

# FLORISTIC INVENTORY OF AN ESTUARINE AREA IN NORTHEASTERN BRAZIL (PONTA DO TUBARÃO SUSTAINABLE DEVELOPMENT RESERVE)

MARCOS MEDEIROS CAVALCANTI-JÚNIOR,<sup>1</sup> JACICLEIDE MACEDO OLIVEIRA,<sup>1</sup>  
ANNYELLE KELLY DA SILVA COSTA,<sup>1</sup> CARLINDA RAILLY FERREIRA MENDONÇA,<sup>1</sup>  
CAROLINE STEFANI DA SILVA LIMA,<sup>1</sup> MAXCIELL RICARDO AZEVEDO DA SILVA,<sup>1</sup>  
RAFAELA SANTOS DIAS GOUVEIA,<sup>1</sup> THELMA LÚCIA PEREIRA DIAS,<sup>1</sup>  
JOSELINE MOLOZZI,<sup>1</sup> SABRINA SOARES FIGUEIREDO,<sup>1</sup> LAMARCK ROCHA,<sup>2</sup>  
RAMIRO GUSTAVO VALERA CAMACHO,<sup>3</sup> AND JOSÉ IRANILDO MIRANDA DE MELO<sup>1,4</sup>

**Abstract.** We examined the floristic composition and similarity of the Ponta do Tubarão Reserve of Sustainable Development, Diogo Lopes District, Macau, Rio Grande do Norte State, Brazil. During the Field Course of Ecology I and II of the Postgraduate Program in Ecology and Conservation of the State University of Paraíba (PPGEC-UEPB), herbarium collections of fertile specimens were made in the four recognized phytophysionomies of the area; Caatinga, Dunes, Islands, and Mangrove. Our results were complemented by data from the speciesLink network. A total of 140 species, belonging to 102 genera and 47 families, were collected and identified. Four of the species are new records for the state of Rio Grande do Norte: *Calliandra depauperata* Benth., *Calliandra spinosa* Ducke and *Bauhinia dubia* G. Don (Fabaceae), which is also a new record for the Caatinga vegetation area, and *Schultesia doniana* Progel (Gentianaceae). Fabaceae was the most represented family with 23 species. Similarity analyses indicated three distinct vegetation groups, composed of the combined Dunes and Mangrove areas, the Island area, and the Caatinga area.

**Keywords:** Semiárida flora; Northeastern Brazil; Conservation Units.

Vegetation represents one of the world's most important natural resources, providing food and shelter for humans and other organisms and preventing soil erosion, among other things. Studies that can aid in its management and preservation are critical, including descriptions of vegetation types and analyses of local floristic compositions (Pescott and Stewart, 2014).

The Caatinga ecoregion of Brazil is the largest nucleus of seasonally dry tropical forests and woodlands biome (SDTFW, *sensu* Queiroz et al., 2017). It predominates in all northeastern states, including portions of Minas Gerais. This ecoregion is home to a heterogeneous variety of vegetation types, but frequently has low rainfall rates and extended dry periods, resulting in leafless vegetation cover for much of the year (e.g., Moro et al., 2014, 2015; Queiroz et al., 2017; Fernandes et al., 2020).

The entire area occupied by Caatinga vegetation has experienced some degree of anthropogenic modification due to agricultural and pastoral uses, and 30–50% of the biome is considered to have been extremely impacted (Castelletti, 2003). The anthropogenic alterations of the Caatinga region are mainly related to the substitution of native species with cultivated crops and non-native grasses,

deforestation, burning for agro-pastoral uses, and the direct use and consumption of native plant resources (MMA, 2002). However, recent studies reveal an extraordinary richness, with 3,347 recorded species, of which 526 are endemic (Fernandes et al., 2020).

The Caatinga is currently the most threatened Brazilian biome, with only 1.3% of its total area under some form of legal protection, including 16 federal and seven state-level conservation areas (Silva et al., 2004; Leal et al., 2005a, b; Teixeira et al., 2021). These conservation areas are typically fairly old, and their administration is often driven by economic aspects distinct to each locality, with larger considerations of environmental protection often ignored. Nonetheless, these areas are extremely important, not only for the preservation of the biological heritage of the nation, but also for scientific research (e.g., Camphora and May, 2006).

The Ponta do Tubarão Sustainable Development Reserve (PTSDR) is located between the municipalities of Macau and Guararé on the northern coast of Rio Grande do Norte State, Northeast Brazil. Artisanal fishing provides the economic basis of the region. PTSDR covers an area of more than 12,000 ha, and includes Caatinga vegetation, mangrove swamps, sand dunes, restinga (sandy coastal

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<sup>1</sup> Programa de Pós-Graduação em Ecologia e Conservação, Complexo Três Marias, Universidade Estadual da Paraíba, 58429-500 Campina Grande, Paraíba, Brazil.

<sup>2</sup> Instituto Nacional do Semiárido, 58434-700 Campina Grande, Paraíba, Brazil.

<sup>3</sup> Departamento de Ciências Biológicas, Faculdade de Ciências Exatas e Naturais, Universidade do Estado do Rio Grande do Norte, 59610-090, Mossoró, Rio Grande do Norte, Brazil.

<sup>4</sup> Corresponding author: [tournafort@gmail.com](mailto:tournafort@gmail.com)

vegetation), oceanfront cliffs, and beaches. The reserve was created in 2003 and was the first Sustainable Development Reserve in Rio Grande do Norte State (Cunha, 2006). Despite its phytophysiognomic richness, the knowledge of the species that comprise the different vegetation formations is still limited.

We performed a floristic survey of the plant formations of

the Reserve, that we found to harbor almost 100 species of flowering plants. Additionally, we assessed the composition of plant formations with a similarity analysis. These surveys are especially relevant in Sustainable Development Reserves, and, in parallel with species compilations, they can support policies for the sustainable use and management of local flora (e.g., Mattos et al., 2011).

#### MATERIALS AND METHODS

##### *Study area*

Ponta do Tubarão Sustainable Development Reserve (5°05'37"S, 36°32'21"W), is located in Diogo Lopes district, Macau municipality, northern coast of Rio Grande do Norte State, Brazil (Fig. 1). The regional rainy season lasts 3 to 4 months, usually occurring from February to May, with the greatest rainfall rates between March and May. The dry period generally extends for 8 to 9 months, from June to

January (INMET, 2012–2013). These factors characterize a semiarid climate with evapotranspiration rates greater than the annual precipitation (IDEMA, 2004). The reserve is located at the estuary of the Tubarão River, which is bordered by mangrove vegetation, and includes Caatinga, restinga, moving and fixed dune fields, and ocean-front cliffs (Dias, 2006), characterizing different phytophysiognomies (Fig. 2).

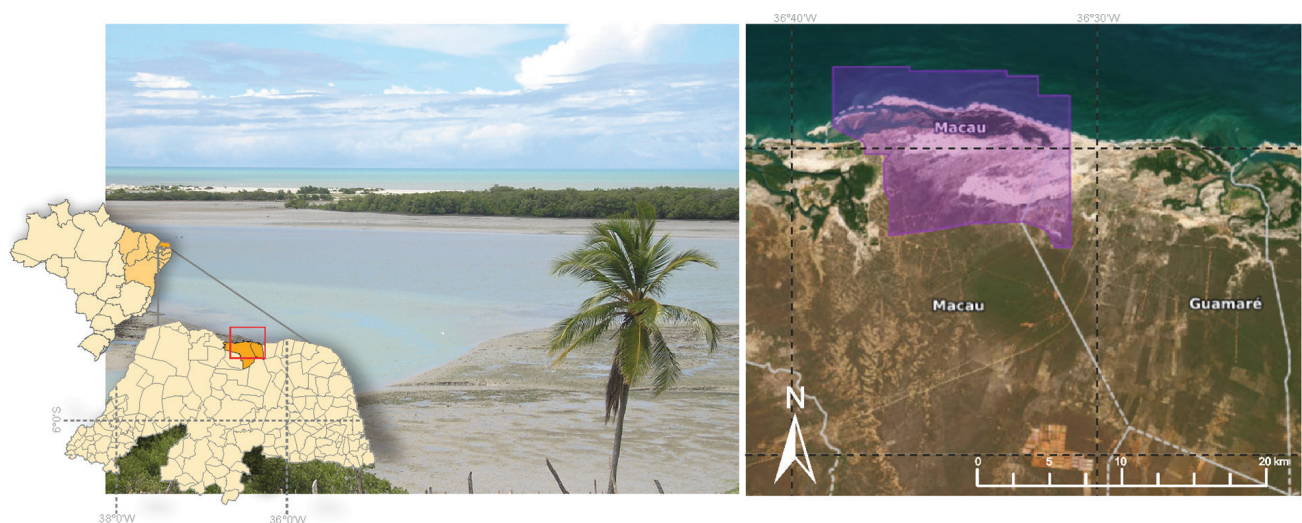


FIGURE 1. Map indicating the location of the Ponta do Tubarão Sustainable Development Reserve (PTSDR) study area, in the district of Diogo Lopes, municipality of Macau, Rio Grande do Norte State, Brazil. Photographs by R.G.V. Camacho.



FIGURE 2. The phytophysiognomies of the study areas. A, Caatinga; B, Dunes; C, Mangrove. Photographs: J. M. Oliveira and T. L. P. Dias.

### Sampling techniques and floristic composition

The characterization of the floristic composition of the PTSDR was undertaken mostly during the Field Course of Ecology I and II of the Postgraduate Program in Ecology and Conservation at the State University of Paraíba (PPGEC-UEPB) in May 2015 through botanical collections in four formations within the reserve: Caatinga, island, mangrove, and dune vegetation. Random but massive collections were performed in each environment, where we collected at least five specimens of each fertile species found (with flowers and/or fruits). Our results were complemented by data from the speciesLink network. Taxonomic identifications were based on specialized literature, comparisons with online

herbaria collections (e.g., Flora e Funga do Brasil, 2022) and by specialists in each taxonomic group. The checklist was based on classifications from the Angiosperm Phylogeny Group (APG) IV (2016).

### Similarity analyses

To evaluate the similarities of the floristic compositions of the different phytophysiognomies, a presence/absence binary matrix based exclusively on the species encountered in the study area was prepared using Microsoft's EXCEL software. Clustering was determined based on the Jaccard similarity index using PRIMER 6 (Clarke and Gorley, 2006) and PERMANOVA (McArdle and Anderson, 2001) software.

## RESULTS AND DISCUSSION

### Characterization of the vegetation

The predominant vegetation type in the PTSDR was hyperxerophilic Caatinga, composed of low to medium sized plants. Halophyte vegetation is found in lowland areas bordering watercourses where salt water penetrates during high tides. Restinga vegetation develops on near-shore sand dunes and sandy plains (and is protected by Federal legislation identifying those areas as permanent preservation sites). Coastal mangrove vegetation is dominated by plant species adapted to soils that are flooded by salt water during high tides, with large internal variations in salinity. In general, the PTSDR comprises lowland and periodically flooded tidal plains, and dune, mangrove, and Caatinga vegetation (the latter being found inland). Fixed and mobile sand dunes surround the entire central-southern area of the reserve.

### Floristic richness

A total of 140 species belonging to 102 genera and 47 families of Angiosperms (APG IV) were recorded during the survey (Table 1; Fig. 3). Of this total, 86% of the species (120) were identified to the species level. Of the 16% (22 species) not identified to the species level, 14% (20) were identified to the genus level, while 1.4% (2) remain unidentified. The families Fabaceae (23 spp.), Euphorbiaceae (13 spp.), Malvaceae (10 spp.), Convolvulaceae (9 spp.), Poaceae (7 spp.), Rubiaceae (6 spp.), and Amaranthaceae (5 spp.) comprised 52% of all the species encountered in the study area. In the other families, four were represented by three species each, six contained two species each, and 26 families were represented by only a single species; 118 genera were represented by a single species. Four species are new records for the state of Rio Grande do Norte: *Calliandra depauperata* Benth., *Calliandra spinosa* Ducke and *Bauhinia dubia* G. Don (Fabaceae), and *Schultesia doniana* Progel (Gentianaceae). *B. dubia* G. Don is also a new record for the Caatinga vegetation area.

Caatinga vegetation contains the greatest species richness (66%), with 93 species, while island formations comprise 23% of the total number of species (33), dune areas comprise 24 species (19%), and mangrove areas contain 4 species

(3%). Dune and Caatinga vegetations have seven species in common (5%); the islands and Caatinga vegetations also share seven species (5%). Considering only the Caatinga areas sampled in the present study, the numbers of families encountered there (47) was greater than those encountered in other Caatinga vegetation areas (e.g., Andrade et al., 2005; Cabral et al., 2013; Lucena et al., 2015). The predominance of species of Fabaceae is consistent with the results of other floristic surveys undertaken in other semiarid areas in Brazil, where the family typically has the highest number of species, including many woody representatives (e.g., Andrade et al., 2005; Oliveira et al., 2009; Cabral et al., 2013; Oliveira et al., 2013; Calixto-Júnior and Drumond, 2014; Apagaua et al., 2014).

Mangrove species collected along the margins of the islands (*Avicennia schaueriana* Stapf & Leechm. ex Moldenke, *Conocarpus erectus* L., *Laguncularia racemosa* (L.) C.F. Gaertn., and *Rhizophora mangle* L.) were also reported by Costa et al. (2014) in the estuary of the Apodi-Mossoró River in Rio Grande do Norte State.

In dune vegetation, the best-represented families were Convolvulaceae, Rubiaceae, and Euphorbiaceae. Of these three families, only Euphorbiaceae is represented in floristic surveys undertaken in other areas of dune vegetation in the state of Rio Grande do Norte (Freire 1990), in addition to species of Poaceae, Myrtaceae, and Asteraceae.

### Floristic similarity

Similarity analyses (Fig. 4) indicated the formation of three distinct groups: (1) dune and mangrove vegetation, with 83% similarity; (2) the islands, with 60% similarity; and (3) Caatinga, with 20% similarity. The quantitative floristic similarity analyses of the sampled areas pointed to clear differences between the four phytophysiognomies in the study area. The dune and mangrove combined group may be related to a sampling bias, since the fewest numbers of species were collected in these areas. Environmental pressures specific to the dune and mangrove areas may prevent the establishment of larger numbers of successful species compared to the other two phytophysiognomies that were sampled (e.g., Costa, 2001).

TABLE 1. Floristic list of the study area in the Ponta do Tubarão Sustainable Development Reserve (PTSDR), in the district of Diogo Lopes, municipality of Macau, Rio Grande do Norte State, Brazil.

FAMILY	SPECIES	VEGETATION FORMATION
1-Acanthaceae	<i>Avicennia schaueriana</i> Stapf & Leechm. ex Moldenke	Mangrove
2-Aizoaceae	<i>Sesuvium portulacastrum</i> (L.) L.	Island
3-Amaranthaceae	<i>Alternanthera brasiliana</i> (L.) Kuntze <i>Blutaparon portulacoides</i> (A. St.-Hil.) Mears <i>Froelichia humboldtiana</i> Seubert <i>Pfaffia gnaphalioides</i> (L.) Mart. <i>Pfaffia</i> sp.	Dunes Island Caatinga Island Island, Caatinga
4-Anacardiaceae	<i>Spondias lutea</i> L.	Island
5-Apocynaceae	<i>Allamanda blanchetii</i> A.DC. <i>Aspidosperma pyrifolium</i> Mart. <i>Calotropis procera</i> (Aiton) W.T. Aiton <i>Ibatia</i> cf. <i>ganglinosa</i> (Vell.) Morillo	Caatinga Caatinga Dunes Island
6-Arecaceae	<i>Copernicia prunifera</i> (Mill.) H.E.Moore	Dunes
7-Asteraceae	<i>Blainvillea acmella</i> (L.) Philipson <i>Delilia biflora</i> Kuntze <i>Emilia sonchifolia</i> (L.) DC. <i>Pectis linifolia</i> L.	Caatinga Caatinga Caatinga Island, Caatinga
8-Bataceae	<i>Batis maritima</i> L.	Dunes, Island
9-Boraginaceae	<i>Euploca polyphylla</i> (Lehm.) J.I.M. Melo & Semir <i>Myriopus salzmannii</i> (DC.) Diane & Hilger	Dunes, Caatinga Caatinga
10-Bromeliaceae	Indet.	Caatinga
11-Burseraceae	<i>Commiphora leptophloeos</i> (Mart.) J.B. Gillet	Caatinga
12-Cactaceae	<i>Cereus jamacaru</i> DC. <i>Melocactus</i> sp. <i>Tacinga inamoena</i> Taylor <i>Xiquexique gounellei</i> (F.A.C. Weber ex K. Schum.) Lavour & Calvente	Island, Caatinga Caatinga Caatinga Caatinga
13-Capparaceae	<i>Cynophalla flexuosa</i> J. Presl	Island
14-Celastraceae	<i>Monteverdia rigida</i> (Mart.) Biral	Island
15-Cleomaceae	<i>Tarenaya longicarpa</i> Soares-Neto & Roalson	Caatinga
16-Combretaceae	<i>Combretum lanceolatum</i> Pohl ex Eickl. <i>Combretum leprosum</i> Mart. <i>Conocarpus erectus</i> L. <i>Laguncularia racemosa</i> C. F. Gaertn.	Caatinga Caatinga Mangrove Mangrove
17-Commelinaceae	<i>Commelina erecta</i> L. <i>Commelina obliqua</i> Vahl <i>Commelina</i> sp.	Island Island Island
18-Convolvulaceae	<i>Distimake aegyptius</i> (L.) A.R. Simões & Staples <i>Evolvulus sericeus</i> Sw. <i>Ipomoea asarifolia</i> Roem. & Schult. <i>Ipomoea incarnata</i> Choisy <i>Ipomoea longiracemosa</i> Choisy <i>Ipomoea</i> sp. <i>Jacquemontia confusa</i> Meisn. <i>Jacquemontia evolvuloides</i> Meisn. <i>Jacquemontia glaucescens</i> Choisy	Caatinga Caatinga Dunes Caatinga Caatinga Dunes Dunes Caatinga Caatinga

TABLE 1 CONT. Floristic list of the study area in the Ponta do Tubarão Sustainable Development Reserve (PTSDR), in the district of Diogo Lopes, municipality of Macau, Rio Grande do Norte State, Brazil.

FAMILY	SPECIES	VEGETATION FORMATION
19-Cyperaceae	<i>Bulbostylis</i> sp. <i>Cyperus crassipes</i> Vahl <i>Cyperus ligularis</i> L. <i>Eleocharis filiculmis</i> Kunth	Dunes Island Caatinga Dunes
20-Erythroxylaceae	<i>Erythroxylum pyan</i> Costa-Lima	Caatinga
21-Euphorbiaceae	<i>Bernardia sidoides</i> (Klotzsch) Müll. Arg. <i>Chamaesyce</i> sp. <i>Cnidoscopus urens</i> (L.) Arthur <i>Cnidoscopus quercifolius</i> Pohl ex Baill. <i>Croton blanchetianus</i> Baill. <i>Croton heliotropifolius</i> Kunth <i>Croton pedicellatus</i> Kunth <i>Jatropha curcas</i> L. <i>Jatropha gossypifolia</i> L. <i>Jatropha mollissima</i> (Pohl) Baill. <i>Jatropha mutabilis</i> Baill. <i>Jatropha ribifolia</i> (Pohl) Baill. <i>Manihot pseudoglaziovii</i> Pax & K. Hoffm.	Dunes, Caatinga Caatinga Caatinga Caatinga Caatinga Caatinga Caatinga Caatinga Caatinga Dunes, Caatinga Caatinga Caatinga
22-Fabaceae	<i>Bauhinia dubia</i> G. Don  <i>Calliandra depauperata</i> Benth. <i>Calliandra spinosa</i> Ducke <i>Calopogonium caeruleum</i> (Benth.) C. Wright <i>Cenostigma bracteosum</i> (Tul.) Gagnon & G.P. Lewis <i>Centrosema sagittatum</i> Humb. & Bonpl. ex Willd. Brandegee <i>Centrosema</i> sp. <i>Chamaecrista hispidula</i> (Vahl) H.S. Irwin & Barneby <i>Chamaecrista rotundifolia</i> (Pers.) Greene <i>Chamaecrista</i> sp. <i>Chloroleucon foliolosum</i> (Benth.) G.P. Lewis <i>Indigofera microcarpa</i> Desv. <i>Libidibia ferrea</i> (Mart. ex Tul.) L.P. Queiroz <i>Mimosa acutistipula</i> Benth. <i>Mimosa sensitiva</i> L. <i>Piptadenia moniliformis</i> Benth. <i>Pithecellobium diversifolium</i> Benth. <i>Pityrocarpa moniliformis</i> (Benth.) Luckow & R.W. Jobson <i>Senna occidentalis</i> (L.) Link <i>Tephrosia egregia</i> Sandwith <i>Tephrosia purpurea</i> (L.) Pers. <i>Zornia</i> sp. 1 <i>Zornia</i> sp. 2	Caatinga (New record for RN and Caatinga vegetation) Caatinga (New record) Caatinga (New record) Caatinga Caatinga Caatinga Caatinga Island Caatinga Caatinga Caatinga Dunes, Caatinga Caatinga Caatinga Caatinga Caatinga Caatinga Island Island Island Caatinga Caatinga
23-Gentianaceae	<i>Schultesia doniana</i> Progel	Caatinga (New record)
24-Krameriaceae	<i>Krameria grandiflora</i> A. St.-Hil.	Caatinga
25-Lamiaceae	<i>Mesosphaerum suaveolens</i> (L.) Kuntze	Caatinga
26-Malvaceae	<i>Herissantia crispera</i> (L.) Brizicky <i>Herissantia tiubae</i> (K. Schum.) Brizicky <i>Hibiscus</i> sp. <i>Sida brittonii</i> León <i>Sida galheirensis</i> Ulbr. <i>Waltheria brachypetala</i> Turcz. <i>Waltheria</i> sp. 1 <i>Waltheria</i> sp. 2 <i>Wissadula</i> sp. Indet.	Island, Caatinga Dunes, Caatinga Island Caatinga Caatinga Caatinga Caatinga Caatinga Dunes Dunes

TABLE 1 CONT. Floristic list of the study area in the Ponta do Tubarão Sustainable Development Reserve (PTSDR), in the district of Diogo Lopes, municipality of Macau, Rio Grande do Norte State, Brazil.

FAMILY	SPECIES	VEGETATION FORMATION
27-Molluginaceae	<i>Mollugo verticillata</i> L.	Caatinga
28-Nyctaginaceae	<i>Boerhavia coccinea</i> Mill.	Dunes
29-Oxalidaceae	<i>Oxalis debilis</i> Kunth	Caatinga
30-Passifloraceae	<i>Passiflora cincinnata</i> Mast. <i>Passiflora subrotunda</i> Mast.	Island, Caatinga Island
31-Plantaginaceae	<i>Bacopa monnieri</i> (L.) Wettst. <i>Stemodia maritima</i> L.	Dunes Dunes
32-Plumbaginaceae	<i>Plumbago scandens</i> L.	Caatinga
33-Poaceae	<i>Antheophora hermaphrodita</i> Kuntze <i>Digitaria ciliaris</i> (Retz.) Koeler <i>Eleusine indica</i> (L.) Gaertn. <i>Eragrostis amabilis</i> (L.) Wight & Arn. <i>Hymenachne amplexicaulis</i> (Rudge) Nees <i>Melinis minutiflora</i> P. Beauv. <i>Sporobolus indicus</i> (L.) R. Br.	Caatinga Island Caatinga Caatinga Island Island Island
34-Polygalaceae	<i>Polygala</i> sp.	Caatinga
35-Portulacaceae	<i>Portulaca hirsutissima</i> Cambess. <i>Portulaca oleracea</i> L. <i>Portulaca umbraticola</i> Kunth <i>Portulaca</i> sp.	Caatinga Island Dunes, Caatinga Island, Caatinga
36-Primulaceae	<i>Jacquinia armillaris</i> Jacq.	Restinga
37-Rhamnaceae	<i>Sarcomphalus joazeiro</i> (Mart.) Hauenschild.	Caatinga
38-Rhizophoraceae	<i>Rhizophora mangle</i> L.	Mangrove
39-Rubiaceae	<i>Borreria multiflora</i> (DC.) Bacigalupo & E.L. Cabral <i>Coutarea</i> sp. <i>Hexasepalum apiculatum</i> (Willd. ex Roem. & Schult.) Delprete & J.H. Kirkbr. <i>Mitracarpus</i> sp. <i>Richardia brasiliensis</i> Gomez <i>Richardia grandiflora</i> (Cham. & Schltdl.) Steud.	Dunes  Island Caatinga Dunes  Caatinga Dunes
40-Santalaceae	<i>Phoradendron</i> sp. 1 <i>Phoradendron</i> sp. 2	Caatinga Caatinga
41-Sapindaceae	<i>Cardiospermum corindum</i> L.	Island
42-Sapotaceae	<i>Bumelia sartorum</i> Mart. <i>Sideroxylon obtusifolium</i> (Roem. & Schult.) T.D. Penn.	Caatinga Caatinga
43-Solanaceae	<i>Nicotiana glauca</i> Graham	Dunes, Caatinga
44-Talinaceae	<i>Talinum fruticosum</i> (L.) Juss.	Caatinga, Island
45-Turneraceae	<i>Piriqueta viscosa</i> Griseb. <i>Turnera subulata</i> Sm.	Caatinga Island
46-Verbenaceae	<i>Stachytarpheta coccinea</i> Schauer <i>Stachytarpheta microphylla</i> Walp.	Caatinga Caatinga
47-Ximeniaceae	<i>Ximenia americana</i> L.	Caatinga

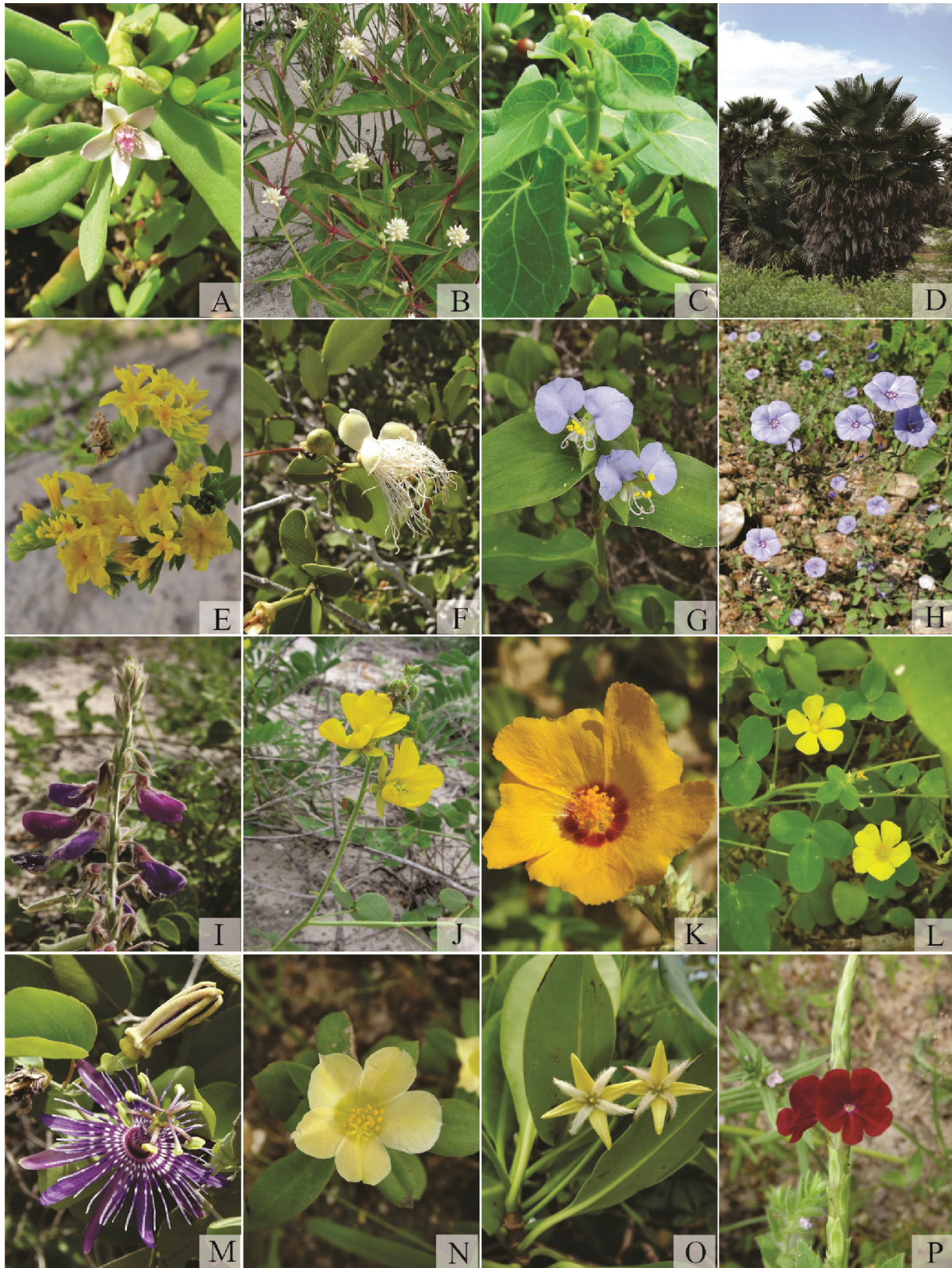


FIGURE 3. Plant species in the Ponta do Tubarão Sustainable Development Reserve (PTSDR) study area, in the district of Diogo Lopes, Macau, Rio Grande do Norte State, Brazil. **A**, *Sesuvium portulacastrum* (L.) L.; **B**, *Pfaffia glomerata* (Spreng.) Pedersen; **C**, *Ibatia ganclinosa* (Vell.) Morillo; **D**, *Copernicia prunifera* (Mill.) H.E. Moore; **E**, *Euploca polyphylla* (Lehm.) J.I.M. Melo & Semir; **F**, *Cynophalla flexuosa* J. Presl; **G**, *Commelina erecta* L.; **H**, *Jacquemontia evolvolvuloides* Meisn.; **I**, *Tephrosia egregia* Sandwith; **J**, *Chamaecrista hispidula* (Vahl) H.S. Irwin & Barneby; **K**, *Sida galheirensis* Ulbr.; **L**, *Oxalis debilis* Kunth; **M**, *Passiflora cincinnata* Mast.; **N**, *Portulaca hirsutissima* Cambess.; **O**, *Rhizophora mangle* L.; **P**, *Stachytarpheta microphylla* Walp. Photographs: J. M. Oliveira.

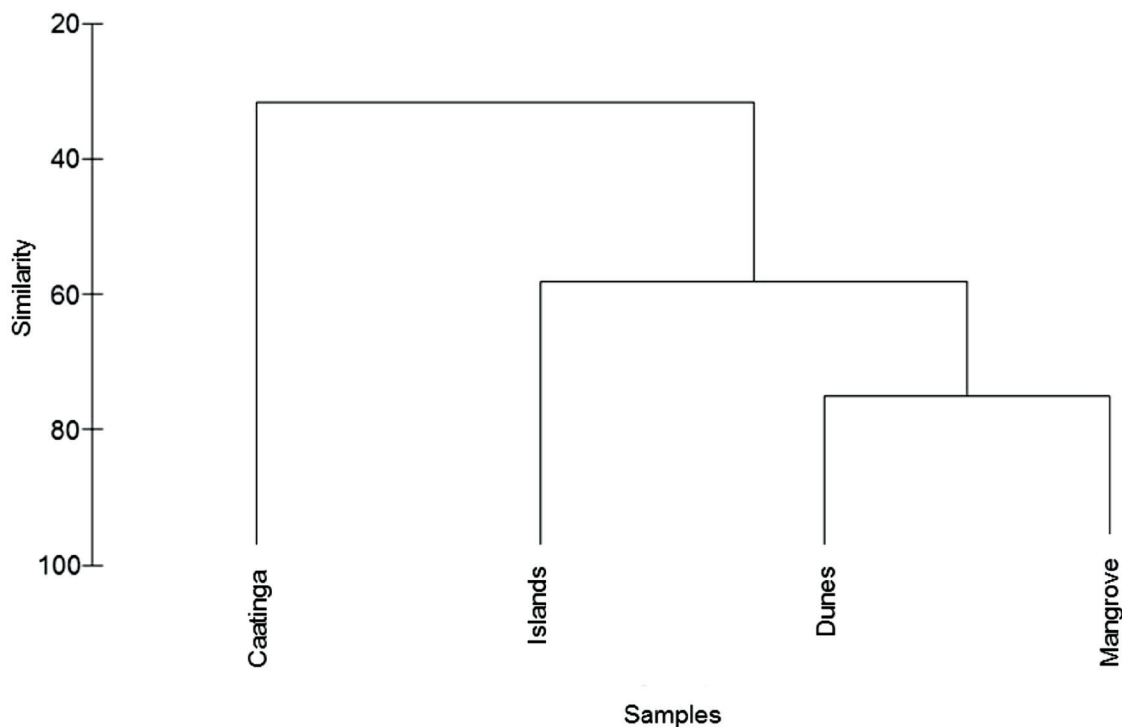


FIGURE 4. Floristic similarity dendrogram obtained from the grouping analyses of the four phytophysiognomies identified in the study area (Caatinga, Dune, Islands, and Mangrove) at the Ponta do Tubarão Sustainable Development Reserve (PTSDR) study area, in the district of Diogo Lopes, Macau, Rio Grande do Norte State, Brazil.

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