Floristic similarity and dispersal syndromes in a rocky outcrop in semi-arid Northeastern Brazil

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Abstract: Floristic studies provide valuable information on species richness in a region, and are particularly important if these areas belong to less studied environments, such as rocky outcrops, that may increase our knowledge. An important aspect for species colonization includes the mechanisms of diaspores dispersal in each community; these are essential to understand its structure, dynamics, and the regeneration process, and constitute an important tool for conservation. We developed a floristic survey on a granite-gneiss outcrop with the objective to increase the knowledge on plant diversity, through a floristic similarity analysis and detection of dispersal syndromes of sampled species, in a semi-arid region of Brazil. The fieldwork included collection and observation of the botanical material *in loco* during a period of 12 months. A total of 161 species belonging to 127 genera and 50 families of angiosperms were recorded. Fabaceae, Asteraceae and Convolvulaceae were the most representative families in number of species. *Allophylus quercifolius* (Mart.) Radlk. (Capparaceae) and *Lafoensia pacari* A. St.-Hil. (Lythraceae) represented new records for the State of Paraíba. The autochoric syndrome was the most representative, with 51.5 % of the recorded species; the anemochory was the second most representative syndrome with 26.7 % of the species; and finally the zoochory, representing 22.3 % of the species. The floristic similarity dendrogram showed the formation of three well-defined groups, whose area with the highest value (J = 33.2) is located in a Caatinga region called Cariri Paraibano, while the lowest value observed (J = 5.2), occurred in a settled area in two geomorphological units, a crystalline complex and a plateau region. These results may be due to the varying topographic conditions and edaphic heterogeneity arising from the specific geological formation of the region. These results yet demonstrate that, in rocky outcrops, abiotic syndromes represent an effective dispersion of its diaspores, favoring plant specie's colonization dynamics. Rev. Biol. Trop. 63 (3): 827-843. Epub 2015 September 01.

Key words: inselbergs, floristic similarity, diasporas, xeric corridor, South America.

With a wide distribution in tropical areas, *inselbergs* feature a range of sizes and degrees of isolation associated with major biomes of the world, allowing experimental work, as well as being excellent elements to address different topics related to biodiversity and conservation (Porembski & Barthlott, 2000; Romer, 2005).

Due to its own characteristics, *inselbergs* form centers of diversity for certain functional groups of plants that are well adapted to extreme environmental conditions, and where the occurrence of seeds adapted to these conditions, becomes also greater in these formations than in the adjacent matrix (Hunter, 2003; Porembski, 2007). Its rocky structure is capable of forming xeric islands within a tropical rainforest matrix, resisting harsh soil edaphic and microclimate conditions (Sarthou, Larpinb, Fontyc, Pavoined, & Ponge, 2010).

Studies in outcrops of Brazilian semi-arid region showed that, while the dominant climate is the semi-arid, the formation of

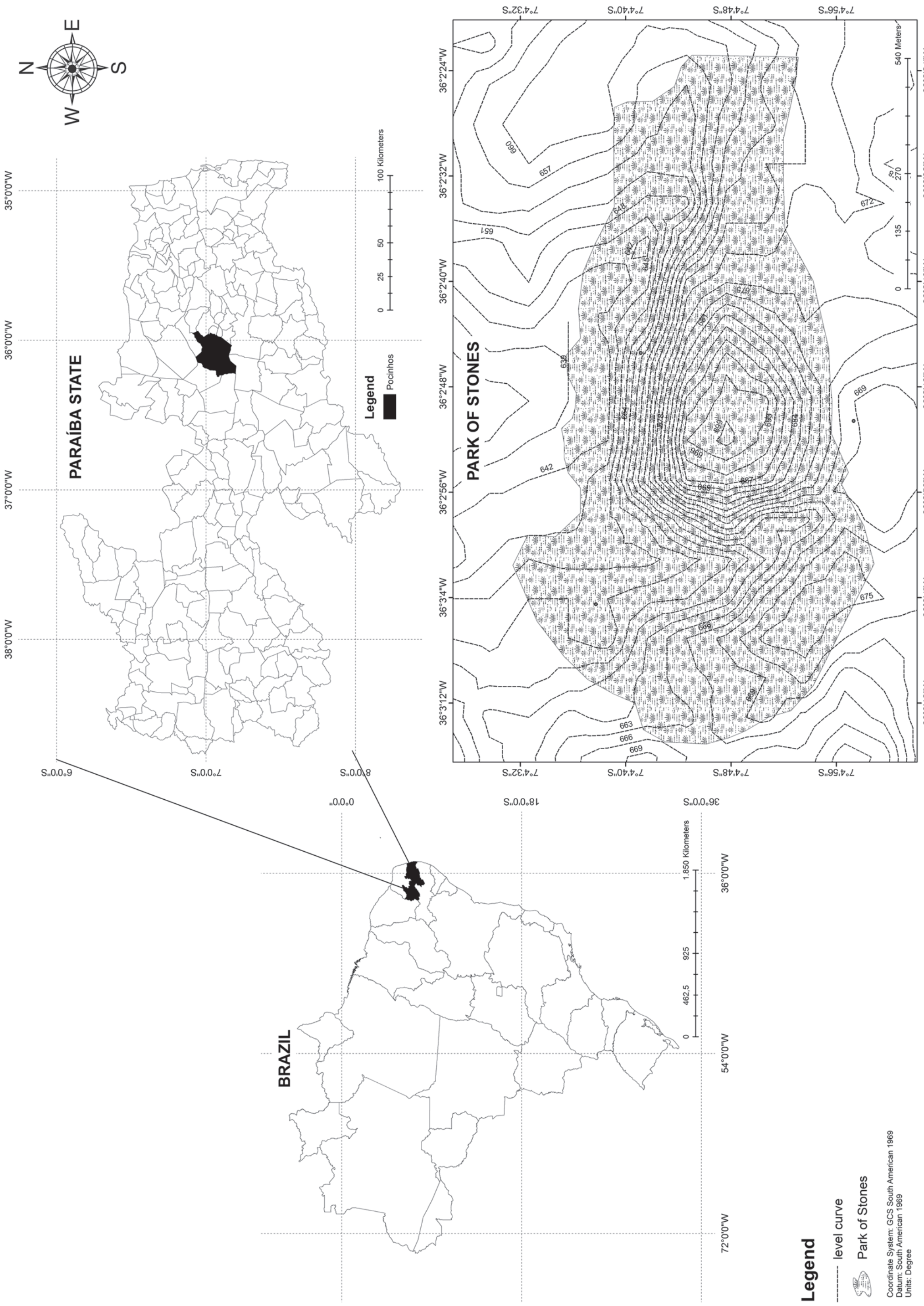

Fig. 1. Location map of the study area, Parque das Pedras, Pocinhos, Paraíba state, Brazil.

semi-deciduous forests may happen, which characterizes the local occurrence of wetter environments, favoring the establishment of phanerophytes (França, Melo, & Santos, 1997). According to Araújo, Oliveira & Lima-Verde (2008), the vegetation that is established on rocky outcrops in the semi-arid region has a high species richness, demonstrating the relevance of studies related to the biology and ecology of these species, and the conservation actions for these areas (Scarano, 2007).

Due to the absence of large substrate accumulations, water storage becomes incipient and much of it is rapidly lost by runoff. Due to the little substrate available and extreme microclimate conditions, the vegetation that is established in these environments is very different from its surroundings, favoring even the development of ephemeral vegetation (Sarthou & Villiers, 1998). Environmental conditions inherent to these formations are capable of providing niches to different *taxa*, depending on the surrounding vegetation and environmental pressure. In such harsh environments, the presence of effective dispersive mechanisms is of paramount importance for the development and establishment of seedlings (Willson & Traveset, 2000).

Based on the premise that short distances associated with abiotic syndromes may influence the floristic composition in rocky environments, this study aimed to verify the composition, and to perform a floristic similarity analysis and detect dispersion syndromes of the species of a granite-gneiss outcrop, situated in the semi-arid tropic in Northeastern Brazil. This study sought to answer the following questions: a) what is the degree of similarity/dissimilarity of this area in relation to other areas with rocky environments already studied in Northeastern Brazil?; b) do the dispersal syndromes corroborate the patterns found in outcrops of other arid or semiarid regions?

MATERIAL AND METHODS

Study area: The outcrop selected for this study is located in the municipality of Pocinhos, Agreste mesorregion of Paraíba state, in the semi-arid Northeastern Brazil. It is located in a private estate with approximately 55 ha known as Parque das Pedras (07º 05’ 14’’ S - 36º 03’ 56’’ W), and, although it is open to tourism, it is visibly preserved (Fig. 1). The Agreste is one of mesorregion of the state of Paraíba. It is characterized as a climatic transition area where winds heated in the depression zone ascends and cools up, causing rainfall (Rodríguez, 2000), with annual average rates ranging from 600 to 1 000 mm (AESA, 2014). According to the new updated classification of Köppen-Geiger (Peel, Finlayson, & McMahon, 2007), the climate in this region is characterized as BSh, hot semi-arid, and the annual precipitation rates are close to littoral rates (Rodríguez, 2000). It presents well-developed soils with clayey characteristics (Oliveira & Oliveira, 2008). The vegetation of this unit consists of semideciduous and deciduous forests, particular to areas of Agreste (Beltrão et al., 2005).

Floristic survey: For the record of the species that occur in the outcrop, 16 excursions were made in the period from December 2012 to November 2013, consisting of monthly collections in the dry season and bimonthly collections in the rainy season throughout the study area. Fertile branches (flowers and/or fruits) of individuals belonging to all strata of vegetation were obtained (Fig. 2 and Fig. 3). The specimens were processed according to the usual techniques (Judd, Campbel, Kellogg, Stevens, & Donoghue, 2009) and led to dry in the Herbarium Manuel de Arruda Câmara (ACAM) of the State University of Paraíba (UEPB), Campina Grande, Paraíba state, Brazil. The taxonomic identification was based on the taxonomic literature or by comparison with specimens, identified by experts, belonging to the collections of herbaria in the state of Paraíba (EAN, JPB) and in the Virtual Herbarium of the Brazilian Flora (REFLORA). Acronyms of the herbaria were mentioned according to Holmgren, Holmgren and Barnett (1990). Specimens and scanned images also were sent to confirmation and/or identification

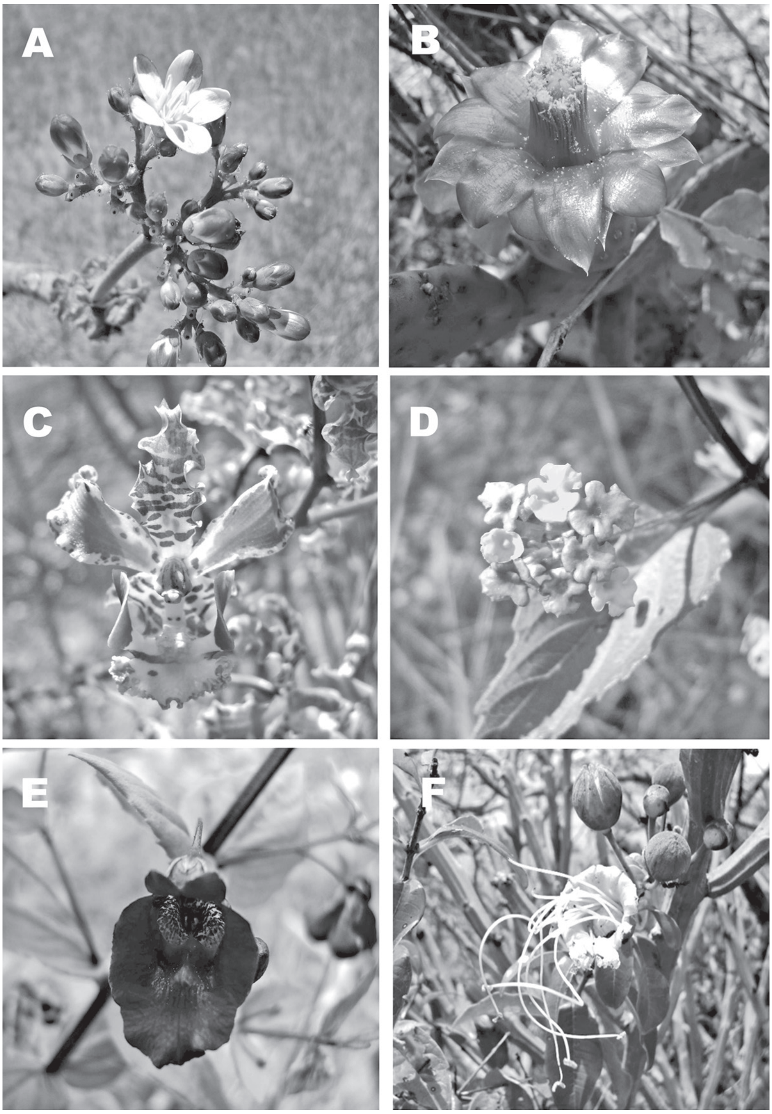

Fig. 2. Species recorded in the studied rocky outcrops: A) *Jatropha mollissima.* B) *Tacinga inamoena*. C) *Cyrtopodium holstii*. D) *Lantana camara*. E) *Angelonia campestris*. F) *Lafoensia pacari*.

by experts in different taxonomic groups in Brazil. Exsiccatae were incorporated into the collection of the Herbarium Manuel de Arruda Câmara (ACAM). The species were listed in alphabetical order by family, according to the *Angiosperm Phylogeny Group* - APG III (2009). The spelling of the names of species and their respective authors were found in the database of the *Missouri Botanical Garden* (Tropicos, 2013) and in the *online* Species List of Brazilian Flora (Forzza et al., 2014). This work has been included exclusively the native species and for this reason, the only exotic species recorded in the study area was not included in the floristic list.

Dispersal syndromes: To determine dispersal syndromes, young and mature fruits of almost all species recorded in outcrop were collected, except for *Lippia grata* Schauer

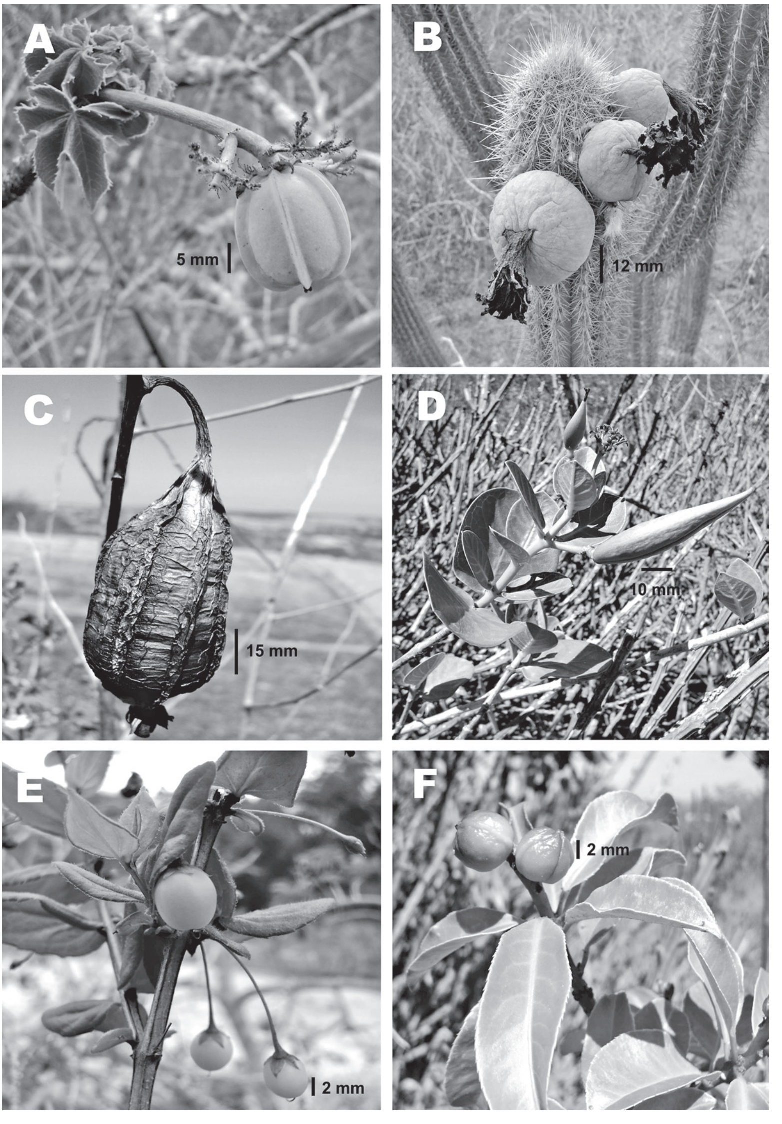

Fig. 3. Species recorded in the studied rocky outcrops: A) *Jatropha mollissima.* B) *Pilosocereus pachycladus.* C) *Cyrtopodium holstii.* D) *Marsdenia caatingae*. E) *Angelonia campestris.* F) *Sapium argutum.*

(Verbenaceae), *Justicia aequilabris* (Nees) Lindau (Acanthaceae), *Mitracarpus salzmannianus* DC., *Staelia virgata* (Link *ex* Roem. & Schult.) K. Schum. (Rubiaceae), and *Evolvulus ovatus* Fernald (Convolvulaceae) and their syndromes' determinations were conducted through taxonomic literature consulted or with expert assistance. For the other species, the syndromes were classified according to the work by Van der Pijl (1972), being classified into three categories: I-Anemochoric: when diaspores presented some sort of appendix with wings, feathers or in the form of dust; II-Zoochoric: when some attractive element, such as, for example, strong colors and/or a food source in its diaspores, is presented, as well as those with adhesive structures in the form of hooks, bristles, spines or mucilage;

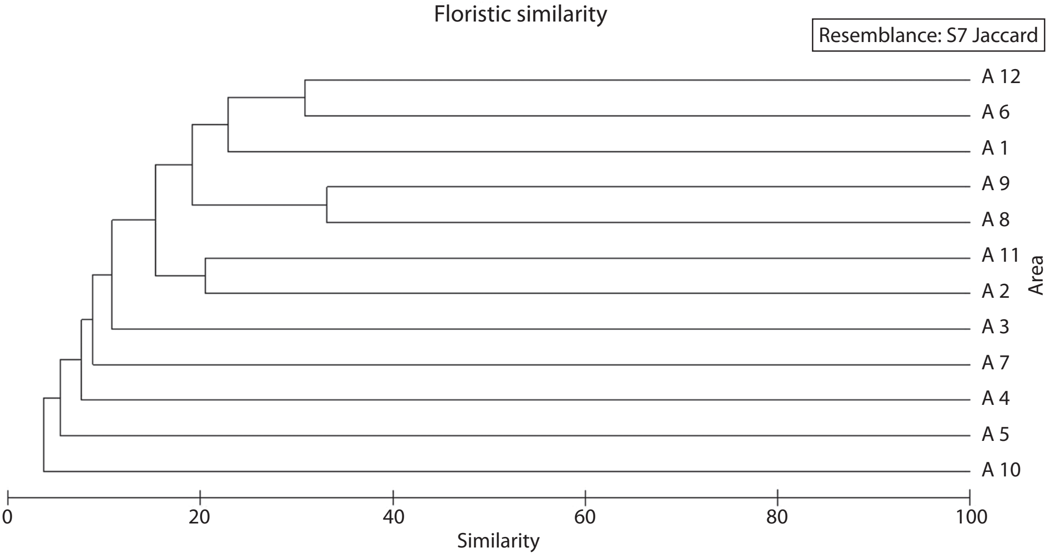

Fig. 4. Dendrogram of floristic similarity linking the study area with 11 studies on rocky outcrops and other areas of the surrounding matrix (Caatinga vegetation). A1 – Present study, A2 – Gomes et al. (2011), A3 – Porto et al. (2008), A4 – Araújo et al. (2008), A5 – França et al. (2005), A6 – Tölke et al. (2011), A7 – Gomes & Alves (2009), A8 – Machado-Filho (2011), A9 - Lima (2012), A10 – Araújo et al. (2005), A11 – Barbosa et al. (2005), A12 - Araújo et al. (Inéd. 2013).

III-Autochoric: when the diaspores showed no characteristic that allowed their classification in the previous two categories.

According to Van der Pijl (1972), the autochoric dispersion may occur in two main forms: active, when the plant expels the diaspores with a ballistic action associated with dehiscence of the fruit; and passive, when they are carried by the movement of the sediment or by small animals. In the latter, species with explosive dispersion or by gravity (barochoric) were grouped. Of the species recorded in the area, two did not have their dispersal syndromes identified due to the absence of fruiting material or because they had immature fruits. All fruits collected in the study area were classified according to Spjut (1994), and, for species that did not fruit during fieldwork, the classification was determined based on the specific literature and with expert advice.

Similarity analysis: To calculate the floristic similarity, originally a list consisting of the compilation of 11 floristic references was compiled using Excel software version 7.0, generating a presence/absence binary matrix with all elements identified at the species level. The selected studies included studies in rocky environments inserted in areas of Caatinga in states from the Northern and Southern portion of Northeast of Brazil (Table 1).

To avoid repetition and synonyms, the current nomenclature of each species was used. The dendrogram was obtained with the Primer 6.0 software, using the Jaccard index, based on the *Unweighted Pair Group Method using Arithmetic averages* (UPGMA) method.

RESULTS

Floristic: In the study area, 161 species belonging to 127 genera and 50 families of angiosperms were recorded (Table 2, Fig. 2 and Fig. 3). Among the species, five were identified up to the genus level. The most representative family was Fabaceae (24 spp.), followed by Asteraceae and Convolvulaceae, with 12 and 11 species, respectively; together, they correspond to 29 % of all recorded species.

TABLE 1
Floristic studies in semi-arid Northeastern Brazil compiled from the elaboration of the matrix of presence/absence of species

Reference	Municipality/ municipalities	Latitude-longitude	Area/m²	Physiognomy
This area	Pocinhos - PB	07°05'14'", 36°03'56"	550.000	Parque das Pedras
Gomes et al., 2011	Venturosa - PB	08°34'30", 36°52'45"	30.000	Parque Municipal da Pedra Furada
Porto et al., 2008	Esperança - PB	07°1'0.8", 35°52'50.3"	30.000	Fazenda Timbaúba
Araújo et al., 2008	Quixadá - CE	04°57'20.6", 39°01'28"	N/I*	Sítio Santa Luzia
França et al., 2005	Feira de Santana - BA	12°16'18"-39°03'39"	50.000	Fazenda Jibóia
Tolke et al., 2011	Puxinanã - PB	07°08'62.1", 35°58'31.4"	15.000	N/I*
Gomes & Alves, 2009	Bezerros - PB	08°20', 35°50'	70.000	Pedra Antônio Bezerra
Machado-Filho, 2012	Boa Vista - PB	07°12'10.3", 36°10'02.2"	70.000	APA do Cariri
Lima, 2012	Boa Vista - PB	N/I*	N/I*	Fazenda Salambaia
Araújo et al., 2005	Crateús - Ceará	05°15', 40°15'	N/I*	Reserva Natural Serra das Almas
Barbosa et al., 2005	Araruna, Arara, Cacimba de Dentro, Dona Inês, Solânea, Campo de Santana - PB	06°25', 35°30'	N/I*	Parque Estadual da Pedra da Boca, Fazenda Cachoeira de Capivara
Araújo et al., 2013	Puxinanã - PB	07°08'62.1", 35°58'31.4"	N/I*	N/I*

*NI = Not identified.

TABLE 2
Floristic list containing names of families and species, types of fruits and their dispersal syndromes of species recorded in the study area, Parque das Pedras, Pocinhos, Paraíba state, Brazil

Families / species	Types of fruits	Dispersal syndromes	Habit
Acanthaceae			
Anisacanthus trilobus Lindau	Caps	Autho	Herb
Justicia aequilabris (Nees) Lindau	Caps	Autho	Herb
Ruellia asperula (Mart. *ex* Ness) Lindau	Caps	Autho	Herb
Ruellia bahiensis (Ness) Morong	Caps	Autho	Herb
Ruellia sp.	Caps	Autho	Herb
Amaranthaceae			
Froelichia humbolditana (Roem. & Schult.) Seub.	Utric	Anemo	Herb
Gomphrena vaga Mart.	Utric	Anemo	Herb
Anacardiaceae			
Anacardium occidentale L.	Bac	Zoo	Arbor
Schinus terebinthifolius Raddi	Bac	Zoo	Arbor
Schinopsis brasiliensis Engl.	Sam	Anemo	Arbor
Spondias tuberosa Arruda	Bac	Zoo	Arbor
Apocynaceae			
Aspidosperma pyrifolium Mart.	Folic	Anemo	Arbor
Mandevilla tenuifolia (J.C. Mikan) Woodson	Folic	Anemo	Herb
Marsdenia caatingae Morillo	Folic	Anemo	Subsh
Araceae			
Anthurium affine Schott	Drup	Zoo	Subsh
Asparagaceae			
Agave sisalana Perriene	Caps	Autho	Subsh
Asteraceae			
Acmella uliginosa (Sw.) Cass.	Cyps	Autho	Herb

TABLE 2 (Continued

Families / species	Types of fruits	Dispersal syndromes	Habit
Ageratum conyzoides L.	Cyps	Anemo	Herb
Bidens pilosa L.	Cyps	Anemo	Herb
Centratherum punctatum Cass.	Cyps	Anemo	Herb
Conocliniopsis prasiifolia (DC.) R.M. King & H. Rob.	Cyps	Anemo	Herb
Delilia biflora (L.) Kuntze	Cyps	Anemo	Herb
Emilia fosbergii Nicolson	Cyps	Anemo	Herb
Lepidaploa chalybaea (Mart. *ex* DC.) Rob.	Cyps	Autho	Herb
Pectis sp.	Cyps	Autho	Herb
Sonchus oleraceus L.	Cyps	Autho	Herb
Tridax procumbens L.	Cyps	Anemo	Herb
Verbesina macrophylla (Cass.) S.F.Blake	Cyps	Autho	Subsh
Begoniaceae			
Begonia saxicola A. DC.	Caps	Anemo	Herb
Bignoniaceae			
Handroanthus impetiginosus (Mart. *ex* DC.) Mattos	Caps	Anemo	Arbor
Boraginaceae			
Heliotropium angiospermum Murray	Schizo	Autho	Herb
Tournefortia salzmannii DC.	Drup	Zoo	Subsh
Varronia dardani (Taroda) J.S. Mill.	Drup	Zoo	Subsh
Varronia globosa Jacq.	Drup	Zoo	Subsh
Bromeliaceae			
Encholirium spectabile Mart. *ex* Schult. & Schult.f.	Caps	Anemo	Herb
Hohenbergia catingae Ule	Bac	Zoo	Herb
Orthophytum disjunctum L.B.Sm.	Bac	Zoo	Herb
Neoglaziovia variegata (Arruda) Mez	Caps	Anemo	Herb
Tillandsia loliacea Mart. *ex* Schult. f.	Caps	Anemo	Epiph
Tillandsia polystachia (L.) L.	Caps	Anemo	Epiph
Tillandsia recurvata L.	Caps	Anemo	Epiph
Burseraceae			
Commiphora leptophloeos (Mart.) J.B.Gillett	Drup	Zoo	Arbor
Cactaceae			
Melocactus ernestii Vaupel	Bac	Zoo	Herb
Melocactus zehntneri (Britton & Rose) Luetzelb.	Bac	Zoo	Herb
Pilosocereus pachycladus F.Ritter	Bac	Zoo	Shr
Tacinga inamoena (K. Schum.) N.P. Taylor & Stuppy	Bac	Zoo	Subsh
Tacinga palmadora (Britton & Rose) N.P.Taylor & Stuppy	Bac	Zoo	Subsh
Capparaceae			
Cynophalla flexuosa (L.) J. Presl	Caps	Zoo	Arbor
Neocalyptrocalyx longifolium (Mart.) Cornejo & Iltis	Bac	Zoo	Arbor
Cleomaceae			
Hemiscola aculeata (L.) Raf.	Siliq	Autho	Herb
Physostemon guianense (Aubl.) Malme	Caps	Zoo	Herb
Commelinaceae			
Callisia filiformis (M.Martens & Galeotti) D.R.Hunt	Caps	Autho	Herb
Commelina erecta L.	Caps	Autho	Herb
Tradescantia ambigua Mart.	Caps	Autho	Herb
Convolvulaceae			
Evolvulus ovatus Fernald	Caps	Autho	Herb
Ipomoea bahiensis Willd. *ex* Roem. & Schult.	Caps	Autho	Vin

TABLE 2 (Continued

Families / species	Types of fruits	Dispersal syndromes	Habit
Ipomoea brasiliana (Choisy) Meisn.	Caps	Autho	Vin
Ipomoea longeramosa Choisy	Caps	Autho	Vin
Ipomoea marcellia Meisn.	Caps	Autho	Vin
Ipomoea nil (L.) Roth	Caps	Autho	Vin
Ipomoea setosa Ker-Gawl.	Caps	Autho	Vin
Jacquemontia corymbulosa Benth.	Caps	Autho	Herb
Jacquemontia evolvuloides (Moric.) Meisn.	Caps	Autho	Herb
Merremia aegyptia (L.) Urb.	Caps	Autho	Herb
Turbina cordata (Choisy) D.F.Austin & Staples	Caps	-	Vin
Cucurbitaceae			
Momordica charantia L.	Bac	Zoo	Herb
Cyperaceae			
Cyperus schomburgkianus Nees	Ach	Anemo	Herb
Pycreus macrostachyos (Lam.) J. Raynal	Ach	Anemo	Herb
Dioscoreaceae			
Dioscorea campestris Griseb.	Caps	Anemo	Vin
Euphorbiaceae			
Cnidosculus bahianus (Ule) Pax & K.Hoffm.	Caps	Zoo	Subsh
Cnidosculus urens (L.) Arthur	Caps	Zoo	Subsh
Croton heliotropiifolius Kunth	Caps	Autho	Subsh
Euphorbia comosa Vell.	Caps	Autho	Herb
Euphorbia phosphorea Mart.	Caps	Autho	Herb
Jatropha mollissima (Pohl) Baill.	Caps	Zoo	Shr
Manihot carthaginensis (Jacq.) Müll. Arg.	Caps	Autho	Shr
Sapium argutum (Müll. Arg.) Huber	Caps	Autho	Shr
Fabaceae			
Chamaecrista calycioides (DC. *ex* Collad.) Greene	Leg	Autho	Shr
Chamaecrista flexuosa (L.) Greene	Leg	Autho	Shr
Chloroleucon dumosum (Benth.) G.P.Lewis	Leg	Autho	Shr
Crotalaria holosericea Nees & Mart.	Leg	Anemo	Herb
Desmodium glabrum (Mill.) DC.	Lom	Anemo	Herb
Dioclea grandiflora Mart. *ex* Benth	Leg	Zoo	Vin
Dioclea violacea Mart. *ex* Benth	Leg	Autho	Vin
Enterolobium timbouva Mart.	Leg	Autho	Arbor
Erythrina velutina Willd.	Leg	Zoo	Arbor
Inga sp.	Leg	Autho	Arbor
Libidibia ferrea (Mart. *ex* Tul.) L.P. Queiroz	Leg	Autho	Arbor
Lonchocarpus araripensis Benth.	Leg	Anemo	Arbor
Macroptilium sp.	Leg	Autho	Herb
Mimosa candollei R. Grether	Leg	Autho	Shr
Mimosa ophthalmocentra Mart. *ex* Benth.	Crasp	Anemo	Shr
Mimosa paraibana Barneby	Leg	Anemo	Shr
Piptadenia stipulacea (Benth.) Ducke	Leg	Autho	Shr
Piptadenia viridifolia (Kunth) Benth.	Leg	Anemo	Shr
Senna cearensis Afr. Fern.	Leg	Autho	Shr
Senna macranthera (DC. *ex* Collad) H.S. Irwin & Barneby	Leg	Autho	Shr
Senna martiana (Benth.) H.S. Irwin & Barneby	Leg	Anemo	Shr
Senna splendida (Vogel) H.S. Irwin & Barneby	Leg	Anemo	Shr
Stylosanthes viscosa (L.) Sw.	Leg	Anemo	Shr

TABLE 2 (Continued

Families / species	Types of fruits	Dispersal syndromes	Habit
Zornia brasiliensis Vogel	Lom	Autho	Shr
Lamiaceae			
Hypenia salzmannii (Benth.) Harley	Nuc	-	Herb
Hyptis martiusii Benth.	Schizo	Autho	Herb
Loasaceae			
Aosa rupestris (Gardner) Weigend	Caps	Autho	Herb
Mentzelia aspera L.	Caps	Autho	Herb
Loranthaceae			
Struthanthus marginatus (Desr.) Blum	Bac	Zoo	Hemipar
Lythraceae			
Cuphea impatientifolia A.St.- Hil.	Caps	Autho	Herb
Lafoensia pacari A.St.-Hil.	Caps	Anemo	Shr
Malpighiaceae			
Byrsonima gardneriana A. Juss.	Drup	Zoo	Shr
Byrsonima vaccinnifolia A. Juss.	Drup	Zoo	Shr
Stigmaphyllon paralias A. Juss.	Sam	Anemo	Herb
Stigmaphyllon rotundifolium A. Juss.	Sam	Anemo	Herb
Malvaceae			
Helicteres eichleri K. Schum.	Caps	Autho	Shr
Herissantia crispa (L.) Brizicky	Schizo	Autho	Herb
Herissantia tiubae (K.Schum.) Brizicky	Schizo	Autho	Herb
Melochia tomentosa L.	Caps	Autho	Herb
Sida galheirensis Ulbr.	Schizo	Autho	Herb
Sidastrum paniculatum (L.) Fryxell	Schizo	Autho	Herb
Waltheria brachypetala Turcz.	Caps	Autho	Herb
Waltheria rotundifolia Schrank	Caps	Autho	Herb
Melastomataceae			
Tibouchina heteromalla (D. Don) Cogn.	Caps	Anemo	Shr
Molluginaceae			
Mollugo verticilata L.	Caps	Autho	Herb
Olacaceae			
Ximenia americana L.	Drup	Zoo	Shr
Orchidaceae			
Acianthera ochreata (Lindl.) Pridgeon & M. W. Chase	Caps	Anemo	Herb
Cyrtopodium flavum Link & Otto *ex* Rchb. f.	Caps	Anemo	Herb
Cyrtopodium holstii L.C. Menezes	Caps	Anemo	Herb
Habenaria obtusa Linal.	Caps	Anemo	Herb
Prescottia plantaginifolia Lindl. *ex* Hook	Caps	Anemo	Herb
Oxalidaceae			
Oxalis divaricata Mart. *ex* Zucc.	Caps	Autho	Herb
Oxalis psoraleoides Kunth	Caps	Autho	Herb
Passifloraceae			
Passiflora cincinnata Mast.	Bac	Zoo	Vin
Plantaginaceae			
Angelonia biflora Benth.	Caps	Zoo	Herb
Angelonia campestris Nees & Mart.	Caps	Zoo	Herb
Angelonia pubescens Benth.	Caps	Zoo	Herb
Plumbaginaceae			
Plumbago scandens L.	Caps	Autho	Herb

TABLE 2 (Continued

Families / species	Types of fruits	Dispersal syndromes	Habit
Poaceae			
Anthaenantia lanata (Kunth) Benth.	Caryop	Anemo	Herb
Cenchrus ciliaris L.	Caryop	Autho	Herb
Polygalaceae			
Asemeia violacea (Aubl.) J. F. B. Pastore & J. R. Abbott	Caps	Autho	Herb
Polygala paniculata L.	Caps	Autho	Herb
Portulacaceae			
Portulaca elatior Mart.	Caps	Autho	Herb
Portulaca mucronata Link	Caps	Autho	Herb
Portulaca oleracea L.	Caps	Autho	Herb
Rhamnaceae			
Ziziphus joazeiro Mart.	Drup	Zoo	Arbor
Rubiaceae			
Diodella apiculata (Willd. *ex* Roem. & Schult.) Delprete	Schizo	Autho	Herb
Guettarda angelica Mart. *ex* Müll. Arg.	Drup	Zoo	Shr
Leptoscela ruellioides Hook. f.	Caps	Autho	Herb
Mitracarpus salzmannianus DC.	Caps	Autho	Herb
Richardia grandiflora (Cham. & Schltdl.) Steud.	Schizo	Autho	Herb
Staelia virgata (Link *ex* Roem. & Schult.) K. Schum.	Caps	Autho	Herb
Santalaceae			
Phoradendron affine Pohl *ex* DC.	Bac	Zoo	Hemipar
Phoradendron piperoides (Kunth) Trel.	Bac	Zoo	Hemipar
Sapindaceae			
Allophylus quercifolius (Mart.) Radlk.	Caps	Autho	Shr
Serjania glabrata Kunth	Sam	Anemo	Herb
Scrophulariaceae			
Ameroglossum sp.	Caps	Autho	Subsh
Solanaceae			
Solanum rhytidoandrum Sendtn.	Bac	Zoo	Subsh
Turneraceae			
Turnera cearensis Urb.	Caps	Autho	Herb
Turnera subulata Sm.	Caps	Autho	Herb
Verbenaceae			
Lantana camara L.	Bac	Zoo	Shr
Lippia grata Schauer	Schizo	Autho	Herb
Vitaceae			
Cissus decidua Lombardi	Bac	Zoo	Herb
Zygophyllaceae			
Kallstroemia tribuloides (Mart.) Steud.	Schizo	Autho	Herb

Types of fruits: Caps = Capsule; Crasp = Craspedium; Ach = Achene; Foll = Follicle; Utric = Utricle; Drup = Drupe; Sam = Samara; Cyps = Cypsela; Bac = Bacca; Schizo = Schizocarp; Leg= Legume; Lom = Lomentum; Caryop = Caryopsis; Nuc = Nutlet. Dispersal syndromes: Autho = Authocory; Anemo = Anemochory; Zoo = Zoochory. Habit: Herb = Herbaceous; Arbor = Arboreous; Shr= Shrub; Subsh = Subshrub; Vin = Vine; Epiph= Epiphyte; Hemipar = Hemiparasitic; Siliq= Silique (Collector = *E.C.S. Costa*).

Allophylus quercifolius (Mart.) Radlk (Sapindaceae) and *Lafoensia pacari* A. St.-Hil. (Lythraceae) constituted new records for the state of Paraíba. Regarding monocots, the Bromeliaceae family should be highlighted; it was represented by five genera and seven species, being *Tillandsia* the most representative genus, with three species. Within Orchidaceae, represented by five species and three genera, *Cyrtopodium* is the most representative genus with two species. Poaceae, Cyperaceae and Araceae totaled 3.1 % of the total species recorded.

With regard to habits, the herbaceous stratum was the most representative, with 54 % of the total composition of the outcrop. Shrub (15 %) and subshrubs (12 %) components make up together 27% of all recorded species, and vines and epiphytes total 12.5 %. Three species of hemiparasites belonging to two families were recorded: *Phoradendron affine* Pohl *ex* DC., *Phoradendron piperoides* (Kunth) Trel. (Santalaceae) and *Struthanthus marginatus* (Desr.) Blume (Loranthaceae).

Similarity analysis: The similarity dendrogram showed the formation of well-defined clusters and a block whose areas appear forming similar subgroups among them (Fig. 4). The first group consists of rocky outcrops located in the municipality of Puxinanã (Araújo et al., 2013, unpublished data- A12, Tölke, Silva, Pereira & Melo, 2011 - A6) with an index of floristic similarity between areas of J = 30. The studied area (A1) demonstrated greater affinity with this group, being presented, in the dendrogram, as its subgroup. This floristic relationship can be explained by the fact that the whole work was done in areas geographically close together. The second group comprises the works of Machado-Filho (2011) - A8 and Lima (2012) - A9 (both with unpublished data), showing the highest similarity index (J = 33.2), being these works developed in a region called Cariri, located in Northeastern Brazil. The third group comprises the studies of Barbosa, Lima, Agra, Cunha & Pessoa (2005) - A11, held at Eastern Curimataú of Paraíba state and Gomes, Costa, Rodal & Alves (2011) - A2, in the semi-arid region of the state of Pernambuco.

Some areas settled in the Caatinga domain formed subgroups apart from the rest. These areas include rocky habitats (França et al., 2005; Araújo et al., 2008; Porto, Almeida, Pessoa, Trovão, & Félix, 2008; Gomes & Alves, 2009), and one study was conducted in the backlands ("sertão") of Ceará State by Araújo, Costa, Figueiredo & Nunes (2005), being the most dissimilar (J = 0.6) among selected studies when compared to this study.

Dispersal syndromes: With respect to the dispersion mode of the diaspores, the results showed a predominance of abiotic syndromes, where authocory was the most representative totaling 51.5 % (83 spp.) of total species. This mode of dispersion is the result of the plant's own mechanisms through explosive dehiscence of dried fruits or by gravity. The second most representative syndrome is anemochory, with 26.7 % (43 spp.) of the recorded species, followed by zoochory, comprising 22.3 % (36 spp.). In this category, plants depend on animals to disperse as far as possible from the mother-plant.

DISCUSSION

Bromeliaceae, Poaceae and Cyperaceae are very representative families in outcrops in South America (Sarthou & Villiers, 1998). However, Poaceae and Cyperaceae, in this study, were represented by two species each. *Melinis minutiflora* P. Beauv. (Poaceae) was one of the species found in the outcrop, but, because it is an exotic and invasive species, it was not included in the floristic list. Bromeliaceae is represented by seven species, and the genera *Encholirium* and *Tillandsia* occur throughout the outcrop. This pattern of occurrence for the above mentioned genera was also observed by França, Melo and Gonçalves (2006).

Corroborating the works of Araújo et al. (2005), Barbosa et al. (2005), Lima, Sampaio, Rodal and Araújo (2009) and Santos & Melo

(2010), Fabaceae was the family best represented, with 24 species, corresponding to 15 % of species richness in the studied area. Considered the most taxonomically diverse of the Caatinga, this family is the third largest among angiosperms, whose economic importance makes it even more known (Judd et al., 2009).

Asteraceae was the second best represented family in number of species and its wide distribution, particularly common in open areas (Souza & Lorenzi, 2012), illustrates the predominance of its species in its different aspects, represented in the works of Lima (2012), Neves & Conceição (2007) and Zappi et al. (2003).

Cactaceae, with five species, proved to be frequent in the study area, showing species with herbaceous to arborescent habits. Among the species found, *Melocactus zehntneri* (Britton & Rose) Luetzelburg is noteworthy because it is threatened by exploration and/or by anthropic pressure on their habitats (Fabricante, Andrade, & Marques, 2010). According to these authors, *M. zehntneri* plays a very important ecological role in the succession process, being able to colonize xeric environments and make them less harsh.

With regard to the habit, the tree component was the least representative, comprising 9 % of the total and, in that sense, Caiafa and Silva (2007) and Safford and Martinelli (2000) note that some outcrops showed shallow rock fractures, forming microenvironments characterized by the accumulation of 5 to 12 cm of soil, thus limiting the development of this stratum.

In the dendrogram, the highest value was found among the areas studied by Machado-Filho (2012) and Lima (2012), both settled in the Environmental Protection Area (EPA) of Cariri, in the semi-arid region of the state of Paraíba, Brazil. This close relation was expected, given that the studies were developed in the same geographical area between the municipalities of Cabaceiras and Boa Vista, Paraíba, whose climate and soil conditions are very similar and where rocky outcrops predominate.

The studies conducted in rocky environments settled in the city of Puxinanã, in Agreste mesorregion of Paraíba (Tölke et al., 2011; Araújo et al., 2013, unpublished data), showed a floristic relation (J = 31) closer with each other rather than with the studied area (J = 19). However, it was expected, because they are geographically nearby areas, that the similarity value between them would be higher than the one recorded (Kunz, Ivanauskas, Martins, Silva, & Stefanello, 2009; Oliveira & Nelson, 2001). This dissimilarity can be explained partly by species recording, which occurred only in this study: *Chloroleucon dumosum* (Benth.) G.P. Lewis, *Cuphea impatientifolia* A. St.-Hil., *Helicteres eichleri* K. Schum., *Jacquemontia corymbulosa* Benth. and *Ximenia americana* L.

The areas studied by Barbosa et al. (2005) and Gomes et al. (2011) formed a subgroup with a similarity value of J = 20, both located in the Agreste of the states of Paraíba and Pernambuco, respectively, showing weather conditions with erratic rainfall, varying from 664 mm to 1 054 mm, and similar frequency of rock formations. The most representative families in the two areas were Fabaceae and Euphorbiaceae, common in areas of caatinga (Cardoso & Queiroz, 2007; Sátiro & Roque, 2008), confirming the results obtained in the area under study.

The other areas had low similarity values (J < 20), in particular the study by Araújo et al. (2005), conducted in the Natural Reserve of Serra das Almas, CE, where three different formations were explored, contemplating areas from dense scrub vegetation to thorny deciduous trees and shrubs, with a dissimilarity between the flora of the surrounding matrix and the flora that is established on rocky outcrops. This vegetation is probably severely influenced by strict environmental aspects, demanding a greater adaptation of individuals, which contributed to this dissimilarity (Porembski & Barthlott, 2000).

Species such as *Jatropha mollissima* (Pohl) Baill. and *Cnidosculus urens* (L.) Arthur –Euphorbiaceae–, recorded in this study, have a passive authocory mechanism (Leal, 2003). According to the same author, seeds released by gravity may be secondarily carried to other areas by ants. *Sapium argutum* (Müll. Arg.) Huber (Euphorbiaceae) presents voluminous seeds, with vivid colors, and, although not mentioned in the study, it is possible that its seeds also present passive authocory by dispersion done by ants or even by sediment carrying along the outcrop.

The anemochoric syndrome includes 26.7 % of the recorded species' total, corroborating the data exposed by the literature, where areas of greatest exposure with low water levels show a predominance of abiotic vectors (Butler, Green, Lamb, McDonald, & Forster, 2007; Barbosa, Silva, & Barbosa, 2002; Griz & Machado, 2001; Machado, Barros, & Sampaio, 1997). Van der Pijl (1972) points out those taxa with wind dispersal present various structures that facilitate its spread. In addition, regarding anemochoric species collected in the study area, winged and feathery seeds were the most frequently observed.

The microclimate aridity of these rocky islands in relation to the surrounding area reflects the predominance of abiotic syndromes, as they represent habitats with a greater exposure to winds and sunlight (Araújo et al., 2008). The zoochorous syndrome amounted to 22.3 %, with most species that falls into this category being collected in wetlands surrounding the studied rocky outcrop. These conditions reflect what was found in the study by Silva and Rodal (2009), after the detection of dispersal syndromes in three areas with different rainfall regimes in the state of Pernambuco, Northeastern Brazil. It can be inferred that there is a gradual change in the spread spectrum of wetlands, dominated by species with zoochorous syndromes.

Thus, conducting floristic surveys associated with ecological aspects, such as the recognition of syndromes, provide a better understanding of the dynamics of species colonization, mainly with regard to the Caatinga vegetation in Northeastern Brazil. The results obtained in this study, compared to other similar studies (Araújo et al., 2008; Barbosa et al., 2002; Lima, 2012; Silva & Rodal, 2009), showed that abiotic syndromes (anemochory or authocory) are prevalent in outcrops and dry forests, supporting patterns found in outcrops in other regions of arid or semi-arid climates. Similar edaphic-climatic conditions are those that best explain the floristic similarity between the compared areas, especially those closer to each other. The combination of short distances and the predominance of abiotic syndromes suggest this affinity in the floristic composition, as observed in the works by Machado-Filho (2011) and Lima (2012).

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RESUMEN

Similitud florística y síndromes de dispersión en un afloramiento rocoso de la región semiárida del noreste de Brasil. Los estudios florísticos proveen información valiosa sobre la riqueza de especies de una región, y son particularmente importantes si estas áreas pertenecen a ambientes menos estudiados como los afloramientos rocosos. Un aspecto importante para la colonización de especies incluye los mecanismos de dispersión de diásporas en cada comunidad; estos son esenciales para entender la estructura, dinámica y el proceso de regeneración, constituyendo una herramienta importante para la conservación. En este estudio se realizó un levantamiento florístico de un afloramiento de granito-gneis con el objetivo de ampliar el conocimiento sobre la diversidad vegetal a través del análisis de similitud florística con la de otros afloramientos rocosos del nordeste brasileño y la detección de los síndromes de dispersión de las especies muestreadas en un área de la región semiárida de Brasil. Los trabajos de campo incluyeron recolección y observación de los materiales vegetales '*in loco*' durante el periodo de 12 meses. Un total de 161 especies pertenecientes a 127 géneros y 50 familias de angiospermas fueron registradas. Fabaceae, Asteraceae y Convolvulaceae fueron las familias más representativas en número de especies. *Allophylus quercifolius* (Mart.) Radlk. (Sapindaceae) y *Lafoensia pacari* A.St.-Hil. (Lythraceae) representan nuevas citas para el estado de Paraíba. El síndrome autocórico fue lo más representativo, con 51 % de las especies registradas; la anemocoria el segundo, con 27.7 % de las especies y finalmente la zoocoria, representando el 22.3 %. El dendrograma de similitud florística ha demostrado la formación de tres grupos bien definidos, cuya área con mayor índice (J = 33.2) está ubicada en una región de Caatinga llamada Cariri Paraibano mientras el menor índice "*in loco*" (J = 5.2) ocurrió en un área ubicada en dos unidades geomorfológicas: un complejo cristalino y una región de Planalto. Estos resultados se deben a las variables condiciones topográficas y a la heterogeneidad edáfica proveniente de la formación geológica especifica de la región. Estos resultados demuestran todavía que en afloramientos rocosos, síndromes abióticos representan una dispersión eficaz de sus diásporas, favoreciendo la dinámica de colonización de las especies vegetales.

Palabras clave: inselbergs, similitud florística, diasporas, pasillo xérico, América del Sur.

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