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Vascular epiphytes (Spermatophytes) of the Baturité Massif, Ceará, Northeast Brazil

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A B S T R A C T

The Baturité Massif, which is surrounded by the Caatinga, is one of the largest remnants of the semi-arid Atlantic Forest, being considered a region with rich biodiversity. As part of the "Flora of Ceará: knowing to conserve" project, this study aimed to survey the vascular epiphytes of the Baturité Massif in Ceará state. The study was based on the analysis of specimens from herbaria ALCB, CEPEC, EAC, HUEFS, HVASF, IPA, JPB, MO, R, RB, S, SP, UFP, UNB and US, specialized bibliography, as well as photos from type-collections. In the Baturité Massif 62 species distributed in seven families (Araceae, Bromeliaceae, Cactaceae, Gesneriaceae, Orchidaceae, Piperaceae and Rubiaceae) were registered. Orchidaceae had the highest number of representatives (58%). The species *Gomesa praetexta*, *Polystachya concreta* and *Trichocentrum cepula* are new occurrences. *Epidendrum anatipedium*, *E. sanchezii* and *Guzmania monostachia* are endemic to Northeast Brazil. *Vriesea baturitensis* and *V. carmeniae* are endemic to the state of Ceará. Therefore, the Baturité Massif is an important area for biodiversity conservation.
Key words: Atlantic Forest, *Epidendrum*, Orchidaceae, *Vriesea*.

Epífitas vasculares (Espermatófitas) da Serra de Baturité, Ceará, Nordeste do Brasil

R E S U M O

A Serra de Baturité, em meio a Caatinga, constitui um dos maiores resquícios de Floresta Atlântica no semiárido, sendo considerada uma região rica em biodiversidade. Como parte do projeto "Flora do Ceará: conhecer para conservar", o presente estudo objetivou realizar o levantamento florístico das epífitas vasculares da Serra de Baturité, no estado do Ceará. A pesquisa foi baseada na análise dos espécimes depositados nos Herbários ALCB, CEPEC, EAC, HUEFS, HVASF, IPA, JPB, MO, R, RB, S, SP, UFP, UNB e US, bibliografias especializadas e imagens de coleções-tipo. Na Serra de Baturité foram registradas 62 espécies, distribuídas em sete famílias (Araceae, Bromeliaceae, Cactaceae, Gesneriaceae, Orchidaceae, Piperaceae e Rubiaceae). Orchidaceae foi à família com maior número de representantes (58%). As espécies *Gomesa praetexta*, *Polystachya concreta* e *Trichocentrum cepula* são novas ocorrências para o Estado. *Epidendrum anatipedium*, *E. sanchezii* e *Guzmania monostachia* são endêmicas do Nordeste do Brasil. *Vriesea baturitensis* e *V. carmeniae*, são endêmicas do estado do Ceará. Portanto, a Serra de Baturité é uma importante área para a conservação da biodiversidade.
Palavras-chaves: *Epidendrum*, Floresta Atlântica, Orchidaceae, *Vriesea*.

Introduction

Epiphytes are non-parasitic plants that use other living plants (mainly trees) for support (phorophyte) throughout or during part of its life cycle, without developing haustorial roots structures. These plants take nutrients directly from the atmosphere and are characterized by having an ecological relationship with their host plants (Madison, 1977; Ramírez-Martínez et al., 2021). Investing in the development of trunks or branches, which mainly reach the forest crowns in search of sunlight, conserving their energy through the production of more specialized stem structures (Mania and Monteiro, 2010).

Epiphytes can be classified into two development types, one of which is hemiepiphyte, comprising plants that can start their life cycle as epiphytes, throwing roots towards the soil and, later, ascending to the treetops, maintaining or losing their connection with the terrestrial environment (Putz and Holbrook, 1986). The other is holoepiphyte (true epiphytes), which includes plants that use another for support during their entire life cycle and never connect to the soil (Madison, 1997).

The distribution of epiphytes throughout host plants can be influenced by abiotic factors such as humidity, luminosity and substrate (Benzing, 1987), as well as biotic factors, such as host plant characteristics, which can also influence the occupation and development of these organisms (Marcusso et al., 2019; Muller et al., 2019). A study by Catchpole and Kirkpatrick (2011) in Peru recorded the presence of 190 species of holoepiphytes and five hemiepiphytes in the canopy and trunk of a single strangler fig tree (*Ficus crassiuscula* Warb. ex Standl.) in a low-altitude forest. The vast majority of vascular species were rare in occurrence, suggesting a high proportion of species distributed in patches within the forest.

In natural ecosystems, epiphytes provide important services such as water accumulation, nutrient cycling and refuge (Barbosa et al., 2015; Céréghino et al., 2019; Seidl et al., 2019), attracting seed dispersers, as well as favoring the dispersion of plant propagules (Meiado, 2008). In addition, they help maintain biological diversity and interactive balance by providing resources and conditions (food, shelter and micro-habitat) for many other organisms, such as micro-organisms, insects, amphibians and reptiles (Pederassi et al., 2012; Brandt et al., 2017). Some epiphyte species such as *Tillandsia usneoides* (L.) L. and *Canistropsis billbergioides* (Schult. & Schult.f.) Leme, both of which belong to the Bromeliaceae family, are able to capture chemical elements from the atmosphere, acting as bioindicators of environmental pollution (Elias et al., 2006; Jucker et al., 2018). However, deforestation, predatory collection and commercial exploitation are factors that have threatened the permanence of these species in their natural habitats, as they create barriers that hinder dispersion, reducing gene flow and genetic variability (Mania and Monteiro, 2010; Dias et al., 2020; Neves et al., 2020; Guariz and Guariz 2020; Silva et al., 2020).

Approximately 9% of the world's vascular flora consists of epiphytes, being represented by 73 families, 913 genera and about 27,614 species (Zotz, 2013). The following families stand out among those with epiphyte representatives: Araceae, Bromeliaceae, Orchidaceae and Polypodiaceae (Madison, 1997). In the Neotropics, the largest number of epiphytes are found in the Andes, the northwestern Amazon, and in tropical and humid subtropical forests (Gentry and Dodson, 1987; Mendieta-Leiva et al., 2020). One reason for such high richness in these areas is the high rainfall rates, important climatological variable for the development of species (Mania and Monteiro, 2010; Silva et al., 2020). In these regions, these individuals are important as they indicate changes in the structure and composition of communities (Dettke et al., 2008; Reed et al., 2019; Nitta et al., 2020).

In the Brazilian Atlantic Forest, one of the most threatened ecosystems in the world, species have a high endemism and diversity, are recognized approximately 2,095 species, 225 genera belonging to 35 recognized (Ramos et al., 2019; Mendieta-Leiva et al., 2020). However, in drier environments there are generally fewer epiphyte species (Benzing, 1987).

The weather is considered one of the most impactful factors that delimits the occurrence of epiphytes, as water availability, combined with irradiation and amount of nutrients available in the atmosphere, strongly interfere in the development of epiphyte communities (Benzing, 1987).

The first study about the epiphytic community in the Brazilian territory was restricted to the Serra do Mar in Paraná (Hertel, 1949). Since then, most studies about the floristic composition and/or structure of vascular epiphytes in Brazilian forests have been concentrated in the Southeast (Fontoura et al., 1997; Dislich and Mantovani, 1998; Mania and Monteiro, 2010; Furtado and Menini-Neto, 2018) and South (Cervi and Borgo, 2007; Dettke et al., 2008). The North region included studies mainly with representatives of the families Bromeliaceae and Orchidaceae (Koch et

al., 2013; Santos Júnior and Jardim, 2017; Brito et al., 2019)

In the Northeast, only four studies focusing on epiphytes have been developed; one in Rio Grande do Norte (Oliveira et al., 2012), another in Paraíba state (Dias-Terceiro et al., 2014), one in Bahia (Leitman et al., 2014) and on Sergipe (Araújo et al., 2019). Additionally, some epiphyte species were also mentioned in the floristic survey carried out at Planalto da Borborema in Pernambuco (Nascimento et al., 2012).

For Ceará state, as well as for the Baturité Massif, one of the most extensive, humid and high residual Massif with vegetation that varies according to altitude and slope (windward/leeward), being considered an area of extreme biological importance for conservation (MMA 2000). No studies have been carried out about the richness and diversity of epiphytes. Although studies for other groups, i.e., Pteridophytes (Paula-Zárate et al., 2007) and Leguminosae (Lima and Mansano, 2011), have already been developed, some epiphyte species have only been mentioned in floristic and/or phytosociological surveys (Guimarães e Giordano, 2004; Lemos and Meguro, 2010). Given the lack of studies on the diversity of epiphytes in this region, the following question arises: Does the Baturité Massif present floristic epiphytic similarity with other areas studied in Brazil?

Considering the importance of epiphytes in structuring forest communities, and the lack of information about the community of vascular epiphyte species from the Massif of Baturité mountain range, this study aimed to survey the species of vascular epiphytes in the Baturité Massif, Ceará, and is included within the "Flora of Ceará: knowing to conserve" project.

Material and methods

Characterization of the study area

The Baturité Massif (Fig.1) covers 13 municipalities and is approximately 100 km from Fortaleza (PDITS, 2014). Located between the central hinterland of Ceará state and the metropolitan region of Fortaleza, it contains humid (Guaramiranga, Mulungu and Pacoti), sub humid (Acarape, Aratuba, Baturité and Palmácia, part of the interior of Itapiúna and Capistrano), and semi-arid (part of the backlands of Aracoiaba, Barreira, Itapiúna, Ocara and Redenção) environments (PDITS, 2014). It is formed by crystalline basement rocks from the Precambrian, constituting a mountainous region with average annual rainfall ranging from 500 mm to 1,500 mm and classified with humid tropical climate (Bastos et al., 2017). Due to its variation in humidity, the forested area is divided into windward and leeward sections. Dense Ombrophilous Forest vegetation, ≥ 1,100 m of altitude, is observed in the windward section, while Seasonal Deciduous Forest, < 600 m, and Seasonal Semi-deciduous Forest, > 600 m, phytophysiognomies are found in the leeward section (Araújo et al., 2006).

With coordinates 4º4'30"S latitude and 38º52'39" W longitude, and an area of 32,690 km^2, the Baturité Massif is the main geographic reference in the massif and constitutes a humid tropical type enclave within the semi-arid region of the Northeast, presenting high diversity of local fauna and flora (PDITS, 2014). The study area was chosen due to its peculiar climate characteristics, which favor the occurrence of epiphytes, as well as because of its ecological importance in the region.

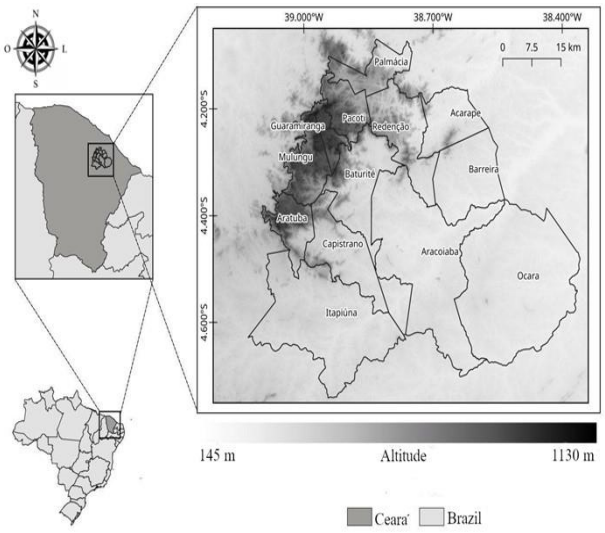

Figure1. Geographic distribution of the municipation of Baturité Massif Ceará Brazil.

Data collect

The species list was obtained from consultations and analysis of images from the collections on the CRIA (2020) and Herbarium Virtual REFLORA (2020) sites. The analyzed specimens are deposited in the herbariums ALCB, CEPEC, EAC, HUEFS, HVASF, IPA, JPB, MO, R, RB, S, SP, UFP, UNB and US, whose acronyms are in accordance with Thiers (continuously updated). Taxonomic identifications were considered reliable when determined by specialists from the families Bromeliaceae (Eduardo Calisto Tomaz and Leonardo de Melo Versieux), Cactaceae (Marcelo Oliveira Teles de Menezes), Orchidaceae (Edlley Pessoa and Luiz Wilson

Lima-Verde), Piperaceae (Luiz Carlos da Silva Giordano), Rubiaceae (Elanatan Bezerra de Souza), and confirmed through image analysis of standard collections available at the Herbário Virtual REFLORA (2020) and Global Plants on JSTOR (2020) sites. The names of authors were based on the International Plant Names Index (IPNI, 2020).

The identification key for families registered for Baturité Massif was prepared according to the characteristics observed in the analyzed collections. Information about the habit and places of occurrence were obtained from the specimens consulted. For the categorization of registered epiphytes, in this study, into holoepiphytes and hemiepiphytes, we adopted the classification of Putz and Holbrook (1986), and these were confirmed through Flora do Brasil 2020.

The vegetation was classified according to the Technical Manual of Brazilian Vegetation (IBGE, 2012). For the classification of species in vegetation types, the model proposed by Rebouças et al. (2020), evidencing the occurrence of representatives by vegetation types registered in the Baturité Massif in Ceará in 0.5° longitude x 0.5° latitude squares, where we provide information from one record per municipality, which make up the Massif of Baturité, of each registered epiphyte species.

Results and discussion

Number of records by municipality

Among the 13 municipalities that make up the Baturité Massif, epiphytes were recorded in two sub-humid areas: Aratuba (four records) and Capistrano (one record); and in three humid areas: Guaramiranga (46 records), Mulungu (six records) and Pacoti (44 records). All species were found in municipalities located within the Baturité Massif Environmental Protection Area (APA). In addition, in the Baturité Massif, the species were distributed in Dense Ombrophilous Forest, Seasonal Semi-deciduous Forest and Arborized Stepic-savanna vegetation types (Tab. 1).

Guaramiranga and Pacoti presented the highest number of records. According to Mania and Monteiro (2010), the high number of epiphytes in more humid locations is due to high rainfall, which provides conditions that favor the development of these species. The availability of water as a limiting factor in the development of epiphytes is also mentioned in the studies Furtado and Menini-Neto (2018) and Marcusso et al. (2019). These municipalities often present annual rainfall averages exceeding 1,500 mm (PDITS, 2014).

For the municipalities of Acarape, Aracoiaba, Barreira, Baturité, Itapiúna, Ocara, Palmácia and Redenção, located in the sub-humid area and semi-arid climate, no records of vascular epiphytes. The absence of records in these areas of the Baturité Massif can be explained by the lack of sampling effort in these municipalities, considering that most field expeditions were concentrated in humid municipalities, according to the CRIA (2020) and Virtual REFLORA Herbarium (2020) databases. Benzing (1987) reported that lower richness of these taxa is common in drier places since epiphytes prefer environments with higher humidity, due to their biological needs throughout their life cycles.

Species richness by Family

In the Baturité Massif, epiphytes are represented by seven families: Araceae (two genera, four spp.), Bromeliaceae (six genera, 15 spp.), Cactaceae (two genera, two spp.), Gesneriaceae (one genus, one sp.), Orchidaceae (21 genera, 36 spp.), Piperaceae (one genus, three spp.) and Rubiaceae (one genus, one sp.), totaling 35 genera and 62 species (Tab. 1/Fig.2).

The botanical families with the highest number of epiphytic representatives in the Baturité Massif were Orchidaceae, followed by Bromeliaceae and then Araceae. These same plant families were also observed in the studies carried out by Gonçalves and Waechter (2003) with 19 spp., 29 spp. and three spp., respectively, and Mania and Monteiro (2010) with 16 spp., 19 spp. and six spp., respectively. According to Madison (1977) and Gentry and Dodson (1987), such results reveal a specification of the epiphytic lifestyle, being an important adaptive character for new world families.

Orchidaceae presented the highest species richness in the Baturité Massif, comprising more than 59% of the registered taxa (Fig. 3). Pioneering studies about epiphytic vascular flora have highlighted the high number of species in this family, corresponding to more than ⅔ of the total number of epiphytes (Furman and Trappe, 1971; Madison 1997). Our results corroborate the studies carried out by Fontoura et al. (1997) and Kersten (2010) in an Atlantic Forest domain and in Dense Ombrophilous Forest (environments with vegetation formations similar to the Baturité Massif), which also indicated Orchidaceae as the family with the highest richness of epiphytes.

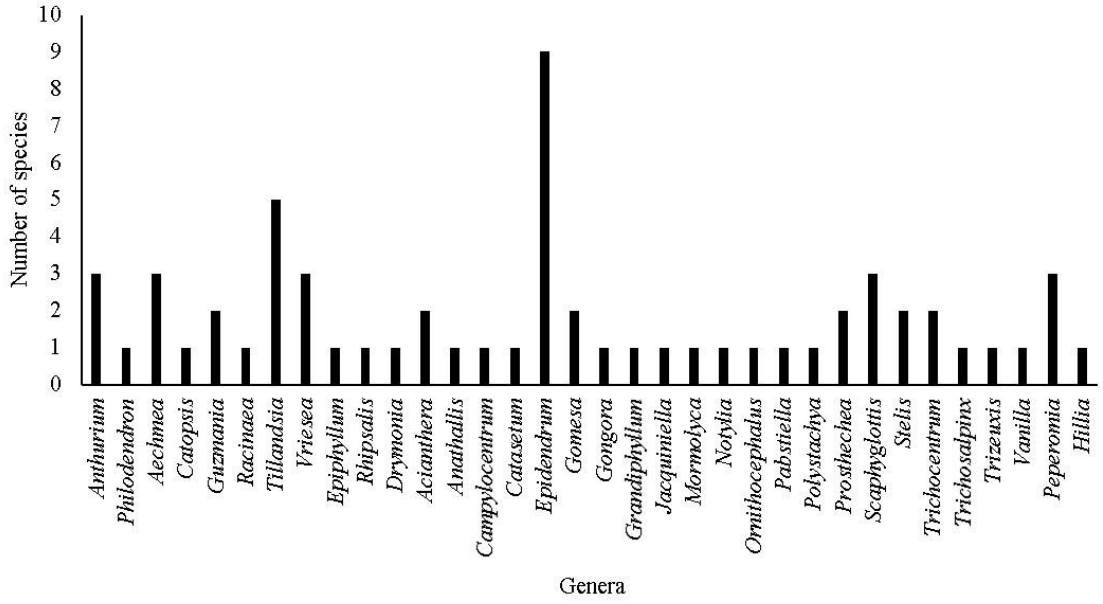

Figure 2. Number of species per genera of vascular epiphytes, in the Massif de Baturité, Ceará, Brazil.

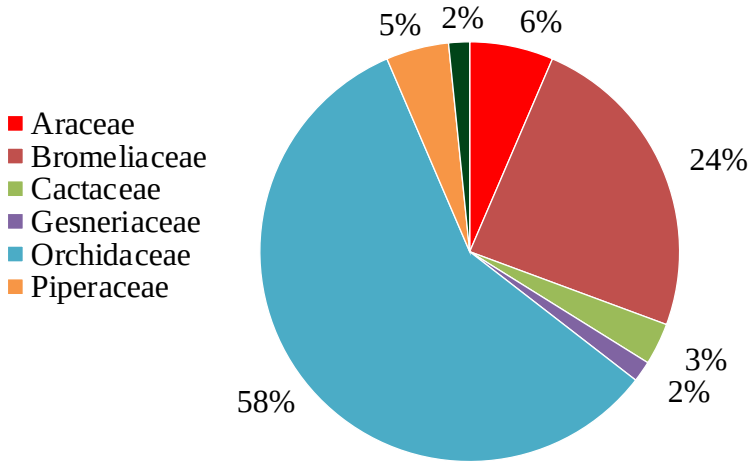

Figure 3. Percentage graph of families of vascular epiphytes, in Baturité Massif, Ceará, Brazil.

In the Baturité Massif, Orchidaceae species were georeferenced in the Dense Ombrophilous Forest (squares B5, B6, C5, C6 and D4), Seasonal Semi-deciduous Forest (squares B4, B5, C4, D5, F4 and F5) and Arborized Stepic-savanna (G6 and G7 squares) phytophysiognomies (Figs. 4, 5, 6 and 7).

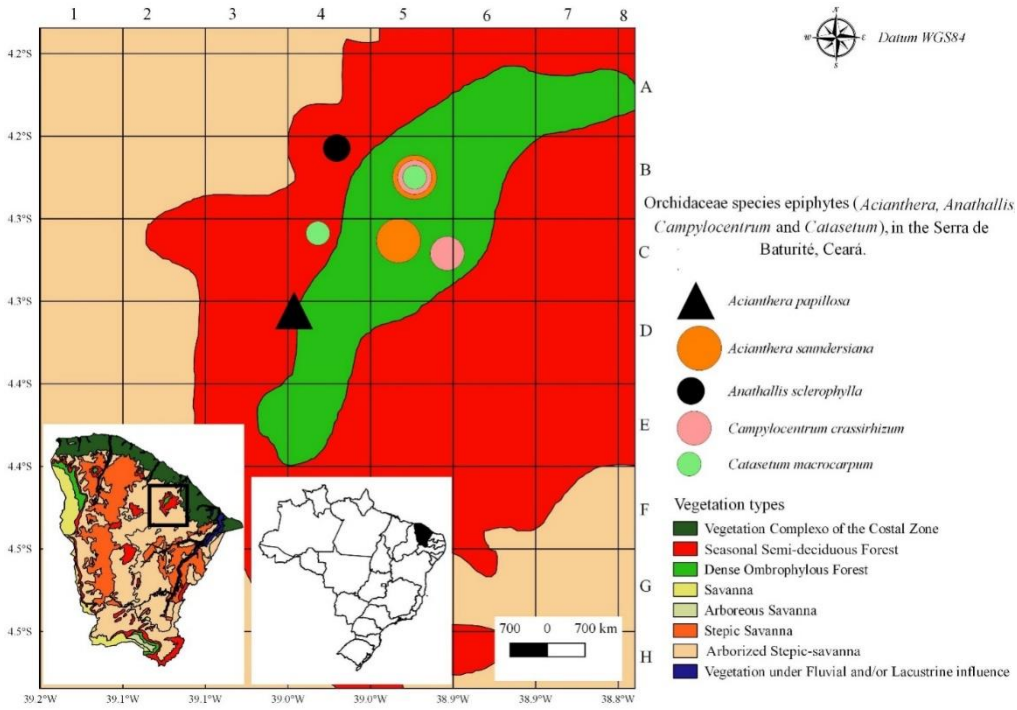

Figure 4. Geographic distribution of Orchidaceae species epiphytes (*Acianthera*, *Anathallis*, *Campylocentrum* and *Catasetum*), in the Baturité Massif, Ceará, Brazil.

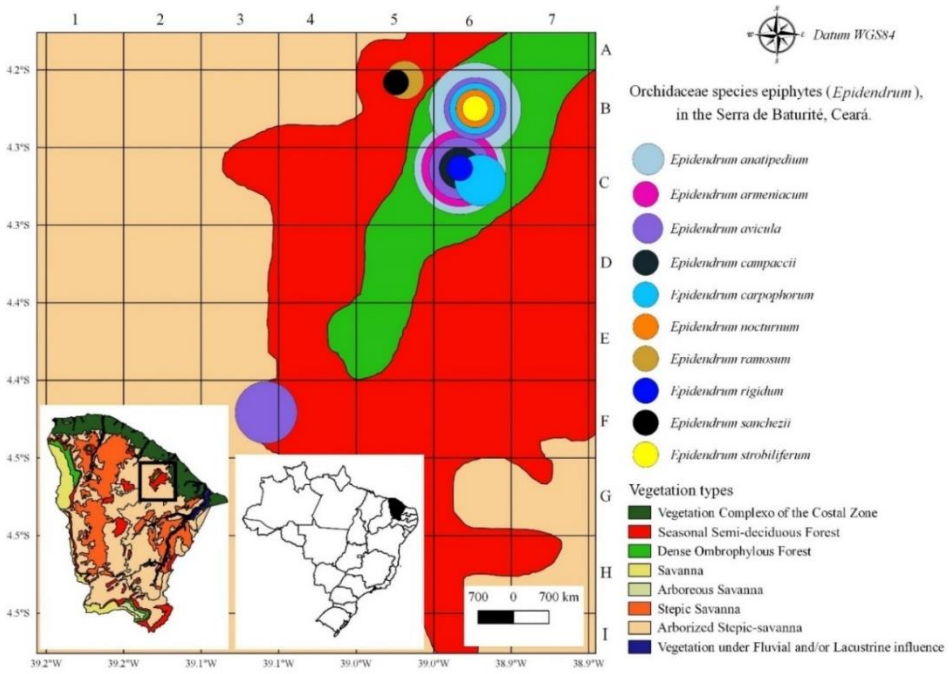

Figure 5. Geographic distribution of Orchidaceae species epiphytes (*Epidendrum*), in the Baturité Massif, Ceará, Brazil.

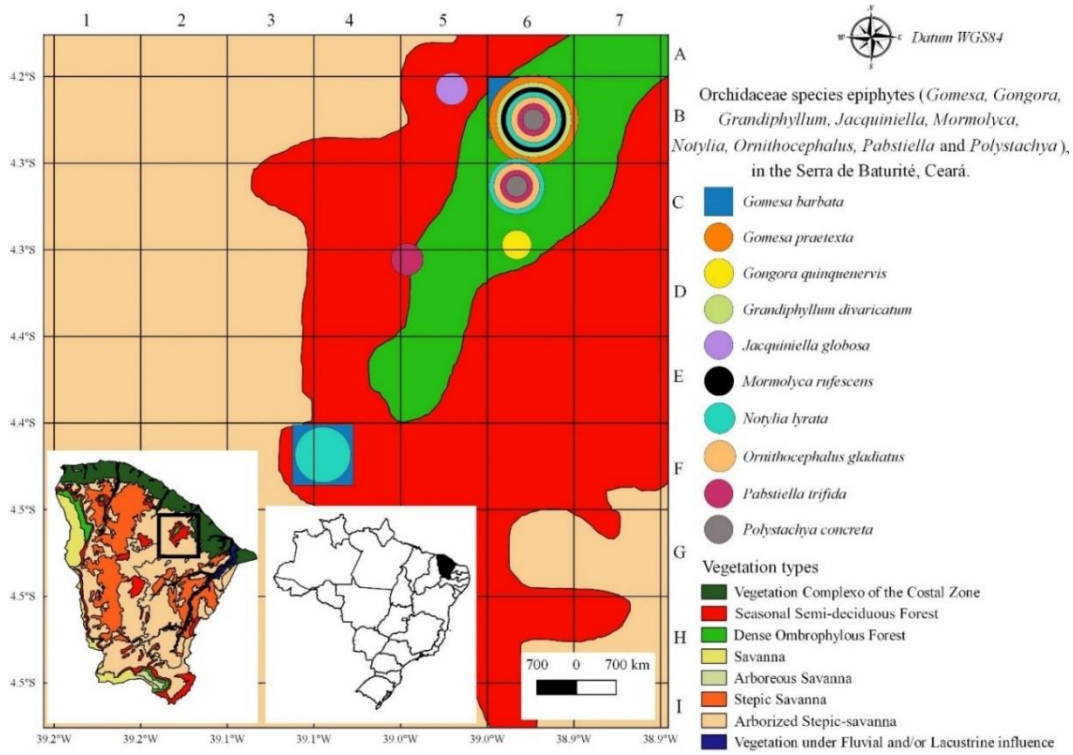

Figure 6. Geographic distribution of Orchidaceae species epiphytes (*Gomesa*, *Gongora*, *Grandiphyllum*, *Jacquiniella*, *Mormolyca*, *Notylia*, *Ornithocephalus*, *Pabstiella* and *Polystachya*), in the Baturité Massif, Ceará, Brazil.

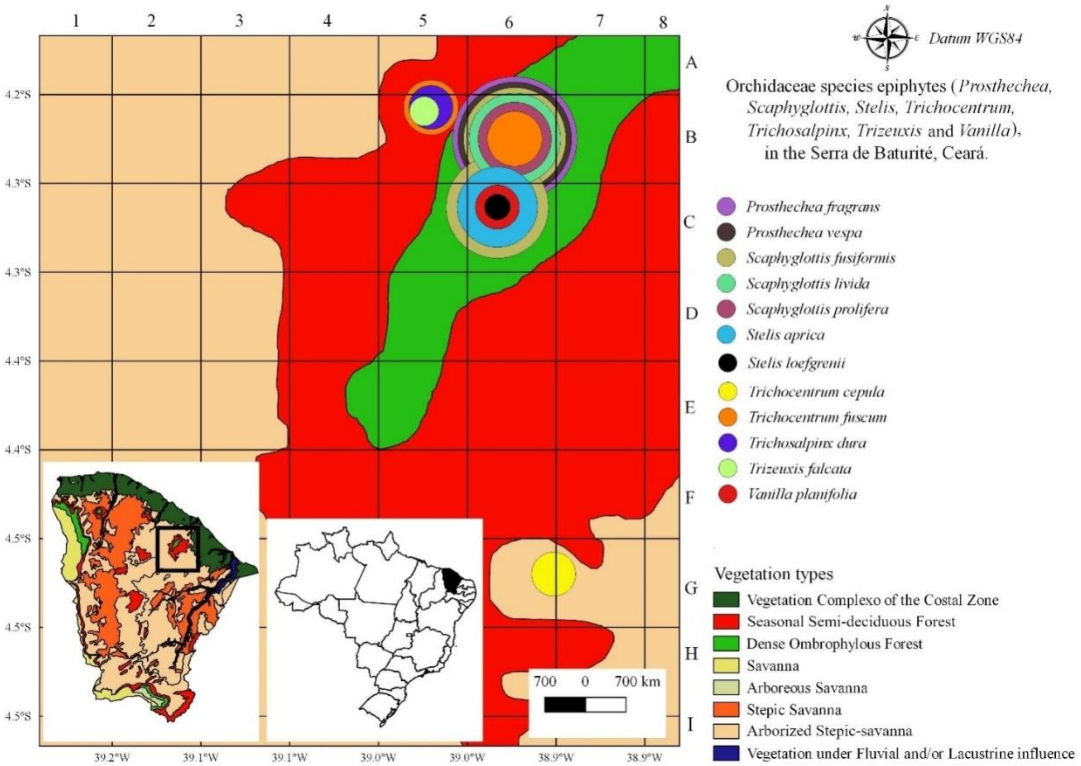

Figure 7. Geographic distribution of Orchidaceae species epiphytes (*Prosthechea*, *Scaphyglottis*, *Stelis*, *Trichocentrum*, *Trichosalpinx*, *Trizeuxis* and *Vanilla*), in the Baturité Massif, Ceará, Brazil.

In the Baturité Massif, Bromeliaceae was the second most representative family,

corresponding to 24% of the registered species (Fig. 3). Representatives of Bromeliaceae were collected in the Baturité Massif, especially in the most humid, Dense Ombrophilous Forest (B5, B6, C5 and C6), with few records in the driest, Seasonal Semi-deciduous Forest (B5, C4 and C5) (Figs. 8 and 9). Surveys of the epiphytic vascular flora from the Atlantic Forest of Southeastern region (Dislich and Mantovani, 1998; Gonçalves and Waechter, 2003) and Southern Brazil (Borgo and Silva, 2003; Breier, 2005) also highlighted Bromeliaceae as the second largest family. Madison (1997) pointed out that this group is probably the most known in terms of physiology and taxonomy of all the botanical families with epiphytic representatives.

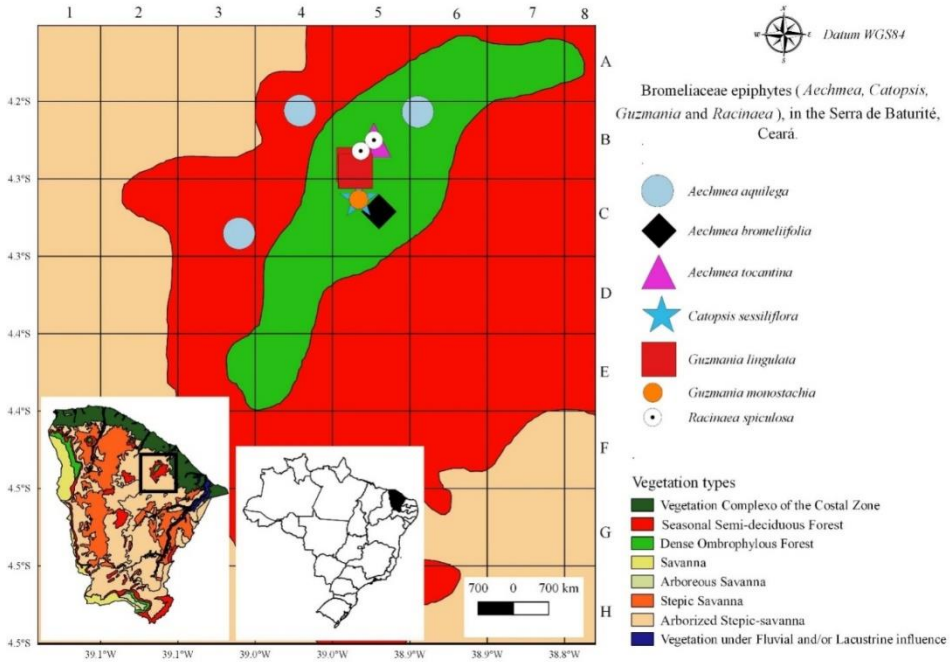

Figure 8. Geographic distribution of Bromeliaceae species epiphytes (*Aechmea*, *Catopsis*, *Guzmania* and *Racinaea*), in the Baturité Massif, Ceará, Brazil.

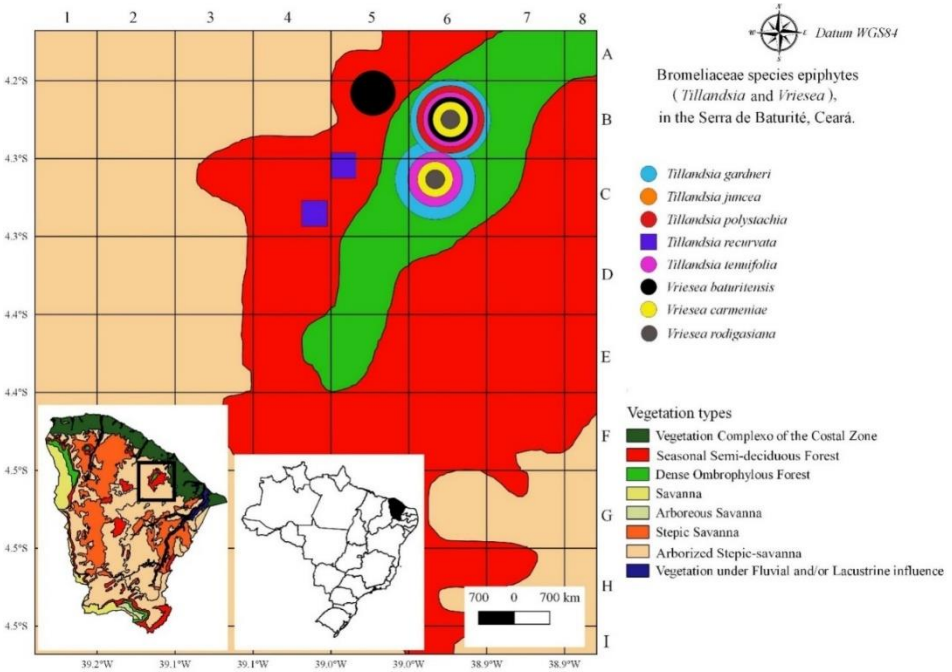

Figure 9. Geographic distribution of Bromeliaceae species epiphytes (*Tillandsia* and *Vriesea*), in the Baturité Massif, Ceará, Brazil.

Araceae was the third richest family in the Baturité Massif, being represented by four species (*Anthurium gracile* (Rudge) Lindl., *A. scandens* (Aubl.) Engl, *A. sinuatum* Benth. ex Schott and *Philodendron pedatum* (Hook.) Kunth), corresponding to 6% of all records (Fig. 2). In the neotropical region this family is very important, being well represented in the Brazilian Amazon Forest (Cruz and Nunes-Freitas, 2019). The *Anthurium* genus stood out with the highest number of species (three spp.). Representatives of this family prefer Dense Ombrophilous Forest vegetation in the B5 and C5 squares (highest and most humid area of the mountain). However, *A. sinuatum* was also found in the Seasonal Semi-deciduous Forest (A4) (Fig. 10). Madison (1997) defined the main characteristics of this group and also delimited the most representative epiphyte genera in Araceae, highlighting *Anthurium* and *Philodendron* with 400-500 spp. and 200-275 spp., respectively. In the Baturité Massif, 89% of vascular epiphytes found are monocotyledons. This data corroborates with Kersten (2010), who emphasized that most of the known epiphytes belong to this great clade of angiosperms, especially the families Orchidaceae and Bromeliaceae.

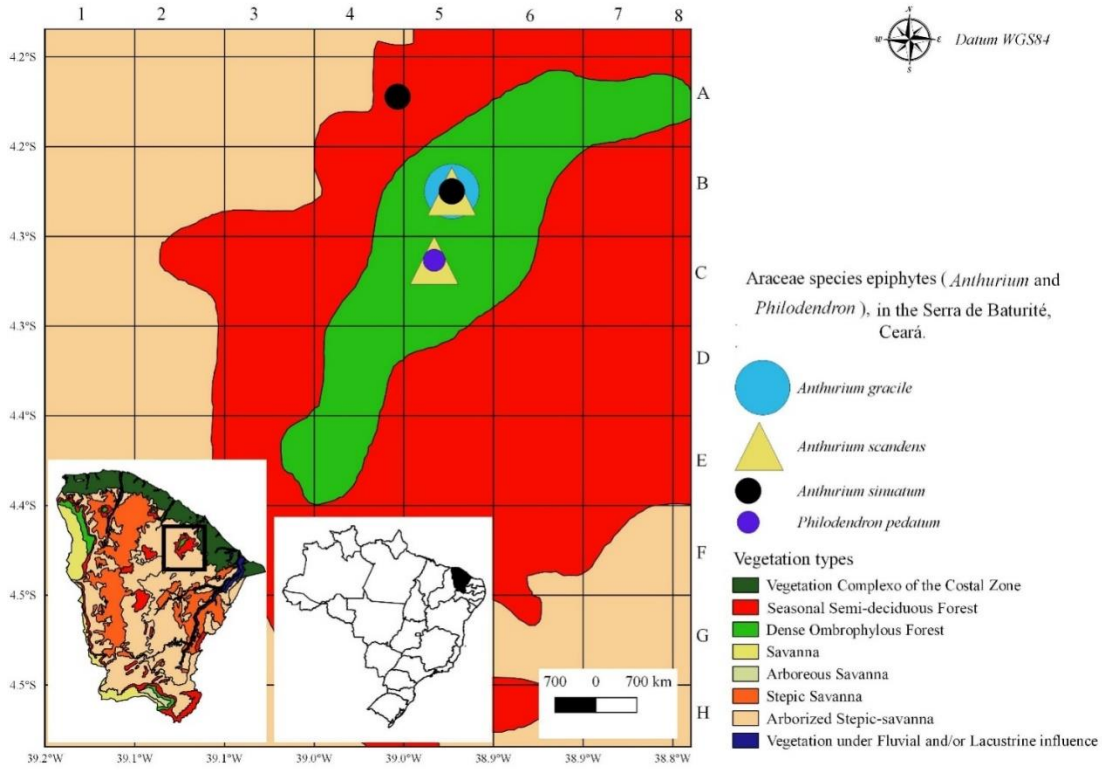

Figure 10.Geographic distribution of Araceae species epiphytes (*Anthurium* and *Philodendron*), in the Baturité Massif, Ceará, Brazil.

Species belonging to the Eudicotyledons (Cactaceae, Gesneriaceae and Rubiaceae) and Angiosperm Basal (Piperaceae) groups correlated to 12% of the epiphytic flora in the Baturité Massif. Such families were also cited in other studies about epiphytic vascular communities (Madison, 1997; Kersten et al., 2009; Cruz and Nunes-Freitas, 2019). In addition, according to Kersten (2010), Cactaceae and Gesneriaceae characterize a small group thatstands out regarding epiphytic species richness, being important in the Neotropical flora. The Cactaceae, for example, are cited in the study by Henriques et al. (2018) as the second family with the highest number of representatives, seven species and 3 genera.

In the Baturité Massif, Cactaceae was represented by the species *Epiphyllum phyllanthus* (L.) Haw. and *Rhipsalis baccifera* (J.M. Muell.) Stearn., which are exclusively found in Dense Ombrophilous Forest (B5 and C5 squares). Both species have already been cited as epiphytic representatives, however, *E. phyllanthus* in all regions of Brazil, while *R. baccifera* is restricted in the North, Northeast and Center-West (Leitman et al., 2014; Zappi and Taylor, 2017; Brito et al., 2019; Flora do Brasil 2020).

Gesneriaceae and Rubiaceae were both represented by a single species in the Baturité Massif: *Drymonia serrulata* (Jacq.) Mart. (collected in the municipality of Guaramiranga) and *Hillia parasitica* Jacq. (registered for Guaramiranga and Pacoti), respectively. These species were collected in the Seasonal Semi-deciduous Forest (grid B4). Rubiaceae was also cited in studies carried out in North America (Cuba) due to its low frequency in epiphytic vascular flora surveys (Reyes and Cantillo, 2017). In Brazil, *H. parasitica* Jacq. was reported by Leitman et al. (2014) and Furtado and Menini-Neto (2018) with epiphytic habit for the states of Bahia and Minas Gerais, respectively.

Herein, Piperaceae was represented by the species *Peperomia circinnata* Link., *P. dahlstedtii* Dusén. and *P. glabella* (Sw.) A. Dietr. Guimarães and Giordano (2004) had already mentioned the two taxa as part of the floristic component of Baturité Massif. The species were observed in both vegetation formations (Dense Ombrophilous Forest and Seasonal Semi-deciduous Forest), from the B4 and C5 squares (Fig. 11).

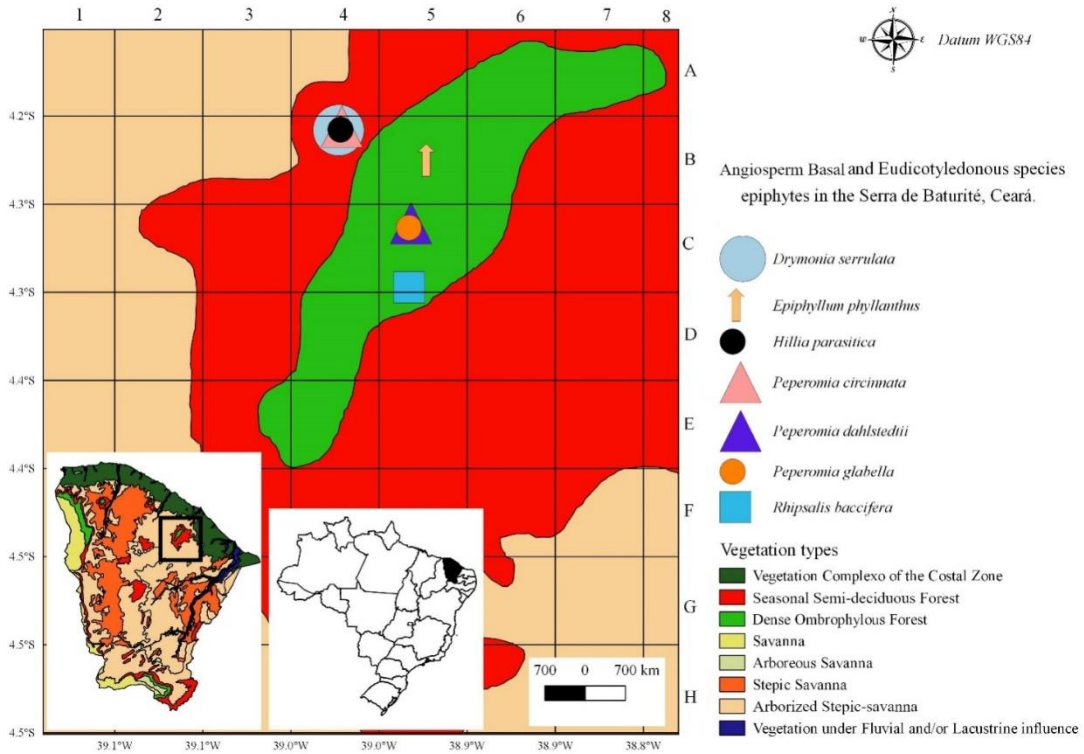

Figure 11. Geographic distribution of Angiosperm Basal and Eudicotyledons species epiphytes in the Baturité Massif, Ceará, Brazil.

Endemism, micro-endemism, new occurrences and conservation.

Among the species recorded, *Acianthera papillosa* (Lindl.) Pridgeon& M.W. Chase, *Anathallis sclerophylla* (Lindl.) Pridgeon & M.W. Chase, *Campylocentrum crassirhizum* Hoehne, *Epidendrum campaccii* Hágsater & L. Sánchez, *Gomesa barbata* (Lindl.) M.W. Chase, *G. praetexta* (Rchb.f.) M.W. Chase & N.H. Williams, *Gongora quinquenervis* Ruiz & Pav., *Pabstiella trifida* (Lindl.) Luer., *Peperomia dahlstedtii* Dusén., *Stelis loefgrenii* Cogn. and *Vriesea rodigasiana* E. Morren are endemic to Brazil and distributed in all regions; nine of which belong to Orchidaceae (Tab. 1) (Flora do Brasil 2020).

Epidendrum anatipedium L.M. Sánchez & Hágsater, *E. sanchezii* E. Pessoa & L.P. Felix and *Guzmania monostachia* (L.) Rusby ex Mez are endemic to the Northeast (Tab. 1), registered from the Atlantic Forest phytogeographic domain in the states of Ceará and Pernambuco (Pessoa et al., 2014; Flora do Brasil 2020). In the Baturité Massif, species were collected in the Pico Alto de Guaramiranga region and in the municipality of Pacoti, both in Dense Ombrophilous Forest vegetation (Wet Forest).

Vriesea baturitensis Versieux & Tomaz and *V. carmeniae* R. Moura & A.F. Costa are micro-endemic vascular epiphytes from Ceará, both from the Bromeliaceae family, being restricted to the municipalities of Guaramiranga and Pacoti in the Baturité Massif (Tab. 1). *V. baturitensis* occur sathigher altitudes > 800 m, being the target of collectors (Versieux et al.,

2013). *V. carmeniae* was recorded at an altitude of 930-1,100 m. In Ceará, the species also occurs in the Serra de Maranguape, in na elevated region. In this context, the relationship between endemism and the restricted distribution of these species, in the Baturité Massif, makes the conservation of these taxa even more worrying.

As epiphytes are very sensitive plants, their growth is slow, making them vulnerable (Cruz and Nunes-Freitas, 2019; Araújo et al., 2019; Monalisa-Francisco and Ramos, 2019; Costa et al., 2019), even more so because, bearing in mind that, to date, no study on the conservation status of these species has been carried out. According to Zizka et al. (2019) about 2/3 (81%) of the 3,503 species of bromeliads in tropical forests may be threatened with extinction. Among the main causes are habitat loss, climate change and, mainly, unsustainable collection (Bastos et al., 2018). This topic deserves more attention, since Baturité Massif receives more than 500 thous and visitors per year (PDITS, 2014), among them the visit of collectors or even local residents, who collect for commercialization. This activity makes the permanence of these species in a vulnerable condition. It can lead to species extinction, collapse of species interactions and impoverishment of native assemblages, as previously proposed for epiphytes (Nöske et al., 2008; Alvim et al., 2019; Gonçalves et al., 2020).

The species *Gomesa praetexta*, *Polystachya concreta* (Jacq.) Garay & Sweet. and *Trichocentrum cepula* (Hoffmanns.) J.M.H. Shaw, constitute new occurrences for Ceará, as consulted in the Flora do Brasil 2020. *G. praetexta* is endemic to Brazil, occurring in the Northeast, Southeast and South regions (Flora do Brasil 2020). In the study area an only record was located for the municipality of Pacoti. In contrast, *P. concreta* is not endemic to Brazilian territory, however, this is the first confirmed taxon record for the state of Ceará and the Northeast region. According to the Flora do Brasil 2020 there is only confirmation of the species distribution for the North and Midwest regions. In the Baturité Massif, *P. concreta* was recorded at nine points, at an altitude of 600-850 m, in the municipalities of Guaramiranga and Pacoti. About *T. cepula*, the species is not endemic to Brazil and occurs in the North, Northeast, Midwest and Southeast regions (Flora do Brasil 2020). In Massif Baturité two records were verified for the municipalities of Capistrano and Mulungu.

Holoepiphytes X hemiepiphytes

Regarding the classification of epiphytes into holoepiphytes and hemiepiphytes, 60 were holoepiphytes (96.77%) and only two were hemiepiphytes (3.22%), of the 62 species sampled in the Baturité Massif. Holoepiphytes were distributed among all the previously mentioned families, as observed in other studies (Cervi and Borgo, 2007; Leitman et al., 2014), while hemiepiphytes were restricted to Araceae (*Philodendron pedatum* (Hook.) Kunth) and Orchidaceae (*Vanilla planifolia* Jacks. Ex Andrews).

In a study carried out about the floristics and ecology of vascular epiphytes in a fragment of restinga forest from Ubatuba-SP, Mania and Monteiro (2010) recorded 64 species of epiphytes similar to those found in the Baturité Massif. Of those 64, 90.6% were holoepiphytes and 9.4% were hemiepiphytes, that is, the species richness of hemiepiphytes was also significantly lower than that of holoepiphytes. Thus, Mania and Monteiro (2010) highlighted holoepiphytes as an important group among epiphytes, with high species richness.

Conclusion

The assemblage of epiphytic species of the Baturité Massif has taxa in common in species listings from works already carried out in Brazil. However, the presence of an expressive number of species endemic to the Northeast and exclusive to Ceará is highlighted. Therefore, the Baturité Massif is an important area for the conservation of vascular epiphyte plant species, acting as a refuge, especially for endemic species in Northeast Brazil and Ceará.

Emphasizing the conservation of this group, all species were collected in the Environmental Protection Area (APA) of the Baturité Massif, making these species less vulnerable to threats. However, this does not eliminate the need to collect new records or for new studies regarding the conservation of species in these mountains. The very few records of representatives from the sub-humid and semi-arid municipalities also highlights the importance of increased efforts to collect representatives from the entire Massif of Baturité territory.

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Table 1. List of families, species, municipalities, vegetation types of occurrence (SSA = Arborized Stepic Savanna; SSF = Seasonal Semi-deciduous Forest; DOF = Dense Ombrophylous Forest) and endemism (EBR = Endemic Brazil; ECE = Endemic Ceará; ENE = Endemic Northeast; NEB = No Endemic Brazil), vascular epiphytes of Baturité Massif, Ceará, Brazil. Note: * = new ocorrence.

Family/Species	Municipalities	Vegetation types in Baturité Massif	Endemism
1. Araceae			
Anthurium gracile (Rudge) Lindl	Pacoti	DOF	NEB
Anthurium scandens (Aubl.) Engl	Guaramiranga/Pacoti	DOF	NEB
Anthurium sinuatum Benth. ex Schott	Guaramiranga/Pacoti	DOF/SSF	NEB
Philodendron pedatum (Hook.) Kunth	Guaramiranga	DOF	NEB
2. Bromeliaceae			
Aechmea aquilega (Salisb.) Griseb.	Guraramiranga/Mulungu/ Pacoti	DOF	NEB
Aechmea bromeliifolia (Rudge) Baker	Guaramiranga	DOF	NEB
Aechmea tocantina Baker	Pacoti	DOF	NEB
Catopsis sessiliflora (Ruiz & Pav.) Mez	Guaramiranga	DOF	NEB
Guzmania lingulata (L.) Mez	Guaramiranga/Pacoti	DOF	NEB
Guzmania monostachia (L.) Rusby ex Mez	Guaramiranga/Pacoti	DOF	ENE
Racinaea spiculosa (Griseb.) M.A.Spencer & L.B.Sm.	Guaramiranga/Pacoti	DOF	NEB
Tillandsia gardneri Lindl.	Guaramiranga/Pacoti	DOF	NEB
Tillandsia juncea (Ruiz & Pav.) Poiret	Guramiranga	DOF	NEB
Tillandsia polystachia (L.) L.	Pacoti	DOF	NEB

Tillandsia recurvata (L.) L.	Guaramiranga/Mulungu	SSF	NEB
Tillandsia tenuifolia L.	Guaramiranga/Pacoti	DOF	NEB
Vriesea baturitensis Versieux & Tomaz	Guaramiranga/Pacoti	DOF/SSF	ECE
Vriesea carmeniae R. Moura & A. F. Costa	Guaramiranga/Pacoti	DOF	ECE
Vriesea rodigasiana E.Morren	Pacoti	DOF	EBR
3. Cactaceae			
Epiphyllum phyllanthus (L.) Haw.	Pacoti	DOF	NEB
Rhipsalis baccifera (J.M.Muell.) Stearn.	Guaramiranga	DOF	NEB
4. Gesneriaceae			
Drymonia serrulata (Jacq.) Mart.	Guaramiranga	SSF	NEB
5. Orchidaceae			
Acianthera papillosa (Lindl.) Pridgeon & M.W.Chase	Mulungu	DOF/SSF	EBR
Acianthera saundersiana (Rchb.f.) Pridgeon &M.W.Chase	Guaramiranga/Pacoti	DOF	NEB
Anathallis sclerophylla (Lindl.) Pridgeon & M.W.Chase	Guaramiranga	SSF	EBR
Campylocentrum crassirhizum Hoehne	Guaramiranga/Pacoti	DOF	EBR
Catasetumm acrocarpum Rich. ex Kunth	Guaramiranga/Pacoti	SSF	NEB
Epidendrum anatipedium L.M.Sánchez & Hágsater	Guaramiranga/Pacoti	DOF	ENE
Epidendrum armeniacum Lindl.	Guaramiranga	DOF	NEB
Epidendrum avicula Lindl.	Aratuba/Guaramiranga/Pacoti	DOF/SSF	NEB
Epidendrum campaccii Hágsater & L.Sánchez	Guaramiranga/Pacoti	DOF	EBR

Epidendrum carpophorum Barb.Rodr.	Guaramiranga/Pacoti	DOF	NEB
Epidendrum nocturnum Jacq.	Guaramiranga/Pacoti	DOF	NEB
Epidendrum rigidum Jacq.	Guaramiranga/Pacoti	DOF	NEB
Epidendrum sanchezii E. Pessoa & L. P. Felix	Pacoti	SSF	ENE
Epidendrum strobiliferum Rchb.f.	Pacoti	DOF	NEB
Gomesa barbata (Lindl.) M.W.Chase & N.H.Williams	Aratuba/Guaramiranga/Pacoti	DOF/SSF	EBR
Gomesa praetexta (Rchb.f.) M.W.Chase & N.H.Williams *	Pacoti	DOF	EBR
Gongora quinquenervis Ruiz & Pav.	Guaramiranga	DOF	EBR
Grandiphyllum divaricatum (Lindl.) Docha Neto	Pacoti	DOF	NEB
Jacquiniella globosa (Jacq.) Schltr.	Guaramiranga/Mulungu	SSF	NEB
Mormolyca rufescens (Lindl.) M.A.Blanco.	Pacoti	DOF	NEB
Notylia lyrata S.Moore.	Aratuba/Guaramiranga/Pacoti	DOF	NEB
Ornithocephalus gladiatus Hook.	Guaramiranga/Pacoti	DOF	NEB
Pabstiella trifida (Lindl.) Luer.	Guaramiranga/Mulungu/Pacoti	DOF/SSF	EBR
Polystachya concreta (Jacq.) Garay & Sweet. *	Guaramiranga/Pacoti	DOF	NEB
Prosthechea fragrans (Sw.) W.E. Higgins.	Pacoti	DOF	NEB
Prosthechea vespa (Vell.) W.E. Higgins.	Pacoti	DOF	NEB
Scaphyglottis fusiformis (Griseb.) Schultes	Guaramiranga/Pacoti	DOF	NEB
Scaphyglottis livida (Lindl.) Schltr.	Pacoti	-	NEB
Scaphyglottis prolifera (R.Br.) Cogn.	Pacoti	DOF	NEB

Stelisa prica Lindl.	Guaramiranga/Pacoti	DOF	NEB
Stelis loefgrenii Cogn.	Guaramiranga	DOF	EBR
Trichocentrum cepula (Hoffmanns.) J.M.H.Shaw *	Capistrano/Mulungu	ASS	NEB
Trichocentrum fuscum Lindl.	Guaramiranga/Pacoti	DOF/SSF	NEB
Trichosalpinx dura (Lindl.) Luer.	Guaramiranga	SSF	NEB
Trizeuxis falcata Lindl.	Guaramiranga	SSF	NEB
Vanilla planifólia Jacks. ex Andrews	Guaramiranga	DOF	NEB
6. Piperaceae			
Peperomia circinnata Link.	Guaramiranga	SSF	NEB
Peperomia dahlstedtii Dusén.	Aratuba/Guaramiranga/Pacoti	SSF	EBR
Peperomia glabella (Sw.) A. Dietr.	Guaramiranga	DOF	NEB
7. Rubiaceae			
Hillia parasitica Jacq.	Guaramiranga/Pacoti	SSF	NEB

Identification key for families of vascular epiphytes in the Baturité Massif, Ceará.

1. Inflorescence spike; non showy flowers, aclamid ..... Piperaceae
1'. Inflorescence in raceme, or summits, or glomerulus, or spadix, or solitary flowers; showy flowers, monoclamids or diclamids 2
2. Stem forming pseudobulbs; corolla with one of the distinct petals (lip); stamen 1; pollen grouped in pollinia ..... Orchidaceae
2'. Stem not forming pseudobulbs; corolla without distinction between petals; stamens 6; pollen not grouped in pollinia 3
3. Leaves often arranged in rosettes, with thorns on the margin; corolla trimer ..... Bromeliaceae
3'. Leaves not arranged in rosettes, without thorns on the margin; absent corolla or pentame 4
4. Inflorescence spadix, subtended by a bract (spat) ..... Araceae
4'. Inflorescence in raceme, or summits, or glomerulus, or solitary flowers 5
5. Succulent, photosynthetic stems, segmented, cladode type; numerous stamens ..... Cactaceae
5'. Non-succulent, non-photosynthetic stems, non-segmented, stem or trunk type; 4 stamens ... 6
6. Leaves with entire margin; interpeciolar stipules ..... Rubiaceae
6'. Leaves with serrate margin; without stipules ..... Gesneriaceae

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