Species composition of Bromeliaceae and their distribution at the Massambaba restinga in Arraial do Cabo, Rio de Janeiro, Brazil

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(With 1 figure)

Abstract

We studied some ecological parameters such as richness, abundance, density, biomass and variation in species composition in four vegetation zones and in a zone with anthropic disturbance in the Massambaba Restinga in Arraial do Cabo, Rio de Janeiro State. We sampled 100 plots of 100 m^2 (10 x 10 m) recording the bromeliad species and their abundance. We found a total of seven bromeliad species, with *Vriesea neoglutinosa* (5647 ramets) and *Tillandsia stricta* (1277 ramets) being the most abundant. The vegetation zone called *Clusia* shrubs had the highest richness (S = 5) and density (6360 $ramets.ha^{-1}$) of bromeliads. The differences found in abundance and variation in species composition among vegetation zones seems to be related to the vegetation structure of each zone.

Keywords: bromeliads, restinga, species composition, vegetation zones.

Composição de espécies de Bromeliaceae e sua distribuição na restinga de Massambaba, Arraial do Cabo, RJ, Brasil

Resumo

Estudamos a riqueza, a abundância, a densidade, a biomassa e a variação na composição de espécies de bromélias em quatro zonas de vegetação e em uma área com distúrbio antrópico da restinga de Massambaba, Arraial do Cabo, RJ. Estes parâmetros foram avaliados através do registro das espécies e de suas abundâncias em 100 parcelas, proporcionalmente distribuídas entre as zonas. Encontramos sete espécies de bromélias, sendo *Vriesea neoglutinosa* e *Tillandsia stricta* as mais abundantes. A arbustiva aberta de *Clusia* foi a zona de vegetação com maior riqueza (S = 5) e abundância total (6360 rosetas) de bromélias. As diferenças encontradas na composição e na abundância de espécies de bromélias entre as zonas parecem estar relacionadas com a estrutura da vegetação de cada zona.

Palavras-chave: bromélias, restinga, composição de espécies, zonação.

1. Introduction

The eastern coast of Brazil extends about 9200 km, of which 79% are covered by restinga habitats (Araujo, 1992; Lacerda et al., 1993; Cogliatti-Carvalho et al., 2001), a type of habitat originated from Quaternary marine deposits and represented by usually arbustive-herbaceous vegetation covering typically sandy soils (Araujo, 1992; 2000; Araujo et al., 1998b; Scarano, 2002). Each patch of restinga along the coast has its own topography, physiognomy and flora (Araujo, 2000). However, the distribution of vegetation in zones seems to be a pattern along the coast (Araujo and Henriques, 1984; Cogliatti-Carvalho et al., 2000), where each zone has a different set of plants with tolerance to extreme environmental conditions such as high temperature, low availability of water in the soil, high salinity and high insolation (Zaluar and Scarano, 2000; Scarano, 2002).

Among the most characteristic plant families in the restingas, the Bromeliaceae usually have a high local richness and abundance (Henriques et al., 1986; Sá, 1992; Fabris and Pereira, 1998; Pereira and Zambom, 1998; Cogliatti-Carvalho et al., 2001). In those formations, the bromeliads have an important role in facilitating the establishment of other plant species (Zaluar and Scarano, 2000) and, therefore, as enhancers of diversity, also providing resources to various groups of animals (Rocha et al., 1997; 2004a). As the species in the family Bromeliaceae respond differently to environmental variations (Benzing, 1980; 2000), and since the vegetation zones in the restingas present different environmental conditions (Freitas et al., 2000), we could expect that different species found in that environment will not be homogeneously distributed among vegetation zones, with each zone instead presenting a distinct set of bromeliad species (Freitas et al., 2000).

The Massambaba restinga, located in the municipality of Arraial do Cabo on the northeastern coast of Rio de Janeiro state, used to be contiguous with the restingas of Praia Seca and Saquarema, and this whole system occupied an area that extended to the margins of the Araruama Lagoon (Araujo, 2000). The high rate of exploitation and the irregular soil occupation around the Área de Proteção Ambiental de Massambaba (Enviromental protection area of Massambaba) interrupted its connection with the adjacent restinga areas and with the Araruama lagoon (Leme, 1985; Rocha et al., 2003). Nowadays, the Massambaba restinga is restricted to the Área de Proteção Ambiental de Massambaba and a few preserved vegetation fragments near the locality of Figueiras. Thus, the knowledge about the species composition, richness and distribution of Bromeliaceae at the Massambaba restinga could be an additional element in behalf of the conservation of this restinga remnant.

In this study we evaluated the variation of ecological parameters in a bromeliad community occupying a fragment of the Massambaba restinga, aiming to answer the following questions: 1) which are the richness, species composition, density and biomass of bromeliads in the study area? 2) is there any variation in the ecological parameters of the Bromeliaceae community between the different vegetation zones at the Massambaba restinga? and 3) which parameters could explain the variations observed?

2. Material and Methods

2.1. Study area

The study was carried out in March, 2000, in a restinga area adjacent to the Massambaba beach (22° 56' S and 42º 12' W), near the northern portion of the Área de Proteção Ambiental de Massambaba (APA de Massambaba), in the municipality of Arraial do Cabo, some 180 km east of Rio de Janeiro city.

The restinga of Massambaba is within the Cabo Frio Center of Plant Diversity, one of the 12 regions in Brazil considered as centers of diversity due to their peculiar vegetation and climate (Araujo, 1997; Araujo et al., 1998a). The region has a markedly seasonal climate, with annual rainfall of 800 mm and most of the rain falling during the summer, and mean annual temperature of 25 °C (Scarano, 2002).

In this region, the vegetation can be subdivided in four different zones: halophilous-psammophilous reptant (HPR); closed post-beach (CPB); open *Clusia* shrubland (OCS); and closed Myrtaceae shrubland (CMS), each of them characterized according to the general aspect of the vegetation and categorized following Araujo and Henriques (1984). Besides those vegetation zones, there is an extensive area with evidences of intense anthropic disturbance, which is here denominated the anthropic zone (AZ). This zone, located between the dunes and the road, is dominated by grasses and was included in the present study due to the presence of bromeliads.

2.2. Methodology

In order to characterize the ecological parameters of richness, abundance, density, and biomass, and the variation in species composition of the bromeliad community at the study area, four transsections were realized perpendicularly to the beach, totaling 100 parcels of 100 m^2 each. The transsections had different lengths and were distant 50 m or more from one another, with the parcels being 10m apart [for more details see Cogliatti-Carvalho et al. (2000) and Freitas et al. (2000)]. Within each parcel the bromeliad species were identified and the number of individual rosettes counted. To estimate the biomass per species, the wet mass of 20 rosettes of each species was taken with Pesola© spring balances (to the nearest g).

We calculated (for the area as a whole and for each of the vegetation zones) the richness (S), abundance (total number of individuals), total absolute density (TAD; rosettes.ha^{-1}), total biomass, and biomass.ha^{-1}. We also calculated for each species (for the area as a whole and for each of the vegetation zones), the absolute density (AD; in rosettes.ha^{-1}), total biomass, and biomass.ha^{-1}.

The variation in species composition among the different vegetation zones was determined through direct ordination of abundances of bromeliad species. The bromeliad abundance values at each of the vegetation zones were expressed as percentages for better visualization of the ordination patterns.

We compared the richness of the taxocenosis of Bromeliaceae from Massambaba with those of 16 other areas along the Brazilian coast for which data are available in the literature.

Voucher material was collected and identified, and housed at the herbarium of the Museu Nacional, Rio de Janeiro (MN).

3. Results

We recorded seven species of Bromeliaceae belonging to six genera at the study area: *Aechmea lingulata* (L.) Baker, *Billbergia amoena* (Lodd.) Lindl., *Bromelia antiacantha* Bertol., *Neoregelia cruenta* (Graham) L.B. Sm., *Tillandsia gardneri* Lindl., *T. stricta* Sol. and *Vriesea neoglutinosa* Mez (Table 1). Among the species sampled, *V. neoglutinosa* (5647 rosettes.ha^{-1}) and *T. stricta* (1277 rosettes.ha^{-1}) had the highest estimated densities, whereas *T. gardneri* had the lowest (4 rosettes.ha^{-1}) (Table 1).

The open *Clusia* shrubland (OCS) was the vegetation zone with the highest species richness (S = 5), the highest total bromeliad abundance (6360 rosettes), the highest estimated density (12000 rosettes.ha^{-1}) and the highest estimated bromeliad biomass (8573 kg.ha^{-1}), whereas the anthropic zone (AZ) had the lowest values for the above parameters (Table 2). At the HPR zone no bromeliads were found.

Ordination of the bromeliad species at the study area, according to their abundances in a zonation gradient, extending from the zone closest to the sea (HPR) to that most distant from it (AZ), presented the following sequence of species: *Billbergia amoena, Bromelia antiacantha, Neoregelia cruenta, Tillandsia stricta, T. gardneri, Aechmea lingulata* and *Vriesea neoglutinosa* (Figure 1).

The values of bromeliad richness for the study area and for other restingas along the Brazilian coast are shown in Table 3.

4. Discussion

In studies on the composition of plant species in Brazilian restinga habitats, the Bromeliaceae has been reported as one of the most representative families in terms of species richness (Henriques et al., 1986; Sá, 1992; Fabris and Pereira, 1998; Pereira and Zambom, 1998; Cogliatti-Carvalho et al. 2001). Araujo (2000) reported 28 bromeliad species for the restingas of the region of Cabo Frio. The Cabo Frio region is an extensive area that embraces all restingas from the Saquarema lagoon, in the municipal-

Table 1. Absolute density, mean biomass, and total biomass of species of Bromeliaceae at the Massambaba restinga, Arraial do Cabo, RJ.

Species	Absolute density (ramets.ha^{-1})	Mean biomass (kg)	Total biomass (kg.ha^{-1})
Aechmea lingulata (L.) Baker	62	0.53	33
Billbergia amoena (Lodd) Lindl.	324	0.50	163
Bromelia antiacantha Bertol.	110	1.03	113
Neoregelia cruenta (Graham) L.B. Sm.	332	0.40	136
Tillandsia gardneri Lindl.	4	0.02	0.1
Tillandsia stricta Sol.	1277	0.03	32
Vriesea neoglutinosa Mez	5647	0.72	4038

Table 2. Species richness (S), total abundance (Ta), total absolute density (TAD; rosettes.ha^{-1}) and total biomass (TB; in kg.ha^{-1}) of bromeliads in each of the four vegetation zones and in the anthropic zone at the Massambaba restinga, Arraial do Cabo, RJ. HPR = Halophilous-Psammophilous Reptant; CPB = closed post-beach; OCS = open *Clusia* shrubland; CMS = closed Myrtaceae shrubland; and AZ = Anthropic zone.

Zone	Species richness (S)	Ta	TAD (ramets.ha^{-1})	Total biomass (kg.ha^{-1})	Sampled area (ha)
HPR	0	0	0	0	0.10
CPB	4	917	4168	1695	0.22
OCS	5	6360	12000	8573	0.53
CMS	4	476	4327	2041	0.11
AZ	1	03	75	54	0.04

Table 3. Species richness of Bromeliaceae in plant communities from different Brazilian restingas. (*) total restinga area sampled equals 200 km (greatest extension of sampled coast) and encompasses several municipalities.

Restinga	Municipality	State	Richness	Source
Praia da Princesa	Maracanã	PA	1	Bastos et al., 1995
Parque Estadual das Dunas do Natal	Natal	RN	4	Freire, 1990
Restingas of northeastern Bahia	*	BA	13	Pinto et al., 1984
Dunas do Abaeté	Salvador	BA	4	Britto et al., 1993
Restinga do Pontal do Ipiranga	Linhares	ES	5	Pereira et al., 1998
Restinga de Interlagos	Vila Velha	ES	10	Pereira and Zambom, 1998
Restinga de Setiba	Guarapari	ES	13	Cogliatti-Carvalho et al., 2000
Restinga de Jurubatiba	Macaé, Carapebus, Quissamã	RJ	6	Araujo et al., 1998b
Restinga de Jurubatiba	Macaé, Carapebus, Quissamã	RJ	10	Freitas et al., 2000; Cogliatti-Carvalho et al., 2001
Grussaí / Iquipari	São João da Barra	RJ	5	Assumpção and Nascimento, 2000
Ipitangas	Saquarema	RJ	23	Sá, 1992
Restinga da Barra de Maricá	Maricá	RJ	6	Silva and Somner, 1984
Restinga da Praia do Sul, Ilha Grande	Angra dos Reis	RJ	13	Araujoand Oliveira, 1988
Restinga da Praia do Sul, Ilha Grande	Angra dos Reis	RJ	19	Rocha et al., 2000
Praia do Ferrugem	Garopaba	SC	8	Danilevicz et al., 1990

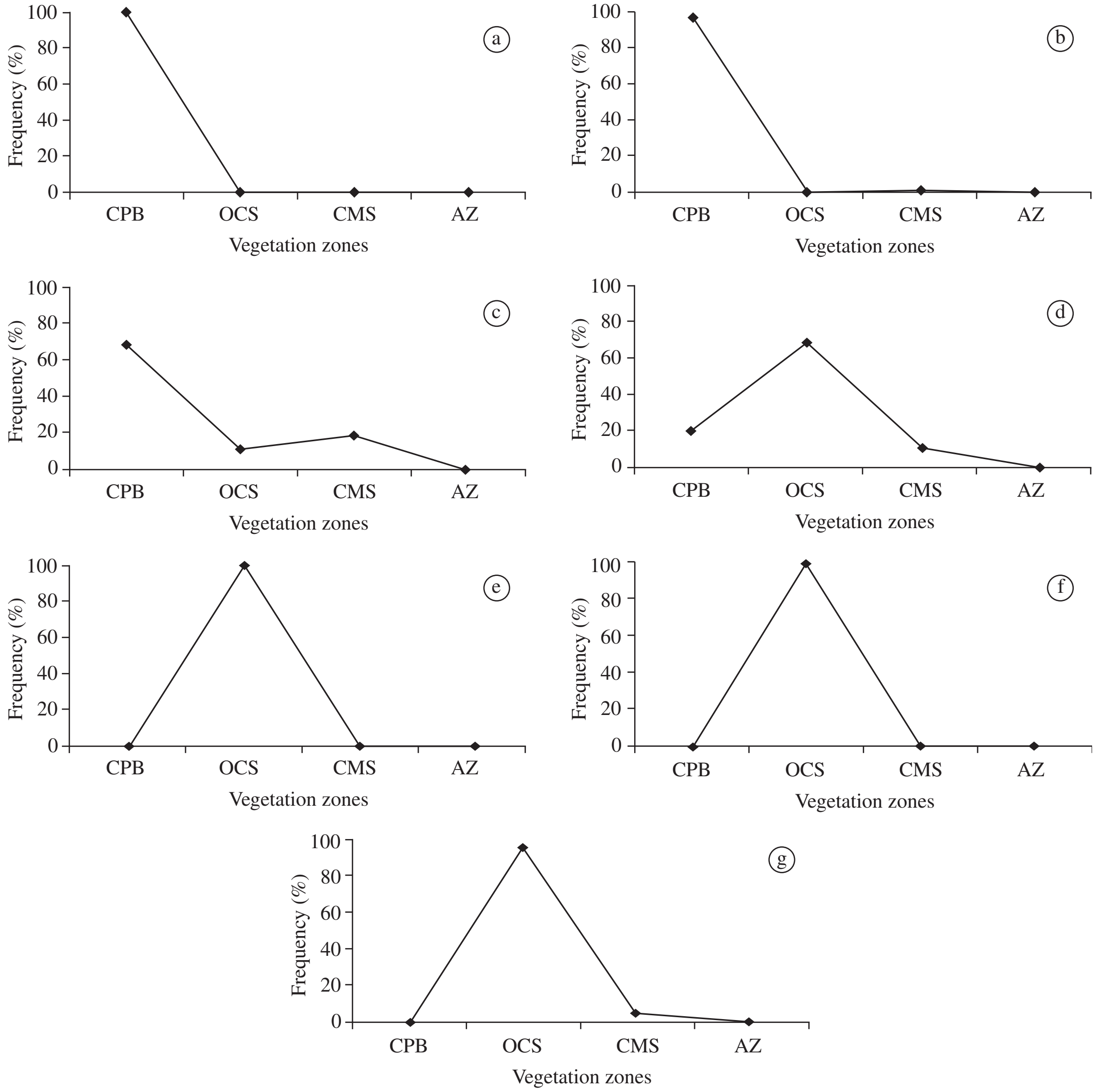

Figure 1. Direct ordenation bromeliad species at the Massambaba restinga according to the abundance of each of them at the four vegetation zones and at the anthropic zone. a) *Billbergia amoena;* b) *Bromelia antiacantha;* c) *Neoregelia cruenta;* d) *Tillandsia stricta;* e) *T. gardneri;* f) *Aechmea lingulata* and g) *Vriesea neoglutinosa;* where: CPB = closed post-beach; OCS = open Clusia shrubland; CMS = closed Myrtaceae shrubland; AZ = Anthropic zone.

ity of Saquarema, to the Atalaia hill in the municipality of Arraial do Cabo (Araújo, 2000), and the Massambaba restinga is located within this region. The species richness (seven species) found at the study area is similar to local richness values reported for other brazilian restingas in other studies. The majority of those studies found a local bromeliad richness value between four and 14 species. The maximum local bromeliad richness value was found at the Ipitangas restinga, in Rio de Janeiro state, where 23 bromeliad species were found (Sá, 1992), whereas at the Praia da Princesa restinga, in Pará state, only one bromeliad species was found (Bastos et al., 1995). This variation in species richness and composition among different restinga habitats could be due to the differences in methodology used in the studies and to other factors such as sampling effort, evolutionary history (geology and biogeography), differences in vegetation zonation patterns, species-area relationship, degree of degradation of each restinga habitat (Rocha et al., 2003; 2004b), and the direct influence of adjacent habitats. However, the statistical analyses done in the present study suggested that the differences in bromeliad species richness among the restinga habitats are related to methodology and sampling effort, which varied greatly among the analyzed studies. The use of different methodologies can lead to different responses and interpretations of the same question (Magurran, 1988; Magnusson and Mourão, 2003), which can make the comparisons among studies difficult.

Vriesea neoglutinosa and *V. procera* are almost identical species, which presents a problem for taxonomic identification. A specimen collected by us had an identification problem, and to solve this we opted to identify it as *V. neoglutinosa,* only because it is disseminated in the literature that *V. procera* does not occur in the restingas of Rio de Janeiro state (Araujo and Henriques, 1984; Araujo et al., 1998b; Araujo, 2000). The high degree of vegetative reproduction of *Vriesea neoglutinosa* and the consequent aggregated distribution pattern could explain the high local abundance of this species (Freitas et al., 2000).

Bromelia antiacantha occurs throughout the Rio de Janeiro coastline and is considered to be representative of the CPB community (Araujo and Oliveira, 1988; Silva and Oliveira, 1989; Araujo, 1992; 2000; Fabris and Pereira, 1998; Pereira et al., 1998; Pereira and Zambom, 1998). however, this species can be found, albeit at lower abundances, in other vegetation zones (Cogliatti-Carvalho et al., 2001). The presence of *B. antiacantha* at the CPB could be indicative of its tolerance to the high salinity characteristic of this vegetation zone (Cogliatti-Carvalho et al., 2001).

Neoregelia cruenta was the most abundant species at the CPB. The CPB is an arbustive zone considerably exposed to sunlight. Other studies of restinga plant communities reported the apparent high tolerance to sunlight of *N. cruenta* (Zaluar and Scarano, 2000; Cogliatti-Carvalho et al. 2001).

The rarity of *Tillandsia gardneri* in this restinga is similar to what has been found for this species at other restinga habitats (Cogliatti-Carvalho, 2003). That author analyzed the richness, distribution and abundance of bromeliad communities from 13 restinga habitats along the southern and northern brazilian coast, and found *T. gardneri* in only six restingas (Praia do Sul, RJ = 6 ramets.ha^{-1}; Grumari, RJ = 11 ramets.ha^{-1}; Maricá, RJ = 21 ramets.ha^{-1}; Massambaba, RJ = 4 ramets.ha^{-1}; Jurubatiba, RJ = 120 ramets.ha^{-1}, and Setiba, ES = 58 ramets.ha^{-1}), and in all of them its abundance was low in comparison to other sympatric bromeliad species.

Clusia hilariana (Schltdl.) was reported as an important pioneer woody plant at the restinga de Jurubatiba, in Rio de Janeiro state (Zaluar and Scarano, 2000). Those authors suggested that *C. hilariana* favors the establishment of other species by providing a greater availability of nutrients, water on soil, microhabitats and reduction of daily sunlight variation and soil temperature in the "islands" of vegetation formed around it. This pioneer role played by *C. hilariana* can be occurring also at the Massambaba restinga, where vegetation "islands" formed around individuals of *Clusia* spp. have relative high richness and abundance of bromeliads. This agrees with the common idea that areas inside or at the edge of vegetation islands are the most suitable microhabitats for the establishment of bromeliad species (Freitas et al., 2000), similarly to what occurs with other plant species (Zaluar and Scarano, 2000; Zaluar, 2002).

The low richness and abundance of bromeliads at the anthropic zone compared to the less disturbed zones of the Massambaba restinga suggests that habitat degradation strongly reduces the local bromeliad diversity. In regenerated restinga habitats *V. neoglutinosa* appears to be the bromeliad species most tolerant to disturbance. The degradation of restinga habitats has been shown as an important cause of bromeliad diversity reduction and, generally, the reduction in species richness is directly proportional to the degree of habitat disturbance (Rocha et al., 2003; 2004b).

We conclude that, at the Massambaba restinga, the bromeliad species are not homogenously distributed along the vegetation zones, with their distribution differing along the restinga. The differences in the actual composition and abundance of bromeliad communities among the different vegetation zones appear to be related to differences in the structure of the zones, which favor the occurrence of more bromeliad species at more complex zones, due to the increased availability of microhabitats.

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