Geotemas, Pau dos Ferros, RN, Brasil
ISSN: 2236-255X, v. 13, 2023.

FLORISTIC DIVERSITY IN LAJEDO DO BRAVO, CARIRI PARAIBANO

Diversidade florística no Lajedo do Bravo, Cariri paraibano

Diversidad florística en Lajedo do Bravo, Cariri paraibano

Maria do Socorro Silva SALVADOR – Universidade Federal do Paraná (UFPR)
ORCID ID: https://orcid.org/0000-0002-6777-9317
URL: http://lattes.cnpq.br/6169398381945558
EMAIL: maria.salvador6991@gmail.com

Igor Emanoel Sales BERNADO – Universidade Estadual da Paraíba (UEPB)
ORCID ID: https://orcid.org/0000-0003-2487-686X
URL: http://lattes.cnpq.br/2254587823096821
EMAIL: igor1000@gmail.com

Valéria Raquel Porto de LIMA – Universidade Estadual da Paraíba (UEPB)
ORCID ID: https://orcid.org/0000-0001-7744-3502
URL: http://lattes.cnpq.br/7578689485360424
EMAIL: vrportol@yahoo.com.br

Inocencio de Oliveira BORGES NETO – Universidade Federal do Paraná (UFPR)
ORCID ID: https://orcid.org/0000-0002-1380-3879
URL: http://lattes.cnpq.br/4686404634264289
EMAIL: iobngpb@gmail.com

Article History
Reveived: 07 june, 2023
Accepted: 06 november, 2023
Published: 08 december, 2023

ABSTRACT

The study of biodiversity enables the understanding of the dynamics of nature, and, this understanding has significance both for the production of new knowledge and as well as for society. Therefore, the main objective of this research was to analyze the floristic diversity of the Caatinga Domain in a spatial area carried out in Lajedo do Bravo, Cariri, Paraíba. For this purpose, the Linear Transect Method for Phanerophytes and Chamaephytes (MTLFC) was used, in order to inventory tree-shrub species and examine the Alpha Diversity (Local), Abundance and Dominance Indices to measure the species richness of the community. The results showed that the transects have a floristic richness of 763 individuals, of which the species that stood out the most were *Bromelia laciniosa* Mart., *Croton urticifolius* Lam. and *Tacinga inamoena* (K. Schum.). The results indicated that the horizontal and vertical coverage of transects TR3 and TR10 stood out for having characteristics of vegetation of wetlands, taller size and greater canopy coverage, in addition to a relevant floristic diversity. As for the areas with typical shrub/arboreal caatinga vegetation, the TR1, TR2, TR6 and TR8 transects stand out for their species diversity. In this way, it was concluded that the realization of the floristic survey in Lajedo do Bravo made it possible to know the floristic diversity, verifying the richness of species, thus showing that the locality needs management actions aimed at conservation, with initiatives both from the responsible agencies and from the local communities.

Keywords: Biodiversity; Caatinga Biome; Semi-arid.

RESUMO

O estudo da biodiversidade possibilita o entendimento da dinâmica da natureza, esta compreensão possui significativa importância tanto para a construção de novos saberes, como também, para a sociedade. Diante disso a presente pesquisa teve como objetivo principal analisar a diversidade florística do Domínio da Caatinga em um recorte espacial realizado no Lajedo do Bravo, Cariri paraibano. Para isto utilizou-se do Método de Transecto Linear para Fanerófitos e Caméfitos (MTLFC), com a finalidade de inventariar espécies arbóreo-arbustiva, e do Índices de diversidade alfa (local), abundância e dominância para medir a riquezas de espécies de uma comunidade. Os resultados obtidos demostraram que os transectos possuem riqueza florística de 763 indivíduos, destes, as espécies que mais se destacaram foram a *Bromelia laciniosa* Mart., o *Croton urticifolius* Lam. e a *Tacinga inamoena* (K. Schum.). Os resultados apontam que a cobertura horizontal e vertical dos transectos TR3 e TR10 obtiveram destaque por possuir características de vegetação de áreas úmidas, de porte mais alto e maior cobertura de dossel, além de uma diversidade florística relevante. Quanto as áreas com vegetação de caatinga típica de porte arbustivo/arbóreo, destacam-se os transectos TR1, TR2, TR6 e TR8, por sua diversidade de espécies. Desta forma, concluísse que a realização do levantamento florístico no Lajedo do Bravo, possibilitou o conhecimento da diversidade florística constatando a riqueza de espécies, mostrando assim que a localidade necessita de ações de manejo visando a conservação, com iniciativas tanto dos órgãos responsáveis, quanto das comunidades locais.

Palavras-chave: Biodiversidade; Bioma Caatinga; Semiárido.

RESUMEN

El estudio de la biodiversidad permite la comprensión de la dinámica de la naturaleza, esta comprensión tiene una importancia significativa tanto para la construcción de nuevos conocimientos, como para la sociedad. Por lo tanto, el objetivo principal de esta investigación fue analizar la diversidad florística del Dominio Caatinga en un área espacial realizada en Lajedo do Bravo, Cariri, Paraíba. Para ello, se utilizó el Método de Transecto Lineal para Fanerófitas y Caméfitas (MTLFC), con el fin de inventariar especies arbóreas-arbustivas, y los Índices de Diversidad Alfa (Local), Abundancia y Dominancia para medir la riqueza de especies de una comunidad. Los resultados mostraron que los transectos tienen una riqueza florística de 763 individuos, de los cuales las especies que más se destacaron fueron *Bromelia laciniosa* Mart., *Croton urticifolius* Lam. y *Tacinga inamoena* (K. Schum.). Los resultados indican que la cobertura horizontal y vertical de los transectos TR3 y TR10 se destacó por tener características de vegetación de humedales, de mayor tamaño y mayor cobertura de dosel, además de una diversidad florística relevante. En cuanto a las zonas con vegetación típica arbustiva/arbórea de caatinga, los transectos TR1, TR2, TR6 y TR8 destacan por su diversidad de especies. De esta forma, se concluyó que la realización del relevamiento florístico en Lajedo do Bravo permitió conocer la diversidad florística, verificando la riqueza de especies, demostrando así que la localidad necesita acciones de manejo dirigidas a la conservación, con iniciativas tanto de los organismos responsables como de las comunidades locales.

Palabras clave: Biodiversidad; Bioma de Caatinga; Semi árido.

1 INTRODUCTION

Understanding the aspects related to the diversity and structure of vegetation, through phytosociological studies, is the foundation for defining a management and conservation strategy.

This article aims to analyze the alpha floristic diversity of the Caatinga vegetation within a spatial fragment known as Lajedo do Bravo, located in the Cariri region of Paraíba. The Caatinga is a type of dry tropical forest (Pennington et al., 2004), covering approximately 10.1% (862.639 km^2) of the Brazilian territory (IBGE, 2019). Typical of the Brazilian Northeast, the Caatinga is one of the least protected ecosystems in the country (Leal; Tabarelli; Silva, 2003; Dombroski et al., 2011). Furthermore, the remnants located in conservation units (UCs) generally lack adequate management plans and have been undergoing a process of environmental alteration and deterioration, leading to species loss (Giulietti et al., 2002; Souza; Menezes; Artigas, 2015; Souza; Souza, 2016). Therefore, the advancement of studies with floristic surveys and biodiversity analyses becomes significant.

Given the threats to biodiversity highlighted elsewhere, studies on floristic diversity are one of the various means to understand the dynamics of nature. This can be analyzed through floristic surveys and to assess biodiversity at alpha (local), beta (habitat), and gamma (regional) scales. For the research presented here, alpha biodiversity was used, as it involves a survey in a fragment of Caatinga vegetation on a specific scale.

The chosen fragment of Caatinga vegetation for local biodiversity analysis is situated between the municipalities of Boa Vista and Cabaceiras, which is part of the Environmental Protection Area of Cariri, a conservation unit (UC) established by the state government of Paraíba by decree Nº. 25.083, of 2004. The UC still lacks a management plan and zoning, leaving the environment extremely vulnerable to threats and pressures on local biodiversity. Threats to biodiversity are present in the exploitation of local minerals such as bentonite, and the inadequate handling of vegetation by the local population (Araújo; Farias; Sá, 2008; Seidel; Lima; Silva, 2023).

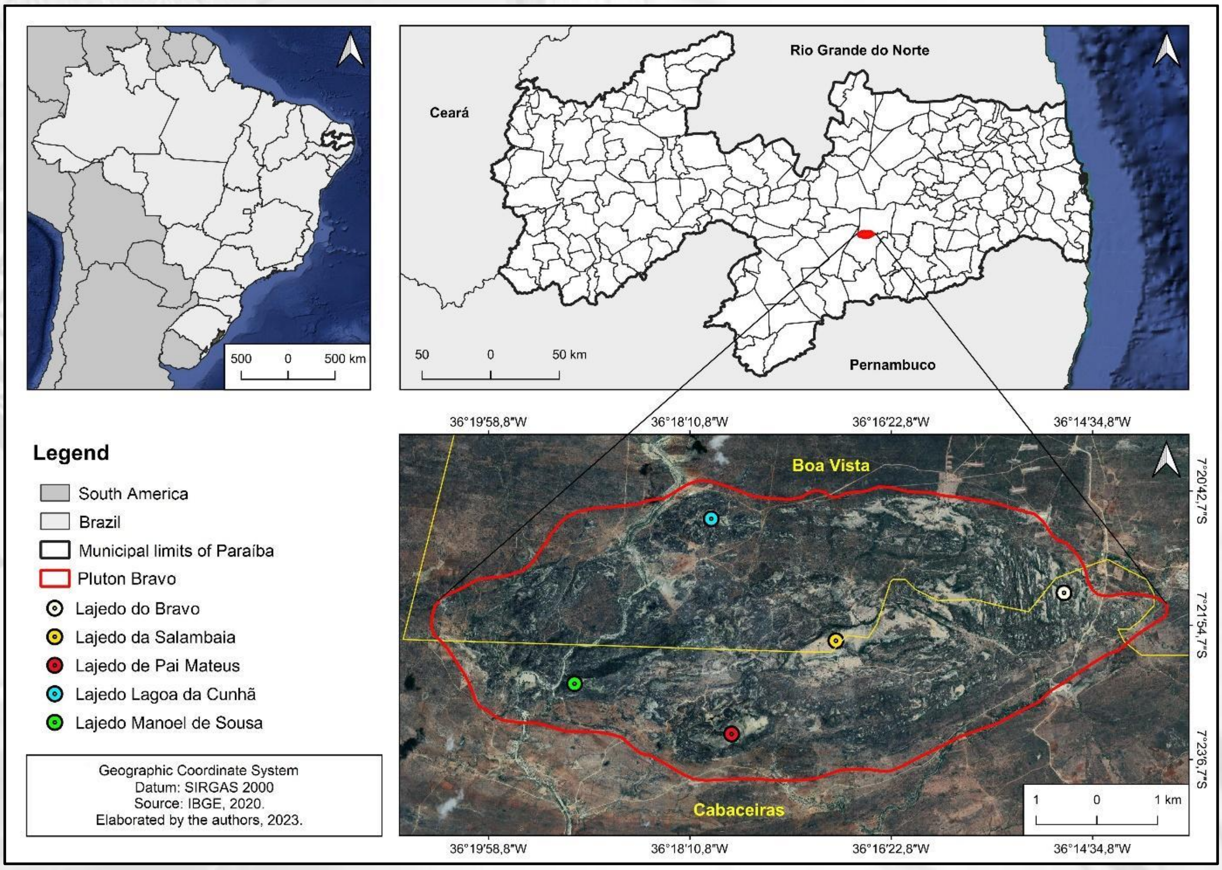
Currently, understanding the biodiversity of the Caatinga serves to counterpoint the academic literature that described the Caatinga domain as an environment poor in species and endemism, per Vanzolini et al. (1980), Andrade-Lima (1982) and Prance (1987). Such a statement was certainly associated with the physiognomy of vegetation during drought periods due to the semi-arid climate and vegetation management such as burning and plant exploitation for domestic use. More recent research on floristic surveys and biodiversity, such as those by Lunguinho (2018), Souza et al. (2019), Queiroz et al. (2020), show that the Caatinga has significant floristic biodiversity, and therefore, it is necessary to implement management tools aimed at conserving vegetation.

2 MATERIALS AND METHOD

2.1 Study area

The study was conducted at Lajedo do Bravo, located between the municipalities of Boa Vista and Cabaceiras, in the Cariri region of Paraíba (Figure 01). The area covers an extent of 22.8 hectares and is situated within an Environmental Protection Area (EPA) of Cariri. It is also a region with considerable abiotic scenic beauty, which has triggered the possibility of creating a geopark (Lages et al., 2018).

Figure 01 – Location of the study area.



Source: IBGE (2020). Produced by the authors (2023).

In geological terms, Lajedo do Bravo (located to the east) is just one of several flat rocky outcrops present in the Pluton Bravo, which in turn is a large intrusive magmatic body, nestled between two shear zones, that crystallized around 580 M.a. (Lages et al., 2013).

These granitic intrusions, in turn, give rise to exceptional landscapes (LAGES et al., 2013; Maia; Nascimento, 2018; Xavier, Borges Neto; Cunha, 2021) and constitute the so-called "granitic landforms" (Maia; Nascimento, 2018) or “residuals” (Corrêa et al., 2010) – examples include symmetrical ridges, residual massifs, inselbergs, and flat rocky outcrops. Corrêa et al. (2010) reported that these reliefs are typically supported by granitic intrusions from the Borborema Geological Province, which were exposed by the differential erosion of ancient orogenic areas, and later reworked by erosive processes from distinct morphogenetic systems fluctuating throughout the Cenozoic (Maia et al., 2015).

Geomorphologically, the Pluton Bravo is located on the Geoenvironmental unit of the Borborema Plateau, more precisely in the compartment of the Paraiban Intraplanaltic Depression (Corrêa et al., 2010). Characteristics such as higher elevation relative to its surroundings, low porosity, and the distinct morphologies of the rocky outcrops typically govern the flow of water, sediments, nutrients, and plant/animal residues to the lower areas within the rocky bodies (gnammas, fissures, etc.) and especially around the outcrops, forming depositional zones and water recharge areas (Burke, 2002; Meyer et al., 2021; Pérez, 2023).

According to Köppen's classification, Lajedo do Bravo falls within a Bsh climate, which is defined as a hot and dry semi-arid type, presenting factors of scarcity and irregular rainfall, strong insolation, high evaporation rates, and average temperatures of 27 ºC (Nascimento; Lima; Lima, 2014).

The predominant vegetation in the Cariri region of Paraíba is the hyper-xerophilous Caatinga (Silva et al., 2017), characterized by the predominance of deciduous xerophilous species, with the common occurrence of thorny plants adapted to drought (Souza, 2008). It is generally dominated by species such as Pereiro (*Aspidosperma pyrifolium*), Pinhão bravo (*Jatropha molíssima*) and Xique-Xique (*Pilosocereus gounellei*), while on the margins of intermittent streams the presence of the exotic Algaroba (*Prosopis juliflora*) is notable (Souza; Menezes; Artigas, 2015).

According to Souza and Souza (2016), this area has an ancient European occupation process (since the 17^{th} century), having over time suffered constant deforestation for the expansion of agriculture and livestock and wood extraction for various purposes (construction of houses and fences, production of charcoal, and extraction of firewood for energy purposes, both domestic and industrial), which explains the dominant scenario of vegetation cover degradation.

2.2 Methodological procedures

For the analysis of the vegetation cover, the Linear Transect Method for Phanerophytes and Chamaephytes (MTLFC) was used, developed by Cámara and Del Olmo (2004) available at: https://personal.us.es/rcamara/index_archivos/mifc.htm, and used for the first time in Brazil by Lima (2012). The methodology is an adaptation of the procedure originated by Gentry (1982 and 1988), justified by the deficit and needs of the study of shrub and tree formations (Cámara; Del Olmo, 2013). The MTLFC technique allows for a more detailed observation of the vegetation due to quantitative and qualitative studies of phanerophytic and chamaephytic plant formations.

Species identification was performed using taxonomic keys, in addition to consultations with the virtual herbarium of Reflora (http://reflora.jbrj.gov.br/reflora) and species not identified in the field were collected in exsiccatae and sent to the Botanical Research Laboratory of the State University of Paraíba. The technique used was that of linear transects measuring 50 m x 2 m, delimited by a tape measure, in which data were collected for all individual plant species, noting the position in the transect, height, phenological aspects, major and minor radii, larger and smaller diameters, and the diameter at breast height - DBH for individuals with a value equal to and/or greater than 2 cm. The MTLFC recommends that 10 transects with homogeneous vegetation be performed to form 1 plot of similar physiognomic types.

The floristic surveys of the present study were obtained through the realization of 10 transects between the years 2017 and 2018 (Table 01): for the development of these, the phenological dynamics of the species of the Caatinga biome were taken into account in relation to the climatic conditions of the region, marked by pluviometric irregularity.

Table 01 – Transects conducted in field work.

Field Work	Dates	Transects - TR
1º	Oct 27-28, 2017	TR1-TR2
2º	Feb 08-09, 2018	TR3-TR4-TR5
3º	Jun 03, 2018	TR6-TR7-TR8
4º	Jul 11, 2018	TR9-TR10

Source: Produced by the authors (2023).

The field data collected were entered into TEFA tables developed in Excel Software with the purpose of more efficiently tabulating the collected values and their elements, in relation to the characteristics of the sampled units and their attributes, the structural characteristics of the plant formation, and the Diversity Index.

The analysis of the graphic representation of the vertical structure of the vegetation is presented through a bubble diagram, produced using Excel Software, which aimed to calculate the surface of the cover according to the area of the ellipse with the product of the semiaxes by the number π $(a * b * \pi)$, or the canopy area if the shrubs and trees have diameter at breast height (DBH) from the average radius. The diversity data were analyzed in the software Past.

2.2.1 Diversity, abundance, and dominance indices

Diversity, abundance, and dominance indices are used for *α, β* and *y* types, as these measure the species richness of a community, the degree of change and substitution in the species composition of different communities, and their combined richness within these communities (Cámara; Del Olmo, 2013). For the analysis of the indices, the methods of Simpson (C) and Shannon-Weaver (H') were used. The Simpson index considers the representativeness of species with the highest importance value without evaluating the contribution of the others. The formula for the Simpson index is given by the following expression:

$$\lambda = \Sigma p_i^2$$

Where p_i is the proportional abundance of the species and *i* refers to the number of individuals of the same species divided by the total number of individuals in the sample. This calculation is strongly influenced by the importance of the more dominant species over others and indicates the relationship between richness or number of species and abundance or number of individuals per species in any place. Values closer to 1 represent the predominance of one or some species over others. As its value is inversely related to evenness, diversity can be calculated as $(D = 1 - \lambda)$ which indicates that the closer to the value of 1, the greater the evenness.

The Shannon Index (H'), in turn, is used to analyze a community when it cannot be completely inventoried. Its formula is represented by the following expression:

$$H' = -\sum[(p_i)ln\,(p_i)]$$

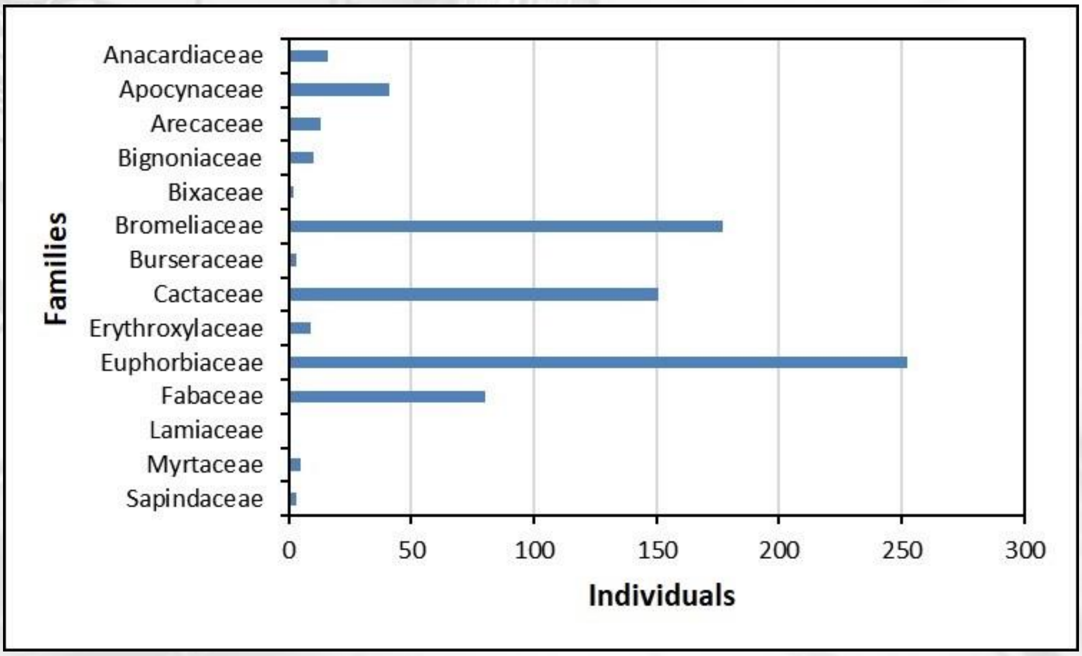
The value of p_i is represented by the formula $p_i = n_i$/N, and here it represents the relative abundance of species *i*; n_i corresponds to the number of species *i* in the sample, and N is the total number of individuals in the sample.

After obtaining the value of *pi*, its logarithm is taken and multiplied by the initial value of p_i. The resulting values are summed and then multiplied by -1. In this index, if the values reach numbers like 1.5 to 2, it means that the plot analyzed presents a good diversity of species.

3 RESULTS AND DISCUSSION

The results obtained through the 10 linear transects carried out in the field identified a floristic richness of 763 individuals (Figure 02), comprising 50 species, distributed across 16 families, and 37 genera (Table 02).

Figure 02 – Number of individuals per family.



Source: Produced by the authors (2023).

Table 02 – Data on tree and shrub species cataloged in the transects

Nº	Family	Species	Popular Name
1	Anacardiaceae	*Myracrodruon* M. Allemão	Aroeira
2	Anacardiaceae	*Schinopsis brasiliensis* Engl.	Baraúna
3	Apocynaceae	*Allamanda blanchetii* A.DC.	
4	Apocynaceae	*Aspidosperma pyrifolium* Mart. & Zucc.	Pereiro
5	Arecaceae	*Syagrus cearensis* Noblick	Catolé
6	Bignoniaceae	*Handroanthus impetiginosus* (Mart. ex DC.) Mattos	-
7	Bignoniaceae	*Tabebuia aurea* (Silva Manso) Benth. & Hook.f. ex S. Moore	Paratudo
8	Bixaceae	*Bixa orellana L.*	Urucum
9	Bixaceae	*Cochlospermum vitifolium* (Willd.) Spreng.	-
10	Boraginaceae	*Cordiaceae* R.Br. ex Dumort.	-
11	Boraginaceae	*Varronia dardani* (Taroda) J.S.Mill.	-
12	Bromeliaceae	*Bromelia laciniosa* Mart. ex Schult. & Schult.f.	Macambira
13	Bromeliaceae	*Neoglaziovia variegata* (Arruda) Mez	Caroá
14	Burseraceae	*Commiphora leptophloeos* (Mart.) J.B.Gillett	Imburana-de-cambão
15	Cactaceae	*Opuntia Mill.*	Palma
16	Cactaceae	*Opuntia palmadora* Britton & Rose	Palmatória
17	Cactaceae	*Pilosocereus pachycladus* F.Ritter	Facheiro
18	Cactaceae	*Pilosocereus polygonus*	Xique-xique
19	Cactaceae	*Tacinga inamoena* (K.Schum.) N.P.Taylor & Stuppy	Combeba
20	Erythroxylaceae	*Erythroxylum revolutum* Mart.	-
21	Erythroxylaceae	*Erythroxylum rimosum* O.E.Schulz	
22	Erythroxylaceae	*Erythroxylum suberosum* var. denudatum O.E.Schulz	-
23	Euphorbiaceae	*Cnidoscolus pubescens* Pohl	Cansanção
24	Euphorbiaceae	*Cnidoscolus quercifolius* Pohl	Faveleiro
25	Euphorbiaceae	*Cnidoscolus urens* (L.) Arthur	-
26	Euphorbiaceae	*Croton sonderianus* Müll.Arg.	Marmeleiro
27	Euphorbiaceae	*Croton sp.*	-
28	Euphorbiaceae	*Croton urticifolius* Lam.	-
29	Euphorbiaceae	*Euphorbia phosphorea* Mart.	-
30	Euphorbiaceae	*Jatropha mollissima* (Pohl) Baill.	Pinhão bravo
31	Euphorbiaceae	*Jatropha ribifolia* (Pohl) Baill.	-
32	Fabaceae	*Amburana cearensis* (Allemão) A.C.Sm.	Umburana de Cheiro
33	Fabaceae	*Anadenanthera colubrina* (Vell.) Brenan	Angico
34	Fabaceae	*Bauhinia cheilantha* (Bong.) Steud.	Mororó
35	Fabaceae	*Caesalpinia pulcherrima* (L.) Sw.	Catingueira
36	Fabaceae	*Erythrina velutina* Willd.	Mulungu
37	Fabaceae	*Hymenaea courbaril* L.	Jatobá
38	Fabaceae	*Hymenaea rubriflora* Ducke	-
39	Fabaceae	*Libidibia ferrea* (Mart. ex Tul.) L.P.Queiroz	Pau-ferro

40	Fabaceae	*Mimosa arenosa* (Willd.) Poir.	Jurema-branca
41	Fabaceae	*Mimosa hostilis* Benth	Jurema-preta
42	Fabaceae	*Mimosa ophthalmocentra* Mart. ex Benth.	Jurema-de-imbira
43	Fabaceae	*Senna martiana* (Benth.) H.S.Irwin & Barneby	Canafístula
44	Fabaceae	*Senna obtusifolia* (L.) H.S.Irwin & Barneby	-
45	Fabaceae	*Stylosanthes viscosa* (L.) Sw.	-
46	Lamiaceae	*Vitex sp.*	-
47	Myrtaceae	*Campomanesia eugenioides (Cambess.) D.Legrand ex Landrum*	-
48	Myrtaceae	*Eugenia brejoensis* Mazine	-
49	Myrtaceae	*Eugenia sp.*	-
50	Sapindaceae	*Talisia esculenta* (Cambess.) Radlk.	-

Source: Produced by the authors (2023).

Among the species observed, the most prominent throughout the transects were *Bromelia laciniosa* Mart. ex Schult. & Schult.f. with 150 individuals, *Croton urticifolius* Lam. with 173 and *Tacinga inamoena* (K. Schum.) N. P. Taylor & Stuppy with 66 individuals. These species are characteristic of a secondary Caatinga, as well as adapted to low rainfall indices.

Bromelia laciniosa is quite prevalent in the area as it is characteristic of the Caatinga. It's a xerophytic species with morphological and physiological structures adapted to the semi-arid climate (Souza et al., 2021).

According to data from Flora do Brasil (2020), there are currently 132 species of bromeliads recorded in the phytogeographic domain of the Caatinga, with 75 being endemic. These species have a wide range of uses such as ornamental plants, medicinal plants, animal feed, among others (Souza et al., 2021), however, despite this potential for being widely and diversely used, these species were very abundant in the study area, possibly related to the fact that the location is difficult to access and because it is a conservation unit.

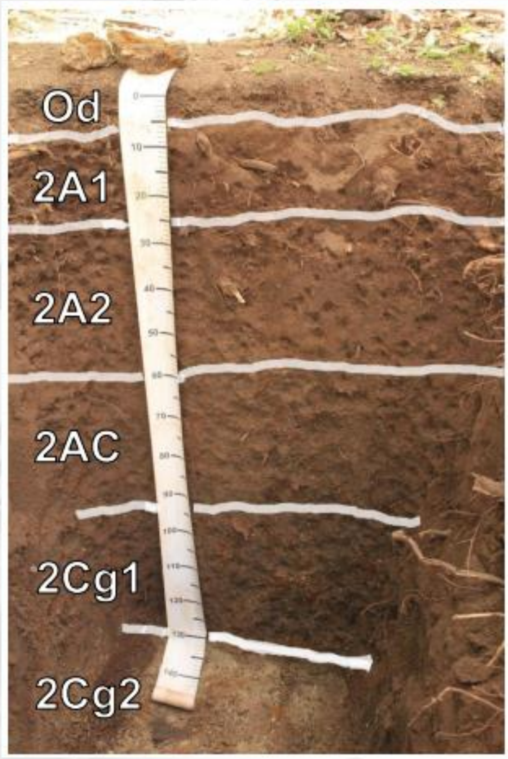
Another species with abundance found in the area was *Croton urticifolius*. This species can be easily found in the Cariri region of Paraíba, as in the study by Medeiros (2019). *Croton urticifolius* occurs predominantly in dry environments in Brazil, being found in the states of Alagoas, Bahia, Ceará, Espírito Santo, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, and Sergipe in Caatinga vegetation environments, deciduous forest, and rocky fields (Silva et al., 2010).

In addition to the phytogeographic domain of the Caatinga (stricto sensu), according to Flora do Brasil (2020), the *Croton urticifolius* can be found in the Cerrado and Atlantic Forest, with vegetation types including Carrasco, Seasonal Deciduous Forest, and Restinga.

The species *Aspidosperma pyrifolium* Mart. & Zucc stands out for its arboreal size and presents a total of 36 individuals along the transects, being considered an endemic species of the Caatinga. It can be found mainly in riverine floodplains and lands near ground elevations - ranges, plateaus, or cuestas - (Maia, 2012; Souza, 2016). In this research, *Aspidosperma pyrifolium* is located in the lower part of the rocky outcrops, an environment that receives the entire flow of rain due to its morphological position.

It is important to highlight that in this environment, according to the Brazilian Soil Classification System - SiBCS (Santos et al., 2018) a soil class called gleysol (Figure 03) was identified, which includes the presence of plinthite and a mottled appearance, rarely found in semi-arid environments. Probably this soil-type evolved from the accumulation of water on the edges of the flat rocky outcrops, since the morphology of the rocky outcrops recurrent in the study area would favor the flow and accumulation of water.

Figure 03 – Soil profile opened in the field for classification



Source: Collection of Nádson Souza (2018).

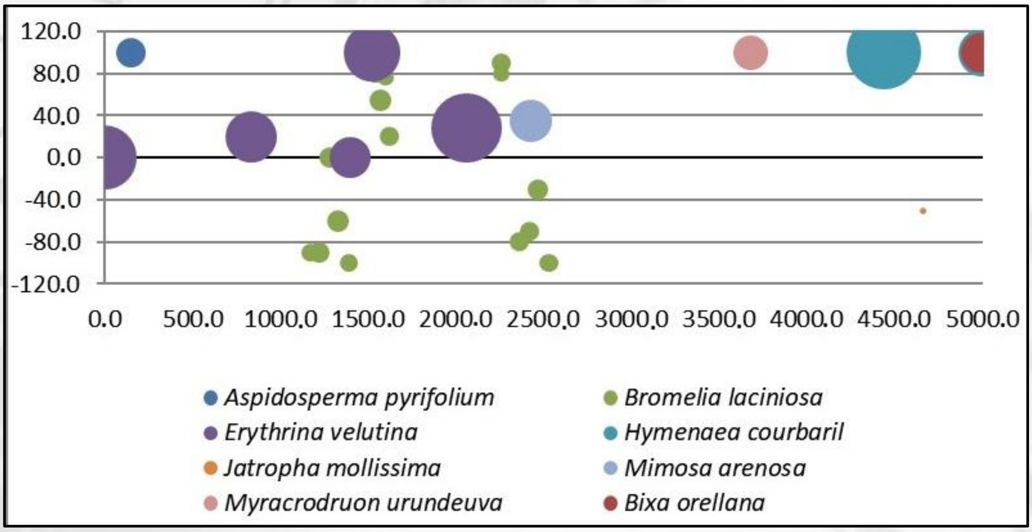
The species *Erythrina velutina* Willd., with 7 individuals, stands out in this environment for its tall arboreal stature, whereas *Anadenanthera colubrina* (Vell.) Brenan, with 8 individuals, is deciduous, heliophilous, wild, and selectively xerophilous. In the successional group, as an initial secondary species, *Hymenaea courbaril* L., with 21 individuals, has a wide distribution and can be found in the Amazon, Atlantic Forest, Pantanal, and Cerrado biomes.

The species *Erythrina velutina* Willd. is native to the Caatinga in the semi-arid region of Northeastern Brazil, with dispersion linked more to the humid sub-areas of riverbanks, or lower areas, which are a bit more floodable during the rainy season (Carvalho, 2008; Santos et al., 2013). The presence of this species with a considerable number of individuals occurs due to the capacity of the environment to converge water during the rainy period at the site, becoming a true "moisture accumulation box". Studies such as those by Guimarães et al. (2021) and Lunguinho (2018), showed and confirmed this assertion.

The presence of a large number of tree species with an average height of 6 to 15 meters in the transects carried out in the lower part of the outcrop shows the influence that the morphology of the flat rocks exerts on the size of the vegetation, and consequently on the floristic composition of such environments. The individuals inventoried in the higher part of the flat rocks were smaller, with an average between 40 and 80 centimeters, and stood out by the abundance of bromeliads and cacti, as seen, for example, in transect TR10.

When analyzing the horizontal coverage of the transects, represented in bubble charts, it is possible to observe the distribution of species throughout the sample and the numbers of individuals. Such a distribution of individuals and of species allows for a didactic reading of the characteristics of the sampled environments, as can be seen in a comparative analysis of TR3 (Figure 04) and TR10 (Figure 06).

Figure 04 – Horizontal coverage of the transect 3 (TR3).



Source: Produced by the authors (2023).

Transect TR3 was carried out in the lower part of the rocky outcrop, with 40.70% of the species being arboreal and with high coverage. In this case, the canopies of the taller trees prevent the passage of sunlight into the interior of the remnant, reducing or preventing the development of various plant species.

In transect TR3, species such as *Erythrina velutina* Willd. (Figure 05) and *Hymenaea courbaril* L. are arboreal species that require humid environments for their development.

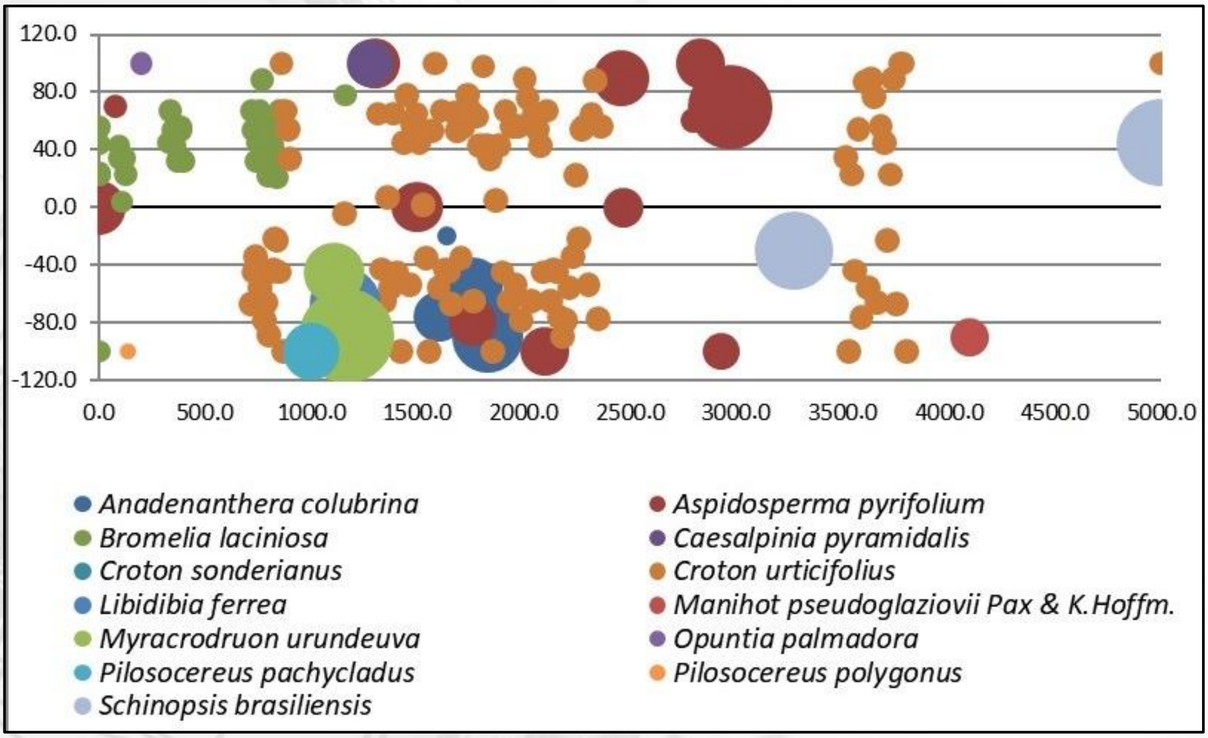
Figure 05 – Example of the species *Erythrina velutina* Willd.

Source: Authors (2018).

Throughout transect TR3, represented by Figure 04, it is noted that there was not a great variety of species (totaling 8) in terms of diversity; however, there was the presence of arboreal species in the locality. This presence is explained by the location being sandwiched between rocky outcrops, thus forming an ecological corridor and a humid and favorable environment for the development of these species (*Erythrina velutina* Willd. and *Hymenaea courbaril* L.). As stated by Guimarães et al. (2021), the pattern of rocky topography formation in the area creates small valleys that are slowly filled with sediments, generating differentiated conditions for water storage. Thus, the areas around the rocky outcrops can retain soil moisture, allowing the development of a more stratified and diversified Caatinga.

In TR10, a significant quantity (approximately 10%) of shrubby species was observed along the transect. The species *Croton urticifolius* Lam. and *Bromelia laciniosa* Mart. were the most abundant. The environment where the transect was conducted is on the upper part of the rocky outcrop.

Figure 06 – Horizontal coverage of the transect 10 (TR10).



Source: Produced by the authors (2023).

TR10 stood out from the other transects conducted because, despite being located on the flat rocks, it showed a great diversity of plant species. This characteristic is due to the structure of the rock, which allows for areas similar to an ecological corridor, enabling the existence of different species.

Regarding the alpha diversity indices, the values obtained point to different situations in the research area, as can be observed in Table 03. The transects that stood out the most in the Shannon and Simpson indices are TR1, TR2, TR6, and TR8, all of which reached values above two. This indicates that these areas have a great diversity of species.

For years, it was believed that the Caatinga, presenting predominantly shrubby stature and xerophilous aspects over much of its area, had low flora diversity. However, biodiversity studies of this biome carried out by Leal, Tabarelli and Silva (2003), showed contrary results. When comparing the diversity data obtained in the research with local diversity results presented by Lima (2012), Medeiros (2019), Souza, Artigas and Lima (2015) in the Cariri region of Paraíba, the values are similar. These data help to demystify the old view of the Caatinga biome as being poor in diversity. The transects with the highest diversity indices are located along the corridor, below the rock outcrop.

Table 03 – Alpha diversity index.

Transects	Simpson	Shannon
TR1	0.9008	2.466
TR2	0.8089	2.189
TR3	0.6302	1.429
TR4	0.6263	1.423
TR5	0.7193	1.709
TR6	0.8902	2.534
TR7	0.5774	1.348
TR8	0.9072	2.550
TR9	0.7603	1.836
TR10	0.6647	1.427

Source: Produced by the authors (2023).

Transects that presented diversity lower than 1.5 indicate low diversity in the analyzed location. However, this situation does not necessarily mean that each transect has an abundance of individuals. TR10 is an example of this by presenting a total of 221 individuals, and it appears to have a great diversity, but when analyzing the number of species, it has a total of 13 species, with the greatest dominance of individuals such as *Bromelia laciniosa* Mart. ex Schult. & Schult.f. with 35 individuals, *Opuntia palmadora* Britton & Rose with 47, and *Croton urticifolius* Lam. with 113 individuals.

Throughout the other transects (TR4 and TR7), this situation repeated itself, which characterizes areas above the rock outcrop as prone to having little diversity, yet there is a significant dominance by one species and abundance of individuals. This occurs because above the rock outcrops, there is not a great depth and concentration of soil and water, respectively, a condition promoted by the runoff process generated by the slope. The species that tend to develop are those that do not require humidity, having good adaptation to the dry environment. For arboreal species that require humidity, the situation is different in these localities, due to the lack of necessary conditions, thus few develop which leads to low diversity in these environments.

4 FINAL CONSIDERATIONS

The floristic survey at Lajedo do Bravo has enabled an understanding of the local floristic diversity and, combined with other surveys, can provide an overview of the biodiversity in the Caatinga of the Cariri region in Paraíba. The study confirmed the richness of species of both small and medium/large stature, thus demonstrating the heterogeneity of the site.

With the methodological application and data analysis, it was possible to identify the presence of typical vegetation species of humid environments, with high alpha diversity, as well as the presence of arboreal species. These findings suggest a rich biodiversity in the Caatinga. Therefore, it is concluded that Lajedo do Bravo, which is part of a sustainable use conservation unit, is a place that needs to develop its management plan, as well as zoning so that the activities carried out there ensure the preservation of floristic biodiversity by the managing bodies and local communities.

The responsible agencies could create selective waste collection measures in the area, thus preventing the population from burning solid waste. Furthermore, a project could be developed that addresses environmental education themes for the population on conservation, as well as developing new forms of employment that provide an income for the population, thus preventing deforestation and burning of native vegetation from becoming an option during the dry season.

REFERENCES

ANDRADE-LIMA, D. Present-day forest refuges in northeastern Brazil. In: PRANCE, G. T. (ed.) **Biological diversification in the tropics**. Columbia University Press, Nova York, 1982, p. 245-251.

ANGELIM, A. E. S.; MORAES, J. P. S.; DA SILVA, J. A. B.; GONÇALVES -GERVÁSIO, R. D. C. R. Germinação e aspectos morfológicos de plantas de Macambira (Bromelia laciniosa), encontradas na região do Vale do São Francisco. **Revista Brasileira de Biociências**, v. 5, n. S2, p. 1065-1067, 2007.

ARAÚJO, J. S. B.; FARIAS, P. S. C.; SÁ, A. J. Mineração e industrialização da bentonita e as transformações/permanências no espaço agrário de Boa Vista– PB: um estudo de caso dos Sítios Bravo e Urubu. **Revista de Geografia da UFPE**, v. 25, n. 3, p. 122-142, 2008.

BURKE, A. Properties of soil pockets on arid Nama Karoo inselbergs - the effect of geology and derived landforms. **Journal of Arid Environments**, v. 50, n. 2, p. 219-234, 2002.

CÁMARA, R.; DÍAS DEL OLMO, F. Escalonamiento Bioclimático, Regímenes Ecodinámicos y Formaciones Vegetales de la Isla de la Española en República Dominicana. **Estudios en Biogeografía**. Terrassa, España. Servei de Publications de la Universitat de Girona, p. 39-58, 2004.

CÁMARA, R.; DÍAS DEL OLMO, F. Muestreo en transecto de formaciones vegetales de fanerófitos y caméfitos (I): fundamentos metodológicos. **Estudios Geográficos**. Vol. LXXIV, n. 274, p. 67-88, 2013.

CARVALHO, P. E. R. **Mulungu (Erythrina velutina)**. Circular técnica, 160. Embrapa Florestas: Colombo – PR, 2008. 8p.

CORRÊA, A. C. B.; TAVARES, B. A. C.; MONTEIRO, K. A.; CAVALCANTI, L. C. S.; LIRA, D. R. **Megageomorfologia e morfoestrutura do planalto da Borborema**. Revista do Instituto Geológico, São Paulo, v. 31, n. 1/2, p. 35-52, 2010.

DOMBROSKI, J. L. D.; PRAXEDES, S. C.; FREITAS, R. M. O.; PONTES, F. M. Water relations of Caatinga trees in the dry season**. South African Journal of Botany**, v. 77, n. 2, p. 430-434, 2011.

FLORA DO BRASIL 2020 em construção. **Bromeliaceae**. Jardim Botânico do Rio de Janeiro. Disponível em: http://floradobrasil.jbrj.gov.br/reflora/floradobrasil/FB66>. Acesso em: 05 de jun. 2020.

GIULIETTI, A. M.; HARLEY, R. M.; QUEIROZ, L. P.; BARBOSA, M. R. V.; BOCAGE NETA, A. L.; FIGUEIREDO, M. A. Plantas endêmicas da caatinga. In: SAMPAIO, E. V. S. B.; GIULIETTI, A. M.; VIRGÍNIO, J; GAMARRA-ROJAS, C. F. L. (Ed.) **Vegetação e flora das caatingas**. APNE / CNIP, Recife, PE, 2002, p. 103-115.

GUIMARÃES, Y. C. O.; BARBOSA, V. A.; LIMA, V. R. P.; XAVIER, R. A. Influência da sazonalidade climática na valoração da paisagem da caatinga: aplicação da lambioeva no Lajedo do Bravo - Boa Vista - Paraíba, Brasil. **Revista Espaço e Geografia**, v. 24, n. 2, p. 95-113, 2021.

IBGE - Instituto Brasileiro de Geografia e Estatística. **Diretoria de Geociências. Organização do Território, Malha Territoriais, Malhas Municipais: versão 2020**. Rio de Janeiro, 2020. Disponível em: https://www.ibge.gov.br/geociencias/downloads-geociencias.html

IBGE. Instituto Brasileiro de Geografia e Estatística. **Biomas e Sistema Costeiro-Marinho do Brasil: compatível com a escala de 1:250.000**. Coordenação de Recursos Naturais e Estudos Ambientais - Rio de Janeiro, 2019, 168p.

LAGES, G. A.; FERREIRA, R. V.; MENESES, L. F.; NASCIMENTO, M. A. L.; FIALHO, D. **Projeto Geoparques: Geoparque Cariri Paraibano - Proposta: proposta**. CPRM, 2018, 53p.

LAGES, G. A.; MARINHO, M. S.; NASCIMENTO, M. A. L. do; MEDEIROS, V. C. de; DANTAS, E. L.; FIALHO, D. Mar de Bolas do Lajedo do Pai Mateus, Cabaceiras, PB:

Campo de matacões graníticos gigantes e registros rupestres de civilização pré-colombiana. In: WINGE, M.; SCHOBBENHAUS, C.; SOUZA, C. R. G.; FERNANDES, A. C. S.; BERBERT-BORN, M.; SALLUN FILHO, W.; QUEIROZ, E. T. (Org.). **Sítios Geológicos e Paleontológicos do Brasil**. 1ª Ed. Brasília: CPRM, 2013, v. III, p. 99-112.

LEAL, I. R.; TABARELLI, M.; SILVA, J. M. C. **Ecologia e Conservação da Caatinga**. Ed. Universitária da UFPE. Recife – Pernambuco – Brasil, 2003, 822p.

LIMA, V. R. P. **Caracterización biogeográfica del bioma Caatinga en el sector semiárido de la cuenca del Río Paraíba – Noreste de Brasil:** Propuesta de Ordenación y Gestión de um medio semiárido tropical. Tesis (Doctorado en Geografía Física y Análisis Geográfico Regional). Sevilla (ESP): Universidad de Sevilla, 2012, 355p.

LUNGUINHO, R. L. **Nos caminhos dos relevos residuais:** contribuição à ecohidrologia de encostas no semiárido brasileiro. Tese (Doutorado em Geografia) – Programa de Pós-Graduação em Geografia, Universidade Federal da Paraíba, João Pessoa-PB, 2018, 266p.

MAIA, G. N. **Caatinga:** Árvores e Arbustos e Suas Utilidade**s**. 2 ed. Fortaleza: Printcolor Gráfica e Editora, 2012, 413p.

MAIA R. P.; NASCIMENTO M. A. L. Relevos graníticos do Nordeste Brasileiro. **Revista Brasileira de Geomorfologia**, v. 19, p. 373-389, 2018.

MAIA, R. P.; BEZERRA, F. H. R.; NASCIMENTO, M. A. L.; CASTRO, H. S.; MEIRELES, A. J. A.; ROTHIS, L. M. Geomorfologia do campo de inselbergues de Quixadá, Nordeste do Brasil. **Revista Brasileira de Geomorfologia**, v. 16, n. 2, p. 239-253, 2015.

MEDEIROS, J. R. **Diversidade florística e classificação e caracterização das unidades de paisagem em área de lajedo no cariri paraibano -** o caso do Lajedo da Salambaia. Dissertação de Mestrado, Pós-Graduação em Geografia. Universidade Federal da Paraíba, 2019.

MEYER, N.; KUHWALD, M.; PETERSEN, J. F.; DUTTMANN, R. Soil development in weathering pits of a granitic dome (Enchanted Rock) in central Texas. **Catena**, v. 199, 105084, 14p. 2021.

NASCIMENTO, S. S.; LIMA, E. R. V.; LIMA, P. P. S. Uso do NDVI na análise temporal da degradação da caatinga na sub-bacia do Alto Paraíba. **OKARA:** Geografia em debate, v. 8, n. 1, p. 72-93, 2014.

PEEL, M. C.; FINLAYSON, B. L.; MCMAHON, T. A. Updated world map of the Köppen-Geiger climate classification. **Hydrology and Earth System Sciences**, v. 11, n. 5, p. 1633-1644, 2007.

PENNINGTON, R. T.; LAVIN, M.; PRADO, D. E.; PENDRY, C. A.; PELL, S. K.; BUTTERWORTH, C. A. Historical climate change and speciation: Neotropical seasonally dry forest plants show patterns of both Tertiary and Quaternary diversification. **Philosophical Transactions of the Royal Society B: Biological Sciences**, London, v. 359, n. 1443, p. 517-537, 2004.

PÉREZ, F. L. Geoecology of a granite dome: Spatial interactions between gnammas, rills, soils, and plant cover, Enchanted Rock (Texas, USA). **Catena**, v. 223, 106938, 23p. 2023.

PRANCE, G. T. Vegetation. In: Whitmore T. C.; Prance G. T. (eds.). **Biogeography and Quaternary history in tropical America**. Oxford Science Publications, Oxford, Reino Unido. 1987, p. 28-45.

QUEIROZ, A. B; LIMA, V. R, P; ARTIGAS, R. C; SOUZA, B. I. QUIRINO, Z. G. M; Structure and Diversity of a Tropical Dry Forest on Residual Reliefs in Northeastern Brazil. **RA'E GA - O Espaço Geográfico em Análise**. v.8, n. 2, p. 126-142, 2020.

SANTOS, H. G. S.; JACOMINE, P. K.; ANJOS, L. H. C.; OLIVEIRA, V. A.; LUMBRERAS, J. F.; COELHO, M. R.; ALMEIDA, J. A.; ARAÚJO FILHO, J.C.; OLIVEIRA J. B.; CUNHA, T.J.F. **Sistema brasileiro de classificação de solos**. 5ª Edição, Brasília: Embrapa, 2018.

SANTOS, L. W.; COELHO, M. D. F. B.; AZEVEDO, R. A. B.; LIMA, A. K. B. L. B.; SOUZA, J. W. N. **Erythrina velutina Willd: Fabaceae: Árvore de múltiplos usos no nordeste brasileiro**. Revista Verde de Agroecologia e Desenvolvimento Sustentável, v. 8, n. 5, p. 10, 2013.

SEIDEL, M. A.; LIMA, G. F. C.; SILVA, E. Panorama da mineração na Paraíba: a industrialização como promessa de desenvolvimento. **Geopauta**, v. 6, 2023.

SILVA, J. M. C.; BARBOSA, L. C. F.; LEAL, I. R.; TABARELLI, M. The Caatinga: Understanding the Challenges. In: **Caatinga:** The Largest Tropical Dry Forest Region in South America. Springer International Publishing, 2017, p. 3-19.

SILVA, J. S.; SALES, M. F. D.; GOMES, A. P. D. S.; CARNEIRO-TORRES, D. S. Sinopse das espécies de Croton L. (Euphorbiaceae) no estado de Pernambuco, Brasil. **Acta Botanica Brasilica**, v. 24, p. 441-453, 2010.

SOUSA, J. E. S. **Biométrica de sementes, morfologia e crescimento inicial de cinco espécies arbóreas**. Dissertação de Mestrado, Pós-Graduação em Agronomia/Fitotecnia, da Universidade Federal do Ceará, 2016.

SOUZA, B, I.; ARTIGAS, C, R.; LIMA, E, R, V. Caatinga e Desertificação. **Mercator**, Fortaleza, v. 14, n. 1, p. 131-150, 2015.

SOUZA, B, I.; ARTIGAS, C, R.; PRADO, D. E.; LIMA, V. R. P.; TREJO, I. T.; QUEIROZ, R. T.; MEDEIROS, J. R.; CARDOSO, E. C. M.; MACÊDO, M. L. A. Florística y estructura fito-sociológica comparativa del estrato arboreo y arbustivo em áreas de Caatinga y Mata Atlántica, Paraíba, Brasil. **OKARA: Geografia em debate**, v. 13, n. 1, p. 230-250, 2019.

SOUZA, B. I. **Cariri Paraibano: do silêncio do lugar à desertificação**. Tese (Doutorado em Geografia) – Programa de Pós-Graduação em Geografia, Universidade Federal do Rio Grande do Sul, Porto Alegre, 2008, 198p.

SOUZA, B. I.; MENEZES, R.; ARTIGAS, R. C. Efeitos da desertificação na composição de espécies do bioma Caatinga, Paraíba/Brasil. **Investigaciones Geográficas - Instituto de Geografía**. Universidad Nacional Autónoma de México, v. 1, p. 45-59, 2015.

SOUZA, B. I.; SOUZA, R. S. Processo de ocupação dos Cariris Velhos – PB e efeitos na cobertura vegetal: contribuição à Biogeografia Cultural do semiárido. **Caderno de Geografia**, v. 26, n. 2, p. 229-258, 2016.

SOUZA, E. H; CARVALHO, A. J. A; GAMA, E. V. S; NETO, A. R. H; AONA, L. Y. S. Macambiras, as mais nordestinas das xerófilas: taxonomia, distribuição e potencialidades. **Revista Macambira** v. 5, n.1, jan/jun, 2021.

VANZOLINI, P. E., RAMOS-COSTA A. M. M.; VITT, L. J. **Répteis das Caatingas**. Academia Brasileira de Ciências, Rio de Janeiro, 1980.

XAVIER, R. A. BORGES NETO, I. O.; CUNHA, L. Geodiversidade e Patrimônio Geomorfológico no Cariri Paraibano: A importância dos relevos graníticos. In: SOUZA, B. I.; CUNHA, L.; JACINTO, R.; SUERTEGARAY, D. M. A. (Orgs.) – **Diálogos temáticos e [trans]territoriais:** geodiversidade, recursos e patrimônio natural da Caatinga (PB) ao Pampa (RS). Compasso Lugar-Cultura, Porto Alegre-RS, 2021, p. 235-254.

***