REVISTA FLORESTA Engenharia Florestal
ISSN 1982-4688
Edição 54
Universidade Federal do Paraná
Setor de Ciências Agrárias

DETERMINATION OF FUNCTIONAL GROUPS OF TREE SPECIES IN AN INSULAR ENVIRONMENT

Bruna Brodbeck[1*], João Carlos Ferreira Melo Júnior[2]

[1*]Universidade da Região de Joinville - UNIVILLE, Ciências Biológicas, Joinville, Santa Catarina, Brasil – brunabrodbeckk@gmail.com
[2] Universidade da Região de Joinville - UNIVILLE, Ciências Biológicas, Joinville, Santa Catarina, Brasil - jcmelo_wood@hotmail.com

Received for publication: 19/02/2024 – Accepted for publication: 24/06/2024

Resumo

Determinação de grupos funcionais de espécies arbóreas em ambiente insular. A Mata Atlântica é o terceiro maior bioma do Brasil, porém atualmente restam aproximadamente 12,4% da sua vegetação nativa. Por toda a sua importância e complexidade estrutural, estudos que colaborem ao apelo de sua conservação vêm sendo mais requisitados. Desta forma, a abordagem funcional tem contribuído para melhorar a compreensão dos padrões de coexistência de espécies arbóreas em comunidades florestais. Esta separação de espécies em grupos funcionais visa salientar o funcionamento de um ou mais processos que se tenha interesse. O presente trabalho objetivou identificar os grupos funcionais, a riqueza e a diversidade da vegetação da ilha dos Remédios, localizada no município de Balneário Barra do Sul/SC, possui aproximadamente 246.013 m² de área, está a 1,5 km do continente. Para identificar a vegetação arbórea foi realizada amostragem pelo método de parcelas de 100 m². Foram amostrados 244 indivíduos, pertencentes a 26 espécies de 18 famílias, divididos em 3 grupos funcionais por meio de Análise de Agrupamento Cluster. Registrou-se baixa diversidade de grupos funcionais, com sobreposição destes em alguns atributos ecológicos, corroborando a tendência à redundância funcional em áreas historicamente degradadas como a área de estudo.

Palavras-chave: Ecologia funcional; vegetação insular; Ilha dos Remédios.

Abstract

The Atlantic Forest is the third largest biome in Brazil, but currently, approximately 12.4% of its native vegetation remains. Given its importance and structural complexity, studies that contribute to its conservation appeal have been increasingly requested. In this context, the functional approach has helped improve the understanding of the coexistence patterns of tree species in forest communities. This separation of species into functional groups aims to highlight the functioning of one or more processes of interest. The present study aimed to identify the functional groups, richness, and diversity of the vegetation of Ilha dos Remédios, located in the municipality of Balneário Barra do Sul/SC. The island has an area of approximately 246,013 m² and is 1.5 km from the mainland. To identify the arboreal vegetation, sampling was conducted using the 100 m² plot method. A total of 244 individuals were sampled, belonging to 26 species from 18 families, divided into 3 functional groups through Cluster Analysis. A low diversity of functional groups was recorded, with an overlap of these groups in some ecological attributes, corroborating the trend towards functional redundancy in historically degraded areas such as the study area.

Keywords: Functional ecology; island vegetation; Remedies Island.

INTRODUTION

Ecological studies adopting a functional approach have recently contributed to a better understanding of coexistence patterns among species in natural systems with high biological diversity, such as tropical forests (BURMESTER *et al.*, 2022). This approach has elucidated the mechanisms of niche segregation and partitioning among tree species in communities (SOUZA *et al.*, 2017), as well as resource acquisition strategies in environments with varying resource availability, and the adaptive responses of species to environmental heterogeneity (STOTZ *et al.*, 2021).

The functional approach assumes that the functional traits exhibited by species are the fundamental units that, mediated by environmental filters, make taxonomic entities (species) heterogeneous and responsive to environmental conditions (VIOLLE *et al.*, 2007). These responses indicate the limits of species' geographical distribution (STOTZ *et al.*, 2021), the relationship between natural regeneration and successional stages of forest remnants (GOGOSZ & BOEGER, 2019), also the variations in traits among plant groups capable of overcoming severe and, rapidly changing environmental conditions (HEILMEIER, 2019), and, more broadly, the evolutionary history (ADLER *et al.*, 2014). Moreover, the plastic potential of species depending on the degree of variation in their functional traits (MELO-JÚNIOR & BOEGER, 2016).

A functional trait is any morphological, phenological, ecophysiological, or reproductive characteristic at the individual level that indirectly affects biological fitness, influencing a species' establishment, growth, reproduction, and survival (VIOLLE *et al.*, 2007). These traits help identify species' responses to environmental factors and their roles in the ecosystem (VIOLLE *et al.*, 2007). Functionally similar species, which respond similarly to environmental conditions, are grouped into functional groups, regardless of their phylogenetic position. This approach allows for an understanding of the mechanisms involved in the structuring and maintenance of communities, as species functionality is the most relevant biotic factor directly influencing ecosystem functioning (MORAIS & CIANCIARUSO, 2014).

Research focusing on functional groups is recent in Brazil, especially in environments historically impacted by anthropogenic factors (SEVEGNANI & SCHROEDER, 2013). However, such research is crucial for understanding the internal relationships within ecosystems and their ability to withstand disturbances, as well as inform environmental restoration measures in degraded areas and guide biodiversity conservation actions. Given the Atlantic Forest is the third-largest biome in Brazil and the second-largest tropical rainforest in the Americas, with great structural complexity and worldwide interest in its conservation, studies that substantiate conservation efforts are increasingly necessary. Initiatives to recognize biological diversity in fragmented areas are supported by the national plan for biome recovery (PACT FOR THE RESTORATION OF THE ATLANTIC FOREST, 2009).

Regarding the flora of the State of Santa Catarina, some studies have been developed in recent years, focusing on remnants of Dense Ombrophilous Forest sensu stricto (MISSIO *et al.*, 2017; JARDIM & MELO-JÚNIOR, 2020; BURMESTER *et al.*, 2022) and ecotonal areas between Mixed Ombrophilous Forest and Seasonal Deciduous Forest (SOUZA *et al.*, 2017). However, a significant knowledge gap exists regarding the functional ecology of insular tree vegetation in southern Brazil. Similarly, there is no indication of research on floristic functional groups on Ilha dos Remédios. Given its Atlantic Forest vegetation, previously used for agro-pastoral activities, it is essential to recognize the functional ecological groups that constitute the insular tree community, contributing to understanding the impact of anthropization on the assembly of the insular floristic community, how such a community responds to anthropic disturbances, identifying key species for maintaining ecological services, and providing information useful for management and biodiversity conservation actions.

A study conducted on a group of thirty islands in northern Sweden demonstrated that the loss of functional groups and species often impairs ecosystem processes, although these effects vary depending on the context and are influenced by island size and degradation history. Thus, besides predicting how the loss of species and functional groups affects ecosystem properties, it indicates that the variation of these effects among insular ecosystems is still not well understood (WARDLE & ZACKRISSON, 2005).

The present study aimed to recognize the functional groups within the tree community of the Ilha dos Remédios vegetation in the State of Santa Catarina. It hypothesized that the insular vegetation has few functional groups due to local anthropization and the short time for natural regeneration.

MATERIAL AND METHODS

Area of study

The study was conducted in the vegetation of the Atlantic Forest phytogeographic domain, characterized as a *restinga* forest, located on Ilha dos Remédios, northern coast of Santa Catarina, Brazil (26°27'32.42"S / 48°34'47.01"W) (Figure 1). The island has an approximate area of 246,013 m², with an altitude ranging from 0 to 54 meters, and is located about 1.5 km offshore. Its geology is characterized by tertiary/quaternary marine terraces and sediments and gneissic quartz-feldspar rocks, with a geochemical composition containing 66 to 70% silicon dioxide (SiO2) (BALDIN *et al.*, 2017). Due to weathering, these form sandy spodosols, on which *restinga* vegetation develops (SCARANO, 2002), similar to the condition found on the island of São Francisco do Sul (BALDIN *et al.*, 2017). The presence of sandy soil, superficially white-yellowish but with deposits of organic matter, and the presence of key species such as *Schinus terebinthifolius* (Anacardiaceae), *Ocotea pulchella* (Lauraceae), and *Psidium cattleianum* (Myrtaceae) led to the designation of the vegetation as *restinga* forest, similar to what is observed in large areas on the island of São Francisco do Sul (MELO-JÚNIOR & BOEGER, 2015). The list of woody species and the morphometry of the individuals present on the island suggest, in comparison with the *restinga* forests of São Francisco do Sul (MELO-JÚNIOR & BOEGER, 2015), that the forest is in an intermediate stage of regeneration. The region´s climate is influenced by maritime humidity and has an average annual temperature of 20.3°C and an average annual precipitation of 1,874 mm. Geologically, the area is characterized by protomylonitic and mylonitic orthogneisses from the islands of Balneário Barra do Sul, which have meta-ultramafic, amphibolitic, and gneissic enclaves. These orthogneisses present the same petrographic and structural characteristics as the rocks of the São Francisco do Sul Complex (BALDIN *et al.*, 2017).

Previously named Ilha das Cabras, Ilha dos Remédios experienced degradation approximately until the 1980s. According to data obtained from the Municipality's Environmental Secretariat, in 1950, the island had agricultural activity, including cassava cultivation, a flour mill, and goat and cattle farming. It is estimated that the construction of houses on the island began around this period. Starting in 1980, the flour mill and cattle farming ceased, initiating an environmental conservation movement in the municipality, culminating in 2000 with a ban on new constructions. Consequently, the island has been undergoing natural regeneration for approximately forty years (Figure 1).

REVISTA FLORESTA
Engenharia Florestal
ISSN 1982-4688
Edição 54
Universidade Federal do Paraná
Setor de Ciências Agrárias

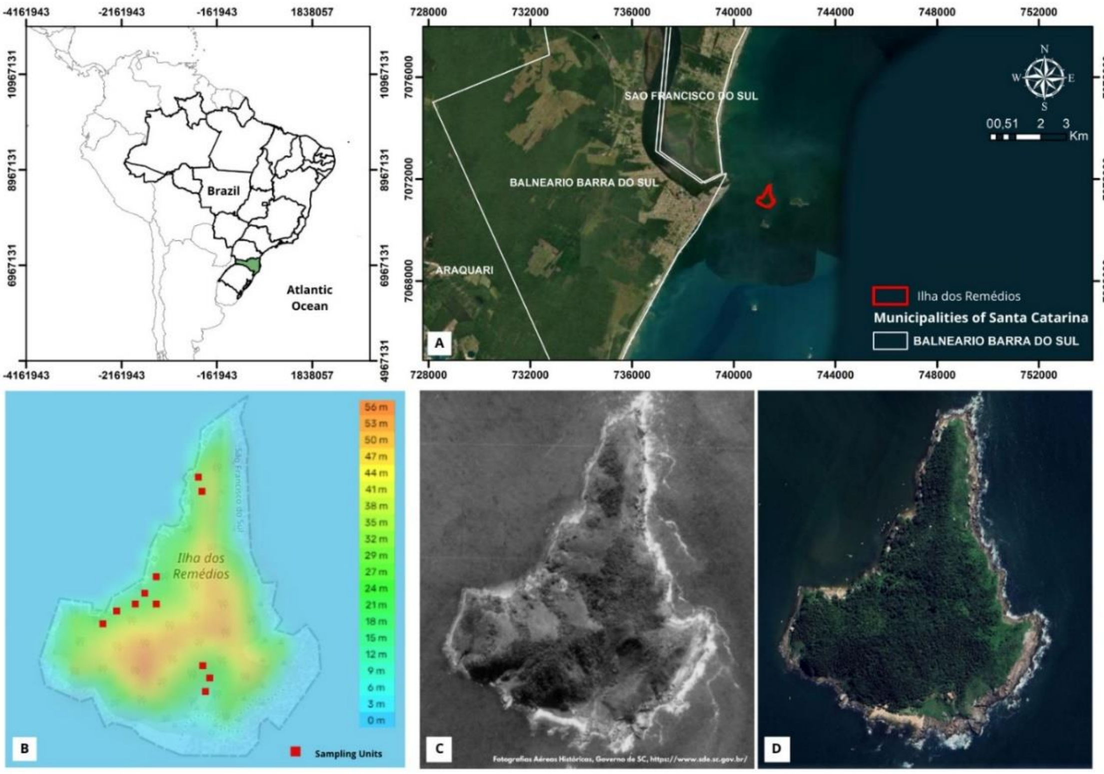

Figure 1. Ilha dos Remédios, Balneário Barra do Sul, Santa Catarina, Brazil. Legend: A - spatial location. B - island altimetry with the allocation of sampling units. C - aerophoto from 1978, showing the vegetation cover during economic activities on the island. D - vegetation cover after natural regeneration. Source: A - Primary, 2023. B - Institute of Environment. C - Government of Santa Catarina - Historical aerial photographs, 1978. D - Google Earth, 2023.

Figura 1. Ilha dos Remédios, Balneário Barra do Sul, Santa Catarina, Brasil. Legenda: A - localização espacial. B - altimetria da ilha com a alocação das unidades amostrais. C – aerofoto de 1978 mostrando a cobertura vegetal durante as atividades econômicas na ilha. D – cobertura vegetal após regeneração natural. Fonte: A - primária, 2023. B – Instituto do Meio Ambiente. C - Governo de Santa Catarina - Fotografias aéreas históricas, 1978. D - Google Earth, 2023.

Survey of functional vegetation attributes

The survey of the island's arboreal vegetation was conducted using the 10 x 10 m (100 m²) plot sampling method, with fifteen randomly selected plots allocated using ArcGIS software. Plots were preferably selected between 9 and 15 meters in altitude, excluding vegetation above 40 meters due to distinct soil characteristics. The inclusion criteria for sampled individuals were a) phanerophyte life form and b) a minimum circumference at breast height (CBH) of 10 cm. Sampling was conducted until the species accumulation curve stabilized, indicating comprehensive species collection.

Branches with fertile structures of the found species were collected as evidence. The botanical material was processed according to standard techniques for plant collection and herbarium preservation. The collected specimens were identified through comparative morphology at the Joinville Herbarium (JOI), and the Virtual Herbarium Reflora of JBRJ, along with specialized literature. The validity of species names and author names was verified through the List of Species of the Brazilian Flora (2020). The collected botanical material was incorporated into the JOI Herbarium collection at the University of the Region of Joinville.

Functional attributes included morphological, phenological, ecophysiological, and reproductive characteristics, based on the manual for measuring plant functional traits (PÉREZ-HARGUINDEGUY *et al.*, 2016). The evaluated morphological attributes were: plant height, obtained with a measuring rod; diameter at breast height (DBH), obtained from the CBH π-1, measured with a tape measure (cm) in the field; fresh leaf mass (g), obtained after twelve hours of water saturation, measured with a precision analytical balance; dry leaf mass (g), obtained after constant dry weight following herbarium drying in an air circulation oven for 72 hours at 70°C, measured with a precision analytical balance; leaf area (cm²) with petiole, measured by a digitized image on a flatbed scanner connected to Sigma Scan pro software (version 5.0, SPSS Inc., Chicago IL, USA); specific leaf area (cm².g-1), calculated as the ratio of leaf area to dry mass; leaf type, phyllotaxy, and leaf blade shape, obtained from literature records and field observation. Leaf mass and area measurements were taken from five leaves of five external canopy branches, preferably intact, using a pruner, totaling twenty-five leaves from an individual of each species (MISSIO *et al.*, 2017). Quantitative data allowed association with Raunkiaer's life form classification system (1934) to establish life forms (nanophanerophytes - height less than 0.5 m; microphanerophytes - height between 0.5 m and 1.9 m; mesophanerophytes - height between 2.0 m and 7.9 m; megaphanerophytes - height over 8.0 m) and the Leaf Working Group system (1999) for determining classes by leaf area (leptophyll < 25 mm², nanophyll > 25 - 225 mm², microphyll > 225 - 2,025 mm², notophyll > 2,025 - 4,500 mm², mesophyll > 4,500 - 18,225 mm², macrophyll > 18,225 - 164,025 mm², and megaphyll > 164,025 mm²).

The evaluated phenological attributes were leaf renewal, observed in the field or through literature records, classified as evergreen or deciduous; flowering period and fruiting period, observed in the field or recorded in literature, classified according to the southern hemisphere seasons. The evaluated ecophysiological attributes were: photosynthetic pathway, determined by literature records or anatomical observation, classified as C3, C4, and CAM; light requirement, classified as heliophyte (plants that grow in full sunlight), sciophyte (plants tolerant of shading), or sciophyte (plants that grow in intense shading) (RANDALL, 1953); and development, classified as pioneer, early secondary, late secondary, and climax species, based on reference works on Brazilian Trees and Brazilian Tree Species. The evaluated reproductive attributes were pollination syndrome, classified as anemophily, cantharophily, phalaenophily, myophily, melittophily, ornithophily, and psychophily; dispersal mechanism, determined by literature records, classified as anemochory, autochory, barochory, and zoochory; and seed number, determined by literature records, classified as monospermic or polyspermic.

To determine the functional groups, the collected data were organized into quantitative or binary matrices (for qualitative data) and analyzed using Cluster Analysis with the K-means algorithm in an R environment, using Euclidean distance.

RESULTS

Among the 244 sampled individuals, a richness of twenty-six tree species was identified, organized into twenty-four genera, and distributed across eighteen botanical families. The collector's curve indicated stabilization of the sampling with a total of eleven plots (1,100 m²) (Figure 2). Table 1 summarizes the qualitative and quantitative functional attributes assigned to the identified species. Based on their functional attributes analyzed through Cluster Analysis, three functional groups were determined (Figure 3).

Table 1. Functional morphological of 26 tree species from Ilha dos Remédios, in Balneário Barra do Sul/SC.
Tabela 1. Características funcionais morfológicas de 26 espécies arbóreas da Ilha dos Remédios, em Balneário Barra do Sul/SC.

Family	Species	Record JOI	Height	DBH	FM	DM	LA	SLA
Anacardiaceae	*Schinus terebinthifolius var. pohliana*	19853	7,0	10,6	0,1	0,01	4,8	371,4
Apocynaceae	*Tabernaemontana catharinensis*	19843	6,3	14,7	0,8	0,2	20,3	121,7
Arecaceae	*Bactris setosa*	19839	2,0	4,8	2,1	0,8	162,3	205,8
Arecaceae	*Syagrus romanzoffiana*	19846	6,3	20,1	1,1	0,5	44,3	84,5
Erythropalaceae	*Heisteria silvianii*	19837	6,0	7,5	0,4	0,1	16,5	158,7
Fabaceae	*Dahlstedtia floribunda*	19856	7,4	8,7	0,5	0,2	22,4	119,1
Fabaceae	*Machaerium hirtum*	19851	10,6	10,8	0,4	0,1	16,9	118,3
Lauraceae	*Nectandra membranacea*	19838	10,0	13,7	0,4	0,1	18,1	160,2
Lauraceae	*Nectandra oppositifolia*	19847	10,2	18,5	2,1	0,8	71,3	89,1
Lauraceae	*Ocotea pulchella*	19855	10,0	18,8	0,2	0,1	9,5	94,8
Malpighiaceae	*Bunchosia pallescens*	19835	3,0	6,4	1,0	0,3	35,9	143,4
Meliaceae	*Guarea macrophylla*	19848	13,0	20,1	1,6	0,5	44,3	84,3
Meliaceae	*Trichilia elegans*	19841	7,3	7,7	0,8	0,2	27,7	142,9
Myrtaceae	*Eugenia stigmatosa*	19836	6,6	14,5	0,4	0,1	10,4	88,7
Myrtaceae	*Eugenia sulcata*	19859	9,0	20,1	0,2	0,1	10,0	104,5
Myrtaceae	*Myrcia strigosa*	19834	3,0	4,5	1,1	0,4	22,7	56,5
Myrtaceae	*Psidium cattleyanum*	19842	5,9	10,7	0,9	0,2	16,1	74,6
Peraceae	*Pera glabrata*	19852	5,6	9,2	0,6	0,1	12,0	164,1
Piperaceae	*Piper arboreum*	19845	8,1	12,6	3,2	0,3	81,6	245,7
Primulaceae	*Myrsine guianensis*	19849	9,8	16,7	4,7	1,1	99,5	94,0
Rubiaceae	*Psychotria carthagenensis*	19860	3,0	3,5	0,3	0,1	10,4	173,8
Salicaceae	*Casearia sylvestris*	19854	8,3	20,3	0,5	0,1	21,1	176,5
Sapindaceae	*Cupania vernalis*	19840	9,8	16,1	1,0	0,3	44,9	153,3
Sapotaceae	*Chrysophyllum marginatum*	19858	4,5	4,8	0,6	0,2	18,0	105,0
Ulmaceae	*Trema micranthum*	19844	6,0	5,8	0,3	0,1	9,7	99,7
Urticaceae	*Cecropia glaziouі*	19850	8,5	17,4	6,2	5,5	657,2	119,5

Legend: Height (m); DBH - Diameter at breast height (cm); FM - Fresh mass (g); DM - Dry mass (g); LA - Leaf area (cm²); SLA - Specific leaf area (cm²/g). Legenda: Altura (m); DAP - Diâmetro a altura do peito (cm); MF - Massa fresca (g); MS - Massa seca (g); AF - Área foliar (cm²); AEF - Área específica foliar (cm²).

Table 2. Functional morphological, phenological, ecophysiological and reproductive characteristics of 26 tree species from Ilha dos Remédios.
Tabela 2. Características funcionais morfológicas, fenológicas, ecofisiológicas e reprodutivas de 26 espécies arbóreas da Ilha dos Remédios.

Species	F 1	F 2	F 3	Leaf renewal	Flowering	Fruiting	Photo path.	Light	Develop.	Pollination syndrome	Dispersal	Seed
S. terebinthifolius	2	1	2	1	1, 2, 3	3	1	3	1, 2	2, 3	1, 3	2
T. catharinensis	1	2	1	1	1	3	1	3	1	3	3	2
B. setosa	2	1	1	1	3, 4	2, 3, 4	2	1	1, 2	3, 6	3, 6, 7	2
S. romanzoffiana	2	1	1	1	5	5	1	3	1, 2, 3	3	2, 3, 5, 6, 7	2
H. silvianii	1	1	1	1	4	1, 4	1	3	2	3	2, 3, 6, 7	2
D. floribunda	2	1	1	1	2	1, 3	1	2	3, 4	3, 6	8	1
M. hirtum	2	1	2	2	2, 3	4	1	3	1	3	4	2
N. membranácea	1	1	1	1	3, 4	4	1	3	1, 3	2, 3, 5	3, 7	2
N. oppositifolia	1	2	1	1	2, 3	1, 4	1	3	2, 4	3, 6	3, 7	2
O. pulchella	1	1	1	1	2, 3	1, 2, 4	1	3	1, 2, 3, 4	3	3, 7	2
B. pallescens	1	2	1	1	2	3	1	3	1, 3, 4	2, 3	3, 4	1
G. macrophylla	2	1	1	1	1, 4	2, 3	1	1	3, 4	3, 7	3	1
T. elegans	2	2	1	1	1, 4	1, 3, 4	1	1	3	3	3	1
E. stigmatosa	1	2	1	1	1, 4	5	1	2	1, 3, 4	3, 6	3, 7	1
E. sulcata	1	1	1	1	1, 2, 4	2	1	3	2, 4	3	3, 6, 7	1
M. strigosa	1	2	1	1	1, 2	3, 4	1	3	4	3	3, 7	2
P. cattleyanum	1	2	2	1	1, 2	1, 2	1	3	2, 3	3	1, 2, 3, 6, 7	1
P. glabrata	1	1	1	1	2, 3	1,2, 5	1	3	1, 3	1, 2, 3, 7	3, 8	1
P. arboreum	1	1	1	1	2, 3	2, 3	1	2, 3	2	1, 2	2	1
M. guianensis	1	1	1	1	5	5	1	3	1, 2	3	3, 7	2
P. carthagenensis	1	2	1	1	5	3, 4	1	1	3	2, 3, 4, 5, 6	3	2
C. sylvestris	1	1	1	1	3, 4	1, 2	1	1, 3	1, 2, 3, 4	3, 4, 5, 6, 7	3, 6	1
C. vernalis	2	1	2	1	2, 3, 4	1, 2	1	1	2, 3	3, 4, 5, 7	3, 6, 7, 8	1
C. marginatum	1	1	2	1	1, 2, 4	4	1	1	3	3	3, 6, 7	1
T. micranthum	1	1	1	1	5	2, 3	1	3	1	1, 2, 3	3, 8	2
C. glazioui	1	1	1	1	1, 4	1, 2	1	3	1	1, 3	1, 2, 3, 6, 7	1

Legend: F1 - Leaf type: Simple: 1, Compound: 2; F2 - Phyllotaxy: Alternate: 1, Opposite: 2; F3 - Leaf shape: Elliptical: 1, Oblong: 2; Leaf renewal - Leaf ren.: Evergreen: 1, Deciduous: 2; Flowering: Spring: 1, Summer: 2, Autumn: 3, Winter: 4, Extended: 5; Fruiting - Frt.: Spring: 1, Summer: 2, Autumn: 3, Winter: 4, Extended: 5; Photosynthetic pathway - Photo path.: C3: 1, C4: 2, CAM: 3; Light requirement - Light: Sciophyte: 1, Facultative heliophyte: 2, Heliophyte: 3; Development - Dev.: Pioneer: 1, Early secondary: 2, Late secondary: 3, Climax: 4; Pollination syndrome - Anemophily: 1, Myophily: 2, Melittophily: 3, Phalaenophily: 4, Psychophily: 5, Ornithophily: 6, Cantharophily: 7; Dispersal - Myrmecochory: 1, Chiropterochory: 2, Ornithochory: 3, Anemochory: 4, Barochory: 5, Primatochory: 6, Mammalochory: 7, Autochory: 8; Seed - Seed: Polyspermic: 1, Monospermic: 2. Legenda: F1 - Tipo de folha: Simples :1, Composta: 2; F2 - Filotaxia – Alterna: 1, Oposta: 2; F3 - Forma da folha: Elíptica: 1, Oblonga: 2; Renovação foliar - Ren. foliar: Perene: 1, Decídua: 2; Floração - Primavera: 1, Verão: 2, Outono: 3, Inverno: 4, Extensiva: 5; Frutificação – Frut.: Primavera: 1, Verão: 2, Outono: 3, Inverno: 4, Extensiva: 5; Via fotossintética – Via fot.: C3: 1, C4: 2, CAM: 3; Requerimento lumínico – Luz.: Esciófita: 1, Ciófita: 2, Heliófita: 3; Desenvolvimento - Desenv.: Pioneira: 1, Secundária inicial: 2, Secundária tardia: 3, Clímax: 4; Síndrome de Polinização – Anemofilia: 1, Miofilia: 2, Melitofilia: 3, Falenofilia: 4, Psicofilia: 5, Ornitofilia: 6, Cantarofilia: 7; Dispersão - Mirmecofilia: 1, Quiropterocoria: 2, Ornitocórica: 3, Anemocoria: 4, Barocoria: 5, Primatocoria: 6, Mamaliocoria: 7, Autocoria: 8; Semente – Polispérmica: 1, Monospérmica: 2.

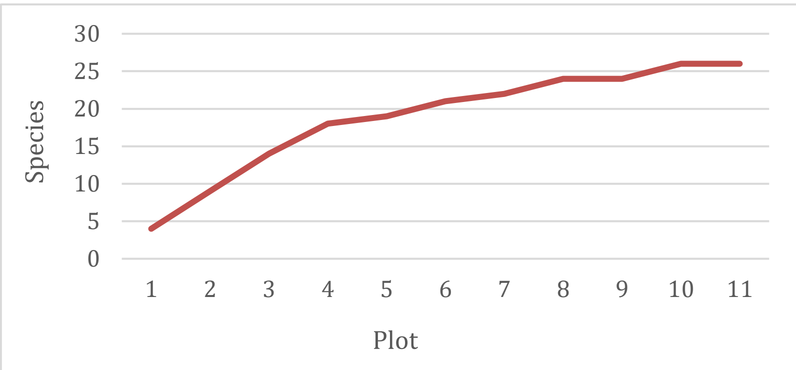

Figure 2. Collector's curve obtained for the survey of tree vegetation on Ilha dos Remédios, Balneário Barra do Sul, Santa Catarina, Brazil. Source: Primary.
Figura 2. Curva do coletor obtida para o levantamento da vegetação arbórea na lha dos Remédios, Balneário Barra do Sul, Santa Catarina, Brasil. Fonte: Primária.

The Functional Group 1 (FG1) consists of six species, making it the smallest group. Its predominant characteristics are: mesophanerophytes (except for *Machaerium hirtum* and *Cecropia glazioui*, which are megaphanerophytes); microphylls (except for *Dahlstedtia floribunda* and *Tabernaemontana catharinensis*, which are notophylls, and *M. hirtum*, which is microphyll); they are sclerophyllous (except for *Trema micranthum*, which is mesophyllous) regarding the Sclerophylly Index; they have simple leaves (except for *D. floribunda* and *M. hirtum*), alternate (except for *T. catharinensis*), elliptical or oblong, evergreen (except for *M. hirtum*); flowering occurs in spring, summer, and winter, while most fruiting occurs in autumn; their photosynthetic pathway is C3, they are heliophytes and pioneers (except for *Chrysophyllum marginatum*, which is a late secondary shade plant and *D. floribunda*, which is a late secondary climax shade plant), pollinated by melittophily and ornithophily, dispersed by ornithochory (except for *D. floribunda*—autochory, and *Machaerium hirtum*—anemochory). Seed types ranged from monospermic to polyspermic, with *D. floribunda* as the group's most abundant species.

Formed by nine species, FG2 has the following characteristics: megaphanerophytes and mesophanerophytes (*Syagrus romanzoffiana*, *Eugenia stigmatosa*, *Myrcia strigosa*, *Psidium cattleyanum*); microphylls (except for *Guarea macrophylla*, *S. romanzoffiana*, *M. strigosa*—notophylls, and *Myrsine guianensis* and *Nectandra oppositifolia*—mesophylls); sclerophyllous (except for *Eugenia sulcata* and *Ocotea pulchella*); simple leaves (except for *G. macrophylla* and *S. romanzoffiana*), alternate or opposite, elliptical (except for *P. cattleyanum*), evergreen; their flowering and fruiting occur throughout the seasons, but predominantly in spring and summer; their photosynthetic pathway is C3; they are heliophytes (except for *G. macrophylla*, which is a shade plant, and *E. stigmatosa*, which is a climax shade plant); they range from early to climax secondary stages, pollinated by melittophily and dispersed by ornithochory and mammalochory, with monospermic seeds (except for *G. macrophylla*, *E. sulcata*, *E. stigmatosa*, and *P. cattleyanum*). The most abundant species is *S. romanzoffiana*. *S. romanzoffiana* was not only the most abundant species in the group but also the most frequently found during sampling, totaling seventy-six individuals (31.2% of the total sampled individuals).

Trichilia elegans is the most abundant species among the eleven that form FG3, the largest group. The group has the following main characteristics: mesophanerophytes (except for *Piper arboreum*, *Casearia sylvestris*, *Cupania vernalis*, and *Nectandra membranacea*, which are megaphanerophytes); microphylls, but *C. sylvestris*, *C. vernalis*, *Bunchosia pallescens*, and *T. elegans* are notophylls, and *Bactris setosa* and *P. arboreum* are mesophylls; sclerophyllous (except for *Schinus terebinthifolia*, *Psychotria carthagenensis*, and *Pera glabrata*); simple leaves (except for *S. terebinthifolia*, *B. setosa*, *C. vernalis*, and *T. elegans*), alternate (except for *B. pallescens*, *T. elegans*, and *P. carthagenensis*), elliptical (except for *S. terebinthifolia* and *C. vernalis*), and evergreen; they have flowering and fruiting mainly in autumn and winter; their photosynthetic pathway is C3 (except for *B. setosa*, which has a C4 photosynthetic pathway). They range from shade to sun plants, pioneers to late secondary species; they are pollinated by myophily and/or melittophily; they have polyspermic fruits, dispersed by ornithochory (except for *P. arboreum*, which is bat-dispersed and has monospermic fruits).

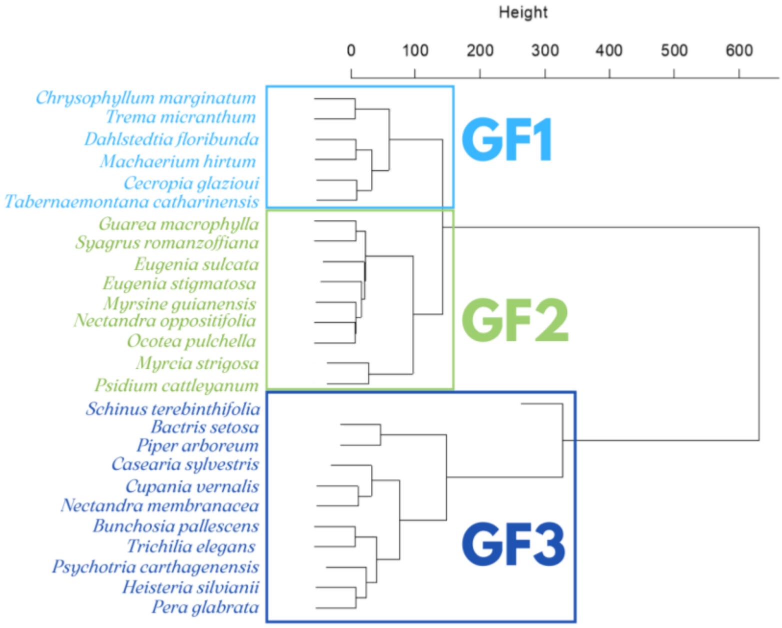

Figure 3. Determination of functional groups (GF1, GF2 e GF3), obtained through Cluster Group Analysis with the Kmeans algorithm in the R environment, for the arboreal vegetation of Ilha dos Remédios, Balneário Barra do Sul, Santa Catarina, Brazil. Source: Primary.

Figura 3. Determinação dos grupos funcionais (GF1, GF2 e GF3), obtida através da Análise de *Cluster* com o algoritmo *Kmeans* em ambiente R, para a vegetação arbórea da Ilha dos Remédios, Balneário Barra do Sul, Santa Catarina, Brasil. Fonte: Primária.

Nectandra oppositifolia was the largest species found, reaching up to 20 m in height, thus being part of the emergent layer of the forest, standing out in the phytophysiognomy. Below this species, there is a group of species that reach between 13 and 16 m in height, including *Cecropia glazioui*, *Cupania oblongifolia*, *Eugenia sulcata*, *Guarea macrophylla*, *Myrsine guianensis*, *Piper arboreum*, *Psidium cattleianum*, *Syagrus romanzoffiana*, *Trema micranthum*, and *Trichilia elegans*, occupying the canopy. Among the sampled individuals found below 12 m are the species *Bactris setosa*, *Casearia sylvestris*, *Chrysophyllum marginatum*, *Dahlstedtia floribunda*, *Eugenia stigmatosa*, *Heisteria silvianii*, *Myrcia strigosa*, *Nectandra membranacea*, *Ocotea pulchella*, *Pera glabrata*, *Psychotria carthagenensis*, *Schinus terebinthifolia*, and *Tabernaemontana catharinensis*.

FG1 had four heliophytic species, one shade plant, and one climax shade plant; FG2 consisted of seven heliophytic species, one shade plant, and one climax shade plant; while FG3 had seven heliophytic species, five shade plants, and one climax shade plant. FG1 and FG3 have pioneer to late secondary species, while FG2 predominantly has early secondary to climax species. Twenty species found in the area are pioneers and/or early secondary (including *Bactris setosa*, *Bunchosia pallescens*, *Casearia sylvestris*, *Cecropia glazioui*, *Cupania vernalis*, *Eugenia stigmatosa*, *E. sulcata*, *Heisteria silvianii*, *Machaerium hirtum*, *Myrsine guianensis*, *Nectandra membranacea*, *N. oppositifolia*, *Ocotea pulchella*, *Pera glabrata*, *Piper arboreum*, *Psidium cattleyanum*, *Schinus terebinthifolia*, *S. romanzoffiana*, *Tabernaemontana catharinensis*, *Trema micranthum*).

The species with the highest leaf area values were *Cecropia glazioui* (657.18 cm²), *Bactris setosa* (162.34 cm²), and *Myrsine guianensis* (99.5 cm²). The species with the lowest values were *Schinus terebinthifolia* (4.83 cm²), *Ocotea pulchella* (9.48 cm²), and *Trema micranthum* (9.67 cm²).

DISCUSSION

Islands harbor a significant portion of all the world's plant species, which are particularly susceptible to anthropogenic disturbances and climate changes. To date, the global pattern of island richness remains poorly documented, and the factors causing differences in species numbers are controversial (KREFT *et al.*, 2008). Some trends have been observed, such as the significant representation of species from the Myrtaceae and Lauraceae families in Brazilian flora in general and in studies conducted in forests and *restinga* in southern Brazil (SCHNEIDER & ROCHA, 2014; MELO-JÚNIOR & BOEGER, 2015).

Despite this observation, the arboreal flora of the studied island presents low species diversity compared to other surveys conducted in *restinga* forests or dense lowland rainforests in the northeastern region of Santa Catarina. In this context, the vegetation mapping of *restinga* in the largest conservation unit of this type of vegetation in SC can be mentioned, in a high degree of preservation, located in the Acaraí State Park, municipality of São Francisco do Sul, with the record of 103 tree species occurring in the forest formation on sandy soils (MELO-JÚNIOR & BOEGER, 2015).

From an ecological perspective, the studied island also has a comparatively lower number of functional groups. A study conducted in a fragment of the Atlantic Forest located in the city of Joinville, based on thirty-one woody understorey species, demonstrated the formation of four functional groups composed of species from different successional stages (JARDIM & MELO-JÚNIOR, 2020). The measurement of the performance of thirty native tree species in the understorey of Dense Ombrophilous Forest in southern Brazil indicated a median occurrence of functional attribute overlap, leading to the functional redundancy of vegetation (JARDIM & MELO-JÚNIOR, 2021). This pattern of convergence and functional redundancy, where several species perform the same function in the environment, can increase community resilience (PILLAR *et al.*, 2013) and be a salutary characteristic in environments with a significant history of degradation, as occurred on Remédios Island.

While the arboreal vegetation is more diverse in continental remnants near Remédios Island, species richness is closely related to the island's area and the diversity of habitats present in these environments. Previous research on twenty-three islands in New Zealand, using regressions between species richness and isolation variables relative to the mainland or neighboring islands, showed only a limited role of isolation in determining island floras (QUINN *et al.*, 1987). A global analysis of 488 island and 970 mainland floras, conducted to test the relationship between island characteristics (area, isolation, topography, climate, and geology) and species richness through traditional and spatial models, showed that area is the strongest determinant factor for the number of island species ($R^2 = 0.66$), but a weaker predictor for continents ($R^2 = 0.25$), while isolation, temperature, and precipitation variables, all with equally strong effects, follow as secondary factors. Elevation and island geology showed relatively weak, but still, significant effects. Together, these variables explain 85% of the global variation in species richness and influence community assembly and structure (KREFT *et al.*, 2008).

The vertical structure of forest formations can be understood as the result of an evolutionary ecological competition among various species for sunlight (MISSIO *et al.*, 2017). Thus, the distribution along the forest's vertical profile is related to light distribution. While canopy species have access to most of the solar radiation, understorey species need other strategies to develop with the remaining radiation, which reaches about 2% of the total light intercepted by the canopy (MISSIO *et al.*, 2017).

According to Burmester *et al.* (2022), abiotic conditions directly influence a plant's photosynthesis rates, with the quality and quantity of light received being one of the most determining environmental gradients for plant development and growth, constituting a primary energy source. Therefore, plant species development depends on their photosynthetic efficiency. As observed in the species of this study, the C3 photosynthetic pathway was predominant, being considered advantageous for tree species since photosynthesis performed by a tree is not limited by CO2 concentration, but by the availability of forest ambient light, which is mostly reduced in the lower strata. Thus, the use of ecophysiological strategies aimed at photosynthetic production can be a determining factor in species perpetuation (JARDIM & MELO-JÚNIOR, 2020; BURMESTER *et al.*, 2022).

Similarly, the light requirement becomes an ecophysiological strategy for plants when associated with their ecological position in the occupied forest stratum. Burmester *et al.* (2022) suggest that the predominance of heliophytic species in the groups indicates this strategy has become advantageous, in this way, these species tend to colonize areas with high light incidence and predominate in the early stages of ecological succession. According to Lôbo *et al.* (2011), in forest fragments with disturbances, heliophytic species are predominant, as can be similarly observed in the regeneration process of Remédios Island.

The continuous replacement of late secondary or climax species, which are shade-tolerant, by pioneer or early secondary light-tolerant species tends to increase in disturbed areas (LÔBO *et al.*, 2011). Pioneer and/or early secondary species can represent up to 80% of the species in environments affected by the edge effect, especially in smaller fragments (JARDIM & MELO-JÚNIOR, 2020). In the study area, they represent 76.9%, which may be in line with the history of degradation and the current situation of natural regeneration on Remédios Island.

Fragments tend to become dominated by pioneer species, reducing the functional diversity of fragmented areas. Jardim & Melo-Júnior (2020) observed that this pattern was identified on Remédios Island due to the increase in generalist heliophytic pioneer species in the forest, to the detriment of climax shade species and late successional species. A notable species is *Syagrus romanzoffiana*, a pioneer, heliophytic, zoochorous species with year-round flowering and fruiting. *S. romanzoffiana* had the highest number of individuals observed in the sampling area (76). Due to its ecophysiological and reproductive characteristics, the primary hypothesis for its dominance on the island is related to bird distribution (BURMESTER *et al.*, 2022).

Increased light intensity on the leaf surface favors a greater expansion of the leaf blade in thickness, accompanied by a reduction in area, increasing the leaf's photosynthetic potential and water loss through transpiration. Species established in environments with reduced water availability, such as in certain points of *restinga*, show an opposite correlation to those observed with species from humid forests. Therefore, in a *restinga* landscape, species established in full sun locations have smaller leaves than those in shaded areas (CHAGAS *et al.*, 2008).

The majority of species identified in this study were perennial, except for *Machaerium hirtum*, the only deciduous species. Perennial species have greater tolerance to drought and high temperatures compared to deciduous species, as they maintain most of their canopy throughout the year, presenting longer leaf lifespan and greater structural investment in leaves.

Among pollinators, bees stand out in natural ecosystems, especially due to their great diversity, wide geographical distribution, and close interactions with flowering plants, representing a key group for ecosystem maintenance (KLOC *et al.*, 2019). The results of this study support this statement as the melittophily pollination syndrome was predominant, observed in twenty-five of the sampled species (96.15%). Bees are the main group of floral visitors for various plant species in *restinga* environments and have also been observed as the most representative in other tropical communities (MELO-JÚNIOR & BOEGER, 2015; JARDIM & MELO-JÚNIOR, 2020; BURMESTER *et al.*, 2022). Pollination is an essential ecosystem service for biodiversity maintenance, as it ensures plant reproduction for fruit and seed formation and promotes gene flow, which enhances plant genetic diversity and, consequently, species resistance to diseases and climate changes (KLOC *et al.*, 2019).

Similarly, the type of dispersal mechanism found among the sampled species is predominantly zoochorous, except for *Dahlstedtia floribunda*, which has autocoric dispersal, and *Machaerium hirtum*, which has anemochoric dispersal (op. cit.).

Only five species in the study area are dispersed by bats, and fourteen by terrestrial mammals, while dispersal by birds was predominant among the studied individuals (23 species), similar to what was observed by Jardim & Melo-Júnior (2020) and Missio *et al.* (2017). Since this is an island area undergoing natural regeneration, the data align with the theory that most species come from seed dispersal by birds from the mainland. During field campaigns, the presence of agoutis (*Dasyprocta sp.*) and a red howler monkey (*Alouatta guariba clamitans*) was identified, the latter being brought to the island years ago by a local resident. One of the oldest residents of the island reported the previous occurrence of coatis (*Nasua nasua*) in the area, but the population came into conflict with domestic dogs and was possibly extinct, as they were no longer found. The possible occurrence of capybaras (*Hydrochoerus hydrochaeris*) on the island is noted due to the discovery of feces and tracks remarkably similar to those recorded for the species.

It is important to emphasize that ecosystem survival and balance maintenance are directly related to pollination syndromes and dispersal mechanisms, enabling ecological succession. Species with long fruiting and flowering periods are vital for providing food resources to animals, ensuring their permanence in the environment (JARDIM & MELO-JÚNIOR, 2020). In the study area, the species with this pattern are: *Trema micranthum* (GF1), *Eugenia stigmatosa*, *Myrsine guianensis*, and *Syagrus romanzoffiana* (GF2), *Piper arboreum* and *Psychotria carthagenensis* (GF3).

As observed in the studies by Jardim & Melo-Júnior (2020) and Burmester *et al.* (2022), which adopted corresponding protocols, functional attributes, and statistical analysis methods, three groups are considered a low number of functional groups for the study area. However, when considering its natural regeneration time, it can be inferred that the arboreal vegetation of Remédios Island has not reached an advanced stage of ecological succession. The overlap of ecological requirements, denoted by the similarity between the functional attributes of the species surveyed on Remédios Island, resembles results obtained for other forest communities in the context of the Atlantic Forest in the northeastern region of Santa Catarina, in response to anthropogenic disturbances (JARDIM & MELO-JÚNIOR, 2020). These findings can help guide future biodiversity actions by environmental management agencies.

Although forest enrichment with species belonging to different functional groups in the forest matrix in question may be a viable forest management option to restore the plant community, a study conducted with a meta-analysis of 133 studies revealed that natural regeneration surpasses active restoration in the success of tropical forest restoration, both in terms of biodiversity (plants, birds, and invertebrates) and vegetation structure (cover, density, litter, biomass, and height). Controlling for biotic and abiotic factors, natural regeneration proved to be 34-56% more effective in restoring biodiversity and 19-56% more effective in vegetation structure. These findings challenge the belief that natural regeneration has limited conservation value, and that active restoration is always superior (CROUZEILLES *et al.*, 2017). Nevertheless, future policies should consider the conditions under which each approach is more effective and economical for tropical forest restoration.

CONCLUSIONS

Based on the analysis of their morphological, ecophysiological, reproductive, and sociological functional traits, as well as their richness and abundance, the following conclusions were drawn:

- Three functional groups were identified on Ilha dos Remédios;
- Species predominantly provided resources for bees and birds in spring and summer;
- A predominance of heliophilous, pioneer, and secondary species was observed to the detriment of sciophilous and climax species, supporting the tested hypothesis. The data suggest that the island's vegetation has not yet reached an advanced stage of regeneration.

It is understood and emphasized that there is a lack of studies on functional groups in restinga vegetation and especially in insular environments in the current literature. This highlights the need for more studies like this one in these understudied vegetation formations to better understand their ecological patterns and contribute more effectively to biodiversity conservation efforts.

ACKNOWLEDGMENTS

We would like to thank CNPq for the research scholarship granted to the first author. We also thank the Fundo de Amparo à Pesquisa da Univille for the financial support provided to the second author.

REFERENCES

ADLER, P. B.; SALGUERO-GÓMEZ, R.; COMPAGNONI, A.; HSU, J. S.; RAY-MUKHERJEE, J.; MBEAU-ACHE, C.; FRANCO, M. Functional traits explain variation in plant life history strategies. **Proceedings of the National Academy of Sciences**, Albuquerque, v. 111, n. 2, p. 740-745, jul. 2014.

BALDIN, M. T.; MESQUITA-BARROS, C. E.; CURY, L. F. Geoquímica e estrutura dos ortognaisses das ilhas do Balneário Barra do Sul e de São Francisco do Sul, litoral norte do Estado de Santa Catarina. **Geologia USP. Série Científica**, São Paulo, v. 17, n. 2, p. 89-105, jun. 2017.

BURMESTER, L. P.; QUANDT, F. L.; MELO-JÚNIOR, J. C. F. Determinação de Grupos Funcionais Para a Gestão da Conservação de Remanescentes da Floresta Atlântica. **Revista Estudo & Debate**, Lajeado, v. 29, n. 1., p. 7-23, feb. 2022.

CHAGAS, M. G. S.; SILVA, M. D.; GALVÍNCIO, J. D.; PIMENTEL, R. M. M. Variações Foliares em Grupos Funcionais Vegetais de uma Paisagem de Restinga, Pernambuco-Brasil. **Revista Brasileira de Geografia Física**, Pernambuco, v.1, n. 2, p. 50-63, sep-dec. 2008.

CROUZEILLES, R.; FERREIRA, M. S.; CHAZDON, R. L.; LINDENMAYER, D. B.; SANSEVERO, J. B.; MONTEIRO, L.; STRASSBURG; B. B. Ecological restoration success is higher for natural regeneration than for active restoration in tropical forests. **Science advances**, Rio de Janeiro, v. 3, n. 11, p. e1701345, nov. 2017.

GOGOSZ, A. M. & BOEGER, M. R. T. Functional morphology of subtropical tree seedlings in southern Brazil. **Rodriguésia**, Rio de Janeiro, v. 70, p. e0031217, mar. 2019.

HEILMEIER, H. Functional traits explaining plant responses to past and future climate changes. Elsevier GmbH. **Flora**, Jena, v. 254, p. 1-11, may. 2019.

JARDIM, R. I. L. & MELO-JÚNIOR, J. C. F. Redundância funcional de plantas lenhosas residentes do subosque de dois fragmentos de Mata Atlântica. **Revista Brasileira de Geografia Física**, Joinville, v. 14, n. 6, p. 3475-3496, dec. 2021.

JARDIM, R. I. L. & MELO-JÚNIOR, J. C. F. Reconhecimento de grupos funcionais em um fragmento de Mata Atlântica em Santa Catarina, Brasil**. Revista Brasileira de Geografia Física**, Pernambuco, v. 13, n. 2, p. 821-833, apr. 2020.

KLOC, P. B.; SILVA, T. M. V.; HOLDEFER, D. R.; OLIVEIRA, F. F.; WOITOWICZ-GRUCHOWSKI, F. C. Diversidade e redes de interação entre abelhas e plantas em áreas de várzea na Floresta Nacional (Flona) de Três Barras – Santa Catarina, Brasil. **Acta Biológica Catarinense**, Joinville, v**.** 6, n. 3, p. 81-97, sep. 2019.

KREFT, H., JETZ, W., MUTKE, J., KIER, G., & BARTHLOTT, W. Global diversity of island floras from a macroecological perspective. **Ecology letters**, United Kingdom, v. 11, n. 2, p. 116-127, mar. 2008.

LÔBO, D.; LEÃO, T.; MELO, F. P. L.; SANTOS, A. M. M.; TABARELLI, M. Forest fragmentation drives Atlantic forest of northeastern Brazil to biotic homogenization. **Diversity and Distributions**, New Jersey, v. 17, n. 2, p. 287-296, mar. 2011.

MELO-JÚNIOR, J. C. F.; BOEGER, M. R. T. Leaf Traits and Plastic Potential of Plant Species in a Light-edaphic Gradient from Restinga in Southern Brazil. **Acta Biológica Colombiana**, Bogotá, v. 21, n. 1, p. 51-62, jan-apr. 2016.

MELO-JÚNIOR, J. C. F.; BOEGER, M. R. T. Riqueza, estrutura e interações edáficas em um gradiente de restinga do Parque Estadual do Acaraí, Estado de Santa Catarina, Brasil. **Hoehnea**, São Paulo, v. 42, n. 2, p. 207-232, apr-jun. 2015.

MISSIO, F. F.; SILVA, A. C.; HIGUCHI, P.; LONGHI, S. J.; BRAND, M. A.; RIOS, P. D.; ROSA, A. D.; BUZZI JR., F.; BENTO, M. A.; GONÇALVES, D. A.; LOEBENS, R.; PSCHEIDT, F. Atributos Funcionais de Espécies Arbóreas em um Fragmento de Floresta Ombrófila Mista em Lages - SC. **Ciência Florestal**, Santa Maria, v. 27, n. 1, p. 215-224, mar. 2017.

MORAIS, J. M. & CIANCIARUSO, M. V. Plant functional groups: scientometric analysis focused on removal experiments. **Acta Botanica Brasílica**, Feira de Santana, v. 28, n. 4, p. 502-51, 2014.

Pacto pela restauração da Mata Atlântica: referencial dos conceitos e ações de restauração florestal. São Paulo, LERF/ESALQ: **Instituto BioAtlântica**, São Paulo, 260 p. 2009.

PEREZ-HARGUINDEGUY, N. *et al.* New handbook for standardised measurement of plant functional traits worldwide. **Australian Journal of Botany**, Melbourne, v. 64, n. 8, p. 715-716, jan. 2016.

PILLAR, V. D., BLANCO, C. C., MÜLLER, S. C., SOSINSKI, E. E., JONER, F., & DUARTE, L. D. Functional redundancy and stability in plant communities. **Journal of Vegetation Science**, Bruxelas, v. 24, n. 5, p. 963-974, sep. 2013.

QUINN, S. L.; WILSON, J. B.; MARK, A. F. The island biogeography of Lake Manapouri, New Zealand. **Journal of biogeography**, New York, p. 569-581, nov. 1987.

SEVEGNANI, L. & SCHROEDER, E. Biodiversidade catarinense: características, potencialidades, ameaças. **Edifurb**, Blumenau, 260 p., 2013.

SOUZA, K.; HIGUCHI, P.; SILVA, A. C.; SCHIMALSKI, M. B.; LOEBENS, R.; BUZZI JR., F.; SOUZA, C. C.; RODRIGUES JR., L. C.; WALTER, F. F.; MISSIO, F. F.; ROSA, A. D. Partição de nicho por grupos funcionais de espécies arbóreas em uma floresta subtropical. **Rodriguésia**, Rio de Janeiro, v. 68, n. 4, p. 1165-1175, jul-sep. 2017.

STOTZ, G. C.; LUARTE, C. S.; ESCOBEDO, V. M.; VALLADARES, F.; GIANOLI, E. 2021. Global trends in phenotypic plasticity of plants. **Ecology Letters**, Oxford, v. 24, p. 2267–2281, jul. 2021.

VIOLLE, C.; NAVAS, M. L.; VILE, D.; KAZAKOU, E.; FORTUNEL, C.; HUMMEL, I.; GARNIER, E. Let the concept of trait be functional! **Oikos**, Lund, v. 116, n. 5, p. 882-892, may. 2007.

WARDLE, D. A.; ZACKRISSON, O. Effects of species and functional group loss on island ecosystem properties. **Nature**, v. 435, n. 7043, p. 806-810, jun. 2005.