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Phytosociological study of a riverine forest remnant from Taquari river, State of Rio Grande do Sul, Brazil

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ABSTRACT - (Phytosociological study of a riverine forest remnant from Taquari river, State of Rio Grande do Sul, Brazil). Aiming to characterize the structure of the arboreal community in a riverine forest remnant of the Taquari river, State of Rio Grande do Sul, 42 sampling units of 100 m² (10 × 10 m) were located. Phytosociological parameters were also assessed and the indexes of Shannon diversity (H') and Pielou evenness (J) were evaluated. A total of 39 species, 21 families, 2.83 nats ind^{-1} for H' and 0.77 for J were recorded. Among the species found, the endemic *Callisthene inundata* O.L. Bueno, A.D. Nilson & R.G. Magalh. and *Picrasma crenata* (Vell.) Engl. are included in the list of endangered species. The density found was of 1,557.14 ind ha^{-1}. *Luehea divaricata* Mart. and *Lonchocarpus nitidus* Benth. showed the highest indexes of importance values. Besides contributing to the knowledge of species distribution and community structure, this study points out the need for conservation of existing native forest remnants.
Keywords: alien species, arboreal community, endemic species, riparian vegetation, Taquari-Antas river basin

RESUMO - (Estudo fitossociológico de um remanescente da floresta ribeirinha do rio Taquari, Estado do Rio Grande do Sul, Brasil). Com o objetivo de caracterizar a estrutura da comunidade arbórea de um remanescente de floresta ribeirinha do rio Taquari, foram estabelecidas 42 unidades amostrais de 100 m² (10 × 10 m) e calculados os parâmetros fitossociológicos e índices de diversidade de Shannon (H') e Equabilidade de Pielou (J). Foram amostradas 39 espécies, 21 famílias, 2,83 para H' e 0,77 para J. Dentre as espécies *Callisthene inundata* O.L. Bueno, A.D. Nilson & R.G. Magalh. é endêmica, estando, junto com *Picrasma crenata* (Vell.) Engl., na lista das espécies ameaçadas de extinção. A densidade encontrada foi de 1.557,14 ind. ha^{-1}. *Luehea divaricata* Mart. e *Lonchocarpus nitidus* Benth. apresentaram os maiores índices de valores de importância. Além de contribuir para o conhecimento da distribuição das espécies e estrutura da comunidade, este estudo alerta para a necessidade de conservação dos remanescentes florestais nativos existentes.
Palavras-chave: bacia hidrográfica do rio Taquari-Antas, comunidade arbórea, espécies endêmicas, espécies exóticas invasoras, vegetação ripária

Introduction

Vegetation along watercourses and around springs, known as riverine forest, is characterized by the combination of local climate, hydrology, geology and geomorphology factors, as they define landscape and ecological conditions (Rodrigues & Leitão-Filho 2001). These factors, combined with sedimentation, erosion and flooding, promote floristic diversity and heterogeneity in these formations (AB'Saber 2001, Lima & Zakia 2001). Due to the importance they represent for the maintenance and development of fundamental environmental processes for the conservation of animal and plant diversity, both terrestrial and aquatic (Lima & Zachia 2001), it is essential to understand the variation of this vegetation type in a large number of riverine areas and its role in maintaining floral biodiversity.

Due to these environmental characteristics, in Brazil, riparian formations are considered Permanent Preservation Areas (PPA) protected by the Forest Code (Law No. 4.771/65) since September 1965 (Brasil 1965). In 2012, the approval of the new Brazilian Forest Code (Law 12.651) repealed the Law 4.771/65, continuing riverine forest protection (Brasil 2012). Even so, riverine formations are extremely fragmented as a result of human interference, which is responsible, in large part, by species abundance and composition

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pattern changes, ecological processes alteration (Rambaldi & Oliveira 2005) and performance losses in their environmental functions.

Degradation of river and stream banks from Taquari-Antas river Basin (BHRTA), State of Rio Grande do Sul (RS), Brazil, took place as in all other Brazilian river basins, where few fragments remain preserved (Lima *et al.* 2007, Rempel *et al*. 2007) - today it represents around 26% of the basin area. These fragments need to be studied in order to know their floristic and community structural diversity to create a baseline for the elaboration and implantation of projects aiming to recover the degraded portions of the riverbanks, favoring remnant fragments connection (Santos 2007). The floristic and structural heterogeneity of these formations, even when they are close to other remnants, have to be considered when elaborating recovering projects, and studies to assess this structure are crucial. Besides, native plant formations are being intensively threatened due to the presence of invasive alien species, probably as a consequence of the fast dispersion of their seeds by flood (Ede & Hunt 2008), among others. Invasive alien species usually grow rapidly, affecting native species negatively and resulting in habitat alterations and loss of floristic diversity (Leal *et al.* 2008). Knowing the phytosiocologial parameters of alien species in relation to native species can alert to the need of measures to control such invasions.

Therefore, in order to contribute to information on riverine forests from RS, the objective of this study was to characterize the tree community structure of a riverine forest remnant from Taquari river belonging to BHRTA in the municipality of Muçum, RS, assessing floristic diversity, forest structure and the presence of alien species, besides endangered and endemic species.

Material and methods

Study Area - The present study was conducted in a riverine forest remnant located on the right bank of Taquari river, Taquari-Antas river Basin, municipality of Muçum, Rio Grande do Sul (figure 1). The fragment, with 3.4 hectares, is located on a river curve where the stream floods the forest during heavy rain periods. The forest remnant appears to be well preserved, making limit with an area of cattle grazing on its upper portion, and an area of agriculture farming and forest vegetation with high incidence of alien species on the sides.

According to the Brazilian Institute of Geography and Statistics (IBGE 2012), the local formation belongs to the Atlantic Forest and is inserted in the Seasonal Deciduous Forest phytoecological formation. The soil is characterized by presenting a complex association of Eutrophic Litholic Soils (IBGE 2017). According to Köppen classification, regional climate is humid subtropical (Cfa) (Peel *et al.* 2007).

Data Collection - In order to evaluate the arboreal component, a fixed area method was used by systematic distribution of 42 sample units (SU's) of 100 m² (10 × 10 m) distributed at every 20 meters in transects that were parallel to the riverbed and 10 meters away from each other. The first transect was arranged as close as possible to the river bank. In each of the SU's, height was obtained by visual estimation. Then, circumference at breast height (CBH) of all trees with equal or higher than 20 cm was measured. When specimens had two or more stems, measurement of all stems was conducted if at least one stem had CBH ≥ 20 cm, then the basal area of each stem was defined and the sum of stems was made.

During sampling, fertile and infertile botanical material was collected for further identification using specific dichotomous keys (Sobral *et al.* 2013) and consulting experts. If fertile, the material was herborized and incorporated into the HVAT Herbarium of the Universidade do Vale do Taquari - Univates University Center Natural Sciences Museum. Native species nomenclature followed the International Plant Names Index (http://www.ipni.org), while Tropicos from Missouri Botanical Garden (http://www.tropicos.org/) was used for alien species. Families were classified according to the code for Angiosperm Phylogeny Group (APG IV 2016).

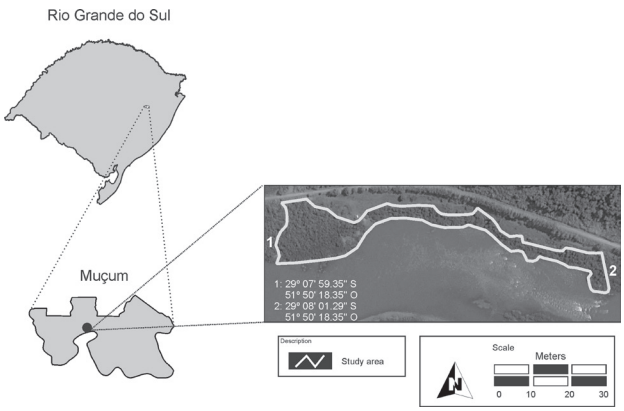

Figure 1. Location of the study area in the municipality of Muçum, State of Rio Grande do Sul, Brazil.

Data Analysis - For each sampled species, basal area (BA), density (D) absolute (A) and relative (R), frequency (F) A and R, dominance (Do) A and R and importance value index (IVI) were calculated (Muller-Dombois & Ellemberg 1974). Arboreal component diversity was estimated by the Shannon Diversity Index (H'), and evenness was evaluated by Pielou's Index (J) using the Past program, 3.0 version (Hammer *et al.* 2001). In order to estimate expected species richness, "Bootstrap" estimator was used through a presence and absence matrix in the "EstimateS" software (Colwell 2006).

Based on height estimation, individuals were grouped into six height classes (with one meter increment), adapted from Budke *et al.* (2004) and Lucheta *et al.* (2015), and the number of individuals per height class was obtained. Similarly, all individuals were grouped into diameter classes (DBH - diameter at breast height) through circumference values conversion, which were obtained during sampling, and grouped into the following classes, adapted from Budke *et al.* (2004) and Lucheta *et al.* (2015): 6.0-8.0 cm; 8.1-12.0 cm; 12.1-20.0 cm; 20.1-30.0 cm; 30.1-40.0 cm; 40.1-50.0 cm; 50.1-60.0 cm; 60.1-80.0 cm; 80.1-100.0 cm; 100.1-140.0 cm; 140.1-180.0 cm; 180.1-200.0 cm; > 220 cm. Thus, the number of individuals in each diameter class was determined.

Species composition pattern in the fragment was verified by a principal coordinates analysis (PCoA) through Multiv software, using a species abundance matrix without data transformation and chord distance as the similarity measure (Pillar 2009). To verify whether this analysis properly summarized the results, we evaluated Mantel correlation between the distance matrix of the PCoA scores (Euclidean distance) and the distance matrix of the original data (Legendre & Legendre 1998).

Results

A total of 654 living arboreal individuals belonging to 39 species, 36 genera and 21 botanical families were sampled. Sampling proved to be enough to represent the community, as the 39 species found in this study accounted for 93% of the total estimated by "Bootstrap" richness estimator (figure 2).

Families with the highest species richness were Myrtaceae, with eight species (23.08%), Fabaceae, with seven species (17.95%) and Euphorbiaceae, with four species (10.26%), followed by Moraceae and Sapindaceae, both represented by two species. The remaining 16 families were represented by only one species each.

Of the 39 recorded species, four were alien (10.3%), which were represented by 26 individuals (6.0%). Among them, *Morus nigra* L. was the most numerous, with absolute density (AD) of 40.48 ind ha^{-1}, followed by *Hovenia dulcis* Thunb., with 16.67 ind ha^{-1} and also *Tecoma stans* (L.) Juss. *ex* Kunth and *Psidium guajava* L., both with AD of 2.38 ind ha^{-1} (table 1).

Total basal area, considering the entire sample, was of 16.47 m², corresponding to a total absolute dominance of 39.23 m² ha^{-1}. The species with the highest absolute dominance (ADo) were *Luehea divaricata* Mart. (10.89 m² ha^{-1}), *Terminalia australis* Cambess (5.80 m² ha^{-1}), *Myrcia palustris* DC. (4.10 m² ha^{-1}), *Lonchocarpus nitidus* Benth and *Pouteria salicifolia* (Spreng) Radlk. (3.84 m² ha^{-1}) (table 1). The absolute density (AD) of the studied area was estimated in 1,557.1 ind ha^{-1}, the species with the highest AD values were *Lonchocarpus nitidus* (124

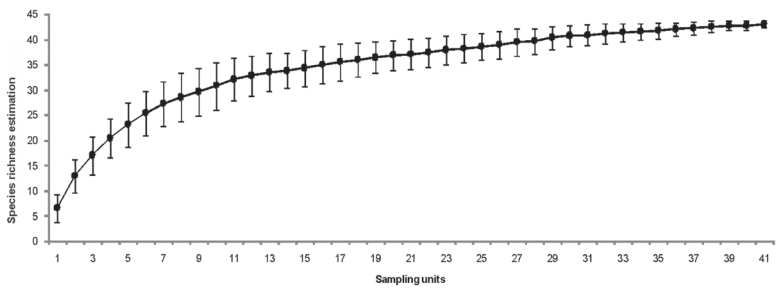

Figure 2. Richness estimative of species in the riverine forest fragment from Taquari river, Muçum/RS, Brazil, by using the "Bootstrap" estimator. Bars indicate standard deviation.

Table 1. Phytosociological parameters estimated for arboreal species of the riverine forest fragment from Taquari river, Muçum/RS, Brazil, in descending Importance Value Index (IVI) order. Ni: number of individuals. BA: basal area (m²). AD: absolute density (ind ha^{-1}). ADo: absolute dominance (m² ha^{-1}). AF: absolute frequency.

Species	Family	Species code	Ni	BA	ADo	AD	AF	IVI
Luehea divaricata Mart.	Malvaceae	Ludi	60	4.57	10.89	142.86	57.14	15.06
Lonchocarpus nitidus Benth.	Fabaceae	Loni	124	1.61	3.84	295.24	78.57	13.36
Myrcia palustris DC.	Myrtaceae	Mypa	69	1.72	4.10	164.29	50.00	9.41
Terminalia australis Cambess.	Combretaceae	Teau	49	2.44	5.80	116.67	30.95	8.92
Gymnanthes klotzschiana Müll. Arg.	Euphorbiaceae	Gykl	55	0.96	2.27	130.95	59.52	7.60
Matayba elaeagnoides Radlk.	Sapindaceae	Mael	62	0.65	1.55	147.62	52.38	7.00
Pouteria salicifolia (Spreng.) Radlk.	Sapotaceae	Posa	27	1.61	3.84	64.29	33.33	6.25
Calyptranthes concinna DC.	Myrtaceae	Caco	35	0.33	0.80	83.33	35.71	4.18
Campomanesia xanthocarpa O.Berg	Myrtaceae	Caxa	24	0.41	0.97	57.14	30.95	3.54
Morus nigra L.*	Moraceae	Moni	17	0.35	0.83	40.48	21.43	2.60
Eugenia uniflora L.	Myrtaceae	Euun	16	0.15	0.36	38.10	26.19	2.39
Parapiptadenia rigida (Benth.) Brenan	Fabaceae	Pari	12	0.14	0.33	28.57	23.81	2.04
Myrceugenia glaucescens (Cambess.) D.Legrand & Kausel	Myrtaceae	Mygl	10	0.32	0.77	23.81	14.29	1.85
Allophylus edulis (A.St.-Hil.) Niederl.	Sapindaceae	Aled	11	0.11	0.25	26.19	21.43	1.80
Campomanesia rhombea O.Berg	Myrtaceae	Carh	9	0.13	0.31	21.43	19.05	1.64
Myrsine laetevirens (Mez) Arechav.	Primulaceae	Myla	9	0.11	0.25	21.43	16.67	1.48
Vitex megapotamica (Spreng.) Moldenke	Lamiaceae	Vime	6	0.12	0.28	14.29	14.29	1.23
Hovenia dulcis Thunb.*	Rhamnaceae	Hodu	7	0.20	0.46	16.67	9.52	1.21
Annona neosalicifolia H.Rainer	Annonaceae	Anne	6	0.05	0.12	14.29	9.52	0.87
Machaerium stipitatum Vogel	Fabaceae	Mast	5	0.06	0.14	11.90	9.52	0.84
Bauhinia forficata Link	Fabaceae	Bafo	4	0.01	0.04	9.52	9.52	0.69
Callisthene inundata O.L.Bueno, A.D. Nilson & R.G. Magalh.	Vochysiaceae	Cain	5	0.10	0.23	11.90	4.76	0.68
Gymnanthes schottiana Müll.Arg.	Euphorbiaceae	Gysc	4	0.05	0.12	9.52	7.14	0.65
Blepharocalyx salicifolius (Kunth) O.Berg	Myrtaceae	Blsa	4	0.04	0.10	9.52	7.14	0.63
Machaerium paraguariense Hassl.	Fabaceae	Mapa	3	0.07	0.16	7.14	4.76	0.52
Nectandra megapotamica Mez	Lauraceae	Neme	2	0.04	0.10	4.76	4.76	0.42
Trema micrantha (L.) Blume	Cannabaceae	Trmi	2	0.03	0.07	4.76	4.76	0.39
Alchornea triplinervia (Spreng.) Müll. Arg.	Euphorbiaceae	Altr	2	0.02	0.05	4.76	4.76	0.37
Guettarda uruguensis Cham. & Schltdl.	Rubiaceae	Guur	2	0.01	0.02	4.76	4.76	0.35
Casearia sylvestris Sw.	Salicaceae	Casy	2	0.01	0.02	4.76	4.76	0.35
Inga vera Willd.	Fabaceae	Inve	2	0.01	0.02	4.76	2.38	0.24
Roupala montana var. *brasiliensis* (Klotzsch) K.S.Edwards	Proteaceae	Romo	2	0.01	0.02	4.76	2.38	0.23
Tecoma stans (L.) Kunth *	Bignoniaceae	Test	1	0.01	0.02	2.38	2.38	0.18
Maclura tinctoria (L.) D.Don *ex* Steud.	Moraceae	Mati	1	0.01	0.02	2.38	2.38	0.18
Mollinedia schottiana Perkins	Monimiaceae	Mosc	1	0.01	0.01	2.38	2.38	0.18
Dalbergia frutescens (Vell.) Britton	Fabaceae	Dafr	1	0.00	0.01	2.38	2.38	0.17
Picrasma crenata Engl.	Simaroubaceae	Picr	1	0.00	0.01	2.38	2.38	0.17
Psidium guajava L.*	Myrtaceae	Psgu	1	0.00	0.01	2.38	2.38	0.17
Sapium glandulatum (Vell.) Pax	Euphorbiaceae	Sagl	1	0.00	0.01	2.38	2.38	0.17
TOTAL			654	16.47	39.23	1557.1	692.86	100

* Exotic and # endemic species from Taquari-Antas river basin riparian vegetation

individuals), with 295.24 ind ha^{-1}, *Myrcia palustris* (69 individuals), with 164.29 ind ha^{-1}, *Matayba elaeagnoides* Radlk. (62 individuals), with 147.62 ind ha^{-1}, *Luehea divaricata* (60 individuals), with 142.86 ind ha^{-1} and *Gymnanthes klotzschiana* Müll. Arg., with 55 individuals and density of 130.95 ind ha^{-1} (table 1).

The species with the highest absolute frequency (AF) values were *L. nitidus* (78.57%), *G. klotzschiana* (59.52%), *L. divaricata* (57.14%), *M. elaegnoides* (52.38%) and *M. palustris* (50%) (table 1). The highest importance values indice (IVI) were found for *L. divaricata* (15.06), followed by *L. nitidus* (13.36), *M. palustris* (9.41) and *T. australis* (8.92). Among species, 53.84% had less than 1.0 IVI (table 1).

Shannon diversity (H') and Pielou's evenness (J) indexes were 2.83 and 0.77 nats ind^{-1}, respectively.

Approximately 70% individuals had heights between 5.0 and 8.9 meters (figure 3), and only 23.3% were higher than 9.0 meters. Sampled vegetation average DBH was 27 cm, and of the total number of individuals, 65.5% were in DBH scales corresponding from 6.0 to 30 cm (figure 4).

The first axis of the principal coordinates analysis (PCoA) explained 23.4% of the variation of community data, while the second axis explained 16.4%. The Mantel correlation result (r = 0.31,

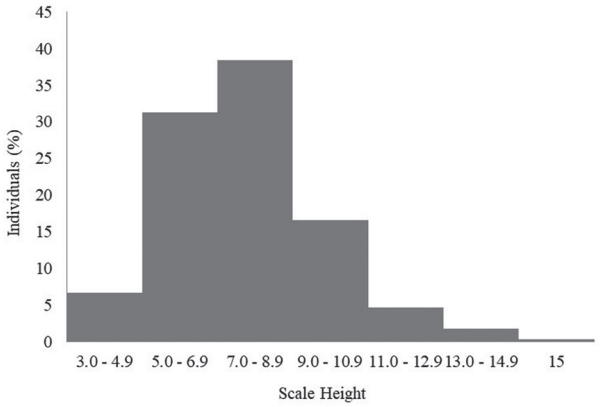

Figure 3. Percentage of individuals sampled in the riverine forest fragment from Taquari river, Muçum/RS, Brazil, by height class.

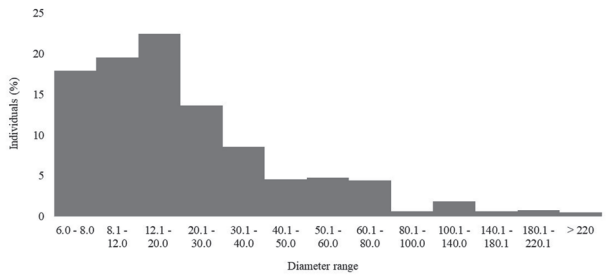

Figure 4. Percentage of individuals sampled in the riverine forest fragment from Taquari river, Muçum/RS, Brazil, by DBH (diameter at breast height).

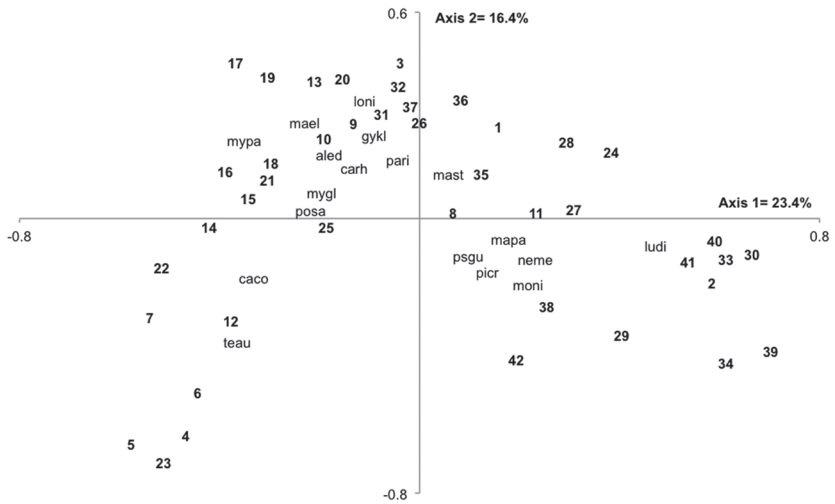

Figure 5. Representation of the first two ordination axes obtained through principal coordinates analysis (PCoA) in a riverine forest fragment from Taquari river, Muçum/RS, Brazil. picr: *Picrasma crenata.* posa: *Pouteria salicifolia.* loni: *Lonchocarpus nitidus.* mael: *Matayba elaegnoides.* mypa: *Myrcia palustris.* aled: *Allophylus edulis.* gykl: *Gymnanthes klotzschiana.* carh: *Campomanesia rhombea.* pari: *Parapiptadenia rigida.* mygl: *Myrceugenia glaucescens.* mast: *Machaerium stipitatum.* caco: *Calyptranthes concinna.* teau: *Terminalia australis.* mapa: *Machaerium paraguariense.* psgu: *Psidium guajava.* neme: *Nectandra megapotamica.* moni: *Morus nigra.* ludi: *Luehea divaricata*.

P = 0.001) validated the adequability of the PCoA. The analysis of ordination showed that the majority (19) of the closest SU's to the river bank were grouped on the left of the second axis. Among these, eight SU's were grouped due to the presence of *Terminalia australis* and *Calyptranthes concinna* DC. and 11 SU's were grouped by *Myrcia palustris*, *Matayba elaeagnoides*, *Lonchocarpus nitidus*, *Pouteria salicifolia*, *Myrceugenia glaucescens* (Cambess.) D.Legrand & Kausel, *Campomanesia rhombea* O.Berg, *Gymnanthes klotschiana*, *Allophylus edulis* (A.St.-Hil.) Niederl. and *Parapiptadenia rigida* (Benth.) Brenan. Some sampling units were grouped at the right side of the second axis, mainly due to the presence of *Luehea divaricata* (figure 5), but also related to the presence of *Machaerium paraguariense* Hassl., *Psidium guajava*, *Nectandra megapotamica* (Spreng.) Mez, *Picrasma crenata* (Vell.) Engl. and *Morus nigra*.

Discussion

As in this study, Myrtaceae and Fabaceae (followed by Euphorbiaceae) are also the most representative in other studies conducted in south Brazil riparian forests (Araujo *et al.* 2004, Brackmann & Freitas 2013, Lucheta *et al.* 2015, Mundeleski *et al.* 2008, SEMA/UFSM-RS 2002, Teixeira *et al.* 2014).

Although there were few alien species individuals in this fragment, their presence is worrisome (Ziller 2001) as invasive alien plants promote ecosystem impoverishment through biodiversity loss. This loss is the result of native population reduced abundance, which leads to local diversity decrease, impacting on ecosystem structure and functioning (Lowe *et al.* 2000). Although there are few studies on Taquari river riverine forest, threats of alien species must be evaluated to understand if they are becoming invasive. Lima *et al.* (2007) has already warned about forest increasing degradation on Taquari river banks, which is likely to favor alien species spread. This was reinforced by Lazzarini *et al.* (2015), showing that an area invaded by *H. dulcis* had lower species diversity, and this species preferably occupied initial or impacted forests. Similarily, Lucheta *et al.* (2015) found the same alien species in another fragment of Taquari river riverine forest, as well as other species found here. Therefore, it indicates that these alien species are dispersing along the Taquari river banks and might be threatening biodiversity, although more studies are needed to confirm this statement.

Callisthene inundata, which is endemic to Taquari-Antas river Basin riverine forest (Martinelli & Moraes 2013), according to the List of Endangered Species of Rio Grande do Sul Flora (2014) and Brazilian Flora 2020, is considered Endangered (EN) as a result of habitat destruction. This is the only species of Vochysiaceae recorded for Rio Grande do Sul, occurring in riverine forest areas subjected to flooding, on stony and shallow soils (Bueno *et al.* 2000). In addition, *Picrasma crenata* is considered "Vulnerable" in the Endangered Flora List (Rio Grande do Sul 2014). The two species had lower density and IVI values, reinforcing the importance of preserving this forest remnant and vegetation formation.

The species *Luehea divaricata* (10.89 m^2 ha^{-1}), *Terminalia australis* (5.80 m^2 ha^{-1}), *Myrcia palustris* (4.10 m^2 ha^{-1}), *Lonchocarpus nitidus* and *Pouteria salicifolia* reached ADo high values because many individuals had more than one stem, generally consisting of large trees. Lucheta *et al.* (2015) and Marchi & Jarenkow (2008) also recorded higher ADo values for *L. divaricata*, 5.66 m^2 ha^{-1} and 8.60 m^2 ha^{-1}, in their studies on riverine forest fragments in RS, although being lower than values found in this study. In the fragment studied by Teixeira *et al.* (2014) in the same river, *L. divaricata* had an ADo of only 3.86 m^2 ha^{-1}, showing community structure differences, even though fragments were not so distant from each other.

The absolute density (AD) of the studied area was intermediate when compared to the ones recorded by Teixeira *et al.* (2014) and Lucheta *et al.* (2015) on the same river banks, using the same sampling methods and criteria for individual inclusion. Teixeira *et al.* (2014) recorded AD of 2,305.56 ind ha^{-1} in a narrow forest zone, while in the fragment studied by Lucheta *et al.* (2015) the AD was of 1,373 ind ha^{-1}. The comparison of these values reinforces the existence of differences in riparian forests community structure, even when considering the same river. Such changes can be influenced by different factors, as the type of soil, geography and the anthropogenic influence. Considering the studied remnant, the low value recorded for AD may be a consequence of both flood and the strong water stream during flood period, probably responsible for the high incidence of shrub species and tree individuals with many stems, these with large diameter and, in general, lower height.

The species with the highest AD values (*Lonchocarpus nitidus*, *Myrcia palustris*, *Matayba*

elaegnoides, Luehea divaricata and *Gymnanthes klotzschiana)* have a different order if compared to ADo. These differences are due to some species with high numbers of lower basal area individuals, while other species had fewer individuals, although having a large DBH or many stems. For example, *L. nitidus*, which had twice the number of individuals in relation to *L. divaricata*, obtained the 5th position if only ADo was considered. Conversely, *L. divaricata*, with fewer individuals, is placed in the 1st position of ADo. Other example is *G. klotzschiana* and *Pouteria salicifolia*. In general, *G. klotzschiana* individuals had fewer stems with smaller circumference. On the other hand, *P. salicifolia* had more stems with larger diameters. High dominance of *Terminalia australis* and *M. palustris* was also a result of the large number of individuals and of the number of stems.

Among the 69 *M. palustris* individuals, 41 had more than one stem and eight had more than 10 stems, while an individual reached 22 stems. In the case of *T. australis*, from the 49 individuals sampled, 40 had more than one stem, and one individual reached 53 stems. By consulting field data obtained in studies by Lucheta *et al.* (2015) and Teixeira *et al.* (2014), in fragments that underwent little flood influence, it was found that individuals have few stems. On the other hand, individuals with many stems was found in riparian forests in Rio Grande do Sul (Dorneles *et al.* 2013, Oliveira *et al.* 2015), indicating possible adaptation to water strength in flood, since this strategy reduces the exposed surface and allows the water to pass through the stems, preventing their removal. According to Bellingham & Sparrow (2009), disturbances can stimulate the growth of existing shoots or the emergence of new ones, then promoting high incidence of multiple stems.

Species present in over 50% of sample units (*L. nitidus*, *G. klotzschiana*, *L. divaricate*, *M. elaegnoides* and *M. palustris*) indicate a broad fragment distribution. Among species with the highest AF values, only *L. nitidus* and *L. divaricata* had higher importance values (IVI). Furthermore, of the total, 22 species occurred in less than 10% of SU's, corresponding to more than 50% of species with low frequency. Other studies in riparian forest fragments in Rio Grande do Sul also reported few species with high frequency value. Among the 29 species found by Marchi & Jarenknow (2008) in a riverine forest fragment along Camaquã river, four had frequency higher than 75%, and all other species occurred in less than 50% of SU's, of which five species (17.25%) were only found in one sampling unit. In Lucheta *et al.* (2015), *L. divaricata*, *Allophylus edulis* and *Trichilia clausseni* C.DC. occurred in over 50% of SU's, and most species (85.5%) were recorded in less than 20% of sampling units. These results show the diversity in riparian forests, as, for example, *T. clausseni*, with high frequency in Lucheta *et al.* (2015), was not recorded in the area of the present study, both located on the same riverbed. The variation on species diversity, distribution and abundance of tropical plant communities can be influenced by different factors that vary from biogeographic to microenvironmental scale (Zuquim *et al.* 2007). For Svenning (1999), altitude, slope, topographic position, drainage and soil fertility are among the factors determining species distribution. Cámara-Leret *et al.* (2017) showed, for example, that all palm species had differences in distribution along soil nutrient gradients in Western Amazon. In the case of the present study, it is likely that flood, associated to water force, infuences species selection, distribution and abundance. The low declivity and the water flow favor periodic flood and prolonged flood that can influence the vegetation strata (De Morais *et al.* 2013). For the plant community composition and structure of four phytophisionomies in Pantanal of Poconé, Mato Grosso, flood pulse could be responsible for habitat and niche formation, favoring spatial heterogeneity and determining species distribution and the formation of a landscape mosaic (De Morais *et al.* 2013).

Luehea divaricata was the species with the highest IVI in the forest remnant, however its presence was higher in plots that were further from the riverbank. Its main habitats are riparian forests or hillsides, and this species is important for degraded areas recovery, as it tolerates short or long-term periodic flooding, low temperatures and has quick growth, besides tolerating shading when young (Gris *et al.* 2012). Furthermore, the fragment was mainly represented by *Lonchocarpus nitidus*, *Myrcia palustris*, *Terminalia australis*, *Gymnanthes klotzschiana*, *Matayba elaegnoides*, *Pouteria salicifolia*, *Calyptranthes concinna* and *Campomanesia xanthocarpa*, which showed the highest values of IVI and are characteristic species of riparian forests. The species with the second highest IVI was *L. nitidus,* a common species in riparian forests, which can be used for riparian forest recovery (Silva & Tozzi 2012). The occurrence of deciduous hygrophytes species, adapted to alluvial environments was also recorded, such as *L. divaricata*, *Vitex megapotamica* (Spreng.) Moldenke, *Inga vera* Willd. and *G. klotzschiana* (IBGE 2012).

Shannon diversity and Pielou's evenness indexes presented slightly lower values than those reported in other studies in the same river, probably reflecting the existence of fewer species with unequal number of individuals. Lucheta *et al.* (2015), in the municipality of Lajeado, found a Shannon index of 3.39 nats ind^{-1}and Pielou's index of 0.82. Teixeira *et al.* (2014), also in the municipality of Lajeado, found 3.09 nats ind^{-1} for Shannon index and 0.84 for the evenness index. On the other hand, some studies had lower indexes, as was the case of the study by Jarenkow & Waechter (2001) in a seasonal forest from Rio Grande do Sul, whose indexes were 2.24 nats ind^{-1} for H' and 0.56 for J. Moreover, the study by Damaceno-Junior *et al*. (2005), conducted in a riverine forest of Paraguay river, State of Mato Grosso do Sul, recorded H' = 2.7 when sampling an arboreal community with diameter at breast height of less than 15 cm, which is lower but close to the values of the present study.

L. divaricata and *Hovenia dulcis* had 37 and 4 individuals, respectively, with > 10 meters. The forest studied had few trees with large DBH, as the majority of trees sampled were below 30 cm. This, along with multiple stems, is a strategy to resist to water flow during flood periods.

The principal coordinates analysis (PCoA) indicated higher similarity in sampling units that were slightly further from the riverbank. The same was found by Campos & Landgraf (2001) in Minas Gerais, where *L. divaricata* was present only in the furthest parts of the lake, probably because this species does not tolerate wet soils. According to Damasceno-Junior (2005), flood levels tend to determine the species exchange degree between dry and flooded environments.

The floristic composition found in the area of the present study is somehow similar to the recorded in other studies carried out in riverine forests in Rio Grande do Sul and Santa Catarina (Araujo *et al*. 2004, Avila *et al*. 2011, Brackmann & Freitas 2013, Schneider & Rocha 2014, Teixeira *et al.* 2014, Lucheta *et al.* 2015). However, it differs on the way species are organized. As seen by Durigan *et al.* (2000), riparian forests show a combination of arboreal species with wide and narrow distribution, according with the phytogeographic unit where they are inserted, demonstrated in the present study as the record of one endemic endangered species. These results highlight thus the importance of the studied forest remnant and the need to adopt measures for its conservation and understanding the role of alien species, if they are transient or if they will become invasive.

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