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PHYTOGEOGRAPHIC OF *Bromelia L.* (BROMELIACEAE) IN THE STATE PARAIBA BRAZIL

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ABSTRACT

The *Bromelia* (Bromeliaceae) is part of the Poales taxonomic group, distributed in the Neotropical Ecosystems of South America, from sea level to altitudes of 5,000 meters in the Andes. In the Brazilian territory there were two settlements, one directly from the plateau of the Guianas and another across the Andes. The family stands out as one of the main taxa of the Brazilian flora, sheltering about 40% of the species of this family, in which 46 genera are recorded, of these 20 are endemic. In the state of Paraíba, because it has three distinct climatic regions, it originates a different phytogeographic distribution of this Family, so this study aims to perform a phytogeographic analysis of *Bromelia* L. (Bromeliaceae), to understand the distribution of the genus, registered in the state of Paraíba, eastern portion of the Northeast. Understand the gender distribution, registered in the state of Paraíba, eastern portion of the Northeast. In this study, two species, *Bromelia karatas* L. and *Bromelia laciniosa* Mart, were identified for the genus *B. Karatas* L. was found in the wetlands of Agreste and Litoral and also in the region of Sertão Paraíba state, in specific areas. Whereas, *B. laciniosa*, only in the regions of the Cariris Velhos, tectonic valley of the Curimataú and Seridó, that are inserted in the field of the Caatinga, but with influence of edaphoclimatic variabilities.

Contribution/Originality: This is the first research that deals with the phytogeographic distribution of Bromeliaceae in the state of Paraiba. In the context of the Northeast region of Brazil, this research will help to compare these data with those from other states and discuss the distribution whit other climatic and thermal characteristics, in addition, these two species have local environmental and cultural features that encourage knowledge of their spatiality.

1. INTRODUCTION

Through landscape analysis, which is a result of the interdependence of geoecological systems, built from the complex relationship of the physical and human systems, these environmental studies are the core of geographical science discussion. The concept of landscape in particular, the vision of distribution of the species, conceived the Biogeography. This science gathers knowledge of biology, ecology and geography. Aiming to understand the distribution patterns of species. In order to analyze the distribution of plant species in general, Biogeography is concerned with aggregating floristic surveys, either in the field or in herbaria, that subsidize studies of environmental and biogeographic analyzes [1]. Contemporaneously, research in herbarium has been developed, in order to develop the database, on the distribution of plant species, to perpetrate projects of conservation and preservation of biodiversity [1, 2]. From ecological analyzes can understand, molecular studies and phytogeographic dry and humid environments. From these studies were found, that the family Bromeliaceae *A. Juss*, sees its center of origin in the plateau of the Guianas, then colonized Central America, the Andes and Brazil by adaptive irradiation. This family has a wide geographic distribution, being recorded in practically all Neotropical Ecosystems of South America. Found from sea level, up to altitudes of five thousand meters above sea level, in the Andes. In the Brazilian territory there were two settlements, one directly from the plateau of the Guianas and another across the Andes. The Andes were colonized three times, initially by the Tillandsioideae, then by *Fosterella* and finally by the genus *Puya* . It is considered that Brazil was also colonized by three different events, initially at *cottendorfia* group, then the group *Dyckia* - *Encholirium* and finally by Bromelioideae.

The tropical and subtropical regions of the world gather 58 genera and 3.539 species of the family Bromeliaceae *A. Juss* [1] thus constituting one of the most present families in the American tropical forests [3, 4]. Brazil stands out as the holder of about 40% of the species of this family, in which 44 genera are recorded, of which 20 are endemic [2, 5]. Traditionally the family Bromeliaceae has been divided into three families: Bromelioideae and (31 genera and 724 species), Tillandsioideae (9 genera and approximately 1100 species) and Pitcairnioideae , (16 genera and 946 species) [3, 6]. Bromeliaceae can establish itself in the most inhospitable places. Due to its adaptive capacity to diverse environments this family is present in the whole Brazilian territory. These are recorded in environments of Caatinga, Altitude Fields, Rock Fields, Amazon Rainforest, Restinga and especially in the Atlantic Forest [7].

The evolutionary history of Bromelia is represented by the combination of an epiphytic habit, tank formation, CAM metabolism (special process of photosynthesis by plants living in environments with a warm and dry tropical climate that reduces water loss. Thus, these species achieve a wide recent diversification in the neotropical region, mainly in the forest formations along the east coast of Brazil [1, 3].

In general, the species may be terrestrial, epiphytic or rupicolous [7] and stand out for having physiological and anatomical adaptations. These are presented bypelletized trichomes or scales, in the absence of roots, has the function of fixation in the substrate. These characteristics are present in epiphytic or rupicular species, possessing a function of storing water and nutrients. The State of Paraíba presents two different climatic types: Tropical Warm Dry and Tropical Hot and Humid, where the Bromeliaceae family is well represented by 12 genera and 52 species [8]. One of the most common genera, with two species *B. lacioniosa* Mart and *B. karatas*, distributed in different environments: Caatinga and Seasonal Flowers, respectively. In this way, this work proposes to identify the richness and the distribution of *Bromelia* L. (Bromeliaceae) in Paraíba, through a phytogeographic analysis.

2. MATERIALS AND METHODS

2.1.Characterization of the Study Area

The State of Paraíba is located in the eastern portion of Northeast Brazil, between the coordinates - 34°45'54 "and -38°45'45" W, and -6°02'12 "and -8°19'18" S and occupies an area of 56,372 km², corresponding to 3.63% of the Northeast Region Figure 1.

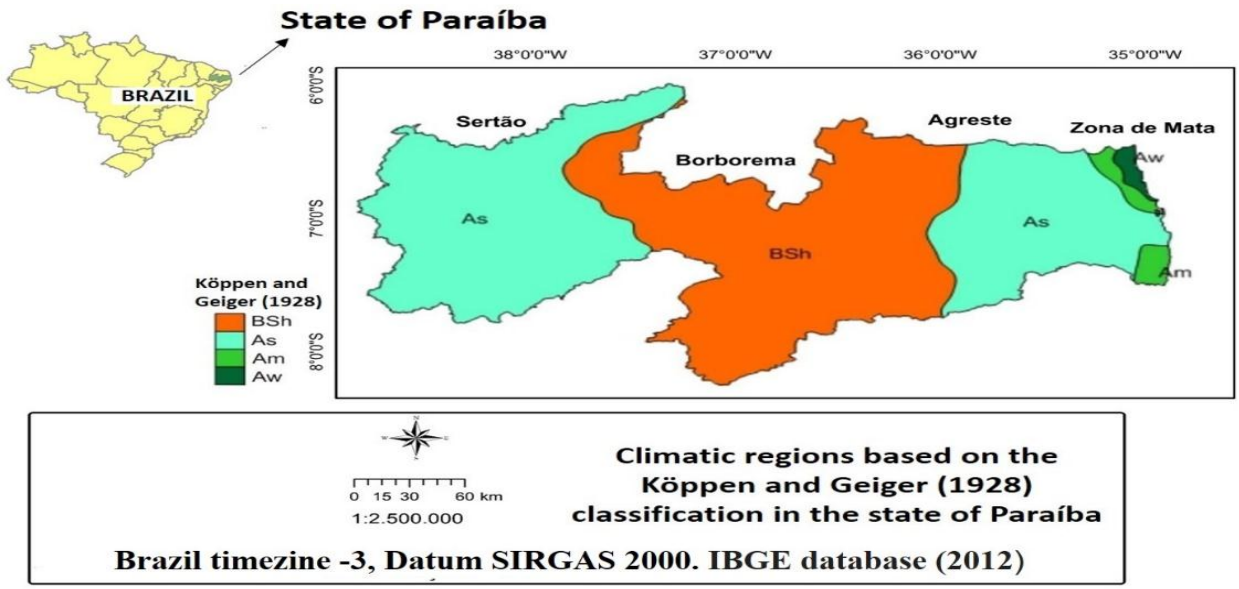

Figure-1. Location of the state of Paraíba, divided into three climatic regions, referring to the study Phytogeographic Analysis of *Bromelia* L (Bromeliaceae) state of Paraíba.

The Northeastern Semi-arid Region comprises the Caatinga biome, which presents extremely significant vegetative and floristic diversity, as well as, compared to other seasonal and deciduous biomes of the Planet [4, 9-11]. As a result of abiotic factors of the Caatinga, such as extreme climatic conditions, such as high solar radiation, due to being in tropical or subequal areas, low cloudiness, high thermal amplitude, low relative humidity and high potential evapotranspiration index, and especially, irregular precipitation and seasonal vulnerability, condition vegetation there is a specific adaptation. According to Macedo, et al. [12] the state of Paraíba is subdivided into three climatic regions, according to the classification of Francisco, et al. [13]. These regions are: Litoral and forest zone, precipitation above 1.700 mm/year; Agreste with means of 1000 mm and Sertão, or Pediplano Sertanejo, with mean values of 821.9 mm/year. The area on the Morfoe struture of the Paraiba Intraplantatic Depression, where the Cariris Velhos and the tectonic valley of the Curimataú are located, presents an altitude between 362m to 778m, with an average precipitation of 516.1mm / year, however, during the periods of El Niño, can register an annual average around 300mm [13, 14]. According to climatic regions, Atlantic Forest, Associated Ecosystems (Manguezal, Restinga, Dunes) and Caatinga [8, 15] predominate in the state. However, the geological base is divided into a basal lithostratigraphic unit of the Pernambuco-Paraíba Sedimentary Basin called the Beberibe Formation [16] and the Granitoid Complex of the Crystalline Basement, y area is constituted by Cenozoic, Neoproterozoic, Mesoproterozoic, Paleoproterozoic and Archaean units [17].

2.2. Visit to the Herbariums

Four herbariums of federal and state institutions were visited in order to understand the different habitats of the phytogeographic distribution of *Bromelia* L. (Bromeliaceae) in Paraíba.

The data for the elaboration of this work were collected from research of collections and databases of herbariums with international support and visits *in loco*:

2.2.1. Herbal Universities

- UFPB - Virtual herbarium of flora and fungi.
- UFPB - Herbarium EAN - Jaime Coelho de Moraes.
- UFCG - Herbarium of the Center for Rural Health and Technology.
- UEPB - Herbarium Manuel de Arruda Câmara.

2.2.2. Herbal Network

- Reflora (Botanical Garden of Rio de Janeiro).
- Virtual Flora and Fungi (link: http://inct.splink.org.br).

2.3. Procedures for Making the Map

The preparation of the map took place in three phases: initially the layer of hypsometry was made; for the second layer, the isoíetas, from the points of equal pluviometric regimes, were specialized, through the database of the Executive Agency of Management of the Waters of the State of Paraíba AESA; and finally the third in the third layer, were specialized municipalities that responded to the phytogeography of the *Bromelias* studied. The *shepefile*, municipalities, is also part of the AESA database.

All geoprocessing of the layers was done in the ArcGIS 9.3 software, licensed to the Multi-user Laboratory of Information Technologies Applied to Human Sciences (LabINFO), of the Courses of the Humanities Center of the Federal University of Campina Grande.

3. RESULTS AND DISCUSSION

We analyzed 58 dried specimens in the four visited herbaria. Of which 4 were depositedon 6 exsiccates EAN, *Bromelia* (Bromeliaceae), da *B. laciniosa* Mart. Ex Schult. f. No JPB were verified eight exsicates of *B. laciniosa* and four *B. karatas* L. (Figures 2, 3, 4 and 5). This species was recorded in two distinct climatic regions, located in the wetlands of Agreste and Litoral and in space, located in the Intermediate Regions of Campina Grande and in the Semi-Arid, in the Sertão (region of state Paraíba).

Figures 2, 3, 4 and 5 Specimens in the four visited herbaria.

Figure-2. B. *laciniosa* mart.EX schult.f.caatinga.foto: SOUZA, M.S.C.

Figure-3.*B.karatas L.* Mata atlantica nordestina.

Figure-4. Species exsicata *Bromelia laciniosa* Mart.EX schult.f.

Figure-5. Species exsicata *Bromelia karatas L.*

The species *B. karatas L* Figure 3 was recorded for ten municipalities, of which seven presented warm and humid tropical climate, of the littoral and agreste Table 1.

Table-1. Phytogeographical distribution of B. *karatas* L by Meso-region and Municipalities, in the state of Paraíba.

Genre	Region	Counties	Vegetation
karatas L	Agreste	Areia	Atlantic forest
		Pilões	
	Mata Paraibana	Sapé	
		Itapororoca	
		Mamanguape	
		Mataraca	
	Sertão	Itaporanga	Caatinga
		Cajazeiras	
		Sousa	
	Borborema	Monteiro	

B. karatas was located in humid and subhumid areas, from which they were located in the Borborema and Sertão mesoregions. In the Sertão mesoregion, it was verified that the species was found in the municipality of Sousa, in the Serra de São Gonçalo at 460m. In the municipality of Cajazeira, it was recorded in the locality of Engenheiro Ávido at 380 m, and in Itaporanga, was recorded in the Serra da Baixa Verde, with an altitude of 420 meters (Figure 6). In addition, in the municipality of Monteiro, Borborema mesoregion, the species was collected in the Serrote Vale do Boqueirão, at an altitude of 680m. However, the average altitude for the region of Sertão Paraibano is 250 to 350 m, and the occurrence of this species in these areas is justified by the highest altitude. Which are located in environment, geographic isolation in high topographic or windward. Analyzing *B. karatas* L., verified that this species is distributed through Central America, Plateau of the Guianas and Brazil, in warm and humid climates. The same is found for Brazil, in areas of Atlantic Forest. The species has a terrestrial habit, and it is located in the interior and surroundings of the humid forests, and capoeiras, like the degraded areas. They have elongated leaves (up to 3.5m long) and are densely spinescent, green, with sessile inflorescence, inserted in the center of the rosette, dense lepidota, flowers with lilac petals, which emerge from the inflorescence and have large fruits, measuring from

5 to 6 cm long, fleshy and succulent. In the region of the Brejo Paraibano this species is popularly called "banana-de-raposa", and its sweet fruit is dispersed in the forests by animals.

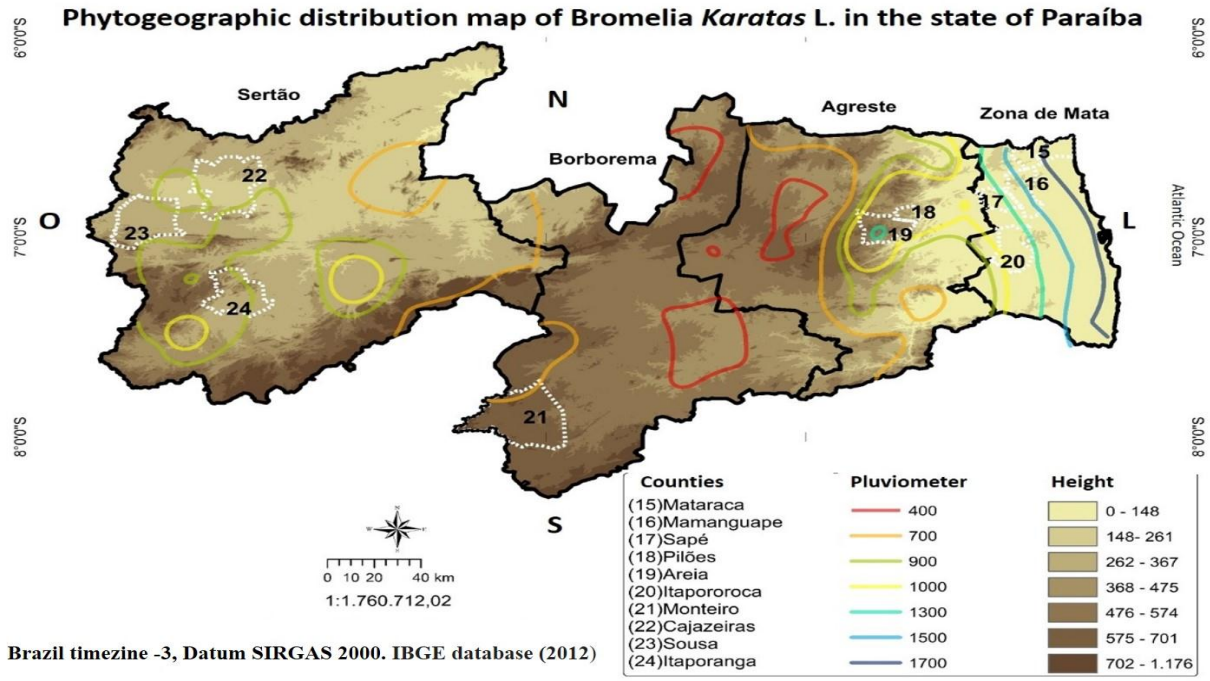

Figure-6. Map of Phytogeographic distribution *karatas Bromelia* L. based on altitude and rainfall variability related to study fitogeográfica Analysis *Bromelia L.* (Bromeliaceae) in Paraíba.

The species *B. laciniosa* , has records in 14 municipalities (Table 2) . Of which ten are described in the INCT Virtual Herbarium of Flora and Fungi (REFLORA) , and four in the EAN Herbarium Jaime Coelho de Moraes, which is not yet computerized. These municipalities are located in areas of the Borborema Plateau, with orographic positions to Sotavento, in areas of Cariri, Curimataú and Seridó Paraíba, respectively, with altitude averages ranging from 400 to 500m Figure 7.

Table-2. Phytogeographic distribution of *B. lacinious* Mart. former Schult. f. by Meso-region and Municipalities, in the State of Paraíba. Source: systematization of authors.

Genre	Mesoregion	Counties	Vegetation
laciniosa Mart. & Schult. F	Agreste	Barra de Santa Rosa	Caatinga
		Solane	
		Soledade	
		Ingá	
		Cacimba de Dentro	
		Olivedos	
		Pocinhos	
	Borborema	Pedra Lavrada	
		São João do Cariri	
		Serra Branca	
		São José dos Cordeiros	
		Boqueirão	
		Barra de Sao Miguel	
		Barra de Santana	

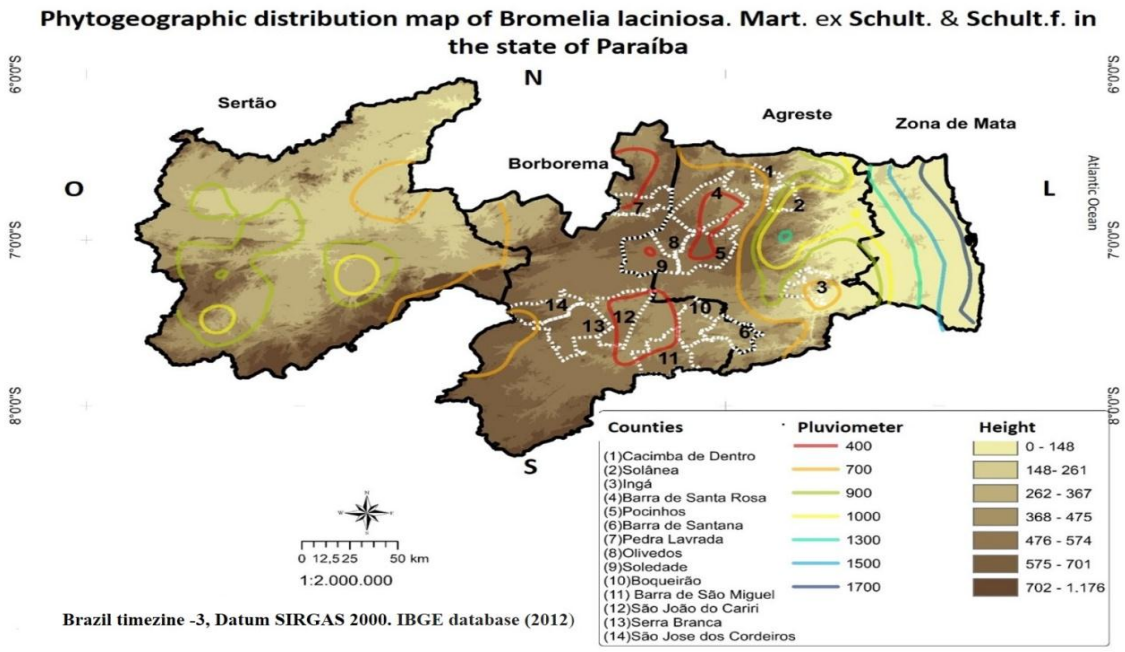

Figure-7. Phytogeographic distribution map of *B. laciniosa* Mart. Ex. Schult f. based on the pluviometric variability and altimetry, referring to the study Phytogeographic Analysis of *Bromelia* L. (Bromeliaceae) in Paraíba.

The species *laciniosa* , According to Silva [8]; Ferreira, et al. [5] presents as endemic to the Caatinga, is distributed in almost all d the Northeast, except the state of Maranhão, (Flora 2020 under construction). The species is earthy and presents as a procumbent herb of 92 cm of height, with floras measuring from 56 to 70 cm, arranged in rosettes. The leaves are green or reddish-green. The morphology is represented by floral inflorescence with 32 cm, with tabular flowers erect white-purplish. The fruits are in the form of berries, measuring from 2.8 to 3.5cm, yellow, ellipsoid and robust. This species is used in the Northeast region, mainly for the dry season, as forage, for cattle and goats [7]. When analyzing the phytogeographic distribution of the two species of *Bromelia L, it is* verified that the climatic characteristics of the State of Paraíba, influence in its occurrence. Such climatic conditions are mediated by precipitation mechanism, which are determined on the macro scale, the general cir culação atmosphere ENOS (El-Niño, La-Niña), masses of Equatorial and Atlantic Tropical air, marine currents, Zone of Intertropical Convergence - ZCIT, the meso and micro scales by orography, maritime and convection [13, 14, 18]. These characteristics influence the environment, through soil formation and morphosculture of the relief [19]. The wetlands of the Coastal and Agreste, mainly the Brejo de Altitude, are in the windward, on the influence of Humid Air Masses, such as the Subperenifolia Forest, or Submontane Rain Forest in Areia - PB (Figure 8A), where species *B. karatas L.* These areas They have a position in submontana mainland Northeast, parallel existence of the rain forests of the Atlantic domain as shown in Figure 8 [15, 20].

Already the *laciniosa* Mart. Ex Schult f. (Figure 8B) occurred in the state of Paraíba, only in regions of extreme edaphoclimatic variability, as in dry seasonal or seasonal deciduous areas such as the Caatinga in Boa Vista-PB. These areas are part of the Borborema Structural Province, which guided the formation of folds of pre-Cambrian rocks, surmounted in the form of vaults. As a result, the area comprises a smooth-undulated relief, with residual relief of varied lithotripsy origin, dissected and disseminated in the regional landscape, without large altimetric compartments, with terrain dimensions of 350-500 m [17].

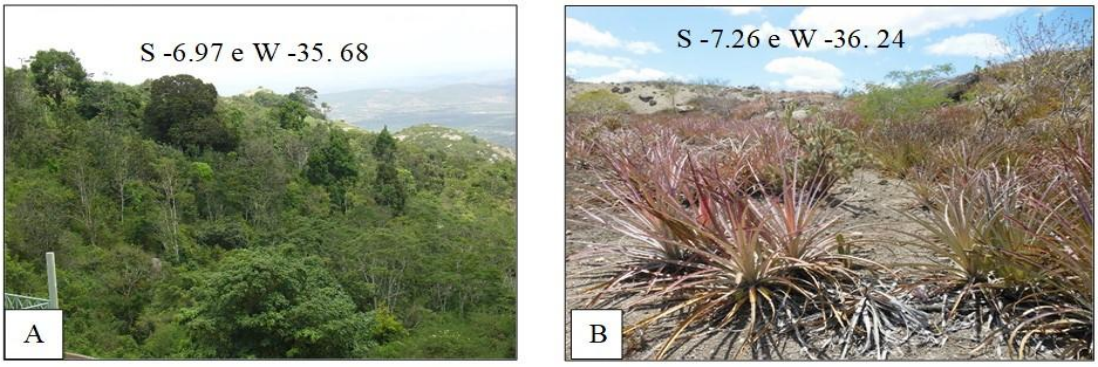

Figure-8. Landscape features, where the species occur: **A -** *B. karatas L*, wetlands, such as Subperenifolia Forest, or Submontana Rain Forest in Areia - PB. **B -** *B. laciniosa* Mart. Ex. Schult f. recorded in dry areas of seasonal deciduous forest or seasonal Caatinga as in Boa Vista-PB relating to study fitogeográfica Analysis *Bromelia* L. (Bromeliaceae).

According to Macedo, et al. [12]; Francisco, et al. [13] the variability of the rainfall index of the Brejo and Agreste region may vary from 700 to 1,200mm, and on the coast in average from 1.200 to 1.700mm . However, in the Cariri and Curimataú regions, the lowest values of precipitation can occur , are around 400 to 700mm . Therefore, in the Sertão and Alto Sertão in this precipitation is around 700 to 900 mm, as described in the Figures of Figure 5 and 6. Even though there are periods of extreme drought, due to the strong influence of ENSO, the Central Sertão region of Paraíba and Alto Sertão, such as the municipality of Sousa, Cajazeiras and Itaporanga, precipitation tends to be larger than the areas of Cariri, Curimataú and Seridó state Paraíba.

4. CONCLUSIONS

From the altitudinal and pluviometric variables or climatic conditions, it was possible to perform the phytogeographic analysis of *Bromelia* L, according to the orographic position to Barlavento, that is, more humid areas such as Subperenifolia Forest, or Atlantic Rain Forest submontana to *B. karatas* L. because this presents with greater availability of water. In contrast, for deciduous seasonal or seasonal forests such as the Caatinga, *B. laciniosa* Mart. Ex Schult f. These areas deserve attention, since orographic position to East and foot of the slopes, in the areas physiographics of the Borborema Plateau limit the expansion of this species.The registered species are adapted to the environment of origin. Of these, *B. karatas* was found in the wetlands of Agreste and Litoral and in the space, and also in the mesoregion of Sertão Paraibano in specific areas. And the *laciniosa* , only recorded in the regions of the Cariris Velhos , tectonic valley of the Curimataú and Seridó paraibano, that are inserted in the field of the Caatinga, but with influence of the edaphoclimatic variability . However, there are no records of this species in the Sertão Paraibano, due to the region having higher rainfall indexes than the areas in which they were recorded. It was found during the research, that the physical and virtual herbariums make up important geographic databases, however, some are not computerized, making it difficult to conduct research. Being this, the first phytogeographic study of the Bromeliacea *A. Juss*, to the state of Paraíba.

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Competing Interests: The authors declare that they have no competing interests.
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