gomes et al.* 41
	Microstachys sp.	*P. Gomes et al.* 51
	Sapium glandulosum (L.) Morong	*P. Gomes et al.* 35
	Stillingia trapezoidea Ule	*P. Gomes et al.* 43
Fabaceae	*Acacia glomerosa* Benth.	*P. Gomes et al.* 222
	Canavalia brasiliensis Mart. ex Benth.	*P. Gomes et al.* 189
	Chamaecrista flexuosa (L.) Greene	*P. Gomes et al.* 45
	Crotalaria lanceolata E.Mey.	*P. Gomes et al.* 150
	Senna macranthera (DC. ex Collad.) H.S.Irwin & Barneby	*P. Gomes et al.* 221
	Stylosanthes viscosa (L.) Sw.	*P. Gomes et al.* 158
	Fabaceae sp.	Not collected*
Gentianaceae	*Schultesia guianensis* (Aubl.) Malme	*P. Gomes et al.* 110
Gesneriaceae	*Paliavana tenuiflora* Mansf.	*P. Gomes et al.* 62

TABLE 2. (*Cont'd*)

Family	Species	Voucher
	Sinningia nordestina Chauntens, Baracho & J.A.Siqueira	*P. Gomes et al.* 96
Hydroleaceae	*Hydrolea spinosa* L.	*A. Alves-Araújo et al.* 27
Hypericaceae	*Vismia guianensis* (Aubl.) Pers.	*P. Gomes et al.* 213
Hypoxidaceae	*Hypoxis decumbens* L.	*P. Gomes et al.* 198
Iridaceae	*Cipura paludosa* Aubl.	*P. Gomes et al.* 84
	Neomarica gracilis (Herb.) Sprague	*P. Gomes et al.* 61
Lamiaceae	*Hyptis fruticosa* Salzm. ex Benth.	*P. Gomes et al.* 181
	Marsypianthes chamaedrys (Vahl) Kuntze	*P. Gomes et al.* 107
	Vitex regnelliana Moldenke	*P. Gomes et al.* 185
	Lamiaceae sp.	*P. Gomes et al.* 40[a]
Lauraceae	*Cassytha americana* Nees	*P. Gomes et al.* 119
Lentibulariaceae	*Utricularia pusilla* Vahl	*P. Gomes et al.* 85
Loranthaceae	*Struthanthus* sp.	Not collected*
Lythraceae	*Cuphea* sp.	*P. Gomes et al.* 97
Malpighiaceae	*Stigmaphyllon paralias* A.Juss.	*P. Gomes et al.* 24
Malvaceae	*Bakeridesia andrade-limae* Monteiro	*P. Gomes et al.* 149
	Pavonia cancelata (L.) Cav.	*P. Gomes et al.* 210
	Sida sp.	*P. Gomes et al.* 219
	Waltheria indica L.	Not collected*
Marantaceae	*Maranta arundinacea* L.	*P. Gomes et al.* 94
Marcgraviaceae	*Norantea brasiliensis* Choisy	*P. Gomes et al.* 20
Melastomataceae	*Acisanthera* sp.	*P. Gomes et al.* 98
	Pterolepis polygonoides Triana	*P. Gomes et al.* 22
	Tibouchina multiflora Cogn.	*P. Gomes et al.* 60
Molluginaceae	*Mollugo verticillata* L.	Not collected*
Myrtaceae	*Campomanesia aromatica* (Aubl.) Griseb.	*P. Gomes et al.* 176
	Myrcia sp.	*P. Gomes et al.* 187
	Psidium cf. *araca* Raddi	*P. Gomes et al.* 214
Orchidaceae	*Acianthera ochreata* (Lindl.) Pridgeon & M.W.Chase	*P. Gomes et al.* 17
	Brassavola tuberculata Hook.	*P. Gomes et al.* 199
	Cyrtopodium polyphyllum (Vell.) Pabst ex F.Barros	*P. Gomes et al.* 188
	Encyclia oncidioides (Lindl.) Schltr.	*P. Gomes et al.* 83
	Encyclia sp.	*P. Gomes et al.* 169
	Epidendrum cinnabarinum Salzm. ex Lindl.	*P. Gomes et al.* 186
	Epidendrum secundum Jacq.	*P. Gomes et al.* 152
	Habenaria obtusa Lindl.	*P. Gomes et al.* 172

TABLE 2. (*Cont'd*)

Family	Species	Voucher
	Habenaria trifida Kunth	*P. Gomes et al.* 82
	Scaphyglottis fusiformis (Griseb.) R.E.Schult.	*P. Gomes et al.* 107[a]
	Sobralia liliastrum Lindl.	*P. Gomes et al.* 103
Oxalidaceae	*Oxalis frutescens* var. *frutescens* L.	*Y. Melo et al.* 21
Passifloraceae	*Passiflora alata* Curtis	*D. Araújo et al.* 52
	Passiflora cincinnata Mast.	*D. Araújo et al.* 33
	Passiflora foetida L.	*D. Araújo et al.* 78
	Passiflora galbana Mast.	*D. Araújo et al.* 50
Phyllanthaceae	*Phyllanthus* sp.	*P. Gomes et al.* 104
Piperaceae	*Piper nigrum* L.	*P. Gomes et al.* 196
Poaceae	*Andropogon selloanus* (Hack.) Hack.	*J. Maciel et al.* 13
	Axonopus aureus P.Beauv.	*J. Maciel et al.* 17
	Axonopus sp.	*J. Maciel et al.* 22
	Digitaria sp.	*P. Gomes et al.* 224
	Echinolaena inflexa (Poir.) Chase	*J. Maciel et al.* 10
	Panicum trichoides Sw.	*P. Gomes et al.* 232
	Panicum sp.	*P. Gomes et al.* 223
	Paspalum conjugatum P.J.Bergius	*P. Gomes et al.* 233
	Paspalum oligostachyum Salzm. ex Steud.	*P. Gomes et al.* 225
	Paspalum parviflorum Rhode ex Flüggé	*P. Gomes et al.* 234
	Rhynchelytrum repens (Willd.) C.E.Hubb.	*P. Gomes et al.* 226
	Sacciolepis vilvoides (Trin.) Chase	*P. Gomes et al.* 99
	Setaria cf. *geniculata* (Lam.) P.Beauv.	*J. Maciel et al.* 10
	Sporobolus pyramidatus (Lam.) Hitchc.	*J. Maciel et al.* 16
	Trachypogon spicatus (L.f.) Kuntze	*J. Maciel et al.* 11
Polygalaceae	*Polygala paniculata* L.	*P. Gomes et al.* 124
	Securidaca sp.	*K. Pinheiro et al.* 25
Portulacaceae	*Portulaca elatior* Mart. ex Rohrb.	*P. Gomes et al.* 143
Rubiaceae	*Chiococca alba* (L.) Hitchc.	*P. Gomes et al.* 102
	Coutarea hexandra (Jacq.) K.Schum.	*P. Gomes et al.* 171

TABLE 2. (*Cont'd*)

Family	Species	Voucher
	Diodella radula (Willd. & Hoffmanns. ex Roem. & Schult.) Delprete	*P. Gomes et al.* 100
	Guettarda angelica Mart. ex Müll.Arg.	*P. Gomes et al.* 27
	Tocoyena formosa (Cham. & Schltdl.) K.Schum.	*P. Gomes et al.* 208
Salicaceae	*Casearia sylvestris* Sw.	*P. Gomes et al.* 204
Sapindaceae	*Cupania revoluta* Rolfe	*P. Gomes et al.* 125
Solanaceae	*Physalis neesiana* Sendtn.	*P. Gomes et al.* 113
	Solanum americanum Mill.	*P. Gomes et al.* 117
Turneraceae	*Piriqueta duarteana* (A.St.-Hil., A.Juss. & Cambess.) Urb.	*P. Gomes et al.* 29
	Turnera blanchetiana Urb.	*P. Gomes et al.* 209
Urticaceae	*Cecropia pachystachya* Trécul	Not collected*
	Pilea hyalina Fenzl	*P. Gomes et al.* 115
Violaceae	*Hybanthus calceolaria* (L.) Oken	*P. Gomes et al.* 49
Vitaceae	*Cissus erosa* Rich.	*P. Gomes et al.* 19
Xiridaceae	*Xyris jupicai* Rich.	Not collected*

*Species observed in the study area, but not collected due to difficult access or to the lack of fertile material.

Cactaceae were the largest families. Floristic inventories carried out in other inselbergs in the semi-arid region of northeastern Brazil (where richness ranged from 62 to 192 species; França *et al.*, 1997; Pitrez, 2006; Porto *et al.*, 2008) and the data presented here indicate great variability in floristic richness in the Northeast. The reasons for this are still not well known in relation to inselbergs, but abiotic factors – such as substrate and its heterogeneity – are possibly the main causes (Porembski *et al.*, 1997; Safford & Martinelli, 2000).

Another possible explanation for these differences is the fact that identification of some taxa is difficult in the field. In the above-mentioned lists, identification problems are most acute in *Asteraceae*, *Cyperaceae*, *Myrtaceae* and *Poaceae*.

The five families with the highest number of species are considered characteristic of inselbergs in South America and in the tropics in general (Porembski *et al.*, 1997).

Cyperaceae and *Poaceae*, two of the largest families in our study, are also two of the largest families in other inselberg floristic studies in the tropics (Barthlott *et al.*, 1993; Ibisch *et al.*, 1995; Barthlott & Porembski, 2000). However, their representatives do not characterise the physiognomy of the area under study.

The same is true for *Orchidaceae*. This family has a large number of species but they do not stand out physically in the environment. It is a very important family in terms of number of species on Brazilian inselbergs (see Porembski *et al.*, 1997).

The species richness found for *Euphorbiaceae* and *Bromeliaceae* in our study agrees with the findings of Barthlott *et al.* (1993), Porembski *et al.* (1997, 1998) and Seine *et al.* (2000). These studies show that the two families are among the largest groups in inselberg floras in several different regions of the Americas.

The *Bromeliaceae* are cited as the group which best characterises the flora of inselbergs in Paraíba and Bahia (França *et al.*, 2005, 2006; Porto *et al.*, 2008).

In the *Euphorbiaceae*, species of *Croton* L. are important components of the shrub layer of inselbergs of the *Caatinga* domain (França *et al.*, 1997, 2005, 2006; Carneiro-Torres *et al.*, 2002).

General characterisation

The Pedra Antônio Bezerra inselberg is characterised by large areas of bare rock, colonised by lichens and cyanobacteria. Consequently the vascular vegetation of the outcrop is not continuous, being found in islands separated by bare rock.

In the study area these islands are of three main edaphic types, related to the degree and style of weathering of the rock: exposed rock, rock fissures, and depressions in the rock.

1. *Exposed rock.* Annual plants, such as *Cyperaceae* and *Eriocaulaceae*, often associated with cryptogams, are found in vegetation islands established on exposed rock. According to Porembski *et al.* (1998), vegetation is able to attach itself on this surface using a film of cyanobacteria as a substrate. These plants need a lot of water in order to settle on the bare rock (Barthlott *et al.*, 1993).

2. *Rock fissures.* The vegetation islands in rock fissures mainly include herbaceous plants such as species of *Poaceae*. França *et al.* (1997) describe fissures on an inselberg in Bahia (which were called *frestas* – crannies) that had even been colonised by trees. Burbanck & Platt (1964) explain that this large variation among inselbergs is due to the fact that cracks in granite outcrops vary substantially in size and depth. The presence of larger fissures is critical for the establishment of shrubs and trees. The same conclusions can be reached for natural rock depressions with great variation in soil depth.

3. *Rock depressions.* At the Pedra Antônio Bezerra inselberg the islands formed in depressions in the rock are commonly occupied by *Marsdenia loniceroides* (*Apocynaceae*) (species authorities are given in Table 2). The woody species *Clusia nemorosa*, *Clusia intermedia* (*Clusiaceae*), *Cupania revoluta* (*Sapindaceae*) and *Norantea brasiliensis* (*Marcgraviaceae*) are also present in some of the larger islands.

During the rainy season, a group of short-life-cycle plants from different families (such as *Asteraceae*, *Commelinaceae*, *Gentianaceae*, *Lentibulariaceae*, *Melastomataceae* and *Rubiaceae*) were seen in depressions along the edges of the islands. These ephemeral species account for approximately 31% of the flora surveyed (Table 2).

This confirms the importance of seasonality to floristic richness in inselbergs (Burbanck & Platt, 1964; Porembski *et al.*, 2000).

However, *Encholirium spectabile* (*Bromeliaceae*) is the species that visually characterises the physiognomy of the study area, a finding which agrees with França *et al.* (2005, 2006) and Porto *et al.* (2008). From an elevation of 760 m to the summit, another species of *Bromeliaceae*, *Portea leptantha*, and a species of *Orchidaceae*, *Acianthera ochreata*, also form a great number of islands.

The predominance of monocot species in our study corroborates the findings of Porembski *et al.* (1997, 1998), França *et al.* (2005) and other authors. Because of this predominance the term 'Monocotyledonous Mats' (sensu Barthlott *et al.*, 1993) is commonly used to designate these areas.

The distribution of species in the islands is dependent on variables such as island size, soil texture, pH, depth and content of organic matter in the soil, altitude, and also the distance from the edge of the outcrop (Collins *et al.*, 1989; Medina *et al.*, 2006). On Pedra Antônio Bezerra some species are restricted to specific altitudinal ranges, allowing us to divide the area into three zones: lower (713–760 m), middle (761–800 m) and upper (801–835 m) (Table 3). Variations in floristic composition with altitude have previously been observed by Safford & Martinelli (2000). Therefore, we believe that the variability in the vegetation is possibly associated with altitude. Reeder & Riechert (1975) have also observed the influence of altitude, at another site.

TABLE 3. Distribution of some species along an altitudinal gradient on the Pedra Antônio Bezerra inselberg

Species and family	Altitudinal range
Hydrolea spinosa (*Hydroleaceae*)	713–760 m
Maranta arundinacea (*Marantaceae*)	
Merremia cissoides (*Convolvulaceae*)	
Sinningia nordestina (*Gesneriaceae*)	
Acianthera ochreata (*Orchidaceae*)	761–800 m
Blepharodon manicatum (*Apocynaceae*)	
Clusia nemorosa (*Clusiaceae*)	
Cupania revoluta (*Sapindaceae*)	
Physalis neesiana (*Solanaceae*)	
Portea leptantha (*Bromeliaceae*)	
Solanum americanum (*Solanaceae*)	
Acianthera ochreata (*Orchidaceae*)	801–835 m
Alstroemeria longistaminea (*Alstroemeriaceae*)	
Begonia saxicola (*Begoniaceae*)	
Bomarea edulis (*Alstroemeriaceae*)	
Melocactus bahiensis (*Cactaceae*)	
Norantea brasiliensis (*Marcgraviaceae*)	
Portea leptantha (*Bromeliaceae*)	

Similarity

The study site has species in common with all other areas with which it has been compared (83 species in all). However, no species were found in all of the areas. Forty-one species (49%) were found in only one other area; 17 species (20%) in two others; another 17 species (20%) in three, four or five other areas; and eight species (10%) in six or seven other areas.

Among the species in common, 11 are ruderals: *Alternanthera brasiliana* (*Amaranthaceae*), *Jacquemontia densiflora*, *Merremia macrocalyx* (*Convolvulaceae*), *Stylosanthes viscosa* (*Fabaceae*), *Marsypianthes chamaedrys* (*Lamiaceae*), *Waltheria indica* (*Malvaceae*), *Mollugo verticillata* (*Molluginaceae*), *Echinolaena inflexa*, *Rhynchelytrum repens*, *Setaria* cf. *geniculata* (*Poaceae*) and *Solanum americanum* (*Solanaceae*) (Lorenzi, 1991; Kissmann, 1997). It is possible that these species are introductions from the surrounding region where agriculture and grazing predominate.

In the area dendrogram, the flora of Pedra Antônio Bezerra is closer to the other inselbergs analysed than to the other *Caatinga* plant formations included in the study (Fig. 2). The flora of a *campo rupestre* in Bahia (Conceição & Giulietti, 2002) separates first in the analysis, with the other floras forming two major groups (A and B in Fig. 2). Climatic differences appear to explain this pattern, as the *campo rupestre* in Bahia has a wider temperature range than the others (4–20°C; Conceição & Giulietti, 2002). Another important finding is that the *campos rupestres* of Bahia, despite being mainly found within regions otherwise characterised by *Caatinga* vegetation, have floras more closely related to *Cerrados* (Oliveira-Filho & Ratter, 2002).

Climatic differences may not explain the pattern of other areas in the dendrogram, as most of them have a typical semi-arid climate (Ab' Sáber, 2003). The only known climatic difference is a more homogeneous rain distribution in MA (Maturéia in Paraíba State; Agra *et al.*, 2004), which does not appear to have affected its relationship to the other areas (Fig. 2).

Group A in the dendrogram combines the floras of all inselbergs used in this comparison (Fig. 2), except for Pedra Furada in Pernambuco (Costa, 2000). This suggests that in these areas the vegetation found on the inselbergs is quite distinct from the vegetation of the neighbouring *Caatinga*. In Pedra Furada the survey covered the inselberg and the surrounding area (Costa, 2000), masking any distinction.

Pedra Antônio Bezerra and the inselbergs in Paraíba, which form a subgroup (Fig. 2), are all in the Borborema Plateau subregion. Based on these studies geographic proximity is an important factor in determining the floristic composition of northeastern Brazil's inselbergs.

Concluding Remark

The data obtained from this study demonstrate the high richness of angiosperms on an inselberg of the Brazilian semi-arid region. However, only additional floristic

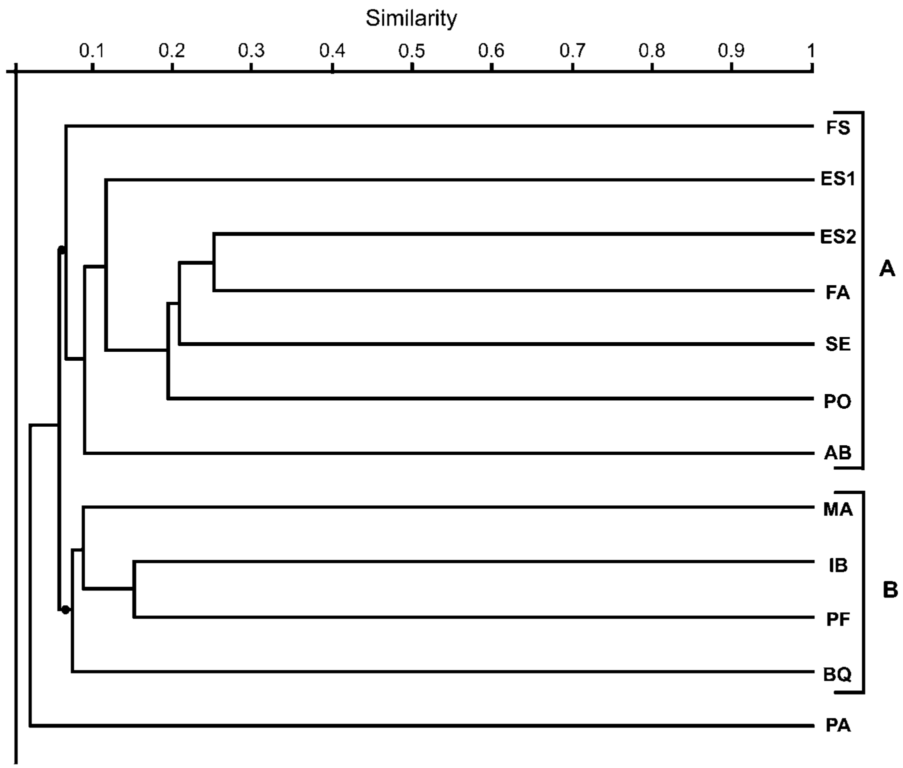

FIG. 2. Floristic similarity dendrogram obtained through the group mean (UPGMA) and Jaccard's similarity index (S_j) (r: 0.9196). Localities in northeastern Brazil: ES – Esperança (ES1 – Porto *et al.*, 2008; ES2 – Pitrez, 2006), FA – Fagundes, SE – Serraria, PO – Pocinhos (all Pitrez, 2006) and MA – Maturéia (Agra *et al.*, 2004), in Paraíba; PA – Palmeiras (Conceição & Giulietti, 2002) and FS – Feira de Santana (França *et al.*, 2005), in Bahia; IB – Ibimirim (Rodal *et al.*, 1999), BQ – Buíque (Andrade *et al.*, 2004), PF – Pedra Furada Municipal Park, Venturosa (Costa, 2000), and AB – Pedra Antônio Bezerra, Bezerros (study area), in Pernambuco. See text for explanation of A and B.

surveys will generate more conclusive data and provide a better understanding of the degree of interaction between the inselbergs and their surrounding vegetation.

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