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inventory

Flora of inland Atlantic riparian forests in southwestern Brazil

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Abstract: The flora of the Atlantic Rainforest of Mato Grosso do Sul, southwestern Brazil, has not been inventoried in spite of being the westernmost inland region of this domain. We present an inventory of the riparian flora of inland Atlantic Forest in Mato Grosso do Sul. We describe the species distribution along three habitats with contrasting flood conditions: non-flooded, seasonally flooded, and swampy forests. The inventory consisted of sampling every reproductive individual, during 12 months on 1.12 ha of plots inside a 24 ha study area. We recorded 1967 individuals of 253 species and 72 families. The most representative families in number of species were Asteraceae (27), Fabaceae (19), Myrtaceae (17), Cyperaceae (12), Rubiaceae, Solanaceae and Orchidaceae (10 each). The most abundant reproductive species were *Guarea macrophylla* (169 individuals), *Miconia chamissois* (85) and *Conyza bonariensis* (80). Eleven species of six families were recorded for the first time in Mato Grosso do Sul, two of them endemic to the Atlantic Forest – *Passiflora jilekii* and *Capanema micromera*. We found 119 species exclusively in non-flooded habitat, 19 in seasonally flooded habitat, and 31 in swampy forest. *Guarea macrophylla* was the most frequent species in swampy forest, and *Gochnatia polymorpha* in non-flooded. The riparian forest flora at the study site resembles the Atlantic Forest and includes wide distribution riparian species; the variation of flood conditions among habitats favors its richness. Our records add new occurrences for Mato Grosso do Sul and new distribution ranges for some plant species, what arises concern upon the local biodiversity conservation.
Keywords: *flood gradient, plant distribution, plant richness, riparian forest, semideciduous forest.*

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Resumo: Vegetação ripária de Floresta Atlântica de interior no sudoeste do Brasil. A flora da Mata Atlântica de Mato Grosso do Sul, sudoeste do Brasil, tem sido muito pouco estudada, embora represente a porção mais oeste e continental deste domínio. Descrevemos aqui a flora de matas ciliares na região de Mata Atlântica de Mato Grosso do Sul, e a distribuição das espécies em três habitas classificados segundo a ocorrência de inundação como: floresta não inundável, floresta sazonalmente inundável, e floresta inundada. O inventário consistiu de um ano de amostragens mensais de todos os indivíduos reprodutivos em 1,12 ha de parcelas em 24 ha. Encontramos 1967 indivíduos de 253 espécies e 72 famílias. As famílias mais representativas foram Asteraceae (27), Fabaceae (19), Myrtaceae (17), Cyperaceae (12), Rubiaceae, Solanaceae e Orchidaceae (10 espécies cada). As espécies reprodutivas mais abundantes foram *Guarea macrophylla* (169), *Miconia chamissois* (85) e *Conyza bonariensis* (80). Onze espécies de seis famílias foram registradas pela primeira vez em Mato Grosso do Sul, duas delas endêmicas da Mata Atlântica – *Passiflora jilekii* e *Capanema micromera*. Encontramos 119 espécies apenas na floresta não inundável, 19 na floresta sazonalmente inundável, e 31 na floresta inundada. *Guarea macrophylla* foi a espécie mais comum na floresta inundada e *Gochnatia polymorpha*, na floresta não inundável. A flora das matas ciliares estudadas assemelha-se à da Mata Atlântica e apresenta espécies ripárias de ampla distribuição; a variação do regime de inundação entre os habitats favorece sua riqueza. Nossos registros adicionam novas ocorrências para Mato Grosso do Sul e novos limites de distribuição para algumas espécies, fatos que trazem preocupação quanto à conservação da biodiversidade local.
Palavras-chave: *distribuição de plantas, gradiente de inundação, floresta ripária, floresta semidecídua, riqueza de espécies.*

Introduction

Floristic inventories are important to know plant species distribution and diversity, and to subsidize conservation initiatives. The southeastern Mato Grosso do Sul's territory has been considered part of the Atlantic Forest domain, indeed its westernmost inland limit (Rizzini 1979). However, this region is widely uncovered regarding plant surveys. Most inventory efforts in the state of Mato Grosso do Sul have focused on the Pantanal and its surrounding Cerrado floras (Pott & Pott 1994, 2000; 2003, Salis et al. 2004, Pott et al. 2006, Lehn et al. 2008, Damasceno-Junior et al. 2009, Noguchi et al. 2009). Additional plant surveys are available for the northeastern and southwestern Cerrado regions of the state (Pott et al. 2006, Arruda & Daniel 2007, Baptista-Maria et al. 2009). This situation occurs, in part, because the Atlantic Forest domain in Mato Grosso do Sul was largely modified for agriculture, and the remaining natural vegetation became limited to riparian forests.

Riparian forests are highly diverse, often presenting low similarity of flora even between adjacent portions (Rodrigues & Nave 2004). Variation of flood conditions is largely associated with heterogeneity in floristic composition and life forms along riparian forests (Fischer & Araujo 1995, Rodrigues & Shepherd 2004). The importance of abiotic and biotic pressures appears to vary along the gradient of flooding. Increased flood depth and duration can select plant taxa whose traits allow escaping from waterlogging, whereas competitive ability is expected to determine plant occurrences in non-flooded forest patches (Fischer & Santos 2001, Rodrigues & Shepherd 2004). Here, we describe the flora of riparian forests along Touro and Tarumã streams in the Mato Grosso do Sul's Atlantic Forest domain, and address species distribution among three contiguous habitats with contrasting flood conditions.

Methods

Study site

The study was carried out in five plots within 24 ha of the Touro and Tarumã riparian vegetation in the Paraná river basin, municipality of Naviraí, Mato Grosso do Sul (Figure 1). The climate is seasonal characterized by rainy summers and dry winters (Cfa of Köppen); mean annual temperature varies from 12 to 28 °C and mean annual rainfall is 1600 mm (IBGE 1984). The region belongs to the Caiuá geological formation, from upper Cretaceous, with 360 m average altitude and fertile soils, mainly Red Latosol and small patches of Red Spodosol (IBGE 1984), and hydromorphic soils on floodable or swampy areas. The study site is located in the western portion of the major continental phytogeographic domain of Atlantic Rainforest (Ab'Saber 2000). Remaining vegetation comprises mainly alluvial or submontane semideciduous forests (Veloso et al. 1991). Hereafter we refer to the study alluvial semideciduous forests simply as 'riparian forests'.

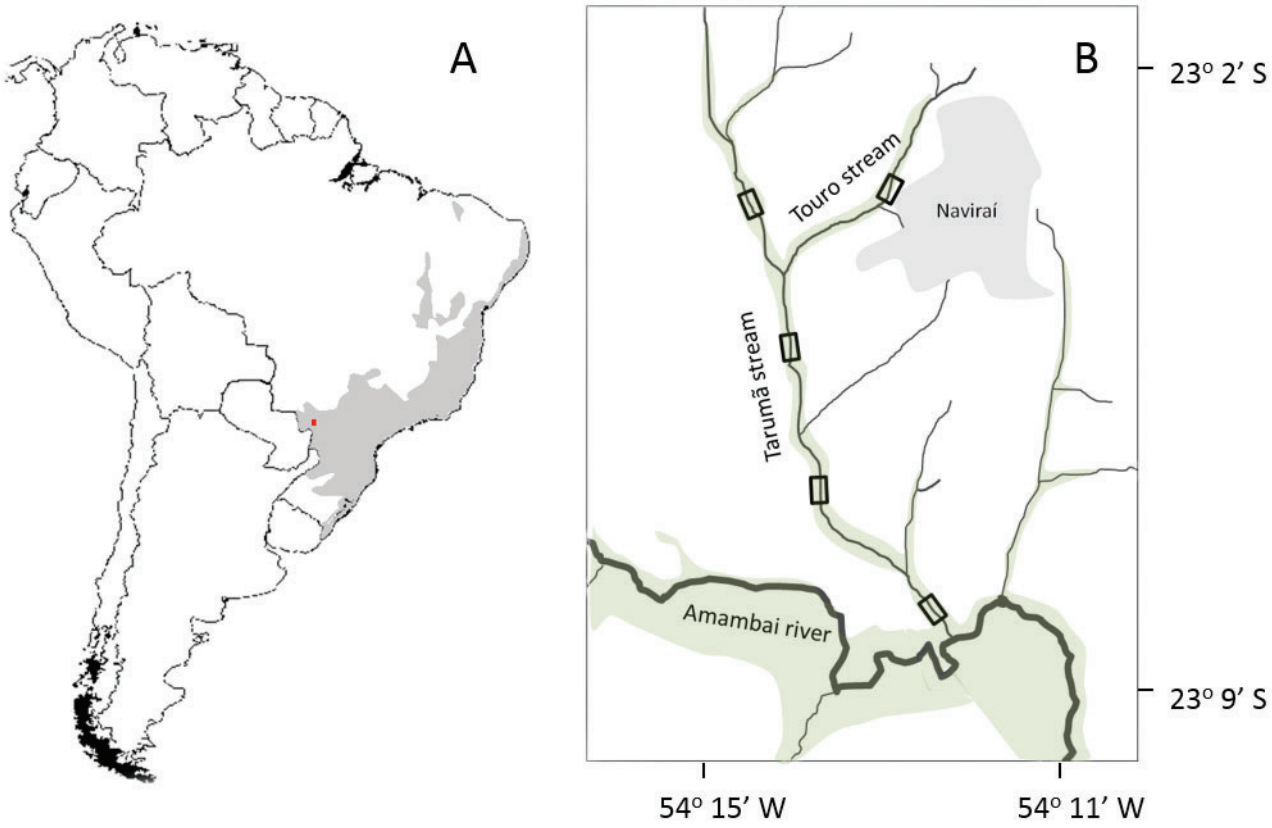

Figure 1. (A) Atlantic Forest domain (gray) and the study site (red dot). (B) Location of plant surveys (rectangles) in the Touro and Tarumã riparian forests (greenish); gray indicates the urban area of Naviraí, and white does pastures and cultivated areas.
Figura 1. (A) Domínio da Mata Atlântica (cinza) e local de estudo (ponto vermelho). (B) Localização das amostragens de plantas (retângulos) nas florestas ripárias (esverdeado) do Touro e Tarumã; cinza indica a área urbana de Naviraí, e branco indica pastagens e áreas cultivadas.

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Data collection and analysis

From July 2009 to June 2010 we monthly surveyed all reproductive plant individuals in six meters wide plots perpendicular to the streams, to include the flood gradient from the river margin to the higher ground of the riparian forest. Plots were placed at least 30 m apart, and their lengths varied from 40 to 180 m according to the riparian forest width at each stretch. The total sampled area was 1.12 ha. To control previously sampled individuals, we marked them with numbered aluminum tags. Samples included all angiosperms of different habits (Guedes-Bruni et al. 2002): ground herbs (without woody stems above ground), shrubs (multiple woody stems), climbers (woody or non-woody with climbing structures), trees (one woody stem; palms included), epiphytes, and parasites. For some species of shrubs and herbs in tussocks or multi-stemmed clumps, each bunch was counted as one individual. We also recorded monthly the flood condition (flooded or not flooded) where individuals, or their hosts if epiphyte or parasite, were rooted. After one year of records of flood conditions we assumed three habitat categories: (1) soil not flooded (non-flooded habitat, hereafter), (2) soil flooded during the rainy season (seasonally flooded habitat), and (3) soil persistently flooded (swampy habitat). We then determined limits of habitats within the plots and estimated the area covered by them with help of field GPS readings checked on Google Earth images, where we measured distances between zones. The altimetric difference between the lowest and the upper sampled areas was ca 43 m. Based on the surveyed area for each habitat (non-flooded = 0.64 ha, seasonally flooded = 0.22 ha, and swampy = 0.26 ha) we calculated density of reproductive individuals per species ($N.ha^{-1}$) per habitat. We then used values of density per habitat as a proxy for number of individuals after controlling for equal size of areas (1 ha) among habitats. Considering the total of individuals estimated for one hectare of each habitat, we calculated the proportion (%) of individuals per habitat for each species separately. Finally we entered the values of proportion of individuals in a species x habitat matrix to ordinate plant species in relation to habitats, in the R program (R Development Core Team 2010); epiphytes and species with less than 10 individuals were not included. Number of surveyed species relative to sample size was evaluated through rarefaction curves; in the Past program (Hammer et al. 2001). Identifications were based on comparisons with herbarium materials, and help of literature and specialists. Taxonomy follows the Angiosperm Phylogeny Group (APG III 2009). Voucher material was included in the Herbarium CGMS, Universidade Federal de Mato Grosso do Sul. Finally, we obtained from literature and herbarium sites (www.tropicos.org; www.floradobrasil.jbrj.gov.br) the occurrences of species throughout the phytogeographical domains. Each species was assigned to a domain when its previous known occurrence was restricted, or assigned as "wide distribution" when its occurrence included more domains, considered as Amazonia, Atlantic Forest, Caatinga, Cerrado, Chaco, Pampas or Pantanal. Species that are not South American natives were assigned as exotic.

Results

Surveyed flora and new occurrences in Mato Grosso do Sul

We recorded 1967 reproductive individuals of 253 species, 193 genera and 72 families (Table 1). The eight richest families included 46% of all surveyed species – Asteraceae (27 species), Fabaceae (19), Myrtaceae (17), Cyperaceae (12), Malvaceae, Orchidaceae, Rubiaceae and Solanaceae (10). Thirty-three families presented two to nine species, and the remaining families presented a single one. The most abundant reproductive species were *Guarea macrophylla* (Meliaceae; 169 individuals), *Miconia chamissois* (Melastomataceae; 85), *Conyza bonariensis* (Asteraceae; 80), *Ocotea lancifolia* (Lauraceae; 65) and *Cecropia pachystachya* (Urticaceae; 57). Eleven species were recorded for the first time in Mato Grosso do Sul – *Campylocentrum grisebachii*, *Capanemia micromera*, *Cohniella jonesiana*, *Microlaelia lundii*, *Rodriguezia decora*, *Sauroglossum nitidum* (all Orchidaceae), *Passiflora jilekii* (Passifloraceae), *Persea willdenovii* (Lauraceae), *Merremia macrocalyx* (Convolvulaceae), *Qualea cordata* (Vochysiaceae), and the saprophyte *Apteria aphylla* (Burmanniaceae). We additionally recorded the parasite *Phoradendron piperoides* (Viscaceae) and four invader species – *Leucaena leucocephala* (Fabaceae), *Tecoma stans* (Bignoniaceae), *Cordia myxa* (Cordiaceae), and *Hedychium coronarium* (Zingiberaceae). Most species were herbs (99; 39%) or trees (72; 28%). Climbers and shrubs included 39 (15%) and 33 (13%) species, respectively, and epiphytes, nine species (4%).

Species distribution among habitats

Floras of swampy and seasonally flooded forests showed less species and so tended to be fully surveyed, but flora of non-flooded forest was richer and less completely surveyed despite its larger area sampled (Figure 2). In general, most species (169 out of 253) were sampled only in one habitat, mainly in non-flooded (119) than in swampy (31) or seasonally flooded (19) (Table 1). On the other hand, considering only those species with 10 or more individuals recorded (n = 49 species), 63% were found in the three habitats, 20% in two habitats, 13% exclusively in non-flooded, 4% in swampy, and none was found solely in seasonally flooded habitat. In overall, densities of the most abundant herbs and shrubs species in swampy and seasonally flooded habitats were one order of magnitude above non-flooded habitat. Among tree species, densities in swampy were one order of magnitude above the other habitats.

Among herbaceous plants, *Conyza bonariensis* (62.5 $N.ha^{-1}$), *Geophila repens* (57.8) and *Triumfetta bartramia* (45.3) were the species with highest densities in non-flooded habitats; *G. repens*, *Elephantopus mollis* (32.8) and *Rhynchospora marisculus* (23.4) occurred in this habitat only (Table 1). The commonest species in swampy habitat were *Coccocypselum lanceolatum* (153.9) and *Calyptrocarya glomerulata* (119.2), whereas *Conyza bonariensis* (182.6) and *Canna indica* (160.0) were the most common in seasonally flooded habitat. Among shrubs, highest densities in non-flooded habitat were found for *Piper aduncum* (32.8), *Psychotria carthagenensis* (31.3) and *Ludwigia sericea* (23.4), and in swampy for *Miconia chamissois* (28.8), *M. theizans* (13.9) and *Gaylussacia brasiliensis* (61.5) (Table 1). Density of *Piper aduncum* (122.7) was one order of magnitude higher than the subsequent most abundant species in seasonally flooded habitat, *M. chamissois* (45.5), *Lantana camara* (31.8) and *Ludwigia sericea* (22.7). The commonest tree species in non-flooded habitat were *Gochnatia polymorpha* (34.4), *Allophylus edulis* (31.25) and *Helietta apiculata* (28.1); *G. polymorpha* and *H. apiculata* were exclusively found in this habitat (Table 1). *Guarea macrophylla* (557.7), *Ocotea lancifolia* (188.5) and *Styrax*

Table 1. Families, species, habits (TRE = trees; SHR = shrubs; EPI = epiphytes; HER = herbs; CLI = climbers; PAR = parasites), number of individuals (n), and density (N.ha^{-1}) in three soil moisture types (NF = non flooded; SF = seasonally flooded; SW = swampy) in the riparian forests along Touro and Tarumã streams, Paraná river basin, Mato Grosso do Sul. Collection number: CF = Claudenice Faxina; Phytogeography: AF = Atlantic Forest, CE = Cerrado, CH = Chaco, WD = wide distribution, EX = exotic.
Tabela 1. Famílias, espécies, hábitos (TRE = árvores; SHR = arbustos; EPI=epífitas; HER = herbáceas; CLI = climbers; PAR= parasita), número de indivíduos (n) e densidade (N.ha-1) em três tipos umidade de solo (NF = não inundado; SF = sazonalmente inundado; SW = permanentemente inundado) ao longo da floresta ripária dos córregos Touro e Tarumã, bacia do rio Paraná, Mato Grosso do Sul. Número de coleta: CF = Claudenice Faxina; Fitogeografia: AF = Mata Atlântica, CE = Cerrado, CH = Chaco, WD = ampla distribuição, EX = exótica.

Family	Species	Habit	n	NF	SF	SW	Phyto-geography	Collection number
Acanthaceae	*Hygrophila costata* Nees	HER	1	1.6			WD	
	Ruellia cf. *brevifolia* (Pohl) C. Ezcurra	SHR	1	1.6			WD	CF 075
Alismataceae	*Echinodorus longipetalus* Micheli	HER	4			15.4	WD	CF 229
	Sagittaria rhombifolia Cham.	HER	1			3.9	WD	
Anacardiaceae	*Schinus terebenthifolia* Raddi	TRE	3	4.7			WD	CF 042
	Tapirira guianensis Aubl.	TRE	32	7.8	36.4	73.8	WD	
Apocynaceae	*Condylocarpon isthmicum* (Vell.) A. DC.	CLI	7	3.2	4.6	15.4	AF	CF 238
	Mesechites sp.	CLI	1	1.6			WD	CF 217
	Tabernaemontana catharinensis A. DC.	SHR	1	1.6			AF	
Aquifoliaceae	*Ilex brasiliensis* Loes.	TRE	13	1.6	9.1	38.5	AF	CF 228
	Ilex affinis Gardner	TRE	2			7.7	WD	CF 174
Araliaceae	*Hydrocotyle leucocephala* Cham. & Schltdl.	HER	9	1.6	4.6	27.9	WD	
	Hydrocotyle verticillata Thunb.	HER	1		4.6		WD	
Arecaceae	*Acrocomia aculeata* (Jacq.) Lodd. ex Mart.	TRE	5	7.8			WD	
	Geonoma brevispatha Barb. Rodr.	TRE	12			46.2	AF	CF 011
	Syagrus romanzoffiana (Cham.) Glassman	TRE	14	9.4	18.2	15.4	AF	
Aristolochiaceae	*Aristolochia triangularis* Cham.	CLI	3	4.7			AF	CF 081
Asteraceae	*Achyrocline satureioides* (Lam.) DC.	HER	5	7.8			WD	
	Aspilia latissima Malme	HER	2	1.6	3.9		WD	
	Baccharis sp.	HER	1	1.6				CF 302
	Barrosoa candolleana (Hook. & Arn.) R. M. King & H. Rob.	HER	1			3.9	WD	CF 274
	Conyza bonariensis (L.) Cronquist	HER	80	62.5	182.6		WD	CF 262
	Chromolaena odorata (L.) R. M. King & H. Rob.	HER	11	9.4	18.2	3.9	WD	CF 063
	Eclipta prostrata (L.) L.	HER	2			7.7	WD	CF 337
	Elephantopus mollis Kunth	HER	21	32.8			WD	CF 125
	Elephantopus palustris Gardner	HER	2	1.6	3.9		WD	CF 112
	Emilia fosbergii Nicolson	HER	2	3.1			WD	CF 141
	Erechtites hieraciifolius (L.) Raf. ex DC.	HER	2		10.0		WD	CF 183
	Gnaphalium pensylvanicum Willd.	HER	1		4.6		WD	CF 143
	Gochnatia polymorpha (Less.) Cabrera	SHR	22	34.4			WD	CF 044
	Gymnocoronis spilanthoides (D. Don ex Hook. & Arn.) DC.	HER	1			3.9	WD	CF 118
	Mikania cordifolia (L. f.) Willd.	CLI	2	1.6	4.6		WD	CF 041
	Mikania micrantha Kunth	CLI	6	9.4			WD	CF 335
	Porophyllum ruderale (Jacq.) Cass.	HER	3	4.7			WD	CF 209
	Sonchus oleraceus L.	HER	2	3.1			EX	CF 128
	Trichogonia crenulata (Gardner) D. J. N. Hind	SHR	2			7.7	WD	CF 108
	Trixis antimenorrhoea (Schrank) Kuntze	CLI	3	4.7			WD	CF 155
	Vernonanthura cuneifolia (Gardner) H. Rob.	HER	6				WD	CF 139
	Vernonia cf. *grandiflora* Less.	HER	2	3.1			WD	CF 297
	Vernonia remotiflora Rich.	HER	4	4.7	4.6		WD	CF 207
	Vernonia sp.1	HER	1	1.6				CF 345
	Vernonia sp.2	SHR	5	6.3	4.6			CF 065
	Indet. 1	HER	1	1.6				CF 263
	Indet. 2	SHR	1	1.6				CF 338
Begoniaceae	*Begonia cucullata* Willd.	HER	22	1.6	18.2	65.4	WD	CF 216

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Table 1. Continued.

Family	Species	Habit	n	NF	SF	SW	Phyto-geography	Collection number
Bignoniaceae	*Anemopaegma chamberlaynii* (Sims) Bureau & K. Schum.	CLI	1	1.6			WD	CF 184
	Fridericia florida (DC.) L.G. Lohmann	CLI	3	4.7			WD	CF 085
	Fridericia sp.	CLI	1	1.6				CF 145
	Pyrostegia venusta (Ker Gawl.) Miers	CLI	2		9.1		AF	CF 043
	Tecoma stans (L.) Juss. ex Kunth	SHR	3	4.7			EX	CF 181
Bromeliaceae	*Aechmea bromeliifolia* (Rudge) Baker	EPI	2	1.6		3.9	WD	
	Bromelia balansae Mez	HER	7	4.7	13.6	3.9	WD	
Burmaniaceae	*Apteria aphylla* (Nutt.) Barnhart ex Small	HER	4			15.4	WD	CF 199
Boraginaceae	*Cordia myxa* L.	TRE	2	1.6	4.6		EX	CF 233
	Cordia polycephala (Lam.) I. M. Johnst.	SHR	5	3.1	9.1	3.9	WD	CF 248
Cactaceae	*Epiphyllum phyllanthus* (L.) Haw.	EPI	1	1.6			WD	
Campanulaceae	*Pratia* cf. *hederacea* (Cham.) G. Don	HER	2				WD	
Cannaceae	*Canna indica* L.	HER	37	1.6	160.0	3.9	WD	CF 048
Cannabaceae	*Trema micrantha* (L.) Blume	TRE	3	4.7			WD	CF 130
Cardiopteridaceae	*Citronella gongonha* (Mart.) R. A. Howard	TRE	5	1.6		15.4	WD	CF 023
Commelinaceae	*Commelina erecta* L.	HER	2		10.0		WD	CF 121
	Floscopa glabrata (Kunth) Hassk.	HER	2	1.6	4.6		WD	CF 313
Convolvulaceae	*Ipomoea* sp.	CLI	1	1.6				CF 298
	Jacquemontia sp.	CLI	1	1.6				CF 187
	Merremia macrocalyx (Ruiz & Pav.) O'Donell	CLI	1	1.6			WD	CF 336
Costaceae	*Costus arabicus* L.	HER	11		45.5	3.8	WD	
Cucurbitaceae	*Melothria* cf. *pendula* L.	CLI	1	1.6			WD	CF 235
Cyperaceae	*Calyptrocarya glomerulata* (Brongn.) Urb.	HER	37	3.1	18.2	119.2	WD	CF 324
	Cyperus haspan L.	HER	20		10.0	69.2	WD	CF 311
	Cyperus luzulae (L.) Rottb. ex Retz.	HER	9		27.3	11.5	WD	CF 260
	Cyperus odoratus L.	HER	5			19.2	WD	CF 256
	Diplacrum longifolium (Griseb.) C. B. Clarke	HER	6		10.0	15.4	WD	CF 325
	Fimbristylis complanata (Retz.) Link	HER	3		13.6		WD	CF 258
	Fuirena umbellata Rottb.	HER	4		13.6	3.8	WD	CF 294
	Pycreus lanceolatus (Poir.) C. B. Clarke	HER	8	3.1	10.0	15.4	WD	CF 242
	Rhynchospora corymbosa (L.) Britton	HER	8	1.6	13.6	15.4	WD	CF 210
	Rhynchospora marisculus Nees	HER	15	23.4			WD	CF 244
	Scleria cf. *bancana* Miq.	HER	21	7.8	22.7	42.4	WD	CF 124
	Scleria melaleuca Rchb.	HER	26	3.1	18.2	76.9	WD	
Dioscoreaceae	*Dioscorea altissima* Lam.	CLI	4	6.3			WD	CF 347
	Dioscorea cf. *trifida* L. f.	CLI	1		4.6		WD	CF 291
	Dioscorea sp.1	CLI	5	1.6		15.4		CF 096
	Dioscorea sp.2	CLI	4	1.6		11.5		CF 259
Ebenaceae	*Diospyros inconstans* Jacq.	TRE	1	1.6			WD	CF 059
Ericaceae	*Gaylussacia brasiliensis* (Spreng.) Meisn.	SHR	16			61.5	WD	CF 107
Eriocaulaceae	*Syngonanthus caulescens* (Poir.) Ruhland	HER	4		4.6	11.5	WD	CF 243
Euphorbiaceae	*Acalypha* sp.	HER	1			3.9		
	Croton lobatus L.	HER	1	1.6			WD	CF 226
	Croton urucurana Baill.	TRE	6	9.4			WD	CF 060
	Euphorbia heterophylla L.	HER	1	1.6			WD	CF 142
	Ricinus communis L.	TRE	5	7.8			EX	
	Sapium haematospermum Müll. Arg.	TRE	8	4.7	18.2	3.9	WD	CF 208
	Sebastiania brasiliensis Spreng.	TRE	18	18.8	18.2	7.7	WD	CF 055
	Tragia sp.	CLI	1	1.6				CF 158
Fabaceae	*Canavalia mattogrossensis* (Barb. Rodr.) Malme	CLI	3	4.7			WD	CF 319
	Centrosema sagittatum (Humb. & Bonpl. ex Willd.) Brandegee	CLI	2	3.1			WD	CF 320
	Chamaecrista nictitans (L.) Moench	HER	1	1.6			WD	CF 343
	Copaifera langsdorffii Desf.	TRE	2	3.1			WD	CF 193
	Crotalaria pallida Aiton	HER	5	7.8			WD	CF 342

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Table 1. Continued.

Family	Species	Habit	n	NF	SF	SW	Phyto-geography	Collection number
	Desmodium cajanifolium (Kunth) DC.	HER	1		4.6		WD	
	Desmodium incanum DC.	HER	3	4.7			WD	CF 299
	Galactia striata (Jacq.) Urb.	HER	1	1,6			WD	CF 300
	Inga vera Willd.	TRE	1	1.6			WD	CF 266
	Leucaena leucocephala (Lam.) de Wit	TRE	1	1.6			EX	CF 071
	Macroptilium lathyroides (L.) Urb.	HER	1			3.9	WD	CF 326
	Mimosa debilis Humb. & Bonpl. ex Willd.	HER	1	1.6			WD	CF 270
	Parapiptadenia rigida (Benth.) Brenan	TRE	2	3.1			AF	
	Rhynchosia edulis Griseb.	CLI	1	1.6			WD	CF 153
	Rhynchosia melanocarpa Grear	CLI	1			3.9	WD	CF 283
	Senegalia riparia (Kunth) Britton & Rose ex Britton & Killip	TRE	3	4.7			WD	
	Senna pendula (Humb. & Bonpl. ex Willd.) H.S. Irwin & Barneby	SHR	1		4.6		WD	CF 070
	Sesbania virgata (Cav.) Pers.	TRE	1	1.6			WD	CF 052
	Vigna caracalla (L.) Verdc.	CLI	1	1.6			WD	CF 305
Gentianaceae	*Irlbachia alata* (Aubl.) Maas	HER	7		22.7	7.7	WD	CF 284
Lamiaceae	*Aegiphila sellowiana* Cham.	TRE	3	4.7			AF	CF 271
	Hyptis althaeifolia Pohl ex Benth.	HER	1	1.6			WD	CF 331
	Peltodon tomentosus Pohl	HER	2	3.1			WD	CF 064
	Vitex montevidensis Cham.	TRE	1		4.6		AF	
Lauraceae	*Endlicheria paniculata* (Spreng.) J. F. Macbr.	TRE	23	28.1	13.6	7.7	WD	CF 078
	Nectandra megapotamica (Spreng.) Mez	TRE	3	4.7			AF	
	Nectandra warmingii Meisn.	TRE	2	3.1			CE	CF 148
	Ocotea lancifolia (Schott) Mez	TRE	65	9.4	45.5	188.5	AF	CF 340
	Ocotea minarum (Nees & C. Mart.) Mez	TRE	2	3.1			WD	
	Persea willdenovii Kosterm.	TRE	2			7.7	AF	CF 349
Lentibulariaceae	*Utricularia gibba* L.	HER	2			7.7	WD	
Lythraceae	*Cuphea* cf. *sessiliflora* A. St.-Hil.	HER	1	1.6			WD	CF 332
	Cuphea melvilla Lindl.	HER	1			3.9	WD	CF 329
	Cuphea retrorsicapilla Koehne	HER	1	1.6			WD	
	Heimia myrtifolia Cham. & Schltdl.	HER	1	1.6			AF	CF 330
Malpighiaceae	*Banisteriopsis pubipetala* (A. Juss.) Cuatrec.	CLI	1			3.9	WD	CF 190
	Heteropterys sp.	CLI	1			3.9		CF 293
	Janusia guaranitica (A. St.-Hil.) A. Juss.	CLI	1	1.6			WD	CF 247
Malvaceae	*Ayenia tomentosa* L.	HER	1	1.6			CH	CF 166
	Luehea candicans Mart.	TRE	8	10.9	4.6		WD	CF 038
	Luehea divaricata Mart.	TRE	13	9.4	31.8		AF	CF 047
	Sida cordifolia L.	SHR	1		4.6		WD	CF 264
	Sida linifolia Cav.	HER	1		4.6		WD	CF 309
	Sidastrum paniculatum (L.) Fryxell	HER	1				WD	CF 287
	Triumfetta bartramia L.	HER	35	45.3	27.3		EX	CF 068
	Urena lobata L.	SHR	1	1.6			EX	CF 103
	Wissadula subpeltata (Kuntze) R. E. Fr.	SHR	1	1.6			WD	CF 312
Marantaceae	*Calathea grandiflora* K. Schum.	HER	2	3.1			WD	CF 215
	Maranta divaricata Roscoe	HER	7	10.9			WD	CF 211
Mayacaceae	*Mayaca sellowiana* Kunth	HER	2			7.7	WD	CF 280
Melastomataceae	*Clidemia* cf. *urceolata* DC.	HER	12	1.6	27.3	19.2	WD	CF 101
	Clidemia hirta (L.) D. Don	HER	1		4.6		WD	CF 140
	Clidemia sp.	HER	1	1.6				CF 225
	Miconia chamissois Naudin	SHR	85	3.1	45.5	280.8	WD	CF 098
	Miconia theizans (Bonpl.) Cogn.	SHR	32	3.1	13.6	103.8	WD	CF 087
	Rhynchanthera verbenoides Cham.	HER	1				WD	CF 246
	Rhynchanthera sp.	HER	7		22.7	7.7		CF 286
Meliaceae	*Guarea macrophylla* Vahl	TRE	169	14.6	68.2	557.7	WD	CF 012
	Trichilia elegans A. Juss.	TRE	10	15.6			WD	CF 076

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Table 1. Continued.

Family	Species	Habit	n	NF	SF	SW	Phyto-geography	Collection number
	Trichilia pallida Sw.	TRE	1	1.6			WD	CF 310
Moraceae	*Ficus* cf. *luschnathiana* (Miq.) Miq.	TRE	1	1.6			AF	
	Ficus sp.	TRE	1			3.9		
Myrsinaceae	*Rapanea gardneriana* (A. DC.) Mez	TRE	30	6.3	27.3	76.9	WD	CF 092
Myrtaceae	*Calyptranthes clusiifolia* (Miq.) O. Berg	SHR	1		4.6		CE	
	Calyptranthes lucida Mart. ex DC.	SHR	16	4.7		50.0	WD	CF 332
	Calyptranthes concinna DC.	SHR					WD	CF 322
	Calyptranthes sp.	SHR	8	1.6		26.9		CF 288
	Campomanesia guazumifolia (Cambess.) O. Berg	TRE	1	1.6			AF	CF 191
	Eugenia hiemalis Cambess.	TRE	1	1.6			AF	CF 150
	Eugenia involucrata DC.	TRE	1	1.6			WD	CF 200
	Eugenia pyriformis Cambess.	TRE	1	1.6			WD	CF 220
	Eugenia speciosa Cambess.	TRE	1	1.6			WD	CF 205
	Eugenia sp.1	TRE	1		4.6			
	Eugenia sp.2	TRE	1	1.6				
	Eugenia sp.3	TRE	1	1.6				
	Myrcia guianensis (Aubl.) DC.	TRE	4	6.3			WD	CF 231
	Myrcia splendens (Sw.) DC.	TRE	3	4.7			WD	CF 224
	Myrcia sp.	TRE						CF 255
	Psidium guajava L.	TRE	2	3.1			EX	CF 180
	Indet	TRE	1	1.6				CF 202
Nyctaginaceae	cf. *Guapira*	TRE	1	1.6				CF 176
Ochnaceae	*Ouratea* cf. *cuspidata* Tiegh.	TRE	2	3.1			AF	CF 253
	Sauvagesia racemosa A. St.-Hil.	HER	1	1.6			WD	CF 106
Onagraceae	*Ludwigia decurrens* Walter	HER	2	3.1			WD	CF 268
	Ludwigia sericea (Cambess.) H. Hara	SHR	21	23.4	22.7	3.9	WD	CF 093
	Ludwigia tomentosa (Cambess.) H. Hara	SHR	12	1.6	18.2	26.9	WD	CF 030
Orchidaceae	*Campylocentrum aromaticum* Barb. Rodr.	EPI	1			3.9	AF, CE	
	Campylocentrum grisebachii Cogn.	EPI	1			3.9	WD	CF 123
	Capanemia micromera Barb. Rodr.	EPI	1			3.9	AF	
	Catasetum sp.	EPI	1	1.6				
	Cochniella jonesiana (Rchb. F). Christenson	EPI	1			3.9	WD	
	Habenaria sp.	HER	1			3.9		CF 353
	Microlaelia lundii (Rchb. f.) Chiron & V. P. Castro	EPI	10			38.5	AF, CE	CF 021
	Oeceoclades maculata (Lindl.) Lindl.	HER	14	17.2	4.6	7.7	WD	CF 051
	Rodriguezia decora (Lem.) Rchb. f.	EPI	5			19.2	AF, CE	CF 113
	Sauroglossum nitidum (Vell.) Schltr.	HER	1			3.9	WD	
Oxalidaceae	*Oxalis corymbosa* DC.	HER	1	1.6			EX	
	Oxalis latifolia Kunth	HER	1	1.6			EX	CF 056
Passifloraceae	*Passiflora alata* Curtis	CLI	6	6.3		7.7	WD	CF 074
	Passiflora jilekii Wawra	CLI	1	1.6			AF	CF 201
	Passiflora misera Kunth	CLI	1	1.6			WD	CF 251
	Passiflora speciosa Gardner	CLI	1	1.6			AF	CF 133
Piperaceae	*Piper aduncum* L.	TRE	52	32.8	122.7	15.4	WD	CF 029
	Piper amalago L.	TRE	3	3.1		3.9	WD	CF 273
	Piper arboreum Aubl.	TRE	2	3.1			WD	CF 058
	Piper umbellatum L.	SHR	8	4.7	4.6	15.4	WD	CF 122
Poaceae	*Merostachys* sp.	SHR	1	1.6			AF	CF 111
	Oplismenus hirtellus (L.) P. Beauv.	HER	4	3.1		7.7	AF, CE	
	Panicum cyanescens Nees ex Trin.	HER	1			3.9	WD	CF 290
	Panicum sp.	HER	3	4.7				CF 245
	Pharus lappulaceus Aubl.	HER	14	18.8		7.7	AF	CF 135
	Setaria parviflora (Poir.) Kerguélen	HER	1	7.8			WD	CF 272

Continued on next page

Table 1. Continued.

Family	Species	Habit	n	NF	SF	SW	Phyto-geography	Collection number
Rhamnaceae	*Gouania mollis* Reissek	CLI	8	9.4	4.6	3.9	WD	CF 045
Rosaceae	*Prunus myrtifolia* (L.) Urb.	TRE	17	4.7	9.1	46.2	WD	CF 306
Rubiaceae	*Chomelia obtusa* Cham. & Schltdl.	TRE	8	12.5			WD	CF 304
	Coccocypselum lanceolatum (Ruiz & Pav.) Pers.	HER	45	7.8		153.9	WD	CF 083
	Emmeorhiza umbellata (Spreng.) K. Schum.	HER	1	1.6			WD	CF 115
	Geophila repens (L.) I. M. Johnst.	HER	37	57.8			WD	CF 062
	Manettia cordifolia Mart.	CLI	1	1.6			WD	CF 315
	Palicourea marcgravii A. St.-Hil.	SHR	17	10.9	13.6	26.9	AF	CF 218
	Psychotria carthagenensis Jacq.	SHR	31	31.3		42.4	AF	CF 234
	Psychotria racemosa Rich.	SHR	18	3.1	9.1	53.9	WD	CF 079
	Randia nitida (Kunth) DC.	TRE	1	1.6			WD	CF 237
	Indet.	TRE	18	25.0	9.1			CF 253
Rutaceae	*Esenbeckia febrifuga* (A. St.-Hil.) A. Juss. ex Mart.	TRE	7	10.9			AF, CE	CF 061
	Helietta apiculata Benth.	TRE	18	28.1			AF, CE	CF 213
	Zanthoxylum rhoifolium Lam.	TRE	1	1.6			WD	CF 223
Salicaceae	*Casearia decandra* Jacq.	TRE	1	1.6			WD	CF 221
Santalaceae	*Phoradendron piperoides* (Kunth) Trel.	PAR	1			3.9	WD	CF 230
Sapindaceae	*Allophylus edulis* (A. St.-Hil., Cambess. & A. Juss.) Radlk.	TRE	22	31.3	9.1		WD	CF 165
	Cupania vernalis Cambess.	TRE	6	9.4			AF, CE	CF 160
	Matayba elaeagnoides Radlk.	TRE	9	14.6			AF, CE	CF 194
	Paullinia pinnata L.	CLI	2	1.6		3.9	WD	CF 069
	Serjania caracasana (Jacq.) Willd.	CLI	4	1.6		11.5	WD	CF 131
	Urvillea ulmacea Kunth	CLI	1	1.6			WD	CF 163
Sapotaceae	*Chrysophyllum marginatum* (Hook. & Arn.) Radlk.	TRE	18	21.9	4.6	11.5	AF, CE	CF 100
Smilacaceae	*Smilax campestris* Griseb.	CLI	16	6.3	45.5	7.7	WD	CF 084
	Smilax fluminensis Steud.	CLI	25	21.9	31.8	15.4	WD	CF 035
Solanaceae	*Capsicum baccatum* L.	HER	1		4.6		WD	CF 269
	Capsicum chinense Jacq.	HER	1	1.6			EX	
	Cestrum axillare Vell.	SHR	9	12.5	4.6		WD	CF 135
	Cestrum mariquitense Kunth	TRE	1	1.6			WD	
	Cestrum schlechtendalii G. Don	SHR	1	1.6			WD	
	Cestrum strigilatum Ruiz & Pav.	SHR	5	3.1	13.6		WD	CF 120
	Physalis angulata L.	HER	1		4.6		WD	CF 189
	Solanum americanum Mill.	HER	3	4.7			WD	CF 053
	Solanum mauritianum Scop.	TRE	3	4.7			AF	CF 040
	Solanum paniculatum L.	SHR	1	1.6			WD	CF 227
Styracaceae	*Styrax pohlii* A. DC.	TRE	47	3.1	36.4	142.4	WD	CF 239
Theophrastaceae	*Clavija nutans* (Vell.) B. Stahl	SHR	7		4.6	23.8	AF, CE	CF 162
Thymelaeaceae	*Daphnopsis racemosa* Griseb.	SHR	3	4.7			AF	CF 161
Urticaceae	*Cecropia pachystachya* Trécul	TRE	57	15.6	95.5	100.0	WD	
	Boehmeria sp.	HER	1		4.6			CF 265
Verbenaceae	*Lantana camara* L.	SHR	10	1.6	31.8	7.7	WD	CF 046
Violaceae	*Hybanthus communis* (A. St.-Hil.) Taub.	HER	1	1.6			WD	
Vitaceae	*Cissus* sp.	CLI	1	1.6				CF 333
Vochysiaceae	*Qualea cordata* (Mart.) Spreng.	TRE	1		4.6		AF, CE	
Xyridaceae	*Xyris laxifolia* Mart.	HER	15		22.7	38.5	WD	
Zingiberaceae	*Hedychium coronarium* J. König	HER	1	1.6			EX	

pohlii (142.4) presented the highest densities among trees in swampy, and *Cecropia pachystachya* (95.5) and *Guarea macrophylla* (68.2) in seasonally flooded habitat.

Density of epiphytes was very low, but they tended to occur in swampy rather than in the other habitats. Six orchid species (*Campylocentrum aromaticum*, *C. grisebachii, Capanemia micromera*, *Microlaelia lundii*, *Cohniella jonesiana* and *Rodriguezia decora*) included 19 individuals exclusively in swampy, and one orchid species (*Catasetum* sp.) presented one individual in non-flooded habitat (Table 1). The bromeliad

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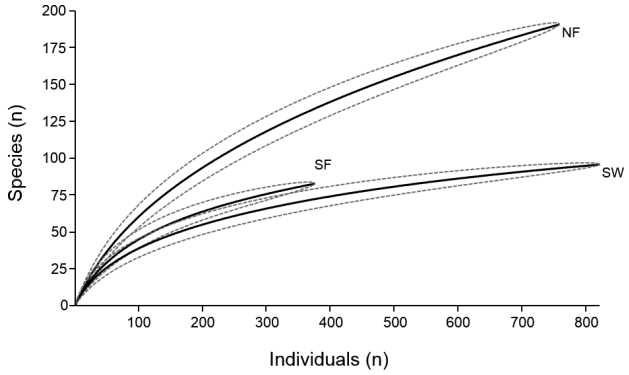

Figure 2. Rarefaction curves for cumulative species according to number of reproductive individuals sampled in non-flooded (NF), seasonally flooded (SF) and swampy (SW) habitats in the riparian forests of Touro and Tarumã streams, southwestern Brazil. Dotted lines show 95% Confidence Intervals.
Figura 2. Curvas de rarefação de espécies com base na quantidade de indivíduos reprodutivos amostrados em habitat não inundável (NF), sazonalmente inundável (SF) e permanentemente inundado (SW) nas florestas ripárias dos rios Touro e Tarumã, sudoeste do Brasil. Linhas pontilhadas mostram Intervalos de Confiança de 95%

Aechmea bromeliifolia showed one individual in swampy and another in non-flooded habitat, where also one individual of the epiphytic cactus *Epiphyllum phyllanthus* occurred.

Based on proportional distribution of species with sample size $\geq$ 10 individuals, most of them presented higher abundance in swampy (25) than in seasonally (10) or non-flooded habitats (14). This pattern was also consistent within habits – herbs, shrubs or trees (Figure 3). The most frequent species in swampy were *Coccocypselum lanceolatum*, *Cyperus haspan*, *Calyptrocarya glomerulata*, *Scleria melaleuca*, *Begonia cucullata*, *Xyris laxifolia*, *Scleria bancana*, *Smilax campestris* (herbs), *Gaylussacia brasiliensis*, *Miconia chamissois*, *M. theizans*, *Psychotria racemosa*, *Ludwigia tomentosa* (shrubs), *Geonoma brevispatha*, *Calyptranthes lucida*, *Guarea macrophylla*, *Styrax pohlii*, *Ocotea lancifolia*, *Ilex brasiliensis*, *Prunus myrtifolia*, *Rapanea gardneriana*, *Tapirira guianensis*, *Cecropia pachystachya* (trees). On the other hand, in non-flooded habitat were *Geophila repens*, *Rhynchospora marisculus*, *Elephantopus mollis*, *Triumfetta bartramia*, *Pharus lappulaceus*, *Oeceoclades maculata* (herbs), *Ludwigia sericea*, *Chrysophyllum marginatum* (shrubs), *Helietta apiculata*, *Trichilia elegans*, *Gochnatia polymorpha*, *Allophylus edulis*, *Endlicheria paniculata*, and *Sebastiania brasiliensis* (trees). Common species in seasonally flooded habitat were *Costus arabicus*, *Canna indica*, *Smilax fluminensis*, *Chromolaena maximilianii*, *Conyza bonariensis* (herbs), *Piper aduncum*, *Lantana camara*, *Clidemia* cf. *urceolata* (shrubs), *Luehea divaricata* and *Syagrus romanzoffiana* (trees). The pioneer tree *Cecropia pachystachya* was equally abundant in swampy and seasonally flooded habitats (Figure 3).

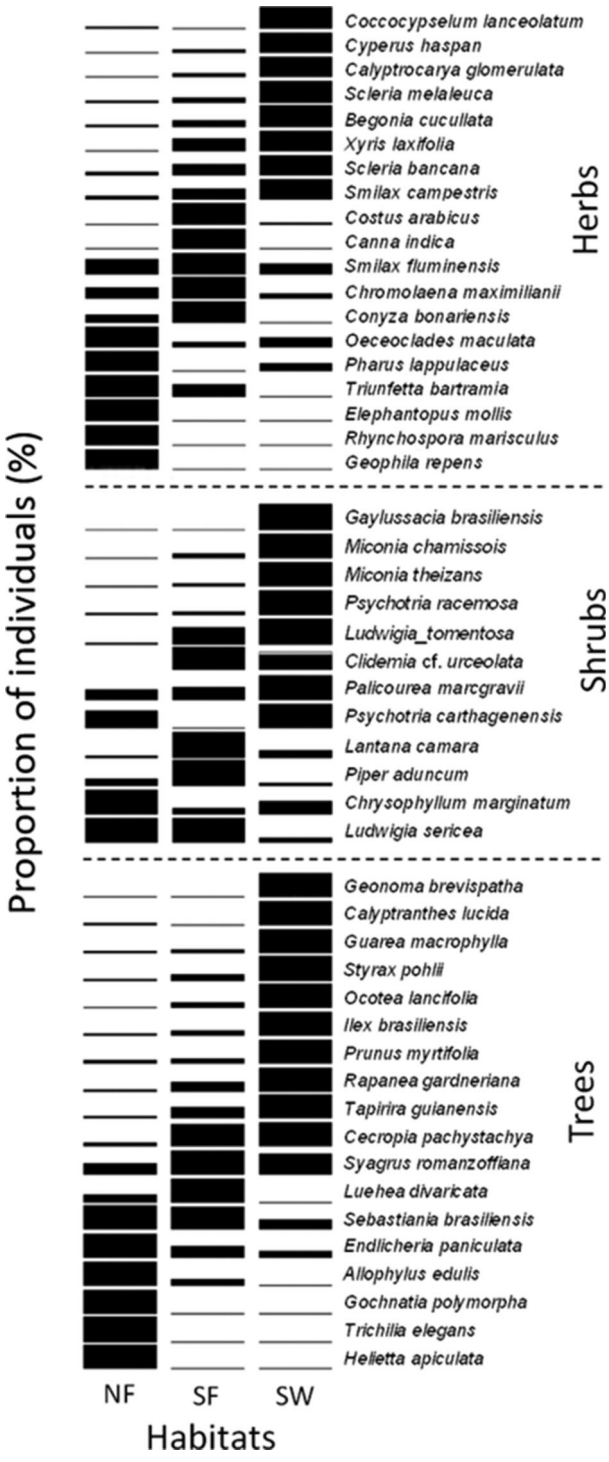

Figure 3. Commonest herbaceous, shrub and tree species ($\geq$ 10 individuals) ordinated according to non-flooded (NF), seasonally flooded (SF) and swampy (SW) habitats along Touro and Tarumã riparian forests, Mato Grosso do Sul. Black bars indicate the proportion (%) of reproductive individuals per habitat for each species, estimated for areas of equal sizes among habitats.
Figura 3. Espécies herbáceas, arbustivas e arbóreas mais comuns (>10 indivíduos) ordenadas conforme os tipos de habitats, não inundável (NF), sazonalmente inundável (SF) e permanentemente inundado (SW), ao longo da floresta ripária do Touro e Tarumã, Mato Grosso do Sul. Barras pretas indicam a proporção (%) de indivíduos reprodutivos por habitat para cada espécie, estimada para áreas de tamanhos iguais entre os habitats.

Discussion

The flora we inventoried seems to be markedly similar to other Atlantic Forest floras elsewhere, as all recorded species indeed occur throughout this domain (sensu Ab'Saber 2000), including two regarded as endemic, *Capanemia micromera* (Orchidaceae) and *Passiflora jilekii* (Passifloraceae) (Cervi 1997, Stehmann et al. 2009, Buzatto & Machado 2011). The richest families in our study site (Asteraceae, Fabaceae, Myrtaceae, Cyperaceae, Malvaceae,

Orchidaceae, Rubiaceae and Solanaceae) also show high number of species in other Atlantic Forest sites (Romagnolo & Souza 2000, Rodrigues & Nave 2004, Stehmann et al. 2009). Furthermore, the local high representativeness of Orchidaceae and low richness of some families, such as Moraceae, differ from the expected for riparian forests in the state's Cerrado domain (Pott et al. 2006, Lehn et al. 2008, Baptista-Maria et al. 2009). Therefore, flora of Touro and Tarumã riparian forests add support to sustain the southeastern Mato Grosso do Sul as an inland region of the Atlantic Forest domain, as formerly suggested by Rizzini (1979).

We found several species that have not been reported in the Mato Grosso do Sul regions of Cerrado or Pantanal, which reinforces the influence of the Atlantic Forest domain on our study site. The orchid *Campylocentrum grisebachii* is known to occur in the Atlantic Forest and Amazon, and our record increases its known distribution (Johnson 2001, Barros et al. 2010) towards the center of South America. In addition, the distribution of *Capanemia micromera* is known along Atlantic Forest in Brazil, and in Paraguay, Uruguay and Argentina (Johnson 2001, Barros et al. 2010, Buzatto & Singer 2010, Buzatto et al. 2011), thus our record enlarges its distribution to 290 km northward and 150 km eastward. Our record of *Microlaelia lundii* (Orchidaceae), distributed in the Atlantic Forest and Cerrado domains (Barros et al. 2010), increases the species' distribution to 290 km north, 650 km south (Dubs 1998), and 300 km westward (Barros et al. 2010). Other orchid species recorded here for the first time in Mato Grosso do Sul have been found 100 and 300 km apart, respectively *Rodriguezia decora* in Atlantic Forest and Cerrado (Johnson 2001, Souza et al, 2009, Barros et al. 2010) and *Sauroglossum nitidum* in Atlantic Forest, Cerrado and Caatinga (Barros et al. 2010). The occurrence of *Passiflora jilekii* in the Touro and Tarumã riparian forests increases its distribution 1100 km westward (Forzza et al. 2010, Cervi et al. 2010). For *Persea willdenovii* (Lauraceae), our record is 600 km northwestern from its previous known distribution (Quinet et al. 2010, Forzza et al. 2010). Additional species recorded for the first time in Mato Grosso do Sul – *Merremia macrocalyx* (Convolvulaceae), *Apteria aphylla* (Burmanniaceae) and *Qualea cordata* (Vochysiaceae) – might be expected since they are widely distributed throughout different domains (Dubs 1998, Bianchini & Ferreira 2010, Forzza et al. 2010, França 2010, Maas & Maas 2010). *Ilex brasiliensis* (Aquifoliaceae), *Gaylussacia brasiliensis* (Ericaceae), *Daphnopsis racemosa* (Thymelaeaceae), *Condylocarpon isthmicum* (Apocynaceae) and *Citronella gongonha* (Cardiopteridaceae) were previously recorded in mid-east regions of Cerrado in Mato Grosso do Sul only (Pott et al. 2006).

In general, the studied flora is highly composed of herbs and contains few tree species, compared to other riparian forests in the Atlantic Forest domain or even elsewhere in Brazil (Oliveira-Filho & Ratter 1995, Metzger et al. 1997, Oliveira-Filho & Fontes 2000, Felfili et al. 2001, Souza et al. 2009). The extension of wetter soils – swampy and seasonally flooded – could partially explain such differences, as they are highly occupied by herbs at the study site. Tree richness is otherwise expected to be favored in non-flooded habitats, where we recorded several species with low abundances. On the other hand, the most abundant species within any habit are the flood-tolerant ones, which occur in the habitats with reduced number of species. This pattern agrees with the expectation that non-flooded sites allow occurrence of most plant species, whose abundances are mainly regulated by interspecific competition, whereas environmental filter determines plant species under flood conditions (Ivanauskas et al. 1997, Fischer & Santos 2001, Marques et al. 2003, Lobo & Joly 2004).

Richness of epiphytes in Touro and Tarumã forests is lower than that in other Atlantic Forest regions with less seasonality and higher annual rainfall than in our study site (1600 mm), as indeed expected since humidity has been regarded as a main factor affecting epiphytic growth (Fischer & Araujo 1995, Rogalski & Zanin 2003, Bataghin et al. 2012; Forzza et al. 2014). Likewise, epiphytes were richer and more abundant in swampy than in non-flooded habitat at the study site probably due to higher humidity in the former. However, additional factors are likely contributing to low richness of epiphytes at the study site, since other Atlantic Forest sites with similar annual rainfall can present remarkably more epiphytic species (Forzza et al. 2014). The narrow forest remnants along Touro and Tarumã streams are enclosed in pasture and cultivated landscapes, thus different sources of disturbance can contribute to the low richness of epiphytes at the study site (Wolf 1994, Pinto et al. 1995, Barthlot et al. 2001, Rogalski & Zanin 2003).

Overall, flora of Touro and Tarumã riparian forests contains several components expected for the Atlantic Forest, although it predominantly included species widespread in different domains. The local flood gradient may favor plant richness. A certain level of disturbance is indeed apparent at the study site due to the relatively high abundance of herbs, the lack of epiphytes in some suitable sites, the conspicuous presence of weedy pioneers, and the occurrence of exotic invaders. The new occurrences for Mato Grosso do Sul and the new limits of distribution for plant species surveyed here highlight the importance of conservation of the remaining forests in the westernmost Atlantic Forest.

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