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Moraceae Gaudich. of Grumari restinga, Rio de Janeiro, Brazil

Moraceae Gaudich. da restinga de Grumari, Rio de Janeiro, Brasil

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Abstract Grumari, in the city of Rio de Janeiro, is one of the last preserved areas in the metropolitan region, but it lacks botanical studies. The present work aims to contribute to the knowledge of Moraceae in the Grumari restinga. The species survey was carried out by consultations of herbarium collections, literature, and fieldwork. Eight Moraceae species were inventoried, with two new records. Most are trees that are pollinated and dispersed by animals. Two species are restricted to two regions of the country, four are endemic to the Atlantic Forest and five are in a vulnerable state of conservation. The richness of Grumari's Moraceae is similar to that found in other restinga studies in Rio de Janeiro and the composition is more similar to Saquarema and Guarapari. The similarity with other areas is generally very low, highlighting the uniqueness of each and the importance of protecting the Grumari restinga.

Keywords: Atlantic Domain, Biodiversity, Conservation, *Ficus*, Rain Forest.

Resumo Grumari, no município do Rio de Janeiro, é uma das últimas áreas preservadas da região metropolitana, mas carece de estudos botânicos. O presente trabalho visa contribuir para o conhecimento das Moraceae na restinga Grumari. O levantamento das espécies foi realizado através de consultas a coleções de herbário, literatura e trabalho de campo. Oito espécies de Moraceae foram levantadas, com dois novos registros. A maioria das espécie são árvores polinizadas e dispersadas por animais. Duas espécies estão restritas a duas regiões do país, quatro são endêmicas da Mata Atlântica e cinco estão em estado de conservação vulnerável. A riqueza das Moraceae de Grumari é semelhante à encontrada em outros estudos de restinga no Rio de Janeiro e a composição é mais semelhante a Saquarema e Guarapari. A semelhança com outras áreas de modo geral é muito baixa, o que evidencia a singularidade de cada uma e reforça a importância da proteção da restinga de Grumari.

Palavras-chave: Biodiversidade, Conservação, Domínio Atlântico, *Ficus*, Floresta Tropical

Introduction

The Moraceae Gaudich. family, known for including fig trees, is characterized by laticifers

distributed throughout the plant, with single and alternating leaves (Santos et al., 2016). Moraceae can occur in the form of trees or shrubs such as terrestrial or liana, although some species occur as epiphytes, hemiepiphytes, hemiparasites or rupicolous (MARTINS et al., 2007; ROMANIUC NETO et al., 2015). The family has wide geographical distribution, with a higher concentration of species in the tropics and smaller in subtropical regions (MARTINS, 2009). The family has 38 genera and 1150 species distributed around the globe, with the main genera being *Ficus* L. and *Dorstenia* L. (SANTOS, 2012; SANTOS et al., 2016). There are 19 genera and 214 species in Brazil, with 70 of them endemic. The Atlantic Forest is specifically home to 10 genera and 101 species (FLORA DO BRASIL 2020). CARAUTA (1996) highlights the richness of Moraceae in the state of Rio de Janeiro, and currently there are 10 genera with 64 species registered in Flora do Brasil 2020. It is worth mentioning here, as they are included in the Red Book of Endemic Flora of Rio de Janeiro: *Dorstenia brevipetiolata* CCBerg and *Dorstenia fischeri* Bureau, assessed as "Vulnerable" (VU), and *Sorocea carautana* MDM Vianna f., as "Endangered" (MARTINELLI et al. 2018). The family is of great ecological importance in the environment, as its fruits, mainly *Ficus*, are food for birds, mammals and even some fish species (CARAUTA, 1989; MENDONÇA-SOUZA, 2006).

The Atlantic Forest is a domain in which Rio de Janeiro is located, and is made up of several distinct phytophysiognomies, among them restingas, with these characterized as plant communities that receive direct influence from seawater (VELOSO et al., 1991; IBGE, 2012) and may have herbaceous, shrub, and forest formations (SILVA, 1999; THOMAZI et al, 2013). Many studies emphasize the high biodiversity of southeastern Brazilian restingas (ARAUJO, 2000; ROCHA et al., 2003; ASSIS et al, 2004; MARTINS et al., 2008), however taxonomic research addressing families, genera and species of these environments is still scarce (SILVA, 1999; PEDERNEIRAS et al., 2014). Thomazi et al., (2003) points out that the restinga vegetation has been destroyed before adequate knowledge about the floristic richness and structure of these peculiar communities is acquired. For Moraceae, there is a lack of specific studies on restinga vegetation. We can mention a few floristic works in the southeast where the family is cited (ASSIS et al., 2004; GUEDES et al., 2006). In the state of Rio de Janeiro, the family appears in the floristic inventories conducted by Araujo & Oliveira (1988) in Praia do Sul, Carauta & Valente (2001) in Jurubatiba, Sá (2002) in Saquarema and by Assumpção & Nascimento (2000) in São João da Barra. Twenty (20) species are recorded in the restingas Moraceae publication of Rio de Janeiro, with 15 of them under some degree of threat of extinction (PEDERNEIRAS et al., 2011), highlighting the importance of conducting family-specific research in each particular restinga.

Grumari is located in the city of Rio de Janeiro, and is one of the few restinga areas of the metropolitan region. It significantly contributes to the conservation of the biodiversity of this phytophysiognomy in the state. Recent research points to a high biological richness in the area, either vegetation (ARAUJO, 2000; NOGUEIRA et al., 2011; MOREIRA et al., 2014; COUTO et al., 2017; CALAZANS et al., 2018) or animal (ROCHA et al., 2008; TELLES et al., 2012). Despite the publications, the lack of knowledge about many taxa and the structure of ecological communities in this restinga is a problem that urgently needs to be overcome to support conservation strategies.

Due to the ecological relevance of Moraceae and the large number of endangered species, as well as the need for taxonomic research in specific areas of restinga, this study aims to contribute to the knowledge of this family in Grumari restinga, Rio de Janeiro, Brazil, presenting floristic and ecological data of the species. We additionally present information on geographic distribution, degree of endemism and conservation status of the species, as well as compare the richness and composition with other restinga areas.

Material and methods

Study Area

The Grumari restinga is part of the Grumari Environmental Protection Area (APA) located in a neighborhood of the same name in the city of Rio de Janeiro, RJ. The restinga areas in the APA are protected by two overlapping protected areas, both

fully protected: the Prainha and Grumari Municipal Natural Parks (REIS & DONATO, 2010). The Prainha Municipal Natural Park, created by Decree No. 17,426, of March 25, 1999, has an area of 126.30 ha, and the Grumari Municipal Natural Park, was created by Decree No. 20,149, of 2/07/2001, with an area of 804.73 ha, both aimed at conserving, protecting and restoring the region's natural resources (FUNBIO, 2012). Grumari's soils are classified as clayey, with many rock outcrops and beaches, the climate is tropical with a dry season, with annual average temperatures between 22ºC and 24ºC. The predominant vegetation is Submontane Dense Ombrophilous Forest and Restinga (FUNBIO, 2012). The restinga is characterized as halophilic formation, reptant psamophyll, post-beach, open shrub, closed shrub and restinga forest (OLIVEIRA & MAIA, 2005), in which xerophyte, hygrophyte, tree, shrub, epiphyte and creeper species can be found (REIS & DONATO, 2010).

Methodology

For the expedited floristic survey to collect botanical material in 2019, all collected material was georeferenced, pressed, kiln-dried, mounted in exsiccates and deposited at the Herbarium of the Universidade Federal do Rio de Janeiro (RFA). It was conducted to complement the list of species obtained from the survey of herbarium consultations of the Museu Nacional (R), Universidade Federal Rural do Rio de Janeiro (RBR), the Universidade Federal do Rio de Janeiro (RFA) and Jardim Botânico do Rio de Janeiro (RB), personally and through the databases: SpeciesLink (http://splink.cria.org.br), Jabot - Database of Brazilian Flora (http://jabot.jbrj.gov.br), and Reflora (reflora.jbrj.gov.br). The identification of the species was based on specific literature, on the study of wooded material and with the help of experts. The scientific names were verified in Flora do Brasil 2020.

Information on life form, substrate where it occurs, geographic distribution and endemism of the species were collected from Flora do Brasil 2020, The Red List Brazilian Flora (MARTINELLI & MORAES, 2013) and family-specific bibliography (PEDERNEIRAS et al., 2011). The life forms adopted were undergrowth, sub-shrub, shrubs and trees, and the types of substrates were terrestrial occurring on the soil, rupicolous on rocks, and hemiepiphytes, but may be epiphyte at some stage of life (Flora do Brasil 2020). The species were considered widely distributed if they occur in more than three Brazilian states. The pollination forms of the species were verified from floral syndromes based on specific bibliographies, with no in-depth research on the reproductive biology of the species. Pollination syndromes were classified according to the categories: anemophilia (through the wind), entomophilia (by insects), ornithophilia (by birds), and chiropterophilia (when it is through bats) (REAL, 1983). Regarding fruit dispersal, the species were classified as autochoric (dispersed by gravity), anemochoric (by wind), and zoochoric (by animals) (PIJL, 1982).

The conservation status of the species was verified in the The Red List Brazilian Flora (Martinelli & Moraes, 2013), in the Official National List of Endangered Flora Species (MMA, 2014), at the portal of the National Center for Plant Conservation (CNCFLORA, 2019) and in the publication by Pederneiras et al. (2011).

We used the publications of Pederneiras et al. (2011), Sa (2002), Carauta & Valente (2001), Araujo & Oliveira (1988) and Assumption & Birth (2000) conducted in the state of Rio de Janeiro, Guedes et al. (2006), developed in Bertioga (SP), Assis et al. (2004), in Guarapari (ES), and Venzke et al. (2012), in Pelotas (RS) to evaluate the similarity of richness and composition of Grumari with other areas of restinga vegetation. The presence/absence matrix was elaborated and the floristic similarity was calculated using the Jaccard Similarity Index (JS), using the PAST version 2.17c program. We also elaborated a Jaccard similarity dendrogram based on cluster analysis with paired groups in the same program.

Results

Floristics and ecology

Eight species of four genera were recorded in the Grumari restinga (Table 1). Ficus L. is the genus with the largest number of species (n = 5, 62.5%),

while the others presented one species each. Only two species were collected in the field sampling: *Ficus clusiifolia* Schott and Sorocea hilarii Gaudich. Both were sterile. *Ficus clusiifolia* and *Ficus eximia* Schott are new records for Grumari restinga. We highlight that F. eximia, deposited in the herbarium RBR, is a new record in restinga vegetation in the state of Rio de Janeiro.

According to the information of the species in Flora do Brasil 2020, most species have tree size (n = 5; 62.5%), two can be considered trees or shrubs (25%), and one can be grass or sub-shrub (12.5%) (Figure 1). Regarding the type of substrate where they occur, half of them are terrestrial (n = 4; 50%), three species can be either terrestrial or hemiepiphyte (37.5%), and one species can be terrestrial or rupicolous (12.5%) (Figure 1). All species have insect pollination syndromes and seven have animal dispersal syndrome (87.5%), and only one has characteristics of autochory (*Dorstenia arifolia* Lam.).

Endemics and conservation

Most of the Grumari restinga Moraceae species are widely distributed in Brazilian regions (n = 6; 75%), with confirmed occurrences in at least three regions of the country. Only two species are more restricted: *Dorstenia arifolia* Lam, which occurs only in the northeast and southeast; and Ficus maximiliana Mart. ex Miq., which is restricted to the southeast, more specifically to the states of Rio de Janeiro and Espírito Santo. *Ficus maximiliana* was synonymized as *Ficus tomentella* (Miq.) Miq., typical of Pará, however Pederneiras et al., (2001) reported its correct description as being restricted to the southeast. All species are native, five are native and endemic to the country (62.5%), and four are endemic to the Atlantic Forest (50%).

According to Pederneiras et al. (2011), five species are classified as "vulnerable" (VU, 62.5%), two "almost threatened" (NT, 25%) and one not listed

Table 1. Moraceae Gaudich. of Grumari restinga, Rio de Janeiro, Brazil, followed by their respective life forms, habitat types, pollination and dispersal syndrome, geographic distribution, phytogeographic domain according, and Conservation Status to current bibliography (PEDERNEIRAS et al., 2011), and finally vouchers from the botanical collections where the materials are deposited. AM = Amazon; SHR = shrub; T = tree; AUTO = autochoric; CA = Caatinga; MW = Midwest; EC = Cerrado; ENT = entomophilia; W = weed; HE = hemiepiphyte; AF = Atlantic Forest; N = North; NA = Not applicable; NE = Northeast; NT = Near Threatened; PA = Pantanal; R = rupicolous; S = South; SE = Southeast; TE = terrestrial; UND = undergrowth; VU = vulnerable; ZOO = zoochoric. Herbarium vouchers according to Index Herbariorum.

Species	Life Forms	Habitat types	Pollination syndrome	Dispersal syndrome	Geographic distribution	Phyto-geographic Domain	Conservation Status	Vouchers
Brosimum guianense (Aubl.) Huber	SHR, T	TE	ENT	ZOO	N, NE, SE, MW	AM, CA, EC, AF	VU	RB 152168; RFA 20395
Dorstenia arifolia Lam.	UND, W	R, TE	ENT	AUTO	NE, SE	AF	VU	RB 141021; RB 153336, RFA 37072; RFA 37363; RFA 37361
Ficus clusiifolia Schott	T	HE, TE	ENT	ZOO	N, NE, MW, SE, S	AM, EC, AF, PA	NT	RFA 43582
Ficus eximia Schott	T	TE	ENT	ZOO	N, NE, MW, SE, S	AM, EC, AF	NA	RBR 43228
Ficus hirsuta Schott	T	HE, TE	ENT	ZOO	NE, MW, S	AF	VU	RB 206019
Ficus luschnathiana (Miq.) Miq.	T	HE, TE	ENT	ZOO	NE, MW, SE, S	AF	VU	RB 152165
Ficus maximiliana Mart. ex Miq.	T	TE	ENT	ZOO	SE	AF	NT	GUA 48700 (*apud* Pederneiras et al. 2011)
Sorocea hilarii Gaudich.	SHR, T	TE	ENT	ZOO	NE, SE, S	EC, AF	NT	R 197433; RB 163979; RB 141024; RFA 32744; RFA 40006; RFA 43583

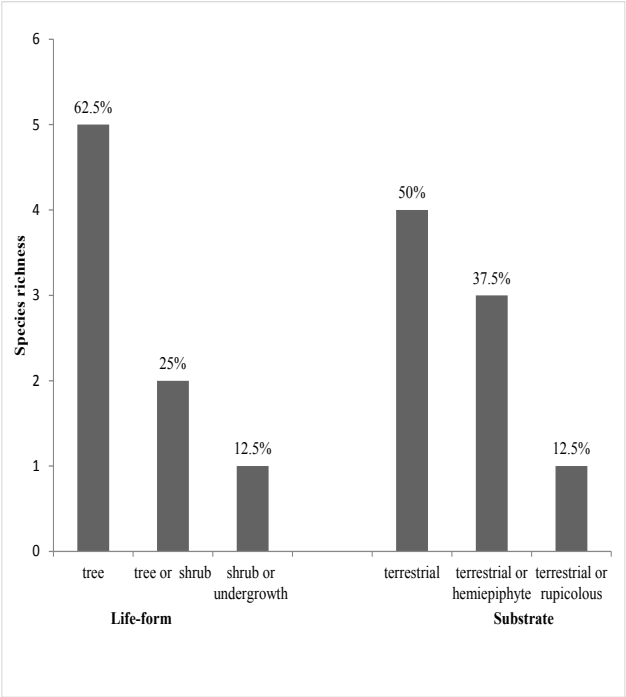

Figure 1. Species richness of Moraceae occurring in Grumari restinga, Rio de Janeiro, RJ, classified according to life-form and types of habit.

(12.5%). *Ficus eximia* Schott was not evaluated by Pederneiras et al. (2011) for being new information for the flora of the restingas of Rio de Janeiro. None of the Grumari Moraceae species is present in the Red List Brazilian Flora (MARTINELLI & MORAES, 2013) and only one is on the Official List of Endangered Flora Species (MMA, 2014), in which *Dorstenia arifolia* Lam. is categorized as "DD", meaning that it does not have information on geographic distribution, threats or other data which allow it to fit in with some threatened condition (MMA, 2014). In the National Center for Plant Conservation (CNCFLORA, 2019), five species were not assessed for threat (found as "NE", 62.5%) and three were in the "not of concern" category (LC, 37, 5%). Only *F. maximiliana* is considered NT ("Near Threatened"), not VU ("Vulnerable"), because it also occurs in the forest regions near the restingas (PEDERNEIRAS et al., 2011).

Comparison of richness and similarity with other restinga areas

The Grumari restinga includes 40% of all Moraceae species that occur in the restingas of Rio de Janeiro. The richness presented in this study is similar to that recorded in Saquarema and Jurubatiba (CARAUTA & VALENTE, 2001; SÁ, 2002), and is superior to surveys carried out in Praia do Sul and São João da Barra (ARAÚJO & OLIVEIRA, 1988; ASSUMPÇÃO & NASCIMENTO, 2000) (Table 2).

An analysis of Jaccard Similarity Indexes (JS) indicates low similarity between the composition of Grumari Moraceae and other restinga areas. Grumari presents greater similarity with Saquarema and Guarapari, and less with the Praia do Sul, Bertioga and Pelotas restingas, highlighting that the last two occur in São Paulo and Rio Grande do Sul, respectively (Table 3).

Table 2. Comparison of species richness of Moraceae in restinga phytophysiognomies in the state of Rio de Janeiro.

Locality	Species richness	Bibliography
Restinga in the state of Rio de Janeiro	20	Pederneiras et al. (2011)
Grumari	8	present study
Jurubatiba	7	Carauta & Valente (2001)
Saquarema	7	Sá (2002)
Praia do Sul	3	Araújo & Oliveira (1988)
São João da Barra	1	Assumpção & Nascimento (2000)

The São João da Barra restinga was not used in the composition analysis because it only presented one generic identified *Ficus* species. The Jaccard similarity dendrogram reflected the results found for the similarity indexes and grouped the Grumari and Saquarema restingas and these two restingas to Guarapari (Figure 2).

Discussion

Floristics and ecology

The floristic results found for Grumari corroborate other studies carried out for the Moraceae family, where Ficus also stands out as the main genus (ARAUJO & OLIVEIRA, 1988; CARAUTA & VALENTE, 2001; SÁ, 2002; PEDERNEIRAS et al., 2011). This is the largest genus in the family and has over 800 species in the world (PELISSARI & ROMANIUC NETO, 2013). The Flora do Brasil 2020 recorded 85 species, 40 of which occur in

Table 3. Similarity matrix represented by Jaccard Similarity Index (JS) values, based on data on species richness and composition of Moraceae from Grumari restinga, Rio de Janeiro, RJ.

	Grumari	Saquarema	Jurubatiba	Praia do Sul	Guarapari	Bertioga	Pelotas
Grumari	1	0,50	0,28	0,1	0,30	0,12	0
Saquarema	-	1	0,25	0	0,50	0	0
Jurubatiba	-	-	1	0,12	0,22	0	0,12
Praia do Sul	-	-	-	1	0	0	0,20
Guarapari	-	-	-	-	1	0	0
Bertioga	-	-	-	-	-	1	0
Pelotas	-	-	-	-	-	-	1

the Atlantic Forest, thereby justifying the greater richness of the genus in restinga ecosystems. Fig trees, as they are known, represent an important component of ecosystems, as their fruits provide food resources for a wide range of animals (CARAUTA, 1989; MENDONÇA-SOUZA, 2006).

Moraceae plays a fundamental role in tropical forests, especially because its species make up a very representative part of the tree strata in the Atlantic Forest (MARTINELLI & MORAES, 2013). The species being pollinated and dispersed by animals

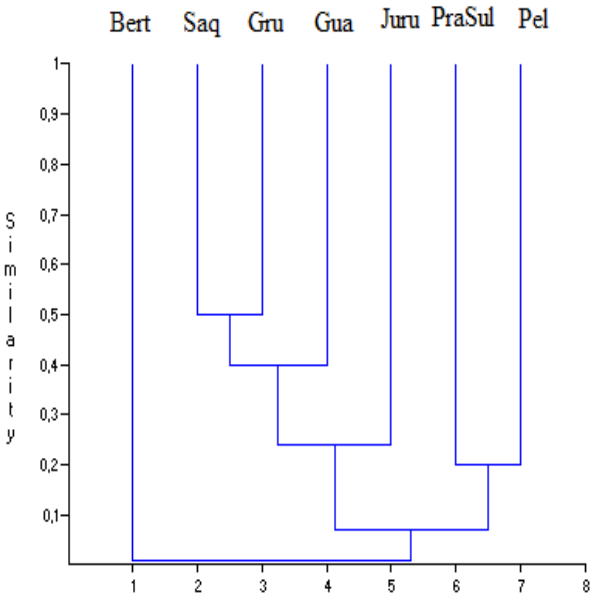

Figure 2. Jaccard similarity dendrogram elaborated by paired cluster analysis for the richness and composition of Moraceae species from Grumari restinga, Rio de Janeiro, RJ, compared to other restinga areas. Bert = Bertioga, SP; Saq = Saquarema, RJ; Gru = Grumari, RJ; Gua = Guarapari; Juru = Jurubatiba, RJ; PraSul = Praia do Sul, RJ; Pel = Pelotas, RS.

underscores their importance for the functioning of restinga ecosystems. Pollination in *Ficus* occurs through a highly specific complex process involving wasps, which is reflected in the evolution of the syconium (genus exclusive cimosa inflorescence) (PEREIRA et al., 2000). Research on pollination for the *Dorstenia* genus is still scarce in the literature, but visits of small insects to inflorescences have been recorded, indicating entomophilia (MARTINS, 2006).

Endemics and conservation

The restricted distribution to the Atlantic Forest may indicate greater vulnerability of species to anthropogenic pressures, and three of the endemic species of this phytogeographic domain are threatened. According to Pederneiras et al. (2011), the vulnerable conservation state in which most species are found is related to the scarcity of sources for propagating propagules to the restingas where they occur.

Pederneiras et al. (2014) recorded the species *Dorstenia arifolia* Lam. confined between rocks on the slopes of a beach in Grumari. The authors point out that the species is very fragile and does not resist anthropogenic disturbances, and that is why it is one of the rarest to be registered today (PEDERNEIRAS et al., 2014). According to Pederneiras et al. (2014), *F. eximia* was recorded only in restingas close to slopes and it is likely that there were no occurrences for restingas in Rio de Janeiro due to the intense degradation that occurred historically.

Comparison of richness and similarity with other restinga areas

The grumari restinga covers a large proportion of the Moraceae species in the state of Rio de Janeiro, emphasizing the importance of its preservation in order to maintain family diversity. The low number of Moraceae species shared among restingas underscores how unique the diversity of each one is and presents taxonomic singularities for this important family. The grouping of Grumari to Saquarema and these to Guarapari and Jurubatiba reinforce results found by other authors that highlight the similarities in the phytophysiognomy of the Rio de Janeiro and Espírito Santo restingas (ARAUJO, 2000; ASSIS et al., 2004; COUTO et al., 2017).

Conclusion

The present study is the first to be specifically conducted for the Moraceae family in the Grumari restinga and brings two new records to the area, *Ficus clusiifolia* Schott and *Ficus eximia* Schott. We highlight the importance of the family as a tree component and for maintaining food resources for invertebrate and vertebrate animals. Each restinga is a particular environment with unique abiotic characteristics and biodiversity. We emphasize the need for further taxonomic and ecological studies with this and other families in the Grumari restinga in order to understand the structure and functioning of ecological communities in this environment. In addition, we emphasize the importance of protecting this area, as it has a considerable richness of Moraceae, endemic species to the Atlantic Forest and most endangered.

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