

Vegetação de Restinga em Ilha Comprida: Condições de Conservação e Estudo Comparativo com outras Áreas de Proteção Ambiental do Estado de São Paulo - Brasil

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Resumo

Efetou-se um levantamento florístico da flora vascular da fisionomia de Praia e Dunas em dois segmentos da Ilha Comprida, uma Ilha-barreira alongada, com 72 km de comprimento e larguras que variam de 2 a 5 km, localizada na costa sul do Estado de São Paulo, Sudeste do Brasil. O primeiro segmento é uma área privada bem preservada, e o segundo uma área com forte influência antrópica. Para verificar o grau de degradação nos dois segmentos, fez-se uma comparação entre eles, correlacionando os impactos humanos sobre as praias e dunas com as espécies de plantas encontradas. Além disso, calculou-se a similaridade florística entre a área de estudo e outras áreas do Estado, utilizando-se o índice de Sørensen. A pesquisa em Ilha Comprida resultou em 75 espécies de plantas vasculares, distribuídas em 61 gêneros e 31 famílias. Poaceae apresentou o maior número de espécies no levantamento (18,67%). Na área com bom nível de preservação encontrou-se *Plantago catharinea*, citada na lista de espécies ameaçadas de São Paulo. Esta área apresentou 74,07% de plantas nativas e 25,93% de plantas invasoras, enquanto a área sob forte pressão antrópica teve 51,22% de plantas nativas e 48,78% de invasoras. Em relação a outras áreas estudadas, Ilha Comprida apresentou maior similaridade florística com a localidade de Guaraú, em Peruíbe (37,84%), e menor similaridade com Ubatuba (12,31%). As espécies exóticas, como as alelopáticas *Casuarina equisetifolia* e *Pinus elliottii*, têm causado forte impacto na vegetação da fisionomia de Praias e Dunas. O rápido desenvolvimento urbano que ocorre na ilha vem provocando alterações na riqueza de espécies e composição florística. Muitas construções irregulares são observadas sobre as dunas, mostrando a necessidade urgente de uma avaliação da situação atual pelas autoridades competentes.

Palavras-chave: florística, plantas invasoras, plantas exóticas, dunas, pressão antrópica.

Restinga Vegetation on Ilha Comprida: Conservation Conditions and a Comparative Study with other Environmental Protection Areas of São Paulo State - Brazil

Abstract

A floristic survey concerning the vascular flora of the physiognomy of beaches and dunes was carried out in two sections of Ilha Comprida, an elongated barrier island on the Southern coast of São Paulo State, in the Southeast of Brazil. The island is 72 Km long and ranges from 2 to 5 km wide. The first section is a private area under special environmental care, whereas the second one is an area where strong anthropogenic disturbances can be observed. To check the degree of degradation to which both areas have been exposed, a comparison was made between them in an attempt to establish a connection between the human impacts on the beaches and dunes and the plant species found in these two areas. In addition, the floristic similarity between the study area and other areas of São Paulo State was calculated with the help of the Sørensen index. The survey on Ilha Comprida resulted in 75 species of vascular plants, distributed in 61

genera and 31 families. Poaceae provided the highest number of species in the survey (18.67%). *Plantago catharinaea*, cited in the list of endangered species of São Paulo, was found in the area that is better preserved. This area shows 74.07% native plants to 25.93% invasive, while the area under stronger anthropogenic impact revealed 51.22% native plants to 48.78% invasive. Amongst the other areas studied, Ilha Comprida exhibited the highest floristic similarity to the study site of Guaraú, in Peruíbe (37.84%), and the lowest similarity to Ubatuba (12.31%). Exotic species, such as the allelopathics *Casuarina equisetifolia* and *Pinus elliottii*, have caused a major impact on the restinga vegetation of beaches and dunes. The rapid urban development occurring on the island has led to changes in the richness of species and floristic composition. Many irregular constructions can be observed where the dunes are, showing the urgent need of an assessment of the current situation by the competent authorities.

Key words: floristic, invasive plants, exotic plants, dunes, anthropogenic disturbances.

Introduction

The estuarine system of Cananeia-Iguape is formed by a sedimentary coastal plain of 130 km long by 40 km perpendicular to the sea and directly affects the marine waters (Tessler 1988). According to Ross and Moroz (1997), the Coastal Plain of Iguape-Cananeia is a plain Cenozoic formation with altitudes ranging from 0 to 20 meters and less than 2% slope.

This unit contains a complex river system, including the Ribeira de Iguape river, which has the highest flow on the whole Sao Paulo State coast. Throughout its plain, a network of canals, lagoons and rivers, which receive tidal influence, separates four major islands: Ilha do Cardoso, Ilha Comprida, Ilha de Cananeia; Ilha de Iguape (Suguio & Martin 1978, Tessler 1998).

These formations are colonized by plant species that arose from the actions of morphodynamic and pedogenetic agents (Milk & Klein 1990). There, sparse grass fields can be found, as well as dense forests and swamps with dense aquatic vegetation. This set of geomorphologic formations, along with their diverse biological communities, receives the generic name of "restinga" (Araujo & Lacerda 1987, Sousa *et al.* 2008).

According to the criteria established by the CONAMA Resolution Number 007/96, these formations are divided into four categories: Beaches Vegetation, Dunes Vegetation, Vegetation on Sand Ridges, and Vegetation Associated with Sandy Depression. This paper will address the Vegetation of Beaches and Dunes.

Primary dunes are deposits formed after the beach or upper shoreface by retention of the coastal sand pioneer vegetation (Giannini *et al.* 2005). According to Hesp (2000), primary dunes begin as incipient or embryonic dunes and evolve. With increasing time, complexity and diversity of morphologic covers for dunes are established. The dune system has a typical plant community and a rich fauna, where resources are important minerals like sand, water, metals and rare earths.

The largest dunes of São Paulo State can be found on Ilha Comprida, where it is possible to recognize dunes with a maximum of 8 meters high, and widths ranging from 100 to 200 m (Barcelos *et al.* 1976).

Because of their location along the coast, salt marshes have been submitted to an intense process of degradation of their natural characteristics since European settlement. In fact, these were the first ecosystems to suffer from human impacts, which only about four centuries after the discovery of the country began to affect ecosystems hinterland. Currently, real estate, tourism and population growth with little planning exert strong pressure on the last remnants of restinga, endangering a diverse flora and fauna (Mantovani 2000).

Another disturbing factor is the selective extraction of plants (bromeliads, orchids, etc.), commonly practiced by marginalized groups of the coastal population in order to trade in handicrafts and ornamental plants, as a supplementary income (Rodrigues 2000).

Unfortunately, despite the fact that the threats to this ecosystem began long ago, it was only in the last two decades that the Brazilian restingas started to be given more attention and systematic studies.

Floristic studies aim at identifying the species that occur in a given geographical area. They are executed through a taxonomic study of the botanical material, and are currently recognized as one of the most important priorities for the conservation and fair use of ecosystems because they provide basic information that will subsidize the subsequent biological studies (Guedes-Bruni *et al.* 2002).

On the Southern coast, the most remarkable studies on restinga vegetation in the estuarine complex were those from Grand & Lopes (1981), Sugiyama and Mantovani (1994) and Sugiyama (1998), on Cardoso Island; Carvalhaes & Mantovani (1994), Melo *et al.* (2000) and Mamede *et al.* (2001), in Iguape; Sztutman and Rodrigues (2002), in Pariquera-Acu; Kirizawa *et al.* (1992), Carrasco (2003) and Silva (2009), on Ilha Comprida.

The restinga environment is currently protected under Brazilian law. This is because restingas are now considered Permanent Preservation Areas by the Forest Code - Federal Law 4771 of September 15th, 1965 (BRAZIL, 2007) and the CONAMA Resolution Number 303, of March 20th 2002 - and also because they belong to the Atlantic Forest biome, which is protected by several statutes (Sampaio *et al.* 2005). However, as pointed out by Araújo (1984), this narrow coastal strip tends to disappear in the immensity of the Atlantic Forest and it is necessary to draw attention specifically to the richness and diversity of coastal environments, represented by edaphic ecosystems.

The Environmental Protection Area (APA, in Portuguese) of Ilha Comprida existed even before the island became a municipality in 1991. It was created in March 1987, by the State Decree 26881, because it contains a well-balanced ecosystem, though fragile, representing an important refuge for marine species; also, it has aquatic organisms liable to cultivation; it is a barrier island, and finally, it shelters communities of fishermen who retain their cultural traditions (CEPAM 2007).

In 1989, the Protected Area was regulated by another law (Decree number 30817), and was also defined as a Special Area of Ecological Interest. A zoning was assigned, which aims at establishing the layout of the necessary measures for the disciplining of land use and activities affecting environmental integrity. The law which created the Protected Area also established a Wildlife Area, which covers a significant part of the island, to protect remnants of the restinga vegetation, wetlands and dunes (Ilha Comprida 2011).

The acknowledgment of all these aspects of the prevailing Ilha Comprida, with possible interferences, makes it a fragile ecosystem, which explains the importance of its Environmental Protection Area (CEPAM 2007).

The lack of management on barrier islands has been inferred in serious environmental damage (Ceia 2009) and despite the protective system of laws for the restinga in Brazil, the place suffers permanent injuries, especially in its more urbanized areas (construction of kiosks, parking lots, "4x4 ride-on vehicles" on the dunes and frequent deposit of garbage).

It is essential to take action of preservation against degradation since the environment on the island is extremely fragile, besides the fact that it is home to a variety of fauna and flora, which need the dunes to survive. Furthermore, due to the features of the underground vegetation system, they also serve as a natural barrier against the advance of the sea.

This study intends to conduct a survey of the vascular flora of the vegetation of beaches and dunes in two different sites of Ilha Comprida, comparing the similarities of the sampled flora with other four dune areas in the State of São Paulo, as well as the degree of degradation of the dunes, indicating the most affected regions. A map containing the locations of occurrences for the species will be dealt with, so as to provide data for future environmental recovery of the disturbed areas.

Material and methods

1. Characterization of the study area

The town of Ilha Comprida (5,000 inhabitants, according to Brazilian 2010 Census) consists of a sandy elongated island on the Southern coast of São Paulo, located between 24°41' and 25°05' South latitude and between 47°27' and 47°55' West longitude (Figure 1). It is about 72 km long and its widths range from 2 to 5 km, with altitudes of less than 7 meters. It has an area of 17, 527 hectares. The island is separated from the mainland by a lagoon, called “Mar Pequeno” and the main access to the island is through the bridge from Iguape, and via ferry-boat from Cananeia. Its main economic activities are tourism and fishing (Gandolfo *et al.* 2001, Ilha Comprida 2011).

According to the model proposed by Suguio and Martin (1978) and Suguio *et al.* (2003), Ilha Comprida has its genesis and evolution associated with variations of Quaternary sea level. The mechanisms of Holocene coastal dynamics, active throughout the coastal region of the shallow Southern coast of São Paulo, was originated by the incident wave systems. The geological formation is mainly sandy, locally worked fine by the wind, with the exception of Morrete, a hill located in the Southern portion of the island, formed by alkaline intrusive rocks (Suguio & Maartin 1978, Spinelli & Gomes 2008).

Throughout the surface of the sand, the presence of sand strands is observed, with up to 65 km long, predominantly parallel to the coastline current. These strands find themselves grouped into two distinct bands of land: an inner band, corresponding to the area closest to the current lagoon channels, and an outer band, near the ocean side. These strips of beach ridges are separated by a low-lying area, occupied by an environment of sandy-clayed sediments (Barcelos *et al.* 1976).

The climate on Ilha Comprida has been indicated according to Köeppen classification (1948), the Cfa (humid subtropical with hot summers), with relative humidity exceeding 80% and absence of a well defined dry season. Registration data from meteorological stations adjacent to Ilha Comprida (Cananeia and Iguape), acquired between 1900 and 1990, indicate an average annual rainfall of 1,611 mm (4.4 mm / day), ranging from 210 mm in the months of December through February and 41.7 mm in the months of June through August (IPCC, 1990).

The average temperature in the same period, 20.7°C per year, varies between 23.1 °C in the warmest quarter, and 17.7°C in the coldest. Records of these stations during the twentieth century suggest increasing tendency to precipitation, temperature and atmospheric pressure. The strongest winds are frequent and blow from SSE, cross the coast, favored by the regular activity of cold fronts (Giannini *et al.* 2007).

2. Methodological procedures

The physiognomy "Beaches and Dunes" was delineated using the CONAMA Resolution Number 7, June 23, 1996. This law resolution establishes the following basic parameters: dominant strata, tree diameter, distribution and height, existence, diversity and quantity of epiphytes, diversity and number of vines, presence or absence and characteristics of litter, diversity and dominance of species and indication of plant species.

The dunes of Ilha Comprida, however, are peculiar, also showing some characteristic species of the physiognomy “Vegetation on Sandy Ridges” (specifically scrub).

In order to develop the work, two sampling areas in the dunes were selected based on visual assessment of the preservation conditions as in Figure 1, and they were called:

1) AREA “A”: A Private Area with special environmental care, which belongs to the movie company “Paris Filmes do Brasil”, with its original vegetation well preserved, located on the face center-South of Ilha Comprida, on the beach of “Pedrinhas”, with about 1.13 km², between 24°54'05,3"S to 24°54'46,9 "S and 47°45'32,3"W to 47°46'23,2"W.

2) AREA “B”: under strong anthropogenic pressure, about 14.44 km², in the north of the island, located between the beaches “Terraça” and “Saveiros”, between 24°42'03,1"S to 24°46'23,5"S and 47°27'45, 4"W to 47°35'16,6"W.

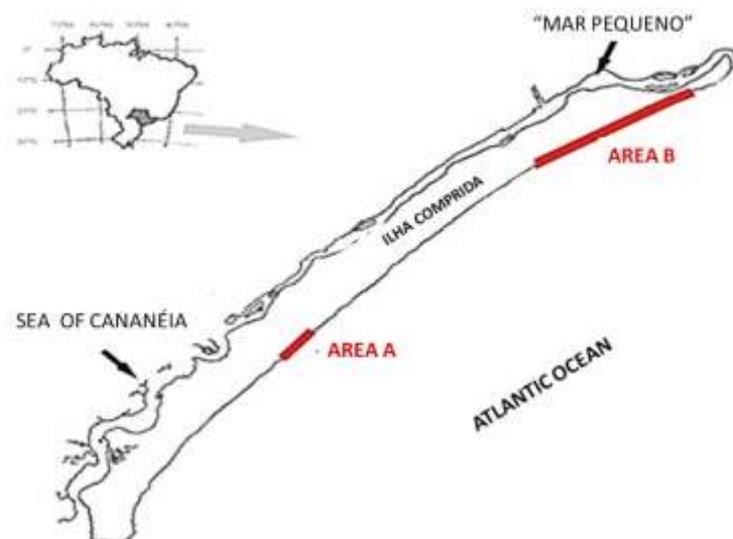


Figure 1: Map of Ilha Comprida, Southern part of Brazil, and the study areas A and B.

2.1. Floristic

Plant material was collected monthly during six expeditions, by hiking along the dunes randomly selected. After the species identification, the vouchers were deposited in the Herbarium of the Universidade Santa Cecília (HUSC), in the city of Santos, in São Paulo State.

Scientific names were checked according to the Missouri Botanical Garden's (2012) and the International Plant Names Index (2007). Abbreviation of the authors' names followed Brummitt and Powell (1992) and Pichi-Sermolli (1996).

The taxa were arranged in alphabetical order by family, genus and species, following the classification system APG III (2009) for angiosperms and Tryon & Tryon (1982) for ferns.

2.2. Degree of degradation of the dunes

The human impacts on the areas were observed and recorded during the field surveys conducted in 2007 and during two incursions in the areas in 2012.

To check the degree of degradation of areas A and B, a comparison was made between them, connecting the human impacts on the beaches and dunes to the plant species found.

Among the species identified, the percentage of native and invasive plants were determined (concepts have been adapted from Thomaz & Monteiro (1992) and Ferri *et al.* (1981), respectively).

2.3. Floristic similarity

To compare the floristic similarity of the study to other areas of São Paulo State, the Sørensen index (Müeller-Dombois & Ellenberg 1974) was used. The selected papers have undergone a very careful review regarding the synonyms found so that no mistake could be made in the comparison of the species in common. To make the comparison between sites, only the vegetation of beaches and dunes of the selected papers were considered.

Results

During the floristic survey carried out in the two sections of dunes on Ilha Comprida, 75 species of vascular plants, distributed in 61 genera and 31 families, were identified (Table 1). The pteridophytes had two genera, two families and two species; the angiosperms were represented by 59 genera, 29 families and 73 species.

Table 1 - List of taxa found on beaches and dunes of Ilha Comprida-SP, Brazil.

Family/Species	Family/Species	Family/Species
PTERIDOPHYTES	CYPERACEAE (cont.)	POACEAE
BLECHNACEAE	<i>Pycreus lanceolatus</i> (Poir.) C.B.Clarke.	<i>Andropogon leucostachyus</i> Kunth
<i>Blechnum serrulatum</i> Rich.	<i>Pycreus polystachyos</i> (Rottb.) P.Beauv.	<i>Andropogon selloanus</i> (Hack.) Hack.
DRYOPTERIDACEAE	<i>Cyperus rotundus</i> L.	<i>Cenchrus echinatus</i> L.
<i>Rumohra adiantiformis</i> (G. Forst.) Ching	<i>Eleocharis geniculata</i> (L.) Roem. & Schult.	<i>Eustachys retusa</i> (Lag.) Kunth.
ANGIOSPERMAE	<i>Fimbristylis quinquangularis</i> (Vahl) Kunth.	<i>Eragrostis pilosa</i> (L.) P. Beauv.
AMARANTHACEAE	<i>Rhynchospora</i> sp.	<i>Imperata brasiliensis</i> Trin.
<i>Blutaparon portulacoides</i> (A. St.-Hil.) Mears	DILLENIACEAE	<i>Paspalum densum</i> Poir.
ANACARDIACEAE	<i>Davilla rugosa</i> Poir.	<i>Paspalum maritimum</i> Trin.
<i>Schinus terenbinthifolius</i> Raddi	EUPHORBIACEAE	<i>Paspalum vaginatum</i> Sw.
<i>Bromelia antiacantha</i> Bertol.	<i>Microstachys corniculata</i> (Vahl) Griseb.	<i>Paspalum virgatum</i> L.
<i>Dyckia encholirioides</i> (Gaudich.) Mez	FABACEAE	<i>Spartina ciliata</i> Brongn.
<i>Quesnelia arvensis</i> (Vell.) Mez	<i>Abarema brachystachya</i> (DC.) Barneby & J.W. Grimes	<i>Stenotaphrum secundatum</i> (Walter) Kuntze
ANACARDIACEAE	<i>Chamaecrista flexuosa</i> (L.) Greene	Poaceae sp.1
<i>Schinus terenbinthifolius</i> Raddi	<i>Dalbergia ecastaphyllum</i> (L.) Taub.	Poaceae sp.2
BROMELIACEAE	<i>Desmodium adscendens</i> (Sw.) DC.	PRIMULACEAE
<i>Bromelia antiacantha</i> Bertol.	<i>Desmodium</i> cf. <i>barbatum</i> (L.) Benth.	<i>Rapanea parvifolia</i> (A. DC.) Mez
<i>Dyckia encholirioides</i> (Gaudich.) Mez	<i>Sophora tomentosa</i> L.	POLYGALACEAE
<i>Quesnelia arvensis</i> (Vell.) Mez		<i>Polygala cyparissias</i> A. St.-Hil. & Moq.
CACTACEAE	LAMIACEAE	RUBIACEAE
<i>Cereus repandus</i> (L.) Mill.	<i>Marsypianthes chamaedrys</i> (Vahl) Kuntze	<i>Spermacoce alata</i> Aubl.
CALYCERACEAE	MELASTOMATACEAE	<i>Diodella radula</i> (Willd. & Hoffmanns. ex Roem. & Schult.) Delprete
<i>Acicarpa spathulata</i> R. Br.	<i>Tibouchina clavata</i> (Pers.) Wurdack	SMILACACEAE
CLUSIACEAE	MYRTACEAE	<i>Smilax rufescens</i> Griseb.
<i>Clusia criuva</i> Cambess.	<i>Psidium cattleianum</i> Afzel ex Sabine	VERBENACEAE
CONVOLVULACEAE	NYCTAGINACEAE	<i>Lantana undulata</i> Schrank
<i>Evolvulus pusillus</i> Choisy	<i>Guapira opposita</i> (Vell.) Reitz	SMILACACEAE
<i>Ipomoea cairica</i> (L.) Sweet	ORCHIDACEAE	<i>Smilax rufescens</i> Griseb.
<i>Ipomoea littoralis</i> (L.) Blume	<i>Cyrtopodium flavum</i> (Nees) Link & Otto ex Rchb.	VERBENACEAE
<i>Ipomoea pes-caprae</i> Roth	<i>Epidendrum fulgens</i> Brongn.	<i>Lantana undulata</i> Schrank
CYPERACEAE	<i>Vanilla chamissonis</i> Klotzsch	
<i>Androtrichum trigynum</i> (Spreng.) H.Pfeiff.	PLANTAGINACEAE	
<i>Cladium mariscus</i> (L.) Pohl	<i>Plantago catharinae</i> Decne.	

Figure 2 shows the five most abundant families in terms of individual numbers. Poaceae was the richest, with 14 species (18.67%), followed by Asteraceae, with 11 species (14.67%). Cyperaceae had 8 species (10.67%); Fabaceae had 7 species (9.33%); and Convolvulaceae had 4 species (5.33%).

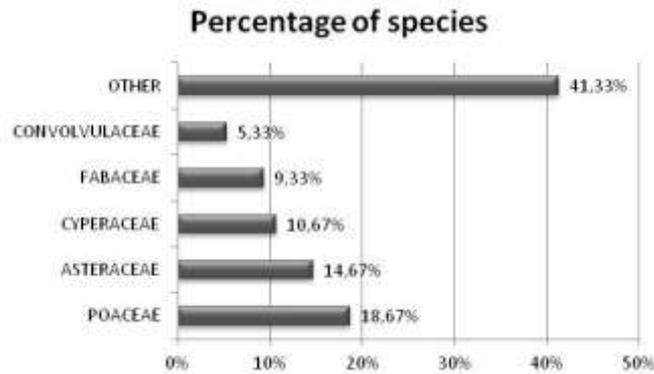


Figure 2: Percentage of vegetal groups with higher species richness in the dunes of Ilha Comprida-SP

Figure 3 shows the most common habits of living of the restinga plants.

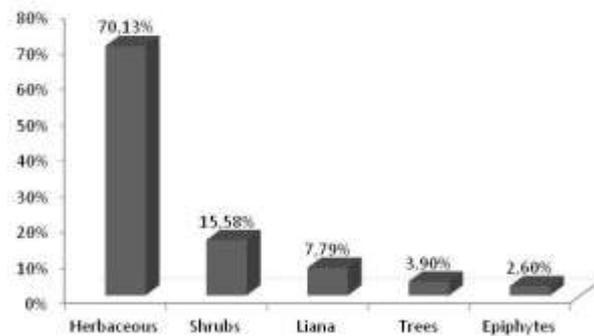


Figure 3: Percentage of species sampled for the habit of living in the dunes of Ilha Comprida - SP.

The area that is well preserved (Area A) showed 74.07% native plants to 25.93% invasive, while the area with strong anthropogenic disturbance (Area B) had 51.22% native plants and 48.78% invasive (Figure 4).

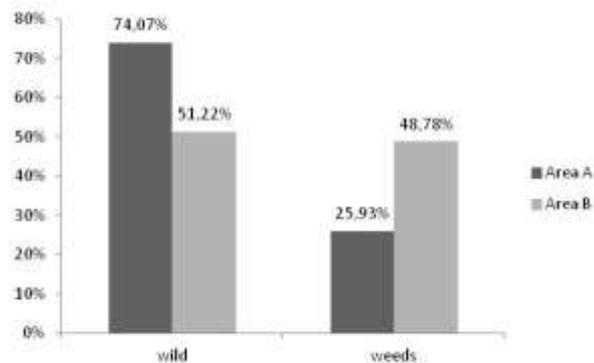


Figure 4: Percentage of native species and invasive in areas A and B.

The Sørensen similarity index was used in order to compare the study areas A and B with four other areas of restinga vegetation in São Paulo State: Ubatuba, Bertioga, Peruíbe and the Jureia-Itatins Ecological Station, as shown in Figure 5. The greatest floristic similarity to the study site was presented by the beach of Guaraú, in Peruíbe (37.84%), followed by the Jureia-Itatins Ecological Station (35.19%), and the beach of Itaguapé, in Bertioga (33.17%). The lowest similarity observed was related to the area of Ubatuba (12.31%) (Table 2).



Figure 5: Location of floristic surveys used to compare the restinga vegetation using the Sørensen similarity index.

Table 2: Percentage of floristic similarity using Sørensen index, comparing different dunes of São Paulo.

	Ubatuba ⁽²⁾	Bertioga ⁽³⁾	Peruíbe ⁽⁴⁾	E.E. Jureia-Itatins ⁽⁵⁾
Ilha Comprida ⁽¹⁾	12.31	33.17	37.84	35.19
Ubatuba ⁽²⁾	-	20.82	10.34	14.44
Bertioga ⁽³⁾		-	14.05	32.45
Peruíbe ⁽⁴⁾			-	34.69

Legends: Table 2: 1 - Present study; 2 - Assis (1999); 3 - Martins *et al.* (2008); 4 - Mirage (2006); 5 - Souza & Capellari Jr. (2004).

Discussion

1. Floristic survey

The results of this study were similar to those presented by Souza and Capellari Jr. (2004) on the beaches of the Jureia-Itatins Ecological Station. They detected as the most important families: Asteraceae (10.49%), Fabaceae (10.49%), Cyperaceae (5.59%) and Poaceae (4.20%), the same four richest families that occur in the dunes of the present study. Still, for the same place, Mirage (2006) pointed Asteraceae (12.33%), Poaceae (10.96%) Cyperaceae and Fabaceae (both with 6.85% of the species). In Peró beach (Rio de Janeiro State), Cordeiro (2005) found Poaceae (21.43%), Asteraceae (14.29%), Convolvulaceae (7.14%) and Amaranthaceae (7.14%). In Jericoacoara (Ceara State), Matias and Nunes (2001) found Poaceae (12.64%) and Cyperaceae (12.64%) as the most important families.

In this floristic study, the beach grasses (Poaceae and Cyperaceae) had great prominence. These families can apparently promote the trapping of eolian sand and develop the foredunes as well as reduce the competence of aeolian transport near the surface of the beach (Kuriyama *et al.* 2005). Their role is crucial for the initial stabilization of the foredunes which, through interaction with environmental factors such as winds and sediment, eventually evolve into more established forms, accompanied by higher density and diversity of plants (Beserra-Neta 1995).

The family Orchidaceae shows an ornamental potential, with some species teetering on the brink of extinction due to extraction, which comes to move fortunes every year, thereby

increasing their exploitation. In the study areas two species of terrestrial orchids were found - *Cyrtopodium polyphyllum* and *Epidendrum fulgens*, besides one epiphyte - *Vanilla chamissonis*, which are typical of open areas.

According to Menezes & Araujo (1999), the coastal flora presents a certain degree of similarity, which is supported by the presence of *Blutaparon portulacoides*, *Cenchrus echinatus* and *Polygala cyparissias* on Ilha Comprida (present study), Jericoacoara (CE) (Matias & Nunes 2001), Praia do Pero (RJ) (Lamb 2005) and Abaeté (BA) (Britto *et al.* 1993).

The presence of *Ipomoea pes-caprae* and *Stenotaphrum secundatum* in the frontal dunes, where there is low concentration of nutrients and reduced water content (Ormond *et al.* 1970), indicates high ability to adapt to prevailing environmental factors, such as the constant action of the sea spray. These species and the four ones of the genus *Paspalum*, also found in the study areas, are considered important for stabilizing dunes, protecting them from the activities triggered by the erosive action of wind and rain (Beserra-Neta 1995). In Area A, there was the occurrence of *Plantago catharinea*, which is cited as vulnerable in the list of endangered species of São Paulo (SMA 2004).

When the soil conditions become more suitable, the plant community gradually goes from herbaceous to shrub species, and these two communities may overlap (Menezes & Araujo 1999). In the context of the soil profile of Ilha Comprida, there is the erosive contact of sedimentary sequences formed during the Pleistocene and the Holocene clay layers, also rich in organic matter deposited in the valleys between two adjacent sand ridges (Gandolfo *et al.* 2001), thus forming a peculiar woody vegetation of approximately 6 meters high filling the hollows between the dunes.

The habit (life form) that prevailed in the dunes of Ilha Comprida was the herbaceous, with 54 species (70.13%), followed by shrubs, with 12 species (15.58%), and the vines, with 6 species (7.79%). The trees, an unusual occurrence in this physiognomy, presented three species (3.90%) and the epiphytes accounted for 2.60%, with two species (Figure 3). *Quesnelia arvensis* (Bromeliaceae) and *Microstachys corniculata* (Euphorbiaceae) showed two different life forms in the study areas.

The herbaceous form of life was also prevalent in Jericoacoara, representing 60.92% of the species (Matias & Nunes 2001) and on the Guaraú beach (Peruíbe, São Paulo State), with 42.47% (Mirage 2006).

The results confirm previous data, according to which large parts of the beaches and dunes along the Brazilian coast are covered by halophyte herbaceous vegetation, with some shrub species related to unstable ground, and covered by recent pioneer vegetation (Araujo 2000).

Within this context, it is critical to understand the spatial and temporal dynamics of the vegetation on dunes, in front of coastal ecosystems under high anthropogenic pressure.

The peculiarities of these environments promote a wide variety of forms and adaptations in the vegetation, so that they can survive and stay in these ecosystems. The action of marine waters and winds, soil conditions and topography of the land are a hallmark of coastal regions (Romariz 1996). These factors, associated with the type and density of vegetation and changes in sea level can promote changes in the morphology of coastal dunes (Carter 1995).

2. Environmental Degradation Level of the dunes

The observed anthropic actions on the dunes were:

Area A: a kiosk built, garbage dumped along the dunes and presence of the exotic *Terminalia Catappa* L. (Combretaceae, from Asia and the subtropical and tropical areas of the Pacific and Indian Oceans) and the allopathic *Casuarina equisetifolia* L., (Casuarinaceae, from Australia, Malaysia, Polynesia and parts of Africa).

Area B: Soccer field, Motocross track, many kiosks, the Fire Department building, public parks on the dunes, amusement park on the sand, pumping station of the Basic Sanitation Company of São Paulo (SABESP), many beach access trails, public restrooms and a lot of garbage dumped along the dunes, planting of exotic species such as the allopathics *Casuarina equisetifolia* L. and *Pinus elliottii* Engel.

The presence of exotic species is of particular concern, especially the allelopathic ones. According to Versfelde & Van Wilgen (1986), groups of pine trees which are not managed tend to become homogeneous stands. Areas where *Casuarina equisetifolia* is present tend to have lower native plants species than areas where it does not occur, which suggests an inhibition of growth of native plants due to the invasion of exotic ones (Hardman 2012). The restinga vegetation on beaches and dunes or low restinga is especially susceptible to biological invasion, since open habitats tend to be more easily invaded by tree species than forested areas. The more reduced the natural diversity, along with richness and life forms, the more susceptible to invasion the environment becomes, because some ecological functions are not met and could be filled by exotic species (Ziller 2006).

This research shows a significant change in terms of floristic composition between the well preserved area and the one under strong anthropogenic impact on Ilha Comprida. The results support the idea advocated by Rickard *et al.* (1994), whereby rapid urban development leads to changes in species richness or floristic composition on coastal ecosystems. Indeed, the recognition of the situation of degradation together with conservation efforts towards these ecosystems must be supported by studies that should go beyond mere qualitative temporal analysis. Studies should be performed involving quantitative analysis as well as structural changes in the community.

With the absence of some plant species, biodiversity is compromised. A practical example is the small number of specimens of *Clusia criuva* Cambess and *Psidium cattleianum* Afzel ex Sabine, in area B. According to Serafini *et al.* (2011), these plants are important constituents in the diet of the purple-faced parrot (*Amazona brasiliensis*), an endangered species which is currently restricted to the Southeastern coast of São Paulo.

According to Brazilian law, in an environmental protected area such as Ilha Comprida, earthmoving activities like mining, dredging and excavation are not allowed, since they may cause damage or degradation to the environment and danger to people or biota. Such activities must be kept far apart at a minimum radius of 1,000 meters around from caves, rapids, waterfalls, natural monuments, geological evidence and other similar situations, depending on the prior approval of environmental impact studies and special licensing issued by the management entity of the environmental protected area (CONAMA 2007). Nevertheless, many irregular constructions can be observed on the dunes, showing the urgent need of assessment of the current situation by the competent authorities.

3. Floristic similarity

The floristic similarities amongst Ilha Comprida and the Guaraú beach in Peruíbe and the beaches of the Jureia-Itatins Ecological Station can be explained by the proximity of the areas and the climate, which is much alike in these places. The average temperature on Ilha Comprida was 20.7 °C, with average annual rainfall of 1,611 mm. The average temperature in the Jureia-Itatins Ecological Station was 21.5 °C, with average annual rainfall of 1,800 mm (Tarifa 2004). It must be stated that the analysis of similarities among the areas had to be carried out with extreme caution, due to the extent of coverage of the samplings and the timing of each work.

The lowest similarity occurred in relation to Ubatuba, which may be explained in part because of the heterogeneity of the restinga forests along the Brazilian Coast, but also because of latitude differences (i.e. relatively more tropical than the other three sites).

Conclusions

The herbaceous habit predominated amongst the sampled species (70.13%). Poaceae was the family with the highest number of species in the survey (18.67%). The genus *Paspalum* (Poaceae), with four different species, was the most representative (6.56%), and played an important role concerning dune stabilization.

The presence of an endangered species in Sao Paulo State (*Plantago catharinea*) in area A should support further studies on the recovery of the dunes, along with government actions to improve environmental protection. After the floristic composition checked in areas A and B, new stages of studies are proposed, such as floristic surveys and a quantitative analysis of the

remaining beaches and dunes of the island, since it is 72 km long. Thus, the present study becomes relevant for the scientific community and environmental agencies, which in turn should present proposals for the preservation and restoration of the vegetation of the beaches and dunes of Ilha Comprida.

Area B, although heavily disturbed, may still be restored, since the kiosks, soccer fields, and amusement parks can be removed. Besides, law violations should be identified and fined, in order to prevent further occupations.

This is really urgent, because the apparent stability between the number of native and invasive species on the coastal ecosystem can cause a false impression that, independent of human activities, vegetation will keep playing its role of setting and stabilizing the dunes, as efficiently as it always did in the past.

In general, the areas with great floristic similarities were Peruíbe - Guaraú beach - and the beaches of the Jureia-Itatins Ecological Station. The restinga of Ubatuba showed very low similarity to the study site, presumably due to the different geographical position of both areas.

It should be noticed that, amongst the areas compared, Ilha Comprida and the beach of Guaraú were the most endangered ecosystems due to rapid urban growth. Bertioiga, specifically the beach of Itaguapé, became a Park in 2010. Thus, it has been protected from real estate development.

This paper strongly reinforces the necessity of preserving the dunes and sandbanks of the State of São Paulo, since its floristic composition is extremely complex in several patchy areas which contain rare species. Besides, it bears just a few species with broad distribution.

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