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TESE

Distribuição e dinâmica de macrófitas aquáticas no sul da Amazônia

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e aos irmãos, Javier, Norbil, Rosyzela e Nelson
por ser o suporte de toda minha vida
e principal motivo para não desistir e seguir em frente.
Aos estagiarios do Herbário CNMT
que me acompanharam e fizeram
parte da minha vida desde 2015.

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A natureza nos surpreende em cada olhar,
nos encanta com cada detalhe
e nos desconcerta com tanta complexidade

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Material Suplementar: Species of Aquatic Macrophytes of Southern Amazonia, Brazil. LF - Life form (AB: Amphibious, EM: Emergent, RF: Rooted Floating, FF: Free-floating, RS: Rooted submerged, FS: Free submerged, CE: climber/epiphyte); HC: Growth habit (hb: herb, sh: shrub, ssh: subshrub, cp: climber, pam: palm); APB: Aquatic Plants of Brazil (+: recorded, -: not recorded); BFD: Brazilian Flora Database (+: recorded, -: not recorded); Habitat (Lo: lotic; Le: lentic; Int: intermediate); Endemic (N: not endemic, Y: endemic). CRE: Risk of Extinction Categories – IUCN (VU: Vulnerable, NT: Nearly Threatened, LC: Least Concern, DD: Insufficient data). NC: Records collector numbers, in parentheses ( ) material selecting from other collectors to prepare the list. Names in square brackets [ ] represent IPNI and World Flora Online valid names. Names with star (*) represent species that do not occur in the Amazon Domain, according to the Brazilian Flora database.

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Material Suplementar:

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Material Suplementar:

RESUMO GERAL

Macrófitas aquáticas colonizam a maioria dos ecossistemas aquáticos. A dinâmica e distribuição macrófitas aquáticas estão sujeitas a inúmeros fatores bióticos e abióticos, sendo que sua diversidade é determinada pela combinação de fatores ambientais como isolamento, diversidade de habitats e hidroperíodo, tamanho da área úmida e pressões antrópicas. Nesse sentido nosso objetivo é entender a dinâmica e distribuição de macrófitas aquáticas no sul da Amazônia, avaliando variações em uma escala ambiental e temporal. Para descrever uma lista de espécies foram utilizadas coletas de campos complementadas com registros de herbários para o sul da Amazônia. Para estudar a variação ambiental e temporal foram selecionados 16 pontos no rio Teles Pires e seus afluentes. Nesses pontos foram registrados a ocorrência, biomassa, e formas de vida da comunidade de macrófitas aquáticas, além de parâmetros limnológicos e vegetação do entorno. Para determinar relações florísticas entre as bacias hidrográficas foram usados os registros de herbários para descrever composições contrastantes entre bacias, sub-bacias e microbacias. Além de uma lista completa de espécies e comparações florísticas com outros domínios, descrevemos de forma clara padrões de variação ambiental e temporal da estrutura da comunidade macrófitas aquática, além de fornecer informações sobre composição destas espécies por bacias hidrográficas no sul da Amazônia.

Palavras-chave: Formas de vida, áreas úmidas, Transição Cerrado-Amazônia, rio Teles Pires

GENERAL ABSTRACT

Aquatic macrophytes colonize most aquatic ecosystems. The dynamics and distribution of aquatic macrophytes are subject to numerous biotic and abiotic factors, with their diversity being determined by the combination of environmental factors such as isolation, habitat diversity, hydroperiod, wetland size, and anthropogenic pressures. In this sense, our aim is to understand the dynamics and distribution of aquatic macrophytes in the southern Amazonia, evaluating variations on both environmental and temporal scales. To describe a species list, field collections supplemented with herbarium records for the southern Amazonia were used. Sixteen points along the Teles Pires River and its tributaries were selected to study environmental and temporal variation. At these points, the occurrence, biomass, and life forms of the aquatic macrophyte community were recorded, along with limnological parameters and surrounding vegetation. Herbarium records were used to determine floristic relationships between watersheds, describing contrasting compositions among basins, sub-basins, and micro-basins. In addition to a comprehensive species list and floristic comparisons with other domains, we clearly describe patterns of environmental and temporal variation in the structure of the aquatic macrophyte community, as well as provide information on the composition of these species by basin in the southern Amazonia.

Keywords: Life forms, wetlands, Cerrado-Amazonia transition, Teles Pires River

INTRODUÇÃO

A conservação e manutenção de ecossistemas terrestres e aquáticos garantiria a preservação desses serviços ecossistêmicos, principalmente os ambientes aquáticos ou áreas úmidas por estar diretamente ligados a recursos hídricos (Alahuhta et al. 2017). Áreas úmidas são ecossistemas oriundos da inundação do solo regidas por diferentes processos bióticos e abióticos, de forma que as comunidades vegetais que habitam esses ambientes possuem adaptações que as tornam tolerantes à essa condição (Keddy, 2000). A biodiversidade das áreas úmidas é composta por diversas espécies de plantas e animais, sendo muitas delas endêmicas (Getzner, 2002). Assim, a conservação da biodiversidade dessas áreas é considerada prioritária (Gibbs, 2000), embora esses ecossistemas estejam entre os mais ameaçados em relação aos recursos naturais (Murphy et al. 2019).

Esses ambientes abrigam uma vegetação característica, representada principalmente por plantas aquáticas, comumente conhecidas como macrófitas aquáticas (Esteves, 1998). Este grupo de plantas colonizam, em diferentes graus, a maioria dos ecossistemas aquáticos determinando suas formas de vida. As formas de vida das macrófitas segundo Irgang e Gastal (1996), com base no zoneamento horizontal de espécies no ecossistema e na profundidade da água: anfíbios, espécies que colonizam a interface entre habitats aquáticos e terrestres; epífitas/trepadeiras, plantas enraizadas em substratos orgânicos (emergentes e/ou flutuantes); emergentes, plantas enraizadas com folhas e flores emersas, ocorrendo em áreas rasas e próximas à costa; submersa e flutuante, espécies de zonas profundas e centrais do corpo de água que ocorrem sob ou sobre a coluna de água, respectivamente. A importância das macrófitas para os ecossistemas aquáticos radica em ser fonte de alimento para a fauna, participar da estrutura e metabolismo do ecossistema (Pott & Pott, 1997, 2012), contribuir para a estruturação física do ambiente aquático, servir de refúgio para os peixes e fauna aquática em geral (Cervi et al., 1983), contribuir na ciclagem de nutrientes (Esteves 1988), além de ser bioindicadoras da qualidade de águas (Pedralli, 2003).

A estrutura e composição da comunidades de macrófitas aquáticas pode ser determinada pela combinação de diversos fatores ambientais, como por exemplo, características físico-químicas da água e do sedimento, conectividade e diversidade de habitats, além do hidroperíodo (Thomaz, 2002; Rolon et al., 2010,). Nesse sentido, a redução das áreas úmidas está relacionada com a redução da vegetação do entorno (Florestas Riparias) principalmente provocado pelo aumento das atividades antrópicas, como usinas hidroelétricas, agropecuária e extração de madeira (Fearnside, 2019). Em ambientes ribeirinhos neotropicais, as variações dos níveis de água favorecem ao aumento diversidade por apresentar maior heterogeneidade de habitats (Murphy et al., 2003; Fortney et al., 2004).

O sul da Amazonia apresenta uma diversidade de áreas úmidas e uma flora característica e rica por incluir a transição Cerrado – Amazônia, maiores domínios fitogeográficos do Brasil, além de apresentar uma forte pressão antrópica com redução de formações vegetais nativas, incluindo áreas úmidas (Maracahipes Santos et al. 2015, Marquez et al. 2020). Nesse sentido nos plantemos as seguintes perguntas: 1. Qual é a diversidade taxonômica de macrófitas aquáticas do sul da Amazonia e quão diferente ela é de outras regiões (Capítulo I, publicado na *Wetland*), 2. Como respondem as macrófitas aquáticas de ambientes ribeirinhos a mudanças ambientais e temporais, considerando riqueza, biomassa, e formas de vidas? 3. Que variáveis ambientais podem influenciar nessas respostas? (Capítulo II, publicado na *Hydrobiologia*), 3. Como as macrófitas se distribuem nas bacias hidrográficas no sul da Amazônia? 4. A composição se relaciona com o ambiente e/ou com a vegetação? (Capítulo III)

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CAPÍTULO I

Aquatic macrophytes in southern Amazonia, Brazil: richness, endemism, and comparative floristics

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Authors' contributions MOC performed all data collection, identification, processing and validation; performed statistical analyses, determined the overall structure of the manuscript and wrote and revised it in general. **JFK** performed the data collection (Teles Pires and Verde rivers), processing and validation at CNMT Herbarium and was an important contributor in writing the manuscript. **DRG** carried out the collection (Xingu, Juruena and Cristalino rivers), data processing and validation at the CNMT Herbarium, **VJP** contributed to identification and validation of the species, **AP** contributed to identification and validation of the species and contributed to the revision of the manuscript. **EGMJ** provided data on aquatic macrophyte species from the Amazonia, Atlantic Forest, Caatinga and Cerrado, **CBRM** guided and supervised the organization of the manuscript, suggested statistical analysis and was an essential contributor in writing. All authors read and approved the final manuscript.

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Abstract

Southern Amazonia harbors a wide diversity of aquatic macrophyte species because of its diverse wetland habitats and location in the Amazon-Cerrado transition zone, which spans the two largest biogeographic domains in South America. We investigated the taxonomic diversity of aquatic macrophytes in the region with a focus on endemism, species richness, and life forms. We present new records of aquatic macrophyte species and compare our results to other Brazilian phytogeographic domains. We found a high number of species of aquatic macrophytes for the southern Amazon region, comparable to extensive inventories in southern, northeastern, and northern regions of Brazil. We recorded 709 species of aquatic macrophytes in 313 genera and 97 families, which includes 90 species endemic to Brazil and five species endemic to the Brazilian Amazonia. The macrophyte species list of southern Amazonia showed <25% similarity to inventories in Amazonia and Cerrado. This high diversity of aquatic

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macrophytes in southern Amazonia, with endemic species and others with restricted ranges, emphasizes the need for conserving these wetlands and vegetation types.

Resumo

O sul da Amazônia abriga uma grande diversidade de espécies de macrófitas aquáticas devido a seus diversos habitats (áreas úmidas) e localização na zona de transição Amazônia-Cerrado, que abrange os dois maiores domínios fitogeográficos da América do Sul. Assim, investigamos a diversidade taxonômica de macrófitas aquáticas na região com foco no endemismo e riqueza de espécies e formas de vida. Apresentamos novos registros de espécies de macrófitas aquáticas e comparamos nossos resultados com outros domínios fitogeográficos brasileiros. Encontramos um número elevado de espécies de macrófitas aquáticas para o sul da Amazônia, comparável a grandes inventários nas regiões sul, nordeste e norte do Brasil. Registramos 709 espécies de macrófitas aquáticas em 313 gêneros e 97 famílias, que inclui 90 espécies endêmicas do Brasil e cinco espécies endêmicas da Amazônia brasileira. A lista de espécies de macrófitas do sul da Amazônia apresentou <25% de similaridade com inventários na Amazônia e Cerrado. Essa alta diversidade de macrófitas aquáticas no sul da Amazônia, com espécies endêmicas e outras com e ocorrência restrita, enfatiza a necessidade de conservação dessas áreas úmidas e tipos de vegetação.

Keywords Amazonian wetlands. Aquatic plants. Cluster Analysis. Endemic species. Floristic similarity. Phytogeographic domains.

Introduction

Aquatic macrophytes grow actively while permanently or periodically submerged, floating, or emerging from the water surface (Chambers et al. 2008) and colonize most aquatic ecosystems to different degrees. The composition, richness, and cover of aquatic macrophytes may be determined by abiotic factors such as climate, isolation, diversity of habitats, nutrients, and hydroperiod (Sousa et al. 2011; Schneider et al. 2019; Yang et al. 2020). The richness of aquatic macrophytes depends mainly on the size of a wetland, although their composition may not follow this pattern (Maltchik et al. 2007). Neotropical aquatic environments, with generally high temperatures, extreme water-level fluctuations, and a wide variety of habitats, harbor the highest richness and endemism of aquatic macrophytes (Murphy et al. 2003; Fortney et al. 2004; Murphy et al. 2019, Moura-Junior et al. 2021).

Brazil is a continental country with several phytogeographic domains (Amazonia, Caatinga, Cerrado, Atlantic Forest, Pampas, and Pantanal) with well-defined morphoclimatic characteristics. However, extensive rivers and watersheds connect these domains. For example, many Amazonia and Caatinga hydrographic basins originate in the Cerrado (Marcuzzo 2017). Due to these hydrologic connections, some aquatic macrophytes are widely distributed across the country, but there are some isolated distributions that are endemic to certain Brazilian phytogeographic domains. (Pivari et al. 2019, Moura et al. 2021).

The Amazon Forest, the largest freshwater reserve globally (except Antarctica), supports one of the highest known levels of biological diversity, including over 50,000 terrestrial vascular plant species (Hubbell et al. 2009). The Amazon Basin, situated between the Guianas Plateau to the north, the Central Plateau to the south, the Andes Mountains to the west, and the Atlantic Ocean to the east, drains parts of eight South American countries besides Brazil (Hess et al. 2003). This phytogeographic domain covers an area of 6,500,000 km^2, with 60% or about 4.2 million km^2 in Brazil, representing 49% of the country (IBGE 2010). Southern Amazonia is a large region with a width of approximately 6000 km that includes a transition zone between the Amazon Rainforest and the Cerrado (Brazilian savanna). This ecotone region contains a diversity of habitats and vegetation types, from dense deciduous or evergreen forests to savanna formations (Marimon et al. 2006; Torello-Raventos et al. 2013). The diverse wetland habitats include permanently or seasonally flooded areas such as streams, rivers, lakes, floodplains, marshes, and swamps, plus several large reservoirs of hydroelectric power plants (Junk et al. 2020). Within this environmental complexity, the Cerrado-Amazonia transition zone is rich in typical Amazonian tree species, also shared with the Atlantic Forest and the Cerrado (Marimon et al. 2006; Oliveira-Filho et al. 2017). The woody flora of this transitional region is well known, but the aquatic macrophyte flora has not been thoroughly studied, which represents a knowledge gap regarding floristic relationships between different regions of the Amazon domain and other Brazilian phytogeographic domains.

Because of heavy deforestation pressures from agricultural, timber, and hydroelectric development, this ecotonal region is also known as the “Amazon deforestation arc” (Fearnside 2005). Deforestation may destroy immense genetic stocks that are not well known, documented in herbaria, or conserved in germplasm banks (Morandi et al. 2016b). Such genetic erosion can result in the loss of valuable information, which may be useful for agriculture, medicine, and industry (Fearnside 2019). Thus, there is an urgent need to investigate and document the diversity of aquatic macrophyte species in the southern Amazonia region (Murphy et al. 2019). Our study investigates the taxonomic diversity of aquatic macrophytes in southern Amazonia with a focus on endemism, species richness, and life forms. We present new records of aquatic macrophyte species and compare our results to other Brazilian regions.

Methods

Study area

In central-western Brazil, the State of Mato Grosso contains parts of three phytogeographic domains (Amazon, Cerrado, and Pantanal) and diverse flora with high socio-economic and environmental potential. Vegetation types in the southern Amazon part of northern Mato Grosso include Transitional Forest, Evergreen Seasonal Forest, and Seasonal Forest of the southern Amazon border (Ivanauskas et al. 2004; Kunz et al. 2008). This part of southern Amazonia is an area of ecological tension (Veloso et al. 1991). The flux of biodiversity in the Cerrado-Amazonia transition and the complex mosaic of vegetation landscapes make it difficult to delimit the phytogeographic domains, especially in the transition zone (Marimon et al. 2006; Morandi et al. 2016a). The Amazon Forest covers approximately 500,000 km² in Mato Grosso, with areas of dense forest containing trees that can reach 50 m in height. The forest is divided by large rivers and includes preservation areas like Cristalino State Park, Rio Ronuro Ecological Station, and Xingu State Park. In the northern region, the Teles Pires and Juruena rivers join to form the large Tapajós River, and together with the Xingu River, they have a highly diverse flora along the banks (Fig. 1).

Collection of data

Survey of aquatic macrophyte species recorded in databases

To develop the species list for the southern Amazonia portion in mid-northern Mato Grosso, we included georeferenced records of herbaria in the region available in the *speciesLink* (https://splink.cria.org.br) and Global Biodiversity Information Facility (GBIF – www.GBIF.org) databases. We checked all records individually and added geographic coordinates of records with detailed information on the site location. Our selection of aquatic species followed the Repository of Aquatic Plants of Brazil (https://sites.icb.ufmg.br/plantasaquaticasbrasil) and the Brazilian Flora database (Flora do Brasil 2020), using the search filters “State: Mato Grosso”, “Phytogeographic domain: Amazonia”, “Substrate: Aquatic” and “Formation: Aquatic Vegetation”. Furthermore, they were considered reports from the state (Pott and Pott 1997) and the Amazon domain (Costa et al. 2016; Moura-Júnior et al. 2015).

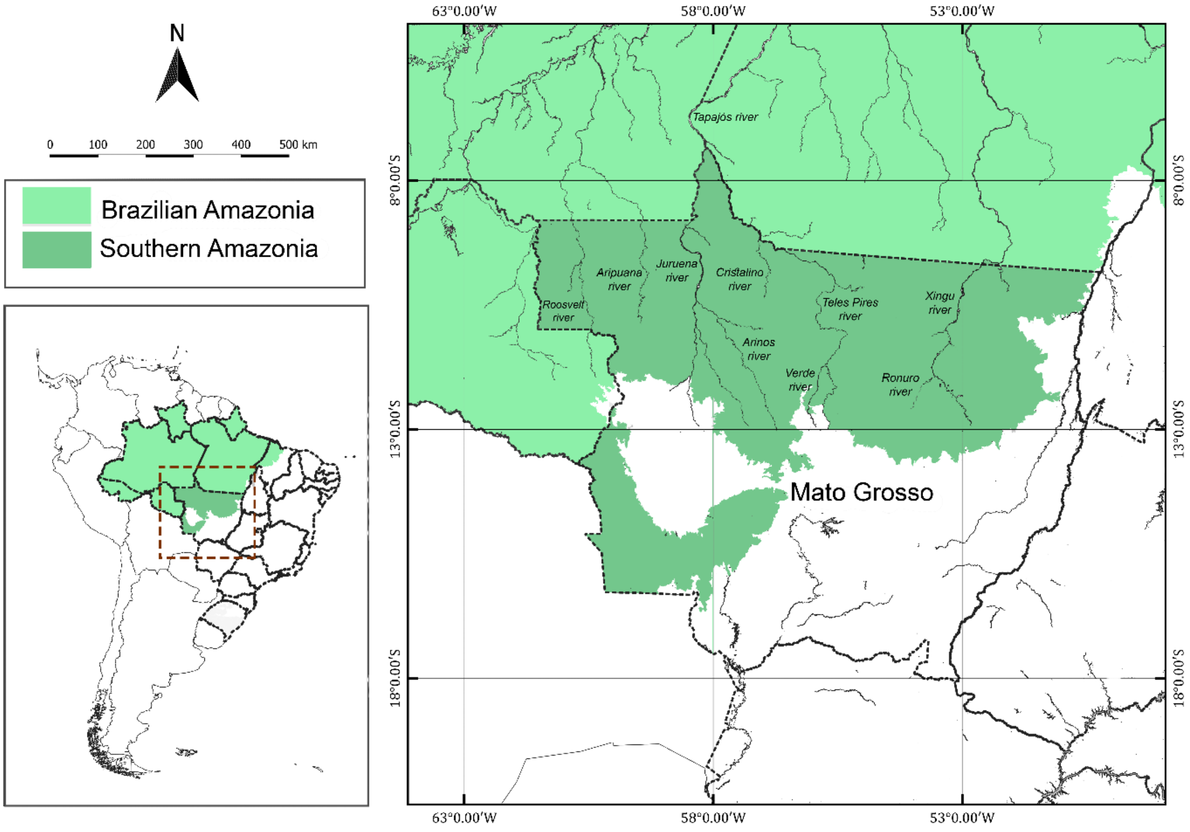

Fig. 1 Study area: the part of southern Amazonia located in the mid-northern and eastern areas of the State of Mato Grosso, Brazil

Field collections

We also incorporated species we collected during five years of field research (2015–2020) in the Tapajós (Teles Pires, Cristalino, Juruena) and Xingu (Xingu and Ronuro) sub-basins of the Amazon River, at different times and hydrological periods (drought, rising water, flood, and drawdown). Fertile specimens were recorded using random sampling, following the procedure described by Filgueiras et al. (1994). We identified the species by consulting literature, taxonomists, and herbarium collections. The specimens are kept in the Centro-Norte-Mato-Grossense Herbarium (CNMT) of the Acervo Biológico da Amazônia Meridional (ABAM) at the Universidade Federal de Mato Grosso (Sinop Campus), and established several unique records for the State of Mato Grosso. We used the concept of aquatic macrophytes suggested by Cook (1996), including plants with photosynthetically active organs that are totally or partially submerged in freshwater or floating in aquatic habitats, either permanently or for several months of the year.

Data processing, life forms, and habitats

We used geographical coordinates to circumscribe the databases and field records in the Amazon part of Mato Grosso with the help of the software QGIS (Q-Gis.org 2020), according to the delimitation of Brazilian phytogeographic domains (IBGE 2010), excluding records from other domains in the state (Cerrado and Pantanal). The habitat description or the collection habitat was useful for selecting relevant records. Target habitats included riparian forests, lakes, ponds, rivers, streams, palm swamps (veredas), floodable grasslands, marshes, swamps, reservoirs, headwaters, igapós (seasonally flooded forests), and igarapés (small streams or channels). We considered records with identification confirmed at the epithet level by taxonomists. The remaining records were verified by consulting herbarium sheets and available or requested images from various herbaria. We obtained information on phytogeographic domains and growth habits from the Brazilian Flora database (Flora do Brasil 2020). The species list followed the classification of families proposed by the Angiosperm Phylogeny Group (APG IV 2016) for angiosperms, the Pteridophyte Phylogeny Group (PPG I 2016) for ferns and lycophytes, and Goffinet and Buck (2004) for bryophytes.

Classification of the aquatic species life forms followed Irgang and Gastal (1996), which is a classification scheme that incorporates water depth and species' horizontal zonation within the ecosystem. Life forms included: (1) amphibious species, which colonize the interface between aquatic and terrestrial habitats; (2) epiphytes/climbers: plants that root and develop on emergent and/or floating plants; (3) emergent species, which are rooted plants with emerging leaves and flowers occurring in shallow areas and close to the shore; and (4) submerged and floating species, which are present in comparatively deep-water bodies, occurring beneath or on the water surface, respectively. We obtained species life forms from record collections and the literature (Pott and Pott 1997; Moura-Júnior et al. 2015; Costa et al. 2016).

We categorized the habitat types as follows: lotic (rivers or streams), lentic (lakes and ponds), and intermediate (reservoirs or ecosystems with abiotic characteristics similar to lotic or lentic habitats) (Thornton 1990; Esteves 2011). We categorized the habitats according to the information in herbarium records. The extinction risk of species was categorized using Red List of the Brazilian Flora (Martinelli and Davila 2012). We obtained the species' characteristics such as endemism and the phytogeographic domain (Amazon and/or Cerrado) from the Brazilian Flora database (Flora do Brasil 2020).

Data analyses

To obtain a general picture of the potential taxonomic richness in the region, we performed a rarefaction analysis of species to compare the observed (from the records) and the estimated richness (Jackknife 1 estimator), considering years with herbarium records of aquatic macrophytes as samples, accounting for 72 samples (years) between 1903 and 2020. We used the function *alpha.accum* of the bat package (R version 3.6.2, Cardoso et al. 2021). We analyzed the floristic similarity between the southern Amazon aquatic macrophyte flora and other Brazilian phytogeographic domains (Table 1), considering the wide geographical distribution of this group of plants in the neotropical region (Murphy et al. 2019). Species that were identified to only the genus or family level, and species requiring confirmation, were excluded from the list. We performed a cluster analysis (UPGMA) based on a presence/absence matrix, using the Simpson index (Magurran 2004). The analysis was conducted in the platform R using the package recluster, function *recluster.cons*, and *recluster.boot* (R version 3.6.2, Dapporto et al. 2020). We updated all species names according to the Brazilian Flora database Flora do Brasil 2020) through the flora package (R version 3.6.2, Carvalho 2020).

Table 1 Floristic studies of aquatic macrophytes in Amazonia, and other Brazilian phytogeographic domains. Moura-Júnior and Cotarelli (2019), Moura-Junior 2015, and Oliveira et al. (2019) present lists for the northeast region (Caatinga and Atlantic Forest), north region (Cerrado and Amazon), and south region (Pampas and Atlantic Forest)

Ecorregion (Olson & Dinerstein 2003)	**Phytogeographic Domain (IBGE 2010)**	**Species Number**	**Reference**
Caatinga	Caatinga	424	Moura-Júnior and Cotarelli (2019)
Atlantic Coastal Forest	Atlantic Forest	941	Moura-Júnior and Cotarelli (2019) Oliveira et al. (2019) Araujo et al. 2020
Pantanal	Pantanal	256	Pott and Pott (1997)
Grassland and Pampa	Pampas	417	Oliveira et al. (2019)
Cerrado	Cerrado	501	Oliveira & Bove 2016 Moura-Júnior et al. (2015) Pivari et al. (2013)
Amazon	Amazonia (except the southern Amazonia)	772	Moura-Júnior et al. (2015) Abe et al. (2015); Medeiros et al. (2015) Costa et al. (2016) Lopes et al. (2020a)

Results

We cataloged 709 species of aquatic macrophytes (5 bryophytes, 29 ferns and lycophytes, and 675 angiosperms) in 313 genera (2 bryophytes, 19 ferns and lycophytes, and 292 angiosperms) and 97 families (2 bryophytes, 13 ferns and lycophytes, and 82 angiosperms). Of this total, 521 species (73%) were classified as aquatic macrophytes according to the Repository of Aquatic Plants of Brazil and the Brazilian Flora database, and 145 species (20%) were classified based on other surveys in the Amazon domain and other domains in Mato Grosso. We collected 334 species (47% of our study total) (Supplementary material; Fig. 2).

The families with the highest number of species were Poaceae (83 species), Cyperaceae (68), Fabaceae (56), Rubiaceae (41), Melastomataceae (27), and Onagraceae (23). These five families represent 43% of the entire aquatic species richness in southern Amazonia. However, 29% of the families have only a single species. The genera with the most species were *Cyperus* (29 species), *Ludwigia* (23), *Rhynchospora* (20), *Utricularia* (18), *Eleocharis* (14), and *Borreria* (12), all belonging to the five richest families, mainly Cyperaceae. Over half (59) of the genera were represented by a single species (Supplementary material).

It is worth highlighting that 15% (100 species) had not been recorded in the Amazon domain, and 12% (79 species) did not have occurrence records for the State of Mato Gross (Brazilian Flora database). Of the aquatic macrophytes recorded in this study, 13% (90 species belonging to 35 families) are endemic to Brazil, particularly the families Podostemaceae (11 species) and Fabaceae (9 species). We found two species in the Vulnerable category (*Mourera weddeliana* Tul., Podostemaceae and *Ipomoea subrevoluta* Choisy, Convolvulaceae), one in Nearly Threatened (*Ottelia brasiliensis* (Planch.) Walp., Hydrocharitaceae), 47 in the Least Concern, and six in Deficient Data (Table 2).

Table 2 Number of species of aquatic macrophytes recorded in the Brazilian Flora database, per group, for the State of Mato Grosso and for Brazilian Amazonia. MT: Mato Grosso and its phytogeographic domains, Ama-MT: Amazon region of Mato Grosso, Cer-MT: Cerrado region of Mato Grosso, Pan-MT: Pantanal region of Mato Grosso, Ama-BR: Brazilian Amazonia, and S-Ama: southern Amazonia

	MT	**Ama-MT**	**Cer-MT**	**Pan-MT**	**Ama-BR**	**S-Ama**
Angiosperms	353	321	258	245	430	675
Ferns and Lycophytes	10	6	5	5	16	29
Bryophytes	6	4	6	4	7	5
Total of species	**369**	**331**	**269**	**254**	**453**	**709**

The year-based rarefaction curve of species richness did not reach an asymptote (Fig. 3). Therefore, southern Amazonia may harbor an even higher number of species than we present here. Southern Amazonia showed low floristic similarity with the Brazilian phytogeographic domains. The similarities with Amazonia and Cerrado were 35% and 25%, respectively, clearly suggesting that the diversity of aquatic macrophytes in our study area was influenced by the adjacent large domains (Fig. 4). Southern Amazonia flora had low similarity (20%) with the Pantanal, Caatinga, Pampas, and Atlantic Forest (Fig. 4).

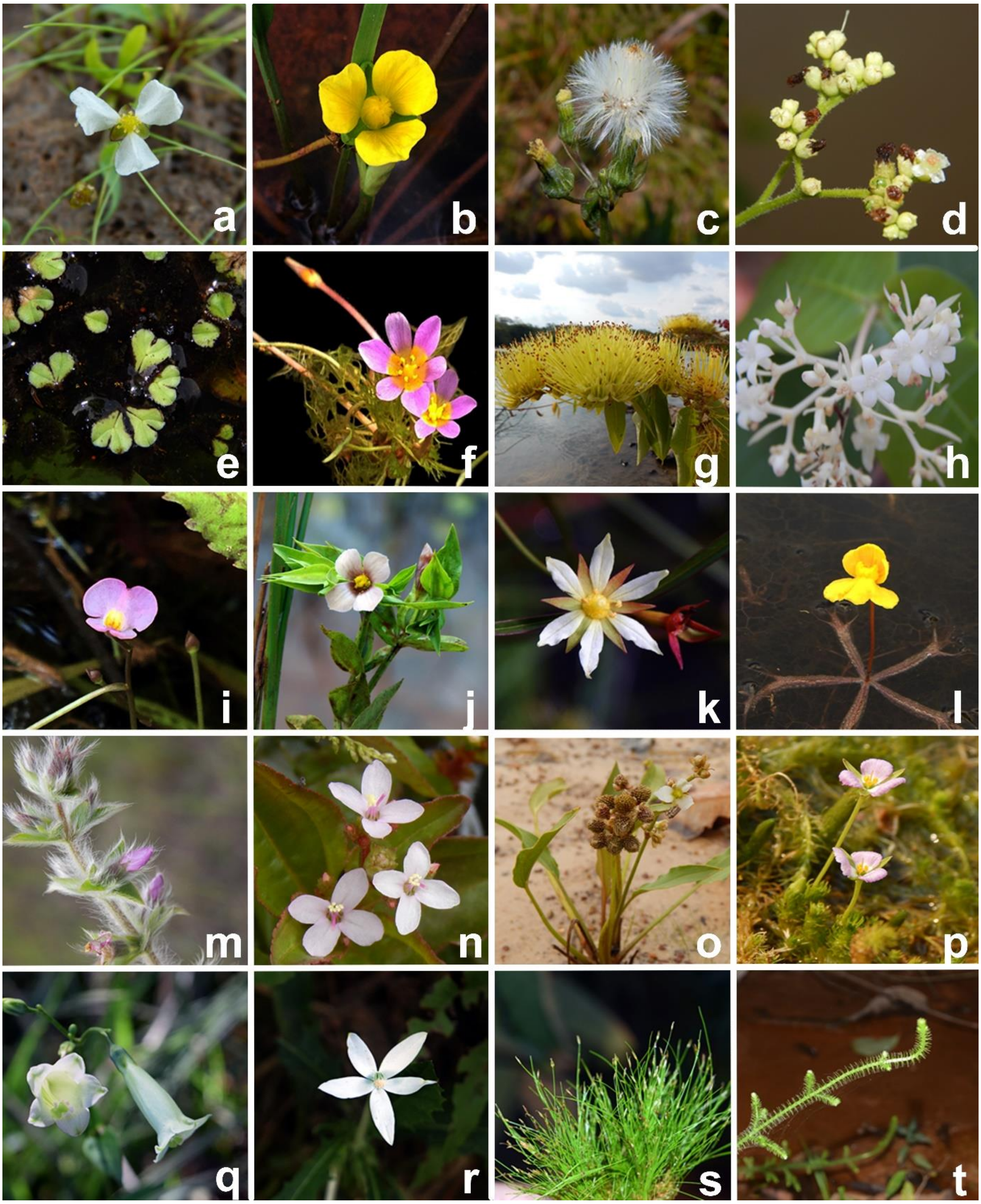

Fig. 2 Examples of species of aquatic macrophytes of southern Amazonia. a. *Helanthium bolivianum* (Rusby) Lehtonen & Myllys, b. *Limnocharis laforesti* Duchass. ex Griseb., c. *Erechtites hieracifolius* (L.) Raf. ex DC., d. *Varronia polycephala* Lam., e. *Ricciocarpos natans* (L.) Corda, f. *Cabomba furcata* Schult. & Schult.f., g. *Combretum lanceolatum* Pohl ex Eichler, h. *Palicourea amplectens* (Benth.) Delprete & J.H. Kirkbr., i. *Utricularia*

hydrocarpa Vahl, j. *Schultesia guianensis* (Aubl.) Malme, k. *Ludwigia torulosa* (Arn.) H. Hara, l. *Utricularia breviscapa* C. Wright ex Griseb., m. *Desmoscelis villosa* (Aubl.) Naudin, n. *Aciotis acuminifolia* (Mart. ex DC.) Triana, o. *Echinodorus subalatus* (Mart. ex Schult.f.) Griseb., p. *Mayaca sellowiana* Kunth, q. *Chelonanthus alatus* (Aubl.) Pulle, r. *Hippobroma longiflora* (L.) G.Don, s. *Eleocharis minima* Kunth, and t. *Palhinhaea camporum* (B. Øllg. & P.G. Windisch) Holub.

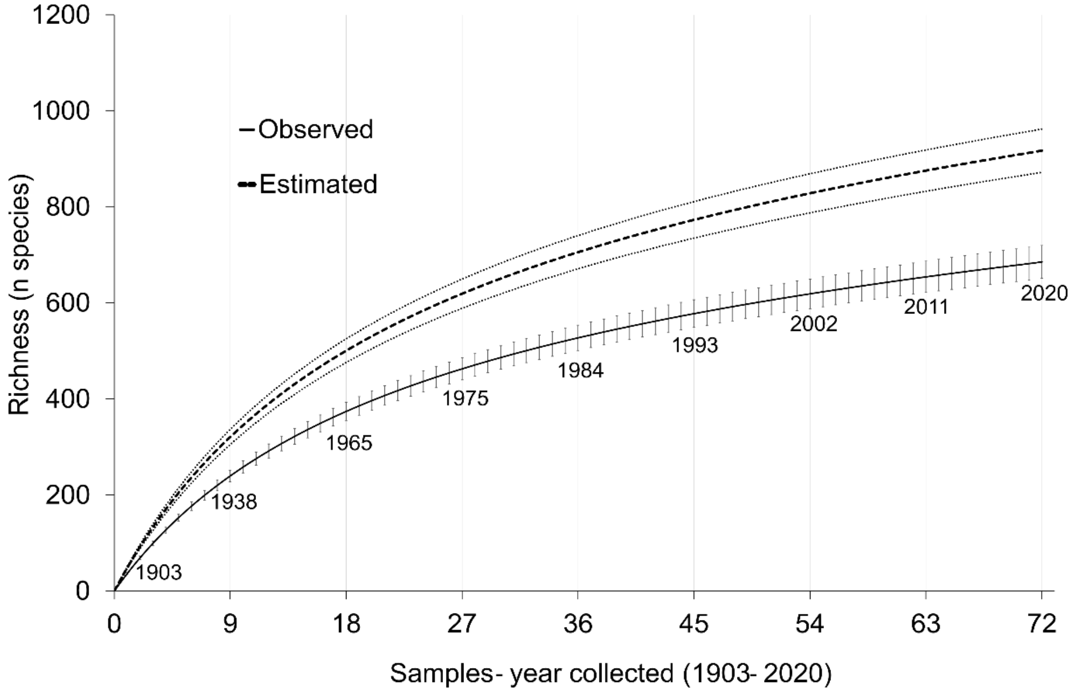

Fig. 3 Sample-based rarefaction curve for observed and estimated (Jackknife 1) species richness of aquatic macrophytes in southern Amazonia. Samples represent years with herbarium records of aquatic macrophytes, accounting for 72 samples (years) between 1903 and 2020. Some long-time intervals represent low numbers of collections in the periods. Only years with collection records were considered, so the number of years (x axis) is not proportional to the total time interval. Dotted lines and bars represent the confidence interval (C.I.=95%).

Discussion

We found a high number of species of aquatic macrophytes (709) for the southern Amazon region, comparable to extensive inventories in Caatinga, Cerrado, Pantanal and Pampa phytogeographic domains and other Amazon parts. We present new records of aquatic macrophyte species and assess their degree of endemism and occurrence restricted to the region. The Neotropical region is recognized for the high diversity of aquatic macrophytes with 1619 species (Murphy et al. 2019). Its known richness continues growing with new studies and records, chiefly in Amazonia and across ecotones of vegetation types. The macrophyte flora of this region shows a high degree of endemism, mainly in the northern part of the Amazon domain (Moura-Júnior et al. 2015; Murphy et al. 2019). The richness of aquatic macrophytes can be related with the sampling area size (Ferreira et al. 2011; Murphy et al. 2003; Moura-Júnior et al. 2015; Moura-Júnior and Cotarelli 2019; Oliveira et al. 2019). Thus, the large area occupied by southern Amazonia (Amazonia of Mato Grosso), with 500,000 km^2 and a variety of wetlands containing rivers of the main Amazon Basins, favors this high diversity of aquatic macrophytes. The bioclimatic conditions related to the low latitude of southern Amazonia, including high temperatures and humidity, variety of water bodies, and plant cover, lead to the high richness of aquatic macrophytes in this region (Murphy et al. 2019). Many studies have documented the increased richness of plant species in lower-latitude regions (Signor 1990; Cox and Moore 2006).

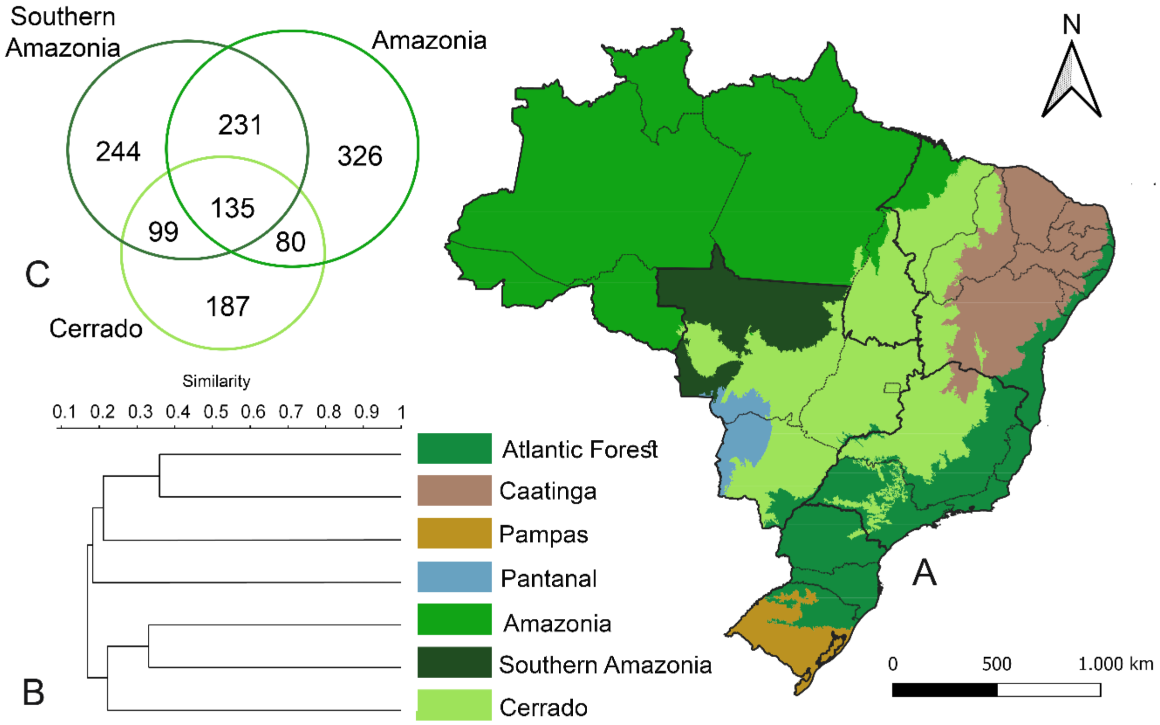

Fig. 4 A. Map showing Brazilian Phytogeographic Domains and location of the study areas included in the analysis of floristic similarity of aquatic macrophytes. **B.** Cluster analysis dendrogram (UPGMA) based on the Simpson similarity index. **C.** Exclusive and shared aquatic macrophyte species of the group formed with southern Amazon in the cluster

The high species richness recorded here may also be related to the location of the study area in southern Amazonia, in the Cerrado-Amazonia transition. This transition area tends to accumulate a high and often unique plant diversity (Marimon et al. 2006; Maracahipes-Santos et al. 2015; Marques et al. 2020). The meeting of the two main biogeographic domains in South America, the Amazon and the Cerrado, provides a wide variety of habitats for the permanent or temporary occurrence of many aquatic macrophytes. Furthermore, the main rivers of southern Amazonia, the Juruena, Xingu, and Teles Pires, formed by the confluence of rivers that arise in the Cerrado, such as the Verde and Ronuro, may facilitate the distribution and colonization of species in the transition to the Amazon region. This transition zone harbors a high phylogenetic diversity of plants (Silva-Pereira et al. 2020).

The species richness found here exceeds that reported in similar studies investigating several types of aquatic ecosystems on large spatial scales, where the number of species did not exceed 300 (Pott and Pott 1997; Costa et al. 2016; Oliveira and Bove 2016). However, comparison among inventories must consider the criteria for inclusion, coverage area, and collecting effort. The highest number of species records of aquatic macrophytes in the North Amazon (515 species) may be related to the larger extent and higher diversity of the areas sampled and the periods when the surveys were taken (Moura-Júnior et al. 2015). Most surveys in the Amazon region were done before 2016. However, we found many records between 2012 and 2019, derived from collections in aquatic-macrophyte monitoring programs for hydroelectric power plants (mainly Teles Pires, Colíder, and Sinop) in the Teles Pires River. The inclusion of this sampling effort in our study contributed to the increase of 343 species records for Amazonia, 29% of which are new occurrences for this phytogeographic domain. In addition, our inventory revealed four species (*Myriophyllum mattogrossensis* Hoehne, *Apinagia fluitans* P.Royen, *Lophogyne aripuanensis* (A.S.Tav.) C.T.Philbrick & C.P.Bove, and *Borreria flexuosa* E.L. Cabral) that occur only in Mato Grosso, and one species, *L. aripuanensis*, that is exclusive to southern Amazonia. For Caatinga and Pampa domains, long-term studies with sampling in widely distributed areas have reported high species richness (637 and 760 species, respectively) (Moura-Júnior and Cotarelli 2019; Oliveira et al. 2019). Besides, these regions are in different phytogeographic domains and present a mosaic of vegetational types, with a great diversity of aquatic environment types and different hydrographic basins (e.g. Parana and São Francisco Rivers) mainly connected with the Cerrado domain (Marcuzzo 2017). The increase in species records for the southern Amazonia region may also be due to failure to include many amphibious/emergent and epiphyte/climber species in the older lists. Labels from collections and herbarium records in *speciesLink* and GBIF do not adequately specify or describe the life form and/or habitat, hindering the characterization of species as aquatic macrophytes. We included many terrestrial plants tolerant of rapid inundation or running water in the sorting criteria. Correct recording of life forms is a key aspect in the study of aquatic macrophytes (Moura-Júnior and Cotarelli 2019). As mentioned above, we found many amphibious and emergent species, which results in a pattern similar to those found in other floristic studies of aquatic macrophytes. The high number of amphibious and emergent species is attributable to habitat types such as riparian forests, where these species are frequent and often abundant in these temporarily flooded areas (V. J. Pott et al., 2011). The seasonality of other life forms, such as floating and submerged plants, may prevent them from being recorded in the field since many appear in wetlands for only a short time; this is reflected in the lower number of species and survey records. Accuracy in the determination and description of life forms often requires studies for extended periods and over several hydrological cycles (Moura-Júnior and Cotarelli 2019; Pivari et al. 2019).

The similarity of the macrophytes of southern Amazonia to the species recorded for the Amazon and Cerrado domains were higher, mainly because of their proximity to southern Amazonia. Nevertheless, the community of aquatic macrophytes showed differences within the Amazon domain, i.e., between central and southern Amazonia, as supported by the species inclusion from inventories in the states of Roraima (Costa et al. 2016) and Amazonas (Lopes et al. 2020a). The environmental traits, such as the white, black and clearwater rivers of the Amazon Basin may have been related to their similarity. White waters are nutrient-rich from the Andes and are found in much of the central Amazon (Furch and Junk 1997), and clear and black waters are found in the Cerrado and other domains (Mounier et al. 1998). In this sense, clear and white waters support a higher diversity of herbaceous aquatic macrophytes than black waters (Piedade et al. 2010; Lopes et al. 2020a). In southern Amazonia, all these types of water favored the similarity with Amazonia and Cerrado domains, increasing species richness. This similarity may also be due to the influence of the Cerrado domain on southern Amazonia, as described for the tree flora of these regions by Morandi et al. (2016b). However, this similarity between southern Amazonia and the Cerrado may change if there were more studies or reviews with all aquatic macrophyte groups (angiosperms, lycophytes and ferns, and bryophytes) carried out in this domain. The absence of such data makes it challenging to generate a more extensive list where similarities could have been more evident. Studies with broader temporal and spatial coverage in these areas are needed to explore their potential richness. The richness of herbaceous aquatic macrophytes influences the similarity between the study sites, particularly regarding Poaceae and Cyperaceae. These families are the richest in wetlands worldwide (Murphy et al. 2019) and are very common in Brazilian wetlands, such as the Pantanal (Pott and Pott 1997) and the Paraná River Basin (Murphy et al. 2003; Ferreira et al. 2011). The Brazilian Flora Database (Flora do Brasil 2020) includes 1653 species of Poaceae. Their efficient vegetative propagation (rhizomes and/or stolons) allows species of Cyperaceae and Poaceae to adapt to temporarily or permanently flooded areas, which explains their occurrence in all analyzed habitats (Henry-Silva et al. 2010, Pott et al. 2011). In addition, Fabaceae is the third species-rich family in southern Amazonia and ranks second in the number of endemic species, which agrees with studies on aquatic macrophytes in other Brazilian phytogeographic domains such a Caatinga (Moura-Júnior et al. 2019) and Pampa (Oliveira et al. 2019). The endemism found and represented mainly by two families (Podostemaceae and Fabaceae) shows the importance of southern Amazonia as a refuge for species of restricted occurrence and threatened with extinction. We highlight the yet unreported high richness of Podostemaceae (16 species) in our study, of which 11 are endemic, in line with that found in northern Amazonia (Moura-Junior et al. 2015). We call attention to the occurring Sphagnaceae (Bryophyta), which are highly endemic in Brazil but not commonly reported for Amazonia since most records and the highest richness were found in the Atlantic Forest and Cerrado domains (Costa and Peralta 2015). The high species diversity in the region emphasizes the importance of conserving wetlands and vegetation types where they grow; many species have restricted habitats, as shown, for example, in the endemism levels. Conservation of the vegetation associated with watercourses is directly related to conserving water resources, mainly in the Amazon region (Zaiatz et al. 2018; Lopes et al. 2020b). Despite this, wetlands in Brazil have not received the economic, ecological and/or social value that they deserve. On the contrary, many people favor transforming these areas for agriculture, cattle ranching, and engineering projects, such as hydroelectric power stations and roads (Junk et al. 2020), primarily in the so-called deforestation arc in southern Amazonia (Fearnside 2019). These changes in the landscape, mainly in water management, can lead to changes in aquatic macrophyte communities, for example favoring fast-growing and rapidly developing invasive species (Fares et al. 2020). Our results reinforces the need for maintenance and conservation of wetlands, especially in ecotone areas such as southern Amazonia.

Floristic studies in wetlands in Brazil have continuously increased in sampling areas and number of species (Pivari et al. 2019). The present findings expand the available information on Amazon areas and habitats and increase the knowledge of species of aquatic macrophytes that occur in transitional areas such as southern Amazonia. This new information will help clarify the classification of these areas, which are often relics of many communities and populations (Márquez et al. 2020). In summary, we recorded a high number of species, families, and life forms of aquatic macrophytes, with high diversity, high degree of endemism, and several species with restricted occurrence in southern Amazonia. Our results exceeded expectations and indicate that further floristic studies are needed in the southern Amazonia region.

Declarations

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Conflicts of interest/Competing interests The authors declare that there is no conflict of interest regarding the publication of this article.

Ethics approval Not applicable.

Consent to Participate Not applicable.

Consent for Publication Written informed consent for publication was obtained from all participants.

Author Contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Milton Omar Cordova, Josiane Fernandes Keffer, Dienenfe Giacoppini, Arnildo Pott, Vali Joana Pott and Cássia Beatriz Rodrigues Munhoz. The list of species from other phytogeographic domains was provided by Edson Gomes de Moura Júnior. The first draft of the manuscript was written by Milton Omar Cordova and all authors commented on previous versions of the manuscript. Later versions were corrected and commented on by Edson Gomes de Moura Júnior and Cássia Beatriz Rodrigues Munhoz. All authors read and approved the final manuscript.

Availability of data and material All data generated or analyzed during this study are included in this article.

Code Availability Not applicable.

Supplementary Material 1 List of aquatic macrophyte species by phytogeographic domain

Supplementary Material 2 Species of Aquatic Macrophytes of southern Amazonia

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Supplementary Material Species of Aquatic Macrophytes of Southern Amazonia, Brazil. LF - Life form (AB: Amphibious, EM: Emergent, RF: Rooted Floating, FF: Free-floating, RS: Rooted submerged, FS: Free submerged, CE: climber/epiphyte); HC: Growth habit (hb: herb, sh: shrub, ssh: subshrub, cp: climber, pam: palm); APB: Aquatic Plants of Brazil (+: recorded, -: not recorded); BFD: Brazilian Flora Database (+: recorded, -: not recorded); Habitat (Lo: lotic; Le: lentic; Int: intermediate); Endemic (N: not endemic, Y: endemic). CRE: Risk of Extinction Categories – IUCN (VU: Vulnerable, NT: Nearly Threatened, LC: Least Concern, DD: Insufficient data). NC: Records collector numbers, in parentheses ( ) material selecting from other collectors to prepare the list. Names in square brackets [ ] represent IPNI and World Flora Online valid names. Names with star (*) represent species that do not occur in the Amazon Domain, according to the Brazilian Flora database.

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
BRYOPHYTES								
RICCIACEAE								
Ricciocarpos natans (L.) Corda	FF	hb	+	+	Le	N		Córdova, M.O. 423
SPHAGNACEAE								
Sphagnum brasiliense Warnst.	AB	hb	-	-	Le/Lo	N		(Hoehne, F.C. 1906)
Sphagnum matogrossense H.A.Crum*	AB	hb	-	-	Le/Lo	N		(Hoehne, F.C. 2106)
Sphagnum palustre L.	AB	hb	-	-	Le/Lo	N		(Abdo, M.A.S. 340)
Sphagnum subsecundum Nees*	AB	hb	-	-	Le/Lo	N		(Windisch, P.G. 1354)
FERNS AND LYCOPHYTES								
BLECHNACEAE								
Neoblechnum brasiliense (Desv.) Gasper & V.A.O.Dittrich	AB	hb	+	-	Lo	N		(Athayde f., F.P. 3831)
Telmatoblechnum serrulatum (Rich.) Rich. Perrie, D.J.Ohlsen & Brownsey	AB	hb	+	-	Le/Lo	N		(Windisch, P.G. 8885)
DENNSTAEDTIACEAE								
Pteridium esculentum (G.Forst.) Cockayne	AB	hb	+	-	Le/Lo	N		(Engels, M.E. 5729)
DRYOPCERIDACEAE								
Cyclodium guianense (Klotzsch) van der Werff ex L.D.Gómez	AB	hb	-	-	Le	N		Giacoppini, D.R. 871
Cyclodium meniscioides (Willd.) C.PreFS	AB	hb	-	-	Int/Le/Lo	N		Córdova, M.O. 737
GLEICHENIACEAE								
Dicranopteris flexuosa (Schrad.) Underw.	AB	hb	+	-	Le/Lo	N		Córdova, M.O. 1242
HYMENOPHYLLACEAE								
Trichomanes crispum L.	AB	hb	+	-	Le	N		(Engels, M.E. 5845)
Trichomanes hostmannianum (Klotzsch) Kunze	AB	hb	-	-	Le/Lo	N		Córdova, M.O. 446
Trichomanes pinnatum Hedw.	AB	hb	-	-	Int/Le/Lo	N		Córdova, M.O. 575
LINDSAEACEAE								
Lindsaea divaricata Klotzsch	AB	hb	-	-	Int/Le/Lo	N		Córdova, M.O. 576
Lindsaea guianensis (Aubl.) Dryand	AB	hb	-	-	Le	N		Córdova, M.O. 594
Lindsaea lancea (L.) Bedd.	AB	hb	-	-	Lo	N		Córdova, M.O. 595
Lindsaea stricta (Sw.) Dryand	AB	hb	+	-	Lo	N		(Amaral, I.L. 831)
LOMARIOPSIDACEAE								
Cyclopeltis semicordata (Sw.) J.Sm.	AB	hb	-	-	Lo	N		Córdova, M.O. 465

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
LYCOPODIACEAE								
Palhinhaea camporum (B. Øllg. & P.G.Windisch) Holub	AB	hb	+	-	Le	N		Córdova, M.O. 447
Palhinhaea cernua (L.) Franco & Vasc. [*P. cernua* (L.) Vasc. & Franco]	AB	hb	+	-	Int/Le/Lo	N		(Engels, M.E. 2658)
LYGODIACEAE								
Lygodium volubile Sw.*	AB	sh	+	-	Lo	Y		(Engels, M.E. 4692)
POLYPODIACEAE								
Cochlidium serrulatum (Sw.) L.E.Bishop	AB	hb	-	-	Le	N		Córdova, M.O. 422
PTERIDACEAE								
Adiantopsis chlorophylla (Sw.) Fée*	AB	hb	+	+	Le	N		(Windisch, P.G. 6757)
Adiantum deflectens Mart.*	AB	hb	+	-	Le/Lo	N		(Engels, M.E. 4175)
Adiantum lucidum (Cav.) Sw.	AB	hb	-	-	Le	N		Giacoppini, D.R. 845
Ceratopteris pteridoides (Hook.) Hieron.	EM	hb	+	+	Int/Le/Lo	N		Córdova, M.O. 425
Ceratopteris thalictroides (L.) Brongn.*	EM	hb	+	+	Lo	N		Córdova, M.O. 609
Pityrogramma calomelanos (L.) Link.	AB	hb	+	-	Le/Lo	N		Giacoppini, D.R. 1181
SALVINIACEAE								
Azolla filiculoides Lam.	FF	hb	+	-	Int	N		(Sasaki, D. 1503)
Salvinia auriculata Aubl.	FF	hb	+	+	Le/Lo	N		(Abdo, M.S.A. 80)
Salvinia biloba Raddi*	FF	hb	+	+	Lo	N		Córdova, M.O. 1489
THELYPCERIDACEAE								
Cyclosorus interruptus (Willd.) H.Itô	AB	hb	+	+	Lo	N		Córdova, M.O. 635
Meniscium serratum Cav.	EM	hb	-	-	Le/Lo	N		Córdova, M.O. 804
ANGIOSPERMS								
ACANTHACEAE								
Hygrophila costata Nees & T.Nees	AB	hb	+	+	Lo	N		Córdova, M.O. 445
Justicia asclepiadea (Nees) Wassh. & C.Ezcurra*	AB	sh	-	-	Le	N		Córdova, M.O. 276
Justicia laevilinguis (Nees) Lindau	AB	sh	-	-	Le	N	LC	Giacoppini, D.R. 988
Ruellia geminiflora Kunth	AB	ssh	+	-	Le/Lo	N		Córdova, M.O. 582
Ruellia jussieuoides Schltdl. & Cham.*	AB	ssh	+	-	Lo	N		Giacoppini, D.R. 882
ALISMATACEAE								
Echinodorus aschersonianus Graebn.*	AB	hb	+	+	Le	N		Cordova, M.O. 667
Echinodorus floribundus (Seub.) Seub.*	AB	hb	-	+	Int	N		(Bleich, M.E. 36)
Echinodorus glaucus Rataj.	EM	hb	-	+	Lo	N		Córdova, M.O. 1494
Echinodorus grandiflorus (Cham. & Schltr.) Micheli*	EM	hb	+	+	Le	N		(Silva, C.A. 326)
Echinodorus grisebachii Small	AB	hb	+	+	Le/Lo	N		(Sasaki, D. 2464)
Echinodorus lanceolatus Rataj.	AB	ssh	+	+	Lo	Y	LC	Córdova, M.O. 1495
Echinodorus longipetalus Micheli*	AB	hb	+	+	Int/Le	N		(Souza, V.C. 14570)
Echinodorus paniculatus Micheli	EM	hb	+	+	Lo	N	LC	Córdova, M.O. 1162

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Echinodorus subalatus (Mart.) Griseb. [*E. subalatus* (Mart. ex Schult.f.) Griseb.]	EM	hb	+	+	Int/Le/Lo	N		Córdova, M.O. 819
Echinodorus trialatus Fassett *	AB	hb	-	+	Lo	N		(Andrade, J.B. 3298)
Helanthium bolivianum (Rusby) Lehtonen & Myllys*	EM	hb	+	+	Le/Lo	N	LC	Córdova, M.O. 841
Helanthium tenellum (Mart.) Britton	EM	hb	+	+	Le/Lo	N		Córdova, M.O. 1498
Hydrocleys nymphoides (Willd.) Buchenau [*H. nymphoides* (Humb. & Bonpl. ex Willd.) Buchenau] *	RF	hb	+	+	Le	N		(Engels, M.E. 4248)
Hydrocleys parviflora Seub.*	RF	hb	-	+	Le	N		Pott, V.J. 2682
Limnocharis flava (L.) Buchenau	RF	hb	+	+	Le	N		Giacoppini, D.R. 984
Limnocharis laforesti Duchass. ex Griseb. [*L. laforestii* Duchass. ex Griseb]	RF	hb	+	+	Le	N		Córdova, M.O. 214
Sagittaria guayanensis Kunth	RF	hb	+	+	Le/Lo	Y		Córdova, M.O.782
Sagittaria montevidensis Cham. & Schltdl.	RF	hb	+	+	Le	N		(Abdo, M.S.A. 163)
Sagittaria rhombifolia Cham.	EM	hb	+	+	Le	N	LC	Pott, V.J. 10413
AMARANTHACEAE								
Alternanthera brasiliana (L.) Kuntze^{+}	EM	cp	+	-	Le	Y		Córdova, M.O. 1129
Alternanthera dentata (Moench) Stuchlik ex R.E.Fr. [*A. ramosissima* (Mart.) Chodat & Hassl.]	EM	ssh	+	-	Le	N		(Macêdo, M. 1951)
Alternanthera tenella Colla	AB	ssh	-	-	Le	N	LC	Córdova, M.O. 231
Amaranthus viridis L.	AB	hb	-	-	Lo	N		(Philcox, D. 3668)
Chamissoa altissima (Jacq.) Kunth	CE	cp	-	-	Le/Lo	N	LC	(Zappi, D.C. 1368)
Gomphrena celosioides Mart.	AB	ssh	+	-	Le	N		(Souza, V.C. 14475)
Hebanthe eriantha (Poir.) Pedersen	AB	ssh	+	-	Le	N	LC	(Soares-Lopes, C.R.A. 1578014)
Pfaffia glomerata (Spreng.) Pedersen	AB	ssh	+	-	Le	N	LC	(Pavan, E. 6)
APIACEAE								
Eryngium ebracteatum Lam.*	EM	hb	+	-	Le/Lo	N		Córdova, M.O. 375
Eryngium elegans Cham. & Schltdl.	EM	hb	-	-	Lo	N		Córdova, M.O. 311
APOCYNACEAE								
Allamanda cathartica L.	CE	cp	+	-	Lo	N		(Nieski, E. 133)
Asclepias curassavica L.	AB	hb	+	-	Le	N		(Silva, C.A. 313)
Funastrum clausum (Jacq.) Schltr.	CE	cp	+	-	Int/Le/Lo	N		Córdova, M.O. 1100
Mandevilla clandestina J.F.Morales*	CE	hb	+	-	Le	Y		(Irwin, H.S. 6461)
Mandevilla hirsuta (A.Rich.) K.Schum.	CE	cp	-	-	Le	N	LC	(Souza, V.C. 18518)
Mandevilla tenuifolia (J.C.Mikan) Woodson	CE	cp	+	-	Le/Lo	N		(Engels, M.E. 2772)
Prestonia quinquangularis (Jacq.) Spreng.	CE	cp	-	-	Lo	N	LC	Córdova, M.O. 1013
Rhabdadenia madida (Vell.) Miers	CE	cp	+	+	Lo	N		Córdova, M.O. 1204
Secondatia densiflora A.DC.	CE	cp	+	-	Le/Lo	N		(Engels, M.E. 4805)
Tabernaemontana siphilitica (L.f.) Leeuwenb.	AB	sh	-	-	Le/Lo	N		Córdova, M.O. 397
Tassadia berteroana (Spreng.) W.D.Stevens	CE	cp	-	-	Le/Lo	N		Córdova, M.O. 763
ARACEAE								
Anaphyllopsis cururuana A. Hay	AB	hb	-	+	Lo	Y		(Engels, M.E. 3900)

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Lemna aequinoctialis Welw.	FF	hb	+	+	Le/Lo	N		Pott, V.J. 9322
Montrichardia arborescens (L.) Schott	EM	hb	-	+	Le/Lo	N		Córdova, M.O. 412
Pistia stratiotes L.	FF	hb	+	+	Lo	N		(Guarim-Neto, G. 435)
Spathiphyllum gardneri Schott	AB	hb	-	-	Le/Lo	Y		Córdova, M.O. 599
Urospatha sagittifolia (Rudge) Schott	EM	hb	+	+	Int/Le/Lo	N		Pott, V.J. 2679
Xanthosoma aristeguietae (G.S.Bunting) Madison*	AB	hb	-	+	Int/Le	N		Córdova, M.O. 579
Wolffia brasiliensis Wedd.	FF	hb	+	+	Int/le	N		(Weddell, HÁ s/n)
ARALIACEAE								
Hydrocotyle leucocephala Cham. & Schltdl.*	AB	hb	+	-	Lo	N		Córdova, M.O. 1259
ARECACEAE								
Bactris hirta Mart.*	AB	pm	-	-	Le	N		Córdova, M.O. 571
Bactris maraja Mart.*	AB	pm	-	-	Le/Lo	N		Giacoppini, D.R.425
Euterpe longibracteata Barb.Rodr.	AB	pm	-	-	Le/Lo	N		Giacoppini, D.R. 217
Mauritia flexuosa L.f.	AB	pm	-	-	Le/Lo	N		(Hatschbach, G. 62406)
Mauritiella aculeata (Kunth) Burret*	AB	pm	-	-	Le/Lo	N		Córdova, M.O. 370
Mauritiella armata (Mart.) Burret	AB	pm	-	-	Le/Lo	N		(Engels, M.E. 3748)
ASTERACEAE								
Conyza bonariensis (L.) Cronquist [*Erigeron bonariensis* L.]	AB	ssh	-	-	Le/Lo	N		Córdova, M.O. 729
Calea polycephala (Baker) H.Rob.	AB	hb	-	-	Le/Lo	Y	NT	Giacoppini, D.R. 1127
Eclipta prostrata (L.) L.	AB	hb	+	+	Lo	N		Giacoppini, D.R. 1297
Erechtites hieracifolius (L.) Raf. ex DC. [*E. hierciifolius* (L.) Raf. ex DC.]	EM	hb	-	-	Le	N		Córdova, M.O. 982
Mikania congesta DC.*	CE	cp	-	-	Lo	N		(Forzza, R.C. 9713)
Mikania cordifolia (L.f.) Willd.	CE	cp	+	-	Le/Lo	N		Córdova, M.O. 1134
Mikania micrantha Kunth	CE	cp	+	-	Le/Lo	N		Córdova, M.O. 199
Orthopappus angustifolius (Sw.) Gleason	EM	hb	+	-	Le/Lo	N		Córdova, M.O. 558
Sphagneticola trilobata (L.) Pruski	AB	hb	+	+	Le	N		Córdova, M.O. 1502
Tilesia baccata (L.f.) Pruski	AB	sh	+	-	Le	N		(Sardelli, L.F. 3194)
BIGNONIACEAE								
Tanaecium pyramidatum (Rich.) L.G.Lohmann	CE	cp	-	-	Le/Lo	N		Giacoppini, D.R. 964
Tynanthus polyanthus (Bureau) Sandwith	CE	cp	-	-	Le/Lo	N		(Sardelli, L.F. 3217)
BORAGINACEAE								
Euploca filiformis (Lehm.) J.I.M.Melo & Semir	AB	hb	+	+	Int/Le	N		(Sobral, M. 11109)
Euploca parciflora (Mart.) J.I.M.Melo & Semir*	AB	hb	-	+	Le	Y		Córdova, M.O. 399
Heliotropium elongatum (Lehm.) I.M.Johnst. [*H. elongatum* (Lehm.) Gürke]	AB	ssh	+	-	Le/Lo	Y		(Sardelli, L.F. 945)
Heliotropium indicum L.	AB	hb	+	+	Le/Lo	N		Córdova, M.O. 1175
Varronia polycephala Lam.*	EM	cp	-	-	Lo	Y		Córdova, M.O. 990
BROMELIACEAE								

Group/Family/Species	**LF**	**GH**	**APB**	**BFD**	**Habitat**	**Endemic**	**CRE**	**NC**
Aechmea bromeliifolia (Rudge) Baker	AB	hb	+	-	Le	Y	LC	Giacoppini, D.R. 584
BURMANIACEAE								
Burmannia capitata (Walterr ex J.F.Gmel.) Mart.	AB	hb	+	-	Le	N		(Souza, V.C. 16823)
CABOMBACEAE								
Cabomba caroliniana A.Gray	RS	hb	+	+	Le	N	LC	(Emmerich, M. s/n)
Cabomba furcata Schult. & Schult.f.	RS	hb	+	+	Le	N	LC	Córdova, M.O. 923
CAMPANULACEAE								
Hippobroma longiflora (L.) G.Don	AB	hb	+	-	Le	N		Córdova, M.O. 1290
CHLORANTHACEAE								
Hedyosmum brasiliense Mart. ex Miq.	AB	sh	+	-	Le/Lo	N		(Engels, M.E. 5849)
COMBRETACEAE								
Combretum lanceolatum Pohl *ex* Eichler^{+}	CE	cp	-	-	Le/Lo	N		Córdova, M.O. 1069
Combretum laxum Jacq.	CE	cp	+	-	Le/Lo	N		Córdova, M.O. 620
COMMELINACEAE								
Commelina diffusa Burm.f.	AB	hb	+	+	Le	N		(Engels, M.E. 5625)
Commelina erecta L.	AB	hb	+	+	Le	N		(Philcox, D. 3203)
Commelina longicaulis Jacq.*	AB	hb	+	-	Le	N		Córdova, M.O. 1504
Dichorisandra hexandra (Aubl.) C.B.Clarke	CE	cp	-	-	Le/Lo	N		(Zappi, D.C. 3265)
Floscopa glabrata (Kunth) Hassk.	EM	hb	+	+	Le/Lo	N		(Kuhlmann, J.G. 1645)
Floscopa peruviana Hassk. ex. C.B.Clarke	AB	hb	-	-	Le/Lo	N		(Engels, M.E. 3414)
Murdannia engelsii M.Pell. & Faden [*M. engelsii* M.Pell.]	EM	hb	-	+	Le	Y		(Engels, M.E. 3474)
Murdannia gardneri (Seub.) G.Brückn.	AB	hb	-	+	Le	Y		(Sasaki, D.1934
Murdannia nudiflora (L.) Brenan	AB	hb	-	+	Le	N		(Engels, M.E. 3195)
Murdannia paraguayensis (C.B.Clarke) G.Brückn.*	AB	hb	-	+	Le	N		(Souza, V.C. 30056)
Murdannia semifoliata (C.B.Clarke) G.Brückn. [*M. semifoliata* (C.B.Clarke ex Chodat) Grückn.]	AB	hb	-	+	Le	Y		(Baldwin, J.T. 3097)
Tripogandra diuretica (Mart.) Handlos [*C. diuretica* (Mart.) Christenh. & Byng]	AB	hb	+	+	Le	N		(Costa, J.A.F. 689)
CONVOLVULACEAE								
Aniseia martinicensis (Jacq.) Choisy	CE	cp	+	-	Le/Lo	N	DD	Córdova, M.O. 771
Camonea umbellata (L.) A.R.Simões & Staples	CE	cp	-	-	Le/Lo	N		Córdova, M.O. 1136
Ipomoea alba L.	CE	cp	+	-	Le/Lo	N		(Souza, V.C. 14236)
Ipomoea asarifolia (Desr.) Roem. & Schult.	CE	cp	-	-	Le	N		(Galvão, I.R. 1)
Ipomoea carnea Jacq.	AB	ssh	+	-	Le/Lo	N		Córdova, M.O. 182
Ipomoea philomega (Vell.) House*	CE	cp	-	-	Le	N		(Sasaki, D. 2182)
Ipomoea quamoclit L.	CE	cp	-	-	Int/Le/Lo	N		Córdova, M.O. 645
Ipomoea rubens Choisy	CE	cp	-	-	Int/Le/Lo	N		Córdova, M.O. 195
Ipomoea setifera Poir.	CE	cp	-	-	Le/Lo	N		Córdova, M.O. 253
Ipomoea squamosa Choisy	CE	cp	+	-	Le/Lo	N		(Souza, V.C. 18750)

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Ipomoea subrevoluta Choisy	CE	cp	-	+	Lo	N	VU	Cordova, M.O. 1409
Ipomoea triloba L.	CE	cp	-	-	Le	N		Córdova, M.O. 264
Operculina hamiltonii (G.Don) D.F.Austin & Staples	CE	cp	-	-	Le	N	LC	Córdova, M.O. 700
COSTACEAE								
Costus amazonicus (Loes.) J.F.Macbr.	AB	hb	-	-	Le/Lo	N		Córdova, M.O. 986
Costus arabicus L.	AB	hb	+	+	Le/Lo	N		Córdova, M.O. 687
Costus spiralis (Jacq.) Roscoe	AB	hb	+	-	Int/Le/Lo	N		Córdova, M.O. 1327
CYPERACEAE								
Bulbostylis capillaris (L.) C.B.Clarke	EM	hb	+	-	Le	N		Córdova, M.O. 1193
Bulbostylis junciformis (Kunth) C.B.Clarke	EM	hb	-	-	Le	N		(Souza, V.C. 14359)
Bulbostylis truncata (Nees) M.T.Strong	EM	hb	-	-	Le	N		(Harley, R.M. 10135)
Calyptrocarya glomerulata (Brongn.) Urb.	AB	hb	+	-	Int/Lo	N		Córdova, M.O. 517
Cyperus aggregatus (Willd.) Endl.	EM	hb	+	-	Le	N		Cordova, M.O. 184
Cyperus articulatus L.*	EM	hb	+	-	Le	Y		(Bieski, I.G.C. s/n)
Cyperus blepharoleptos Steud.	EM	hb	+	+	Int/Le/Lo	N		Córdova, M.O. 221
Cyperus brevifolius (Rottb.) Endl. ex Hassk.	EM	hb	+	-	Le/Lo	N		Córdova, M.O. 403
Cyperus chalaranthus J.Press & C.Press*	AB	hb	-	+	Lo	N		(Soares-Lopes, C.R.A. 3787)
Cyperus corneliiostenii Kük*	EM	hb	+	-	Le	N		Córdova, M.O. 683
Cyperus difformis L.*	EM	hb	+	-	Lo	N		(Silva, J.S. 5)
Cyperus digitatus Rottb.	EM	hb	-	+	Le	N		Córdova, M.O. 559
Cyperus esculentus L.	EM	hb	+	-	Le/Lo	N		Córdova, M.O. 401
Cyperus flavescens L.	EM	hb	+	-	Le	N		Córdova, M.O. 983
Cyperus giganteus Vahl	EM	hb	+	+	Lo	N	LC	(Windisch, P.G. 7088)
Cyperus haspan L.	EM	hb	+	+	Int/Le/Lo	N		Córdova, M.O. 377
Cyperus hermaphroditus (Jacq.) Standl.	AB	hb	+	+	Le	N		(Sasaki, D. 1901)
Cyperus hortensis (Salzm. ex Steud.) Dorr	EM	hb	+	-	Int	N		(Bleich, M.E. 82)
Cyperus incomtus Kunth*	AB	hb	-	-	Le	N		Córdova, M.O. 426
Cyperus iria L.	EM	hb	+	+	Le	N		Córdova, M.O. 441
Cyperus lanceolatus Poir.	EM	hb	+	+	Le	N		Córdova, M.O. 281
Cyperus laxus Lam.	EM	hb	+	-	Int/Lo	Y		Córdova, M.O. 704
Cyperus luzulae (L.) Retz. [*C. eragrostis* Lam.]	EM	hb	+	+	Int/Le/Lo	N		Córdova, M.O. 290
Cyperus meyenianus Kunth	AB	hb	+	+	Le	N		(Soares-Lopes, C.R.A. 3868)
Cyperus mundtii (Nees) Kunth*	EM	hb	+	-	Le/Lo	N		Córdova, M.O. 382
Cyperus odoratus L.	EM	sh	+	+	Int/Le/Lo	Y		Córdova, M.O. 1501
Cyperus rotundus L.	EM	ssh	+	+	Le	Y		Córdova, M.O. 200
Cyperus salzmannianus (Steud.) Bauters*	AB	ssh	-	-	Lo	Y		(Sobral, M. 11262)
Cyperus schomburgkianus Nees*	EM	hb	-	+	Le	N		Córdova, M.O. 992

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Cyperus sellowianus (Kunth) T.Koyama*	EM	hb	-	+	Le/Lo	N		(Koyama, T. 13770)
Cyperus sesquiflorus (Torr.) Mattf. & Kük.	AB	hb	+	+	Le/Lo	N		Córdova, M.O. 400
Cyperus sphacelatus Rottb.	AB	hb	-	+	Le	N		(Harley, R.M. 10712)
Cyperus surinamensis Rottb.	EM	hb	+	+	Int/Le	N		Córdova, M.O. 784
Diplacrum capitatum (Willd.) Boeckeler	EM	hb	-	+	Le	N		Córdova, M.O. 267
Eleocharis acutangula (Roxb.) Schult.	EM	hb	+	+	Int/Le/Lo	N		Córdova, M.O. 600
Eleocharis amazonica C.B. Clarke	AB	hb	-	+	Le	N		(Zappi, D.C. 1334)
Eleocharis capillacea Kunth	EM	hb	+	+	Int/Lo	N		Córdova, M.O. 1257
Eleocharis elegans (Kunth) Roem. & Schult.	EM	hb	+	+	Le/Lo	N		Córdova, M.O. 207
Eleocharis filiculmis Kunth	EM	hb	+	-	Le/Lo	N		Córdova, M.O. 431
Eleocharis geniculata (L.) Roem. & Schult.	EM	hb	+	+	Le/Lo	N		Córdova, M.O. 272
Eleocharis interstincta (Vahl) Roem. & Schult.	EM	hb	+	+	Int/Le/Lo	N		Córdova, M.O. 1309
Eleocharis minima Kunth	EM	hb	+	+	Int/Le/Lo	N		Córdova, M.O. 282
Eleocharis nana Kunth	EM	hb	+	+	Le/Lo	N		Córdova, M.O. 1289
Eleocharis nigrescens (Nees) Kunth	AB	hb	-	+	Int	N		(Bleich, M.E. 46)
Eleocharis nudipes (Kunth) Palla*	EM	hb	+	+	Lo	N		(Pereira, F.S. 21)
Eleocharis pachystyla (C.Wright) C.B.Clarke	EM	hb	+	+	Lo	N		(Thomas, W.W. 3933)
Eleocharis plicarhachis (Griseb.) Svenson	EM	hb	+	+	Int	N		(Bleich, M.E. 88)
Eleocharis retroflexa (Poir.) Urb.*	AB	hb	-	+	Lo	N		(Sick, H. 379)
Fimbristylis aestivalis (Retz.) Vahl	AB	hb	-	-	Le	N		Córdova, M.O. 1167
Fimbristylis complanata (Retz.) Link	AB	hb	+	+	Le	N		Giacoppini, D.R. 1143
Fimbristylis cymosa R.Br.*	AB	hb	-	+	Int	N		(Bleich, M.E. 61)
Fimbristylis dichotoma (L.) Vahl	EM	hb	+	-	Int/Le/Lo	Y		Córdova, M.O. 964
Fimbristylis littoralis Gaudich.	EM	hb	+	+	Int/Le/Lo	N		Córdova, M.O. 1265
Fimbristylis spadicea Rottb.	EM	hb	-	+	Le	N		(Souza, V.C. 17942)
Fuirena umbellata Rottb.	AB	hb	+	+	Int/Le	N		Córdova, M.O. 204
Hypolytrum longifolium (Rich.) Nees	AB	hb	+	-	Int/Le	N		Córdova, M.O. 1423
Lagenocarpus rigidus (Kunth) Nees	AB	hb	+	-	Le	N		Pott, V.J. 10406
Rhynchospora albiceps Kunth*	AB	hb	+	-	Le	N		(Mariotti, P.R. s/n)
Rhynchospora amazonica Poepp. & Kunth	AB	hb	+	+	Lo	N		(Berg, C.C. 18495)
Rhynchospora barbata (Vahl) Kunth	AB	hb	+	-	Le	N		Córdova, M.O. 1646
Rhynchospora candida (Nees) Boeckeler	AB	hb	-	+	Le	N		(Zappi, D.C. 1002)
Rhynchospora cephaloCEs (L.) Vahl	EM	hb	-	-	Int/Le/Lo	N		Córdova, M.O. 289
Rhynchospora comata (Link) Roem. & Schult.[+]	EM	hb	-	-	Le/Lo	N		Córdova, M.O. 814
Rhynchospora corymbosa (L.) Britton	AB	hb	+	+	Le	N		(Harley, R.M. 10236)
Rhynchospora eburnea Kral & W.W.Thomas	EM	hb	-	+	Le	N		(Zappi, D.C. 878)
Rhynchospora emaciata (Nees) Boeckeler	AB	hb	+	+	Le	N		(Souza, V.C. 17540)

Group/Family/Species	**LF**	**GH**	**APB**	**BFD**	**Habitat**	**Endemic**	**CRE**	**NC**
Rhynchospora exaltata Kunth	EM	hb	+	-	Le/Lo	N		Giacoppini, D.R. 1151
Rhynchospora gigantea Link*	AB	hb	+	+	Lo	N		(Bleich, M.E. 51)
Rhynchospora globosa (Kunth) Roem. & Schult.	AB	hb	+	-	Le/Lo	N		(Souza, V.C. 15106)
Rhynchospora hassleri C.B. Clarke*	AB	hb	-	+	Int	N		(Berg, C.C. s/n)
Rhynchospora hirta (Nees) Boeckeler	AB	hb	+	-	Int	N		(Irwin, H.S. 15932)
Rhynchospora holoschoenoides (Rich.) Herter	AB	hb	+	+	Le/Lo	N		(Windisch, P.G. 7800)
Rhynchospora leucoloma A.C.Araújo & Longhi-Wagner	AB	hb	+	-	Le	N		(Zappi, D.C. 3098)
Rhynchospora marisculus Lindl. & Nees	EM	hb	+	+	Le	N		Giacoppini, D.R. 1223
Rhynchospora nervosa (Vahl.) Boeckeler	AB	hb	+	-	Le	N		(Soares-Lopes, C.R.A. 15026)
Rhynchospora pubera (Vahl) Boeckeler	AB	hb	+	-	Le	N		(Zappi, D.C. 3088)
Rhynchospora reptans (Rich.) Kük.	AB	hb	-	+	Lo	N		(Thomas, W.W. 3934)
Rhynchospora rugosa (Vahl) Gale	AB	hb	+	+	Le/Lo	N		Córdova, M.O. 455
Rhynchospora tenuis Willd. ex Link	AB	hb	+	-	Le	N	LC	(Windisch, P.G. 1595)
Rhynchospora velutina (Kunth) Boeckeler	EM	hb	+	+	Le	N		Córdova, M.O. 734
Scleria bracteata Cav.	AB	hb	-	-	Le/Lo	N		Córdova, M.O. 1199
Scleria gaertneri Raddi	AB	hb	+	-	Le/Lo	N		Córdova, M.O. 489
Scleria interrupta Rich.*	AB	hb	-	+	Le	N		
Scleria latifolia Sw.	EM	hb	-	-	Le/Lo	N		Córdova, M.O. 270
Scleria macrophylla J. Press & C. Press	AB	hb	-	-	Int/Le/Lo	N		Córdova, M.O. 591
Scleria microcarpa Nees ex Kunth	AB	hb	+	-	Le	N		(Zappi, D.C. 1088)
Scleria secans (L.) Urb.	EM	hb	-	-	Le/Lo	N		Córdova, M.O. 630
DILLENIACEAE								
Davilla nitida (Vahl) Kubitzki	CE	cp	-	-	Le/Lo	N		Córdova, M.O. 273
Davilla rugosa Poir.	CE	cp	-	-	Le/Lo	N		Córdova, M.O. 706
DROSERACEAE								
Drosera communis A. St.-Hil.	AB	hb	+	-	Le	N		(Engels, M.E. 2838)
ERICACEAE								
Gaylussacia brasiliensis (Spreng.) Meisn.	AB	hb	+	-	Le	Y		(Engels, M.E. 5593)
ERIOCAULACEAE								
Comanthera xeranthemoides (Bong.) L.R.Parra & Giul.	AB	hb	+	-	Int/Le	N	DD	Giacoppini, D.R. 1293
Eriocaulon altogibbosum Ruhland*	AB	ssh	-	+	Int	Y		(Thomas, W.W. 4220)
Eriocaulon gibbosum Körn.*	AB	hb	-	+	Lo	Y		(Carreira, L.M.M. 756)
Eriocaulon humboldtii Kunth	AB	hb	-	+	Le/Lo	N		Giacoppini, D.R. 1221
Eriocaulon setaceum L.	EM	hb	-	+	Le/Lo	N		Cordova, M.O. 1414
Leiothrix flavescens (Bong.) Ruhland *	AB	sh	+	-	Le	Y		Giacoppini, D.R. 1150
Paepalanthus bifidus (Schrad.) Kunth*	AB	hb	-	-	Le	N		(Zappi, D.C. 1061)
Paepalanthus lamarckii Kunth	AB	hb	-	-	Le/Lo	N		Córdova, M.O. 460

Group/Family/Species	**LF**	**GH**	**APB**	**BFD**	**Habitat**	**Endemic**	**CRE**	**NC**
Syngonanthus caulescens (Poir.) Ruhland	AB	ssh	+	-	Le	Y	LC	(Engels, M.E. 5552)
Syngonanthus densiflorus (Körn.) Ruhland	AB	hb	+	-	Le	N		(Zappi, D.C. 879)
Syngonanthus gracilis (Bong.) Ruhland*	EM	sh	+	-	Le/Lo	Y	DD	Córdova, M.O. 376
Syngonanthus nitens (Bong.) Ruhland	AB	hb	+	-	Le	N		(Richards, P.W. 475)
Tonina FFuviatilis Aubl.*	RS	hb	-	-	Int/Le/Lo	N		Córdova, M.O. 790
ERYTHROXYLACEAE								
Erythroxylum anguifugum Mart.	AB	sh	-	+	Le/Lo	Y	LC	Giacoppini, D.R. 143
Erythroxylum deciduum A.St.-Hil.	AB	sh	+	-	Lo	N		(Rombouts, J.E. 226)
EUPHORBIACEAE								
Astraea lobata (L.) Klotzsch*	AB	ssh	-	-	Le/Lo	N	LC	(Sasaki, D. 2144)
Caperonia castaneifolia (L.) A.St.-Hil.	AB	hb	+	+	Le	N		(Zappi, D.C. 1198)
Caperonia palustris (L.) A.St.-Hil.	AB	hb	+	+	Le	N	LC	Córdova, M.O. 785
Croton trinitatis Millsp.	AB	hb	-	-	Le/Lo	N		(Ivanauskas, N.M. 4015)
Dalechampia scandens L.	CE	cp	-	-	Le	N		Giacoppini, D.R. 909
Dalechampia tiliifolia Lam.	CE	cp	-	-	Le	N		(Árbocz, G.F. 3982)
Euphorbia hyssopifolia L.	AB	hb	+	-	Le	N		Córdova, M.O. 1509
Sapium glandulosum (L.) Morong	AB	sh	+	-	Le/Lo	N		(Zappi, D.C. 3266)
FABACEAE								
Abrus pulchellus Wall. ex Thwaites	CE	cp	-	-	Le	N		Córdova, M.O. 788
Aeschynomene americana L.	EM	ssh	+	-	Le/Lo	N		Córdova, M.O. 959
Aeschynomene denticulata Rudd	EM	ssh	-	+	Lo	N	LC	(Soares-Lopes, C.R.A. 2224)
Aeschynomene fluminensis Vell.	EM	ssh	+	-	Le	N		(Andrade, J.B. 3353)
Ctenodon paniculatus (Willd. ex Vogel) D.B.O.S.Cardoso, P.L.R.Moraes & H.C.Lima	EM	hb	+	-	Le/Lo	N		(Harley, R.M. 10017)
Aeschynomene sensitiva Sw.	EM	ssh	+	+	Le	N	DD	Córdova, M.O. 1128
Bauhinia cupulata Benth.	AB	sh	-	-	Le/Lo	N		Córdova, M.O. 1219
Bauhinia rufa (Bong.) Steud.*	AB	sh	+	-	Le/Lo	N		Córdova, M.O. 1226
Calliandra parviflora Benth.	AB	sh	+	-	Le	N		(Krapovickas, A. 32696)
Calopogonium mucunoides Desv.	CE	cp	-	-	Lo	N		Córdova, M.O. 1318
Centrosema brasilianum (L.) Benth.	CE	cp	+	-	Int/Le	N		(Soares-Lopes, C.R.A. 85581)
Chamaecrista desvauxii (Collad.) Killip	AB	hb	+	-	Int/Le/Lo	Y		Giacoppini, D.R. 1044
Chamaecrista diphylla (L.) Greene	AB	ssh	-	-	Le	N		Giacoppini, D.R. 1211
Chamaecrista flexuosa (L.) Greene	AB	hb	+	-	Le/Lo	Y		(Souza, V.C. 18202)
Chamaecrista hispidula (Vahl) H.S.Irwin & Barneby	AB	ssh	-	-	Le	N		(Ratter, J.A. 1297)
Chamaecrista kunthiana (Schltdl. & Cham.) H.S.Irwin & Barneby*	AB	ssh	-	-	Le	N		Córdova, M.O. 642
Chamaecrista nictitans (L.) Moench	AB	ssh	+	-	Le	N		Córdova, M.O. 654
Chamaecrista ramosa (Vogel) H.S.Irwin & Barneby	AB	hb	+	-	Le	Y		(Engels, M.E. 4307)
Chamaecrista rotundifolia (Pers.) Greene	AB	ssh	-	-	Le	N		Córdova, M.O. 268

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Clitoria guianensis (Aubl.) Benth.	AB	ssh	-	-	Le/Lo	N		(Harley, R.M. 10626)
Crotalaria martiana Benth.*	AB	hb	+	-	Le	Y		(Philcox, D. 3735)
Crotalaria micans Link	AB	sh	-	-	Le	N		(Souza, V.C. 18374)
Crotalaria pallida Aiton	AB	ssh	+	-	Int/Le/Lo	N		Córdova, M.O. 1310
Crotalaria pilosa Mill.	AB	ssh	+	-	Int	N		(Harley, R.M. 10801)
Cymbosema roseum Benth.	CE	cp	-	-	Le	N		(Hunt, D.R. 5766)
Deguelia nitidula (Benth.) A.M.G.Azevedo & R.A.Camargo	CE	cp	-	-	Le/Lo	Y		Córdova, M.O. 215
Desmodium barbatum (L.) Benth.	CE	ssh	+	-	Int/Le	N		Córdova, M.O. 697
Desmodium incanum DC.	AB	ssh	+	-	Le	N		(Ikeda, F.S. s/n)
Dioclea violacea Mart. ex Benth.*	CE	cp	+	-	Le/Lo	N		Córdova, M.O. 1067
Dioclea virgata (L.C.Rich.) Amshoff	CE	cp	+	-	Int/Le/Lo	N		Giacoppini, D.R. 1197
Discolobium psoraleifolium Benth.*	EM	ssh	-	+	Le	N	DD	(Simon, M.F. 242)
Eriosema simplicifolium (DC.) G.Don	AB	ssh	-	-	Le	N		(Eiten, G. 9248)
Indigofera hirsuta L.	AB	hb	+	-	Le	N		(Soares-Lopes, C.R.A. 7581)
Indigofera suffruticosa Mill.	AB	hb	+	-	Le	N		(Bieski, I.G.C. 1023)
Macropsychanthus grandiflorus (Mart. ex Benth.) L.P.Queiroz & Snak*	CE	cp	-	-	Lo	Y		Giacoppini, D.R. 938
Macroptilium gracile (Poepp. ex Benth.) Urb.	CE	ssh	+	-	Le	Y		(Soares-Lopes, C.R.A. 625211)
Macroptilium lathyroides (L.) Urb.	CE	cp	+	-	Lo	N		(Soares-Lopes, C.R.A. 7561)
Mimosa debilis Humb. & Bonpl. ex Willd.	AB	ssh	-	-	Int/Le	Y		Córdova, M.O. 643
Mimosa pigra L.	AB	sh	+	+	Le/Lo	N		Córdova, M.O. 218
Mimosa pudica L.	AB	ssh	+	-	Le	N		Córdova, M.O. 212
Mimosa setosa Benth.*	AB	ssh	+	-	Le	N		(Engels, M.E. 3492)
Mimosa somnians Humb. & Bonpl. ex Willd.	AB	hb	-	+	Le	Y		Córdova, M.O. 1545
Mucuna urens (L.) Medik.	CE	cp	-	-	Lo	N		(Soares-Lopes, C.R.A. 3201)
Neptunia oleracea Lour.*	EM	hb	-	+	Int	N		(Cabral, F.F. 258)
Senna obtusifolia (L.) H.S.Irwin & Barneby	AB	ssh	+	-	Le/Lo	N		Córdova, M.O. 1510
Senna occidentalis (L.) Link	AB	sh	-	-	Le/Lo	N		Córdova, M.O. 543
Senna quinquangulata (Rich.) H.S.Irwin & Barneby	AB	sh	-	-	Le/Lo	N		Córdova, M.O. 1072
Senna silvestris (Vell.) H.S.Irwin & Barneby	AB	sh	-	-	Int/Le/Lo	N		Córdova, M.O. 294
Sesbania exasperata Kunth	AB	ssh	+	-	Le/Lo	N		Córdova, M.O. 921
Stylosanthes grandifolia M.B.Ferreira & Sousa Costa	AB	ssh	+	-	Le	N		(Philcox, D. 3963)
Stylosanthes guianensis (Aubl.) Sw.	AB	sh	+	-	Int/Le	Y		(Souza, V.C. 17771)
Stylosanthes viscosa (L.) Sw.	AB	ssh	+	-	Le	N		Córdova, M.O. 395
Vigna juruana (Harms) Verdc.*	CE	cp	-	-	Lo	N		(Sasaki, D. 2446)
Vigna lasiocarpa (Mart. ex Benth.) Verdc.	CE	cp	+	-	Lo	N		(Sasaki, D. 1499)
Vigna unguiculata (L.) Walp.	CE	cp	-	-	Lo	N		Córdova, M.O. 175
Zornia latifolia Sm.	AB	ssh	-	-	Le/Lo	N		(Souza, V.C. 15074)

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Zornia reticulata Sm.	AB	ssh	-	-	Le/Lo	N		Córdova, M.O. 408
GENTIANACEAE								
Chelonanthus alatus (Aubl.) Pulle	AB	ssh	+	-	Le/Lo	N		Córdova, M.O. 208
Chelonanthus purpurascens (Aubl.) Struwe, S.Nilsson & V.A.Albert	AB	ssh	+	-	Int/Le/Lo	N		Córdova, M.O. 769
Chelonanthus viridiflorus (Mart.) Gilg.	AB	hb	+	-	Le	N		Córdova, M.O. 748
Coutoubea ramosa Aubl.	AB	ssh	-	-	Int/Le/Lo	N		Córdova, M.O. 846
Coutoubea spicata Aubl.	AB	ssh	-	-	Le	N		Giacoppini, D.R. 1200
Curtia tenuifolia (Aubl.) Knobl.	AB	hb	+	-	Le/Lo	N		(Souza, V.C. 15311)
Schultesia guianensis (Aubl.) Malme	AB	hb	-	-	Le	N	LC	Córdova, M.O. 1158
GESNERIACEAE								
Drymonia coccinea (Aubl.) Wiehler	AB	ssh	-	-	Le/Lo	N		Pott, V.J. 12429
Sinningia elatior (Kunth) Chautems	AB	hb	+	-	Le	N	LC	(Zappi, D.C. 3288)
HAEMODORACEAE								
Schiekia orinocensis (Kunth) Meisn.	AB	hb	-	-	Le/Lo	N		(Souza, V.C. 15635)
HELICONIACEAE								
Heliconia acuminata L.C. Rich.	AB	hb	-	-	Le	N		Córdova, M.O. 466
Heliconia angusta Vell.*	AB	ssh	-	-	Le	Y	LC	Córdova, M.O. 698
Heliconia marginata (Griggs) Pittier	AB	hb	-	-	Le/Lo	N		(Zappi, D.C. 1328)
Heliconia psittacorum L.f.	AB	hb	+	-	Le/Lo	N		Córdova, M.O. 279
HYDROCHARITACEAE								
Apalanthe granatensis (Humb. & Bonpl.) Planch.	RS	hb	+	+	Le	N		Córdova, M.O. 448
Egeria densa Planch.*	FS	hb	+	+	Int	N		(Rataj, K.C.S. s/n)
Egeria najas Planch.*	FS	hb	+	+	Le/Lo	N		Córdova, M.O. 816
Limnobium laevigatum (Humb. & Bonpl. ex Willd.) Heine	RF	hb	+	+	Le	N		(Emmerich, M. 5526)
Ottelia brasiliensis (Planch.) Walp.*	FS	hb	+	+	Le/Lo	N	NT	(Hatschbach, G. 65642)
HYDROLEACEAE								
Hydrolea elatior Schott	EM	ssh	+	+	Le	N		(Abdo, M.S.A. 942)
Hydrolea spinosa L.	AB	sh	+	+	Le	Y		(Zappi, D.C. 1395)
HYPOXIDACEAE								
Curculigo scorzonerifolia (Lam.) Baker	AB	hb	-	-	Le	ND		(Irwin, H.S. 16012)
IRIDACEAE								
Cipura paludosa Aubl.	AB	hb	+	+	Le	N		Córdova, M.O. 649
Pseudotrimezia juncifolia (Klatt) Lovo & A.Gil *	AB	hb	+	-	Lo	Y		(Thomas, W.W. 6157)
Sisyrinchium vaginatum Spreng.*	AB	hb	+	-	Le	N		(Giulietti, A.M. 450)
LAMIACEAE								
Cantinoa americana (Aubl.) Harley & J.F.B.Pastore	AB	ssh	-	-	Le	N		Córdova, M.O. 419
Cantinoa carpinifolia (Benth.) Harley & J.F.B.Pastore	AB	ssh	+	-	Le	N		(Pires, J.M. 16597)

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Cantinoa mutabilis (Rich.) Harley & J.F.B.Pastore	AB	ssh	+	-	Le	N		Giacoppini, D.R. 840
Hyptis atrorubens Poit.	AB	ssh	-	-	Int/Le	N		Córdova, M.O. 521
Hyptis brevipes Poit.	AB	ssh	+	-	Le/Lo	N		Córdova, M.O. 210
Hyptis caespitosa A.St.-Hil. ex Benth.	AB	ssh	+	-	Lo	N		(Rombouts, J.E. s/n)
Hyptis lorentziana O.Hoffm.	AB	ssh	+	-	Le/Lo	N		Córdova, M.O. 286
Hyptis microphylla Pohl ex Benth.	AB	ssh	+	-	Le/Lo	N		Córdova, M.O. 262
Hyptis paludosa A.St.-Hil. *ex* Benth.*	AB	ssh	+	-	Le	N		(Alves, L.R. 7)
Hyptis parkeri Benth.	AB	ssh	-	-	Le	N		Córdova, M.O. 1181
Hyptis recurvata Poit.	EM	ssh	+	-	Le/Lo	N		Córdova, M.O. 844
Hyptis sinuata Pohl ex Benth.*	AB	ssh	+	-	Le	N		Pott, V.J. s.n.
Marsypianthes chamaedrys (Vahl) Kuntze	AB	ssh	-	-	Le/Lo	N		(Souza, V.C. 18389)
Mesosphaerum pectinatum (L.) Kuntze*	EM	ssh	+	-	Lo	N		Córdova, M.O. 1139
LAURACEAE								
Cassytha filiformis L.	CE	cp	-	-	Le	N		(Engels, M.E. 5423)
LENTIBULARIACEAE								
Genlisea filiformis A.St.-Hil.	AB	hb	+	-	Le	N	LC	(Souza, V.C. 15836)
Utricularia amethystina Salzm. ex A.St.-Hil. & Girard	EM	hb	+	-	Le/Lo	N		(Zappi, D.C. 3239)
Utricularia breviscapa C.Wright ex Griseb.	FS	hb	+	+	Le/Lo	N		Córdova, M.O. 974
Utricularia cucullata A.St.-Hil. & Girard	FS	hb	+	+	Int	N		(Thomas, W.W. 4248)
Utricularia foliosa L.	FS	hb	+	+	Le/Lo	N	LC	(Sasaki, D. 1498)
Utricularia hydrocarpa Vahl	FS	hb	+	+	Le/Lo	N		Cordova, M.O. 756
Utricularia gibba L.	FS	hb	+	+	Le/Lo	N		Córdova, M.O. 300
Utricularia guyanensis A.DC.	EM	hb	-	-	Int	N		(Gifford, D.R. 126)
Utricularia neottioides A.St.-Hil. & Girard	AB	hb	+	-	Le/Lo	N		(Abdo, M.S.A. 351)
Utricularia nervosa G. Weber ex Benj.	EM	hb	+	-	Le	N		(Sasaki, D. 1613)
Utricularia nigrescens Sylvén	EM	hb	+	-	Lo	N	LC	(Lisbôa, P.L.B. 287)
Utricularia olivacea C.Wright ex Griseb.	FS	hb	+	+	Le	N		(Cardoso, M.R.F. 100)
Utricularia poconensis Fromm*	FS	ssh	+	+	Lo	Y		(Abdo, M.S.A. 139)
Utricularia praelonga A.St.-Hil. & Girard*	AB	hb	+	-	Lo	N		(Soares-Lopes, C.R.A. 3146)
Utricularia pusilla Vahl	EM	hb	+	-	Le	N		(Rivadavia, F. 1191)
Utricularia simulans Pilg.	AB	hb	-	-	Le	N		(Faria, J.E.Q. 3504)
Utricularia subulata L.	AB	hb	+	-	Int/Le	N		(Sasaki, D. 1910)
Utricularia trichophylla Spruce ex Oliv.	FS	hb	-	+	Int/Le/Lo	N		(Souza, V.C. 17725)
Utricularia triloba Benj.	FS	hb	+	-	Le/Lo	N		(Souza, V.C. 15835)
LINDERNIACEAE								
Lindernia crustacea (L.) F. Muell.	AB	hb	-	+	Le/Lo	N		(Zappi, D.C. 960)
Lindernia rotundifolia (L.) Alston	AB	hb	+	+	Le	N		Córdova, M.O. 1267

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Torenia thouarsii (Cham. & Schltdl.) Kuntze	AB	hb	+	-	Lo	N		(Tsugaru, S. 1817)
LOGANIACEAE								
Spigelia anthelmia L.	AB	hb	+	-	Le	N		Córdova, M.O. 260
Spigelia scabra Cham. & Schltdl.	AB	hb	+	-	Le	N		(Zappi, D.C. 910)
Strychnos erichonii M.H. Schomb. ex Progel	CE	cp	-	+	Lo	N		(Cordeiro, M.R. 1122)
Strychnos peckii B.L. Rob.	CE	cp	-	-	Le/Lo	N		Córdova, M.O. 1036
Strychnos subcordata Spruce ex Benth.*	CE	cp	-	-	Le/Lo	N		Córdova, M.O. 1016
LYTHRACEAE								
Ammannia auriculata Willd.*	EM	hb	+	+	Lo	N		(Abdo, M.S.A. 169)
Cuphea antisyphilitica Kunth	EM	ssh	-	-	Int/Le/Lo	N		Córdova, M.O. 652
Cuphea carthagenensis (Jacq.) J.F.Macbr.	EM	ssh	+	-	Le/Lo	N		(Árbocz, G.F. 4070)
Cuphea froesii Lourteig	EM	hb	-	-	Le	Y		Córdova, M.O. 707
Cuphea melvilla Lindl.	EM	ssh	+	+	Le/Lo	N		Córdova, M.O. 777
Cuphea micrantha Kunth	EM	ssh	+	-	Le/Lo	N		(Engels, M.E. 4880)
Cuphea odonellii Lourteig	EM	ssh	-	+	Le/Lo	N		(Windisch, P.G. 7873)
Cuphea repens Koehne	EM	hb	+	+	Le/Lo	N		(Eiten, G. 8650)
Cuphea scolnikiae Lourteig	EM	ssh	-	+	Int/Le	N		(Cordeiro, M. 1237)
Cuphea sessilifolia Mart.*	EM	hb	+	+	Lo	Y		Córdova, M.O. 1860
Cuphea strigulosa Kunth*	EM	ssh	+	-	Le	N		Córdova, M.O. 1272
MALPIGHIACEAE								
Diplopterys pubipetala (A.Juss.) W.R.Anderson & C.C.Davis	CE	cp	+	-	Le/Lo	N		(Engels, M.E. 3232)
MALVACEAE								
Byttneria divaricata Benth.	AB	sh	-	-	Lo	N		Córdova, M.O. 1115
Byttneria genistella Triana & Planch.	AB	ssh	-	-	Le	N		(Soares-Lopes, C.R.A. 7340)
Byttneria ramosissima Pohl*	AB	ssh	+	-	Le	N		(Harley, R.M. 10586)
Byttneria scabra L.	AB	ssh	-	-	Le	N	LC	(Macêdo, M. 3577)
Corchorus argutus Kunth	AB	ssh	+	-	Le	N		(Sasaki, D. 1537)
Corchorus hirtus L.	AB	ssh	+	-	Int/Le	N		(Souza, V.C. 15538)
Guazuma ulmifolia Lam.	AB	sh	-	-	Le/Lo	N		Córdova, M.O. 476
Helicteres guazumifolia Kunth	AB	sh	-	-	Le/Lo	N		Córdova, M.O. 1441
Hibiscus bifurcatus Cav.	AB	sh	+	-	Le/Lo	N	LC	Córdova, M.O. 868
Hibiscus dimidiatus Schrank	AB	sh	-	-	Lo	N		(Lisbôa, P.L.B. 553)
Hibiscus diversifolius Jacq.	AB	sh	+	-	Lo	N		(Engels, M.E. 5279)
Hibiscus furcellatus Desr.	AB	sh	-	-	Le/Lo	N	LC	(Souza, V.C. 15323)
Hibiscus sororius L.	AB	sh	+	-	Le/Lo	N	LC	(Souza, V.C. 15324)
Malvastrum coromandelianum (L.) Garcke	AB	ssh	+	-	Le	N		Córdova, M.O. 843
Melochia graminifolia A.St.-Hil.	AB	ssh	-	-	Le	N		(Philcox, D. 4545)

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Melochia pyramidata L.	AB	hb	+	-	Le	N		Córdova, M.O. 1565
Melochia villosa (Mill.) Fawc. & Rendle*	AB	cp	+	-	Le/Lo	Y		(Philcox, D. 4114)
Sida acuta Burm.f.	AB	ssh	-	-	Le	N		(Sasaki, D. 1465)
Sida rhombifolia L.	AB	ssh	+	-	Le/Lo	N		Córdova, M.O. 691
Sida setosa Mart.	AB	sh	-	-	Le	N		(Cordeiro, M.R. 26)
Sidastrum micranthum (A.St.-Hil.) Fryxell*	AB	ssh	+	-	Lo	N		(Souza, V.C. 15440)
Urena lobata L.	AB	sh	+	-	Le/Lo	N		Córdova, M.O. 302
Waltheria indica L.	AB	ssh	+	-	Le	N		Giacoppini, D.R. 983
MARANTACEAE								
Goeppertia capitata (Ruiz & Pav.) Borchs. & S.Suárez	AB	hb	-	-	Lo	N		(Zappi, D.C. 1172)
Goeppertia sellowii (Körn.) Borchs. & S.Suárez*	AB	hb	+	-	Le	N		Giacoppini, D.R. 636
Monotagma laxum (Poepp. & Endl.) K.Schum.	AB	hb	-	-	Le/Lo	N		Córdova, M.O. 823
Thalia geniculata L.	EM	hb	+	+	Le/Lo	N		(Abdo, M.S.A. 125)
MAYACACEAE								
Mayaca kunthii Seub.	RS	hb	+	+	Le/Lo	N		Córdova, M.O. 1263
Mayaca longipes Mart. ex Seub.	RS	hb	+	+	Le	N		(Carreira, L.M.M. 875)
Mayaca fluviatilis Aubl.	RS	hb	+	+	Le	N		Córdova, M.O. 299
Mayaca sellowiana Kunth	RS	hb	+	+	Le/Lo	N		Córdova, M.O. 459
MELASTOMATACEAE								
Aciotis acuminifolia (Mart. ex DC.) Triana	AB	hb	-	-	Int/Le/Lo	N		Córdova, M.O. 298
Chaetogastra gracilis (Bonpl.) DC.*	AB	ssh	+	-	Le	N		(Souza, V.C. 17787)
Clidemia biserrata DC.	AB	sh	+	-	Le	N		(Giulietti, A.M. 453)
Clidemia bullosa DC.	AB	sh	-	-	Le/Lo	N		Córdova, M.O. 776
Clidemia capitellata (Bonpl.) D.Don	AB	sh	+	-	Int/Le/Lo	N		Córdova, M.O. 407
Clidemia hirta (L.) D.Don	AB	sh	+	-	Le/Lo	N		Córdova, M.O. 601
Desmoscelis villosa (Aubl.) Naudin	AB	ssh	-	-	Le	N		Córdova, M.O. 728
Macairea radula (Bonpl.) DC.	AB	sh	+	-	Le/Lo	N		Córdova, M.O. 454
Miconia chamissois Naudin*	AB	sh	+	-	Le/Lo	N		(Engels, M.E. 5801)
Miconia cinerascens Miq.*	AB	ssh	+	-	Le	Y		(Souza, V.C. 15709)
Miconia ibaguensis (Bonpl.) Triana	AB	sh	+	-	Int/Le/Lo	N		Giacoppini, D.R. 624
Miconia macrothyrsa Benth.	AB	sh	+	-	Le/Lo	N		(Souza, V.C. 17752)
Miconia prasina (Sw.) DC.	AB	sh	+	-	Le/Lo	N		(Engels, M.E. 3048)
Miconia pubipetala Miq.	AB	sh	-	-	Le/Lo	N		Córdova, M.O. 487
Miconia stenostachya DC.	AB	sh	+	-	Le/Lo	N		Córdova, M.O. 738
Noterophila crassipes (Naudin.) Kriebel & M.J.R.Rocha*	RS	hb	+	+	Lo	N		Córdova, M.O. 389
Noterophila limnobios (DC.) Mart.	EM	hb	+	-	Le/Lo	N		(Koch, A.K. 31)
Pterolepis repanda (DC.) Triana	AB	hb	+	-	Le/Lo	Y		(Soares-Lopes, C.R.A. 3368402)

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Rhynchanthera cordata DC.*	AB	sh	+	-	Lo	N		(Nave, A.G. 1674)
Rhynchanthera dichotoma (Desr.) DC.*	AB	sh	+	-	Int	N		Córdova, M.O. 1497
Rhynchanthera grandiflora (Aubl.) D.C. [*R. grandiflora* DC.]	AB	sh	+	-	Le/Lo	N	LC	(Souza, V.C. 15827)
Rhynchanthera hispida Naudin	AB	sh	+	-	Lo	N		(Souza, V.C. 18716)
Rhynchanthera novemnervia DC.	AB	sh	+	-	Le/Lo	N		Córdova, M.O. 806
Rhynchanthera serrulata (L.C.Rich.) DC. [*R. serrulata* DC.]	AB	sh	+	-	Lo	N		(Souza, V.C. 15862)
Salpinga secunda Schrank & Mart. ex DC.	AB	ssh	-	-	Lo	N		Giacoppini, D.R. 520
Tibouchina aspera Aubl.	AB	sh	-	-	Le	N		(Hatschbach, G. 65628)
MENISPERMACEAE								
Cissampelos andromorpha DC.	CE	cp	-	-	Le/Lo	N		(Soares-Lopes, C.R.A. 2266)
Cissampelos glaberrima A.St.-Hil.	CE	cp	-	-	Le/Lo	N		(Sasaki, D. 1857)
Odontocarya membranacea (A.C.Sm.) R.Ortiz	CE	hb	+	-	Lo	Y		(Lisbôa, P.L.B. 465)
MENYANTHACEAE								
Nymphoides humboldtiana (Kunth) Kuntze	RF	hb	+	+	Lo	N		(Hatschbach, G. 65594)
MOLLUGINACEAE								
Glinus radiatus (Ruiz & Pav.) Rohrb.	AB	hb	-	-	Le	N	LC	Córdova, M.O. 839
Mollugo verticillata L.	AB	hb	-	-	Le	N		Córdova, M.O. 991
MYRTACEAE								
Psidium riparium Mart. ex DC.	AB	sh	-	-	Lo	N		Córdova, M.O. 1377
NYMPHAEACEAE								
Nymphaea amazonum Mart. & Zucc.	RF	hb	+	+	Le/Lo	N		Córdova, M.O. 752
Nymphaea belophylla Trickett *	RF	hb	-	+	Lo	Y		Córdova, M.O. 686
Nymphaea gardneriana Planch.	RF	hb	+	+	Le/Lo	N		Córdova, M.O. 1511
Nymphaea oxypetala Planch.	RF	hb	+	+	Lo	N		(Abdo, M.S.A. 90)
Nymphaea pulchella DC.*	RF	hb	+	+	Lo	N		(Macêdo, M. 4338)
OCHNACEAE								
Sauvagesia elata Benth.*	AB	ssh	-	-	Lo	N		Córdova, M.O. 534
Sauvagesia erecta L.	EM	hb	+	-	Le/Lo	Y		Córdova, M.O. 378
Sauvagesia longifolia Eichler^{+}	AB	ssh	-	-	Le/Lo	N		Córdova, M.O. 807
Sauvagesia racemosa A.St.-Hil.	AB	hb	+	-	Le/Lo	N		Giacoppini, D.R. 1292
Sauvagesia sprengelii A.St.-Hil.*	AB	hb	-	-	Le	N		(Santos, R.R. 1779)
ONAGRACEAE								
Ludwigia affinis (DC.) H.Hara.	AB	sh	-	+	Int/Le/Lo	N		Giacoppini, D.R. 990
Ludwigia caparosa (Cambess.) H.Hara *	EM	sh	-	-	Lo	N		Córdova, M.O. 462
Ludwigia decurrens Walt.	EM	hb	+	-	Int/Le/Lo	N		Córdova, M.O. 439
Ludwigia densiflora (Micheli) H.Hara	AB	sh	-	-	Lo	N		(Cid Ferreira, C.A. 6245)
Ludwigia elegans (Cambess.) H.Hara *	EM	ssh	+	-	Le/Lo	N		(Koch, A.K. 42)

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Ludwigia erecta (L.) H.Hara	EM	hb	+	-	Le	N		(Souza, V.C. 15521)
Ludwigia filiformis (Micheli) Ramamoorthy*	AB	hb	+	+	Lo	Y		(Richards, P.W. 6679)
Ludwigia helminthorrhiza (Mart.) H.Hara	FF	hb	+	+	Lo	N		(Souza, V.C. 15195)
Ludwigia hyssopifolia (G. Don) Exell	AB	ssh	+	+	Le/Lo	N		Córdova, M.O. 1512
Ludwigia inclinata (L.f.) M.Gómez	RS	hb	+	+	Lo	N		(Abdo, M.S.A. 112)
Ludwigia irwinii Ramamoorthy*	AB	ssh	-	+	Lo	N		(Pereira, F.S. 17)
Ludwigia lagunae (Morong) H.Hara*	EM	ssh	+	+	Le/Lo	N		Córdova, M.O. 239
Ludwigia laruotteana (Cambess.) H.Hara*	AB	hb	+	-	Le	Y		Córdova, M.O. 745
Ludwigia leptocarpa (Nutt.) H.Hara	EM	ssh	+	+	Int/Le/Lo	N		Córdova, M.O. 410
Ludwigia myrtifolia (Cambess.) H.Hara	AB	sh	+	-	Le	Y		(Eiten, G. 9068)
Ludwigia nervosa (Poir.) H.Hara	EM	sh	+	-	Int/Le/Lo	N		Córdova, M.O. 456
Ludwigia octovalvis (Jacq.) P.H.Raven	EM	ssh	+	-	Int/Le/Lo	N		Córdova, M.O. 202
Ludwigia peruviana (L.) H.Hara	EM	sh	-	-	Int	N		(Harley, R.M. 10923)
Ludwigia rigida (Miq.) Sandwith	EM	ssh	-	-	Le/Lo	N		Córdova, M.O. 1351
Ludwigia sedioides (Humb. & Bonpl.) H.Hara	RF	hb	+	+	Le/Lo	N		(Abdo, M.S.A. 551)
Ludwigia sericea (Cambess.) H.Hara*	AB	ssh	+	-	Lo	N		(Soares-Lopes, C.R.A. 2210)
Ludwigia tomentosa (Cambess.) H.Hara.*	AB	sh	+	-	Int/Le/Lo	N		Pott, V.J. 1
Ludwigia torulosa (Arn.) H.Hara*	EM	ssh	+	-	Le/Lo	N		Córdova, M.O. 619
ORCHIDACEAE								
Eulophia alta (L.) Fawc. & Rendle	AB	hb	+	-	Le	N		Córdova, M.O. 694
Habenaria gourlieana Gill. ex Lindl.	AB	hb	+	-	Le	N		(Kuhlmann, J.G. 125)
Pteroglossa macrantha (Rchb. f.) Schltr.*	AB	hb	+	-	Le	N		(Giulietti, A.M. 438)
OROBANCHACEAE								
Agalinis glandulosa (G.M.Barroso) V.C.Souza	AB	ssh	-	+	Lo	Y		(Coêlho, D.F. 15869)
Buchnera palustris (Aubl.) Spreng.	AB	hb	-	+	Le	N		(Engels, M.E. 5260)
Buchnera rosea Kunth	AB	hb	-	-	Le	N		(Irwin, H.S. 15964)
Esterhazya splendida J.C.Mikan*	AB	ssh	+	-	Int/Le	N		(Ratter, J.A. 2143)
Melasma melampyroides (Rich.) Pennell [*M. melampyroides* (Rich.) Pennell ex Britton & P.Wilson]	AB	hb	+	-	Lo	N		Pott, V.J. 9325
OXALIDACEAE								
Oxalis barrelieri L. [*O. barrelieri* Willd. ex Zucc.]	AB	hb	-	-	Le	N		(Engels, M.E. 5373)
PASSIFFORACEAE								
Passflora acuminata DC.	CE	cp	-	-	Lo	N		Córdova, M.O. 972
Passiflora alata Curtis	CE	hb	+	-	Le/Lo	Y		(Engels, M.E. 3821)
Passiflora foetida L.	CE	cp	-	-	Le/Lo	N		(Engels, M.E. 4224)
Passiflora vespertilio L.	CE	cp	-	-	Le	N		(Sasaki, D. 1525)
PHYLLANTHACEAE								

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Phyllanthus niruri L.	EM	hb	+	-	Le/Lo	Y		Córdova, M.O. 838
Phyllanthus orbiculatus Rich.	AB	hb	-	-	Le	N		Córdova, M.O. 1161
Phyllanthus stipulatus (Raf.) G.L.Webster *	AB	sh	-	+	Lo	N		Córdova, M.O. 1160
PHYTOLACCACEAE								
Phytolacca thyrsiflora Fenzl. *ex* J.A.Schmidt	AB	ssh	+	-	Lo	N		(Souza, V.C. 18248)
PIPERACEAE								
Piper caldense C.DC.*	AB	hb	+	-	Le	Y		(Berg, C.C. 18512)
Piper fuligineum Kunth	AB	sh	+	-	Int/Le	N	LC	(Koch, A.K. 116)
PLANTAGINACEAE								
Bacopa arenaria (Schmidt) Edwall	AB	hb	-	+	Le	Y		(Monteiro, O.P. 1345)
Bacopa australis V.C.Souza*	EM	hb	-	+	Lo	Y		Córdova, M.O. 440
Bacopa caroliniana (WalCEr) B.L.Rob.*	AB	hb	-	+	Int	N		(Bleich, M.E. 28)
Bacopa gracilis (Benth.) Edwall	AB	ssh	-	+	Le/Lo	Y		Córdova, M.O. 1165
Bacopa monnierioides (Cham.) B.L.Rob.	EM	hb	+	-	Le	N		(Pereira, F.S. 25)
Bacopa myriophylloides (Benth.) Wettst.	RS	hb	-	+	Lo	N		(Andrade-Lima 3165)
Bacopa reflexa (Benth.) Edwall	RS	hb	-	+	Le	N		(Souza, V.C. 15876)
Bacopa salzmannii (Benth.)Wettst. ex Edwall	EM	hb	-	+	Le/Lo	N		Córdova, M.O. 523
Bacopa serpyllifolia (Benth.) Pennell	AB	hb	-	+	Le/Lo	N		(Sasaki, D. 1614)
Bacopa stricta (Schrad.) Wettst. *ex* Edwall	EM	hb	+	-	Le	Y		Córdova, M.O. 1157
Bacopa verticillata (Pennell & Gleason) Pennell	RS	hb	+	+	Lo	N		(Abdo, M.S.A. 120)
Conobea scoparioides (Cham. & Schltdl.) Benth.	AB	hb	+	-	Le	N		(Eiten, G. 8435)
Myriophyllum mattogrossensis Hoehne [*M. mattogrossense* Hoehne]*	RF	hb	+	+	Le	N		Córdova, M.O. 284
Scoparia dulcis L.	AB	ssh	+	-	Le/Lo	N		Córdova, M.O. 529
POACEAE								
Acroceras zizanioides (Kunth) Dandy	AB	hb	+	-	Le	N		Córdova, M.O. 772
Andropogon bicornis L.	AB	hb	+	-	Le	N		Córdova, M.O. 693
Andropogon hypogynus Hack.*	AB	hb	+	+	Le	N	LC	(Ratter, J.A. 1891)
Andropogon leucostachyus Kunth	AB	hb	+	-	Int/Le	N		(Zappi, D.C. 1004)
Andropogon selloanus (Hack.) Hack.	AB	hb	+	-	Int/Le	N		(Irwin, H.S. 6575)
Andropogon virgatus Desv. ex Ham.	AB	hb	+	-	Le	N		(Eiten, G. 8773)
Anthaenantia lanata (Kunth) Benth.	AB	hb	+	-	Int/Le/Lo	N		(Ratter, J.A. 1963)
Arundinella hispida (Humb. & Bonpl. ex Willd.) Kuntze	AB	hb	+	-	Le/Lo	N		(Irwin, H.S. 6403)
Axonopus aureus P. Beauv.	AB	hb	+	-	Le/Lo	N	LC	(Souza, V.C. 15320)
Axonopus brasiliensis (Spreng.) Kuhlm.	AB	hb	+	-	Int/Le	N		(Ratter, J.A. 1864)
Axonopus fissifolius (Raddi) Kuhlm.	AB	hb	+	-	Int	N		(Irwin, H.S. 6522)
Axonopus leptostachyus (Flüggé) Hitchc.	AB	hb	-	-	Lo	N		(Kuhlmann, M. 79)
Cenchrus echinatus L.	AB	hb	+	-	Le	N		(Eiten, G. 157)

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Coix lacryma-jobi L.	AB	hb	+	+	Le	N		Pott, V.J. 2373
Cyphonanthus discrepans (Döll) Zuloaga & Morrone	AB	ssh	+	-	Le/Lo	Y		(Hatschbach, G. 65497)
Digitaria ciliaris (Retz.) Koeler	AB	hb	-	-	Le/Lo	N		Córdova, M.O. 527
Echinochloa colona (L.) Link	AB	hb	+	+	Le/Lo	N		(Junior, N.P.S. s/n)
Echinochloa crus-galli (L.) P.Beauv.	EM	hb	+	-	Le/Lo	N		Córdova, M.O. 1236
Eleusine indica (L.) Gaertn.	AB	hb	-	-	Le	N		(Bieski, I.G.C. 979)
Eragrostis ciliaris (L.) R.Br.	AB	hb	-	-	Le	N		Córdova, M.O. 525
Eragrostis pilosa (L.) P.Beauv.	AB	hb	-	-	Le	N		(Philcox, D. 3917)
Eragrostis rufescens Schrad. *ex* Schult. [*E. rufescens* Schult]	AB	ssh	+	-	Le	Y		(Harley, R.M. 10911)
Hymenachne amplexicaulis (Rudge) Nees	EM	hb	+	+	Le/Lo	N		Córdova, M.O. 755
Hymenachne donacifolia (Raddi) Chase	EM	hb	+	+	Lo	N		(Zappi, D.C. 1466)
Hymenachne grandis (Hitchc. & Chase) Zuloaga	AB	hb	-	+	Le	N		(Kuhlmann, J.G. 2417)
Hymenachne pernambucensis (Spreng.) Zuloaga	EM	hb	+	+	Le	N	LC	Córdova, M.O. 840
Hyparrhenia rufa (Nees) Stapf	EM	hb	+	-	Le	N		(Harley, R.M. 10910)
Imperata brasiliensis Trin.	AB	hb	+	-	Le	N		Giacoppini, D.R. 1175
Isachne polygonoides (Lam.) Döll	EM	hb	-	+	Int/Le	N		(Zappi, D.C. 3243)
Leersia hexandra Sw.	EM	hb	+	+	Le/Lo	N		Córdova, M.O. 608
Leptochloa virgata (L.) P.Beauv.*	AB	hb	-	-	Le	N		(Ikeda, F.S. s/n)
Loudetia flammida (Trin.) C.E.Hubb.	EM	hb	+	-	Le	N	LC	(Simon, M.F. 2332)
Luziola bahiensis (Steud.) Hitchc.	EM	hb	+	+	Le	N		Córdova, M.O. 252
Luziola spruceana Benth. *ex* Döll	EM	hb	-	+	Le/Lo	N		Pott, V.J. s/n
Megathyrsus maximus (Jacq.) B.K.Simon & S.W.L.Jacobs	AB	hb	+	-	Lo	N		(Kinupp, V.F. 2274)
Melinis repens (Willd.) Zizka*	AB	hb	+	-	Le	N		(Koch, A.K. 6)
Mesosetum loliiforme (Hochst.) Chase [*M. loliiforme* (Hochst. ex Steud.) Hitchc]	EM	hb	-	-	Le/Lo	N		(Souza, V.C. 14803)
Mnesithea balansae (Hack.) de Koning & Sosef	AB	hb	+	-	Int/Le	N		(Zappi, D.C. 3249)
Oedochloa procurrens (Nees *ex* Trin.) C.Silva & R.P.Oliveira	AB	hb	+	-	Le/Lo	N		(Souza, V.C. 17760)
Olyra ecaudata Döll	AB	hb	-	-	Le/Lo	N		(Souza, V.C. 15741)
Olyra longifolia Kunth	AB	hb	-	-	Lo	N		(Sasaki, D. 1277)
Oryza rufipogon Griff.	EM	hb	-	+	Le	N		(Valls, J.F.M. 13754)
Oryza grandiglumis (Döll) Prod.	EM	hb	-	+	Lo	N		(Abdo, M.S.A. 144)
Panicum dichotomiflorum Michx.	AB	hb	+	+	Le/Lo	N		(Abdo, M.S.A. 95)
Panicum millegrana Poir.	AB	hb	+	-	Lo	N		Giacoppini, D.R. 1142
Panicum repens L.	AB	hb	+	+	Lo	N		Córdova, M.O. 519
Paratheria prostrata Griseb.	AB	hb	-	-	Le	N		(Harley, R.M. 11214)
Pariana campestris Aubl.	EM	hb	-	-	Le/Lo	N		Córdova, M.O. 815
Pariana radiciflora Sagot *ex* Döll*	AB	hb	-	-	Int/Le/Lo	N		Córdova, M.O. 634
Paspalidium geminatum (Forssk.) Stapf	AB	hb	+	+	Lo	N		(Abdo, M.S.A. 145)

Group/Family/Species	**LF**	**GH**	**APB**	**BFD**	**Habitat**	**Endemic**	**CRE**	**NC**
Paspalum boscianum Flüggé	EM	hb	-	+	Lo	N		(Eiten, G. 9277)
Paspalum conjugatum P.J. Bergius	AB	hb	+	-	Le/Lo	N		(Souza, V.C. 15319)
Paspalum conspersum Schrad.	EM	hb	+	-	Le/Lo	N		Córdova, M.O. 696
Paspalum morichalense Davidse, Zuloaga & Filg.	AB	hb	-	+	Le	N		(Harley, R.M. 11213)
Paspalum orbiculatum Poir.	AB	hb	-	+	Lo	N		(Shunsuke T. 1800)
Paspalum repens P.J. Bergius	AB	hb	+	+	Le/Lo	N		(Abdo, M.S.A. 111)
Paspalum virgatum L.	AB	hb	+	-	Le/Lo	N		Pott, A. 12418
Paspalum wrightii Hitchc. & Chase	AB	hb	-	+	Lo	N		(Eiten, G. 9277)
Raddiella esenbeckii (Steud.) C.E.Calderon & Soderstr.	AB	hb	-	-	Le/Lo	N	LC	(Souza, V.C. 15861)
Rugoloa hylaeica (Mez) Zuloaga	EM	hb	-	-	Le/Lo	N	LC	Córdova, M.O. 533
Rugoloa pilosa (Sw.) Zuloaga	AB	hb	+	-	Int/Le/Lo	N		Córdova, M.O. 572
Sacciolepis angustissima (Hochst. *ex* Steud.) Kuhlm.	EM	hb	-	+	Int	N		(Philcox, D. 3321)
Sacciolepis myuros (Lam.) Chase	EM	hb	-	+	Lo	N		(Pires, J.M. 16340)
Setaria parviflora (Poir.) Kerguélen	AB	hb	+	-	Le/Lo	N		Córdova, M.O. 1295
Steinchisma laxum (Sw.) Zuloaga	EM	hb	+	+	Int/Le	N		(Bleich, M.E. 50)
Stephostachys mertensii (Roth) Zuloaga & Marrone	AB	ssh	+	-	Le	ND		(Soares-Lopes, C.R.A. 597677)
Trichanthecium cyanescens (Nees ex Trin.) Zuloaga & Morrone	EM	hb	-	+	Le/Lo	N		Córdova, M.O. 682
Trichanthecium nervosum (Lam.) Zuloaga & Morrone	EM	hb	-	+	Int	N		(Philcox, D. 4108)
Urochloa mutica (Forssk.) T.Q.Nguyen*	EM	hb	-	-	Le/Lo	N		Córdova, M.O. 291
PODOSTEMACEAE								
Apinagia membranacea (Bong.) Tul.*	EM	hb	-	+	Lo	Y		(Rosa, N.A. 2030)
Apinagia richardiana (Wedd.) P.Royen	EM	hb	-	+	Le	N		(Bove, C.P. 1896)
Apinagia riedelii (Bong.) Tul.	EM	hb	+	+	Le/Lo	N	LC	(Bove, C.P. 1706)
Castelnavia fluitans Tul. & Wedd.	EM	hb	-	+	Le/Lo	Y		(Bove, C.P. 1900)
Castelnavia multipartita Tul. & Wedd.	EM	hb	-	+	Le/Lo	Y	LC	(Bove, C.P. 1919)
Castelnavia pendulosa (C.T.Philbrick & C.P.Bove) C.T.Philbrick & C.P.Bove	EM	hb	-	+	Le/Lo	Y		(Engels, M.E. 5662)
Castelnavia princeps Tul. & Wedd.	EM	hb	-	+	Le/Lo	Y		(Bove, C.P. 1917)
Lophogyne aripuanensis (A.S. Tav.) C.T.Philbrick & C.P.Bove	EM	hb	-	+	Le	Y		(Berg, C.C. 18570)
Lophogyne royenella C.P.Bove & C.T.Philbrick	AB	cp	-	+	Le/Lo	Y		(Bove, C.P. 1852)
Mourera alcicornis (Tul.) P.Royen*	EM	hb	-	+	Lo	N		(Bove, C.P. 1873)
Mourera aspera (Bong.) Tul.*	EM	hb	+	+	Lo	N		(Thomas, W.W. 3935)
Mourera elegans (Tul.) Baillon	EM	hb	-	+	Lo	Y		Córdova, M.O. 1164
Mourera monadelpha (Bong.) C.T.Philbrick & C.P.Bove	RS	hb	+	+	Le	Y		(Bove, C.P. 1887)
Mourera weddelliana Tul.	EM	hb	-	+	Le/Lo	Y	VU	(Larcher, L. s/n)
Tristicha trifaria (Bory ex Willd.) Spreng.	EM	hb	+	+	Int/Le/Lo	N		(Bove, C.P. 1910)
Weddellina squamulosa Tul.	EM	hb	-	+	Le/Lo	Y		(Bove, C.P. 1902)
POLYGALACEAE								

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Polygala adenophora DC.	AB	hb	-	-	Le	N		(Souza, V.C. 15819)
Polygala gracilis Kunth* [*P. appendiculata* Vell.]	AB	ssh	+	-	Int/Le	N		(Gifford, D.R. 133)
Polygala hygrophila Kunth*	AB	hb	+	-	Le	Y		(Windisch, P.G. 7835)
Polygala longicaulis Kunth	AB	hb	+	-	Le	Y		(Bernacci, L.C. 2338)
Polygala paniculata L.	AB	ssh	+	-	Le	N		(Ratter, J.A. 955)
Polygala poaya Mart. *	AB	ssh	-	-	Le/Lo	N		(Fonsêca, S.G. 1398)
Polygala subtilis Kunth	AB	hn	-	+	Int/Le	N		(Zappi, D.C. 3017)
Polygala tenuis DC.*	AB	hb	+	-	Le	Y		(Philcox, D. 3633)
POLYGONACEAE								
Polygonum acuminatum Kunth [*Persicaria acuminata* (Kunth) M.Gómez]	EM	hb	+	+	Le/Lo	N		Córdova, M.O. 217
Polygonum ferrugineum Wedd. [*Persicaria ferruginea* (Wedd.) Soják]	EM	hb	+	+	Lo	N		(Zappi, D.C. 3170)
Polygonum hydropiperoides Michx. [*Persicaria hydropiperoides* (Michx.) Small]*	EM	hb	+	+	Lo	N		Córdova, M.O. 954
Polygonum meisnerianum Cham. [*Persicaria meisneriana* (Cham. & Schltdl.) M.Gómez]*	EM	hb	+	+	Le	N		Córdova, M.O. 414
Polygonum punctatum Elliott [*Persicaria punctata* (Elliott) Small]	EM	hb	+	+	Le/Lo	N		(Sasaki, D. 2444)
PONCEDERIACEAE								
Eichhornia azurea (Sw.) Kunth	RF	hb	+	+	Le/Lo	N		Córdova, M.O. 248
Eichhornia crassipes (Mart.) Solms	FF	hb	+	+	Le/Lo	N		Córdova, M.O. 258
Eichhornia diversifolia (Vahl) Urb.	RF	hb	-	+	Int/Le/Lo	N		Córdova, M.O. 457
Heteranthera reniformis Ruiz & Pav.	EM	hb	+	+	Le/Lo	N		Pott, V.J. 2667
Heteranthera zosterifolia Mart.	EM	hb	+	+	Int/Lo	N	LC	(Hatschbach, G. 65607)
Pontederia cordata L.	RF	hb	+	+	Le/Lo	N		(Macêdo, M. 4385)
Pontederia parviflora Alexander*	RF	hb	+	+	Le/Lo	N		Córdova, M.O. 916
Pontederia subovata (Seub.) Lowden	RF	hb	+	+	Lo	N		(Abdo, M.S.A. 106)
POTAMOGETONACEAE								
Potamogeton illinoensis Morong	EM	hb	+	+	Lo	N		(Abdo, M.S.A. 142)
RAPATEACEAE								
Rapatea paludosa Aubl.	AB	hb	-	-	Int/Lo	N		Córdova, M.O. 586
RUBIACEAE								
Borreria alata (Aubl.) DC. [*Spermacoce alata* Aubl.]	AB	hb	+	-	Le/Lo	N		(Souza, V.C. 15294)
Borreria capitata (Ruiz & Pav.) DC. [*Spermacoce capitata* Ruiz & Pav.]	AB	hb	+	-	Le/Lo	Y		(Andrade, J.B. 3328)
Borreria cupularis DC. [*Spermacoce cupularis* (DC.) Kuntze]	AB	hb	+	-	Le	Y		(Zappi, D.C. 3116)
Borreria flexuosa E.L.Cabral [*Spermacoce scabiosoides* (Cham. & Schltdl.) Kuntze]	AB	hb	-	+	Le	N		(Kirkbride Jr., J.H. 2986)
Borreria hyssopifolia (Willd. ex Roem. & Schult.) Bacigalupo & E.L.Cabral [*Spermacoce hyssopifolia* Willd.]	AB	hb	-	+	Lo	N		(Sobral, M. 11050)
Borreria latifolia (Aubl.) K.Schum. [*Spermacoce latifolia* Aubl.]	AB	hb	-	-	Le/Lo	N		Córdova, M.O. 573
Borreria multiflora (DC.) Bacigalupo & E.L.Cabral [*Spermacoce multiflora* (DC.) Delprete]	AB	hb	+	+	Int/Le	N		(Abdo, M.S.A. 215)
Borreria ocymifolia (Roem. & Schult.) Bacigalupo & E.L.Cabral [*Spermacoce ocymifolia* Willd.]	AB	hb	+	-	Le	N		(Sasaki, D. 1426)
Spermacoce ocymoides Burm.f.	AB	hb	+	-	Le	N		(Soares-Lopes, C.R.A. 2206)

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Borreria pulchristipula (Bremek.) Bacigalupo & E.L.Cabral [*Spermacoce pulchristipula* (Bremek.) Delprete]	AB	hb	-	+	Le	N	DD	(Kirkbride Jr., J.H. 3000)
Borreria remota (Lam.) Bacigalupo & E.L.Cabral [*Spermacoce remota* Lam.]	AB	hb	-	+	Le	N	LC	(Dário, F.R. 1128)
Borreria schumannii (Standl. ex Bacigalupo) E.L. Cabral & Sobrado [*Spermacoce schumannii* (Standl. ex Bacigalupo) Delprete]	AB	hb	-	+	Le	N		(Zappi, D.C. 3069)
Borreria verticillata (L.) G.Mey. [*Spermacoce verticillata* L.]	AB	hb	+	-	Le	N		(Berg, C.C. 19823)
Coccocypselum guianense (Aubl.) K.Schum.	AB	hb	+	-	Le	N		(Zanatta, M.R.V. 271)
Declieuxia cordigera Mart. & Zucc. ex Schult. & Schult.f.*	AB	sh	+	-	Le	Y		Córdova, M.O. 1361
Diodia kuntzei K.Schum.	AB	hb	-	+	Lo	N		(Barbosa, L.F. 717)
Diodia macrophylla K.Schum.*	AB	cp	-	+	Le	Y		(Mariotti, P.R. s/n)
Galianthe palustris (Cham. & Schltdl.) Cabaña Fader & E.L.Cabral	AB	hb	-	+	Le	N		Córdova, M.O. 1127
Limnosipanea erythraeoides (Cham.) K.Schum.*	AB	hb	-	-	Le	ND		Córdova, M.O. 1599
Palicourea amplectens (Benth.) Delprete & J.H.Kirkbr.	AB	sh	-	-	Le/Lo	N		Córdova, M.O. 194
Palicourea corymbifera (Müll. Arg.) Standl.	AB	sh	-	-	Le	N		Córdova, M.O. 1513
Palicourea crocea (Sw.) Roem. & Schult.	AB	sh	-	+	Le/Lo	N		(Ivanauskas, N.M. 19180
Palicourea grandifolia (Willd. ex Roem. & Schult.) Standl.	AB	sh	-	+	Le/Lo	N		(Sasaki, D. 1421)
Palicourea marcgravii A.St.-Hil.	AB	sh	+	-	Int/Le/Lo	N		Córdova, M.O. 671
Palicourea nitidella (Müll. Arg.) Standl.	AB	sh	-	+	Le/Lo	N		(Sasaki, D. 1828)
Perama hirsuta Aubl.	AB	hb	+	-	Int/Le/Lo	N		(Engels, M.E. 5535)
Psychotria anceps Kunth	AB	sh	+	-	Lo	N		Córdova, M.O. 797
Psychotria bahiensis DC.	AB	sh	-	-	Lo	N		Córdova, M.O. 536
Palicourea violacea (Aubl.) A.Rich.*	AB	hb	-	-	Int/Le/Lo	Y		Córdova, M.O. 1185
Psyllocarpus asparagoides Mart. ex Mart. & Zucc.*	AB	hb	-	-	Le	Y		Córdova, M.O. 655
Retiniphyllum kuhlmannii Standl.	AB	hb	-	+	Le/Lo	Y		(Sasaki, D. 2426)
Richardia brasiliensis Gomes	AB	hb	+	-	Le	N		(Nascimento, F. 12)
Richardia grandiflora (Cham. & Schltdl.) Steud.*	AB	hb	+	-	Le	N		(Ratter, J.A. 1053)
Rudgea cornifolia (Kunth) Standl.	AB	sh	-	+	Le/Lo	N		Córdova, M.O. 318
Rudgea viburnoides (Cham.) Benth.	AB	sh	+	-	Int/Le/Lo	N		Córdova, M.O. 308
Sabicea aspera Aubl.	CE	cp	-	-	Le/Lo	N		Córdova, M.O. 518
Sipanea biflora (L.f.) Cham. & Schltdl.	AB	hb	-	-	Lo	N		Córdova, M.O. 374
Sipanea pratensis Aubl.	AB	hb	+	-	Le/Lo	Y		(Abdo, M.S.A. 209)
Sipanea veris S. Moore	AB	hb	-	+	Int/Le/Lo	N		Córdova, M.O. 632
Staelia virgata (Link ex Roem. & Schult.) K.Schum. [*Staelia virgata* (Willd.) K.Schum.][*Spermacoce virgata* Willd.]	AB	ssh	-	+	Lo	N		Córdova, M.O. 1658
Uncaria guianensis (Aubl.) J.F.Gmel.	CE	cp	-	-	Int/Le/Lo	N		Córdova, M.O. 1076
SANTALACEAE								
Phoradendron platycaulon Eichler	CE	hb	-	-	Lo	N		(Nave, A.G. 2127)
SAPINDACEAE								

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Paullinia stipularis Benth.	CE	cp	-	-	Le/Lo	N		(Zappi, D.C. 3240)
SMILACACEAE								
Smilax polyantha Griseb.*	CE	cp	-	-	Le/Lo	N		Córdova, M.O. 1033
SOLANACEAE								
Physalis angulata L.	AB	hb	-	-	Le/Lo	N		(Souza, V.C. 18220)
Solanum americanum Mill.	AB	hb	+	-	Le/Lo	N		Córdova, M.O. 1379
Solanum anceps Ruiz & Pav.	AB	sh	-	-	Le	N		(Soares-Lopes, C.R.A. 427590)
Solanum subinerme Jacq.	EM	ssh	-	-	Le/Lo	N		Córdova, M.O. 989
SPHENOCLEACEAE								
Sphenoclea zeylanica Gaertn.	EM	ssh	+	+	Lo	N		Córdova, M.O. 349
TURNERACEAE								
Piriqueta cistoides (L.) Griseb.	AB	ssh	+	-	Le/Lo	N		Córdova, M.O. 1282
Turnera melochioides Cambess.	AB	ver	-	-	Le	Y		Córdova, M.O. 661
TYPHACEAE								
Typha domingensis Pers.	EM	ver	+	+	Le	N		Córdova, M.O. 1285
URTICACEAE								
Urera aurantiaca Wedd.	AB	sh	-	-	Int/Le/Lo	N		Córdova, M.O. 760
VERBENACEAE								
Lantana camara L.	AB	sh	+	-	Le	N		Giacoppini, M.O. 899
Lantana canescens Kunth	AB	sh	+	-	Le	N		Córdova, M.O. 719
Lippia alba (Mill.) N.E.Br. ex Britton & P.Wilson	AB	ssh	-	-	Int/Le	N		Córdova, M.O. 251
Phyla betulifolia (Kunth) Greene	AB	hb	-	-	Le/Lo	N		Córdova, M.O. 1272
Stachytarpheta angustifolia (Mill.) Vahl	AB	sh	-	-	Lo	N		(Berg, C.C. 18568)
Stachytarpheta cayennensis (Rich.) Vahl	AB	ssh	+	-	Le/Lo	N		Córdova, M.O. 644
Verbena litoralis Kunth*	AB	hb	+	-	Le	N		(Bieski, I.G.C. 810)
VITACEAE								
Cissus erosa Rich.	CE	sh	+	-	Int/Le/Lo	Y		Córdova, M.O. 196
Cissus gongylodes (Baker) Planch.	CE	cp	-	-	Le/Lo	N		(Dário, F.R. 1280)
Cissus spinosa Cambess.	CE	cp	+	-	Le/Lo	N		Córdova, M.O. 216
Cissus verticillata (L.) Nicolson & C.E.Jarvis	CE	cp	+	-	Le/Lo	N		(Engels, M.E. 5064)
XYRIDACEAE								
Abolboda pulchella Humb. [*A. pulchella* Bonpl.]	AB	hb	+	+	Int/Le	Y		(Zappi, D.C. 886)
Xyris aquatica Idrobo & L.B.Sm.	EM	hb	-	+	Le/Lo	N		(Engels, M.E. 4651)
Xyris hymenachne Mart.	AB	hb	+	-	Le	N		(Souza, V.C. 17790)
Xyris jupicai Rich.	EM	hb	+	+	Int/Le/Lo	N		Córdova, M.O. 277
Xyris lacerata Pohl ex Seub.	AB	hb	-	+	Le/Lo	Y		(Amaral, I.L. 845)
Xyris macrocephala Vahl	EM	hb	+	+	Int/Le/Lo	N		Córdova, M.O. 1363

Group/Family/Species	LF	GH	APB	BFD	Habitat	Endemic	CRE	NC
Xyris malmeana L.B. Sm.	AB	hb	-	+	Lo	N		(Souza, V.C. 15659)
Xyris paraensis Poepp. ex Kunth	AB	hb	-	+	Lo	Y		(Nelson A. 1992)
Xyris savanensis Miq.	EM	hb	+	+	Int/Le/Lo	N		Córdova, M.O. 386
ZINGIBERACEAE								
Hedychium coronarium J.Koening	AB	hb	+	-	Le	N		(Bieski, I.G.C. 1053)

CAPÍTULO II

Environmental and temporal variability of the aquatic macrophyte community in riverine environments in the southern Amazonia

Milton Omar Córdova • Josiane Fernandes Keffer • Dienefe Rafaela Giacoppini • Cássia Beatriz Rodrigues Munhoz

Abstract Temporal variation in limnological characteristics favors an increase in aquatic macrophyte diversity in Neotropical riverine environments. We assessed temporal and environmental variability in the aquatic macrophyte community in riverine environments of the Tapajos river basin, southern Amazonia, Brazil. Hydroperiod, type of riverine environment, limnological variables, and surrounding woody vegetation were found to influence aquatic macrophyte richness, cover, and dry and fresh biomass. A total of 98 species from 68 genera and 40 families were recorded. The greatest observed richness in streams was during the dry period. Richness, cover, and biomass were greater in lagoons and rivers during rising water and flood hydroperiods. Amphibious and emergent species had higher biomass in flood and receding water hydroperiods. Higher richness, cover, and fresh biomass were mostly related to electrical conductivity. Suspended and dissolved solids reduced species richness in all environments. Greater tree abundance in the surrounding vegetation was associated with higher macrophyte richness in streams and with macrophyte cover and biomass in rivers. The aquatic macrophyte community in southern Amazonia is subject to variation in riverine ecosystem type, tree composition and structure in surrounding vegetation, hydroperiod (temporal variation), and limnological parameters (environmental/temporal variation).

Keywords Amazonian wetlands, Aquatic plants, Hydroperiod, Cerrado-Amazon transition, Riparian forest, Biomass

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Introduction

The role of macrophytes in diverse aquatic ecosystems has received particular attention because they increase the spatial heterogeneity of the environment, providing a diversity of habitats for fauna and flora (Murphy et al., 2019). The habitats promoted by macrophytes in continental ecosystems (freshwater) are under pressure, which determines species occurrence patterns (Tundisi & Tundisi, 2008; Gibbs et al. 2010; Fearnside, 2019). Besides, aquatic macrophytes establish a strong connection between the aquatic system and the surrounding terrestrial environment (Baart et al., 2010; Thomaz & Cunha, 2010). The composition, structure, and primary production of aquatic macrophytes can be determined by various factors, such as the physicochemical properties of water and sediment, the connectivity between aquatic environments, habitat diversity, hydroperiod, and interactions among these factors (Rolon et al., 2010; Moura-Júnior et al., 2017; Schenider, 2019; Hachoł et al., 2019). The type of environment and habitat, together with hydroperiod, play a significant role in shaping the differences and similarities in aquatic macrophyte community composition and structure (Murphy et al., 2003; Lacoul & Freedman, 2006; Holtmann et al., 2019).

Aquatic macrophytes are characterized by high primary production (biomass production), especially in shallow regions with slow water flow (Trindade et al., 2018). Primary production is a fundamental process in the functioning of aquatic ecosystems, and it can vary according to the species and life forms present (Esteves, 1998). Considering the strategies adopted by species and their distinct life forms, temporal and spatial variation in each abiotic factor, together with biotic factors, influence macrophytes differently (Bottino et al., 2013). Their responses to this variation determine the basis for the diversity and distribution of these plant communities, especially concerning bioclimatic and geomorphological variables (Grimaldo et al., 2016).

Spatial and temporal variation in water level favors diversity in Neotropical riverine environments by promoting greater habitat heterogeneity (Murphy et al., 2003; Fortney et al., 2004; Marchettia & Scarabotti, 2016). Aquatic macrophyte composition, in particular, can be influenced by these environmental factors, and mainly on wetland size (Maltchik et al., 2007). Coupled with spatial and temporal factors, hydrological (flood flows, disturbances, and connectivity), physical limnological (depth and transparency) and chemical limnological (conductivity, alkalinity, phosphorus, and nitrogen) characteristics are determinants of richness and cover in riverine environments (Reid & Quinn, 2004; Sousa et al., 2011). Riparian forests surrounding macrophyte communities contribute substantially to ecological processes, and fulfill a variety of functions in these environments, mainly regarding the balance of populations that depend on them. Therefore, changes in riparian forests (tree communities) can lead to changes in the entire aquatic ecosystem (Wittmam, 2011). In this sense, aquatic macrophytes tend to increase in species and cover with decreasing tree abundance, in ecotones on a regional scale (Lindholm et al., 2021). Environmental variables comprise the daily course of light exposure, while plant variables include tree canopy area, tree height, and tree geographic position in relation to light exposure, which limits the development of some species, particularly underwater (Ali et al., 2011). These limitations are most evident in small rivers and streams (Khedr & El-Demerdash, 1997). Unlike for terrestrial plants, climate and evolutionary history are not determinants of large-scale patterns of freshwater aquatic macrophyte communities. Instead, local explanatory variables, such as water quality and hydromorphology, are often more important for explaining the composition and structure of these communities (Alahuhta et al., 2017).

The Amazon, the largest river basin of the world (by drainage area), contains the highest known plant species richness on the planet (Hubbell et al. 2009). Southern Amazonia cover an area of c. 152,180 km² of native vegetation influenced by the two largest phytogeographic domains of the South American continent - the Amazon and the Cerrado (Brazilian Savanna) (Maracahipes et al., 2015; Marques et al., 2020). This region is under high anthropogenic pressure and presents large rates of deforestation and is known as the "Amazon deforestation arc" (Fearnside 2019). In addition to cattle and crop farming, the Brazilian government has implemented large hydroelectric power plants in the region, which further compromises its aquatic environments. Southern Amazonia presents a vast variety of environments and habitats with high diversity of aquatic macrophytes, especially the riverine environments of two large Amazonian sub-basins - the Tapajós and Xingu (Córdova et al., 2022). Nevertheless, the relationship of macrophyte composition variability in space and time, of this region is still lacking. In this context, our objective was to evaluate environmental and temporal variation of the macrophyte community in response to the type of riverine environment (lagoon, river, and stream), surrounding vegetation (tree composition and structure), hydroperiod (temporal characteristic), and limnological parameters. We expected that the aquatic macrophyte community would exhibit differences in composition, richness, cover and biomass among the different types of environments (Pereira et al. 2012, 2021), and that hydroperiod would increase (dry) or decrease (flood) these differences, considering that seasonal periods in southern Amazonia are well differentiated with a longer dry period than in the rest of the biome (Lacoul & Freedman 2006, Holtmann et al., 2019; Kaijser et al., 2022). We also expected these differences to be present in the structure of the community, whereby limnological parameters, mainly physical and chemical, influence the richness, cover, and biomass of aquatic macrophytes (Marchetti & Scarabotti, 2016; Kaijser et al., 2022). Furthermore, we expected that the structure of the surrounding vegetation, mainly tree density (abundance) and height, characteristics that determine the shading and spacing of riparian forests (Khedr and El-Demerdash, 1997), would influence aquatic macrophytes community structure, given that areas of lower light exposure and less spacing do not allow the development of some macrophyte species (Ali et al., 2011).

Materials and Methods

Study area

The study was carried out in southern Amazonia in the north-central region of the state of Mato Grosso, Brazil, which includes the Cerrado-Amazon transition. This is an area of approximately 500,000 km², with different types of formations, crossed by large rivers and protected within preservation areas. In the study area, the Teles Pires (also known as São Manuel) and Juruena rivers form the great Tapajós river, which harbors high floristic biodiversity along its tributaries and main beds. The Teles Pires river basin is located between parallels 7°18' and 14°42'S, and meridians 53°58' and 57°47'W, and occupies an area of approximately 145,600 km², including parts the states of Mato Grosso and Pará, of which 113,706.23 km² are in the former (Wenzel et al., 2017). The climate in the region is tropical rainy, Aw 4 type according to the Köppen classification, with a dry winter and average annual temperatures around 24°C. We sampled aquatic macrophytes along an approximately 120 km stretch in the Teles Pires river basin, located in the middle course of the river, crossing the municipalities of Sinop, Sorriso, Ipiranga do Norte, and Itaúba, in the state of Mato Grosso. This is the so-called area under direct influence of the Sinop Hydroelectric Plant (UHE Sinop) (Fig. 1).

Environments and sampling periods

Spatial and temporal sampling were carried out at 16 points along the Teles Pires river and its tributaries. Five of these points were in riverine environments classified as permanent lagoons (attached to the Teles Pires river), five in environments classified as rivers (four on the Teles Pires river and one on the Verde river), and six in environments classified as streams (perennial-effluent tributaries of the Teles Pires river). Sampling was carried out every three months over three years (2016 – 2018), covering the hydroperiods of flood (March), receding water (June), dry (September), and rising water (December) (Umetsu et al., 2007; Wenzel et al., 2017). The width of the streams ranged 8 – 10 m, of rivers 80 – 220 m, and of lagoons 18 – 23 m with an area that ranged 100 – 230 m^2. The lagoons were chosen because they were the only permanent lagoons in the study area. The minimum and maximum straight-line distance between any of the sampling points were 0.85 and 55.8 km, respectively. The minimum and maximum distance between lagoon sampling points was 1.7 and 17.5 km; between river sampling points 3.5 and 48.5 km; and between stream sampling points 12 and 28.5 km (Fig. 1).

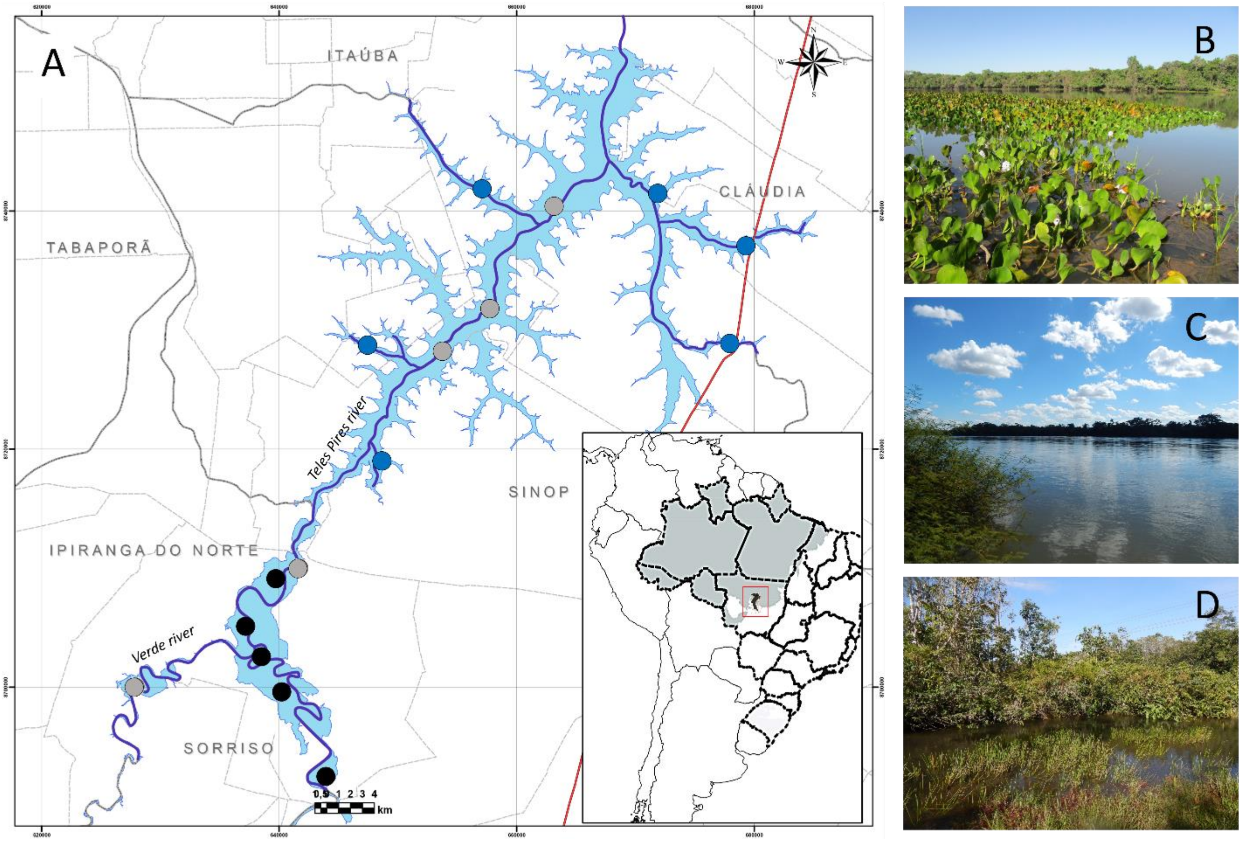

Fig. 1 A Study area. Teles Pires River and its tributaries in southern Amazonia (Mato Grosso state, Brazil). B Blue dots refer to streams, gray to C rivers, and black to D lagoons. The gray zone on the Brazil map (bottom left) represents the Amazonia phytogeographic domain (Biome sensu IBGE 2014). Area under direct influence of the Sinop HPP (light blue) (Source: Adapted from Sinop Energia, 2013)

Floristic and structural sampling

We sampled plants that occurred within 0.5 x 0.5 m squares (sampling unit – SU), delimited by PVC pipes fastened at the ends. Five SUs were sampled in each point (16), in each hydroperiod (4), in the three years of the study (totaling

960 SUs). The five SUs were distributed along the macrophyte community from the water body to the margins. Cover in percentage (% m^{-2}) (modified from Braun-Blanquette, 1979; Sârbu et al., 2021) was estimated for each SU, with a value of zero indicating the absence of aquatic macrophytes. Species were identified based on specialized literature and by consulting virtual herbaria and specialists, and followed the classification of families proposed by the Angiosperm Phylogeny Group (APG IV, 2016) for angiosperms, by the Pteridophyte Phylogeny Group (PPG I, 2016) for ferns and lycophytes, and Buck & Goffinet (2000) for bryophytes. The nomenclature of families and species was checked on the Flora do Brasil website (Flora e Funga do Brasil 2020). Species names were checked and updated using the *flora* package (Carvalho, 2020). All botanical material was collected and deposited in the CNMT Herbarium of the Federal University of Mato Grosso, Sinop campus, Mato Grosso, Brazil. Life forms were classified as: rooted submerged, free submerged, amphibious, emergent, rooted floating, free floating, and climbing (Irgang & Gastal Jr., 1996; Pott & Pott, 2000; Piedade et al., 2018). Productivity (biomass) was measured in each SU by collecting all the plant material above the water line (except for submerged), which was then washed and dried on a paper towel. Fresh and dry biomass in each SU (g m^{-2}) were determined by initially were determined by initially fresh biomass with direct weighing and finally weighed every 24 h, after drying at 70°C for 48 h in a laminar flow oven until the weight stabilized.

Limnological parameters and surrounding vegetation

The following were sampled during the same periods of macrophyte sampling: physical parameters — water temperature, air temperature, turbidity, electrical conductivity, total solids, dissolved solids, suspended solids, depth, transparency, and true color; chemical parameters — chloride (Cl), silica (Si), alkalinity, biological oxygen demand (BOD), chemical oxygen demand (COD), phosphorus (P), total nitrogen (TN), nitrite (NO_2), nitrates (NO_3), organic nitrogen (ON), ammonium nitrogen (NH4+-N), redox potential (RP), pH, and dissolved oxygen (DO); and biological parameters — chlorophyll, total coliforms, and *Escherichia coli*. The following were measured in the field: air and water temperatures with a digital thermometer, depth and transparency with a Secchi disk, pH and Redox potential with a Hach portable pH-meter, and dissolved oxygen with a WTW portable oximeter. The other physical, chemical and microbiological parameters were measured in the laboratory using water collected (at a depth of up to 25 cm) in hermetically sealed plastic containers. Sample collection and preservation followed the parameters of the Standard Methods for the Examination of Water & Wastewater (Carranzo, 2012), Environmental Protection Agency (US EPA, 1991), and the *Associação Brasileira de Normas Técnicas* (ABNT; 1999, 2004, 2005a, 2005b, 2008). The water samples collected in the field were sent to Aquanálise and Bioagri laboratories (Cuiabá, MT), where analyses were performed based mainly on American Public Health Association (APHA) /American Water Works Association (AWWA; 2012) and ABNT standards.

We carried out a floristic survey of the arboreal vegetation (trees and palm trees) within a 500-m buffer around the sampled points by installing a permanent plot of 20 x 20 m at each point to complement the spatial analyses. This also allowed the classification of each sampling point in terms of floristic patterns, helping to characterize the sampled environments. All trees with a circumference greater than or equal to 10 cm, measured at 1.3 m in height (circumference at breast height - CBH), were recorded for each plot and the height of all individuals was visually estimated. Diameter at breast height (DBH) was then calculated from the CBH measured in the field (DBH = CBH/π). Basal area was finally calculated using DBH (Basal area = (DBH/2)^2*π).

Data analyses

We consider as response variables the structural characteristics of the aquatic macrophyte community such as richness (number of species), average cover (% m^{-2}), and average dry and fresh biomass (g m^{-2}) by sampling point (n = 16), type of environment (n=3), hydroperiod (n = 4) and year (n = 3). In addition, matrices of occurrence (absence and presence), cover, and dry and fresh biomass per species (in columns) per environment and per hydroperiod (in lines) were organized for multivariate analysis (Supplemental Table S1). For the different analyses and models, we considered as explanatory variables the limnological parameters and the surrounding vegetation. All analyses were performed on the R version 3.6.2 platform (R Core Team, 2019).

Species diversity was compared among the different types of environments and hydroperiods using diversity profiles based on Rényi entropy, showing an exponential series at a 5% significance level, using the *BiodiversityR* package version 2.6-1 (Kindt & Coe, 2005). Rényi entropy is a quantity that generalizes various notions of entropy, including Hartley entropy, Shannon entropy, collision entropy, and min-entropy, quantifying information while preserving additivity for independent events, forming the basis of the concept of generalized dimensions (Bromiley et al., 2004). Species composition was compared among riverine environment types over hydroperiods by hierarchical clustering analysis by UPGMA using Jacccard's similarity index, which is based on a matrix of presence and absence of species for each environment type per hydroperiod. For this, the *recluster.cons* and *recluster.boot* functions of the *recluster* package were used (Dapporto et al., 2020). The species value index (IndVal) was used to determine the indicator species of each type of environment and hydroperiod using the *multipatt* function with the *r.g* function, for correction of inequal samples, both of the indicspecies package (Dufrêne & Legendre, 1997).

Spatial autocorrelation between sampling points was evaluated using Moran's global spatial association index, with the *Moran.I* function of the *ape* package (Legendre et al., 2015; Paradis, 2022) This index measures spatial autocorrelation based on both feature locations and feature values simultaneously. Given a set of features and an associated attribute, it evaluates whether the pattern expressed is clustered, dispersed, or random (Mitchell, 2005). None of the models for explanatory and response variables displayed spatial autocorrelation patterns ($P > 0.005$). Limnological parameters were selected by excluding redundant variables based on the variance inflation factor (VIF) using the *vifstep* function of the *usdm* package (Naimi et al. 2014). The *vifstep* function identifies collinear variables that should be excluded, only using explanatory variables and without using response variables. VIF is used as an indicator of multicollinearity between explanatory variables in multiple regressions, where VIF = 1 indicates that the predictor variable in question is not related to any other predictor variable in the model, while VIF > 10 suggests strong collinearity (Quinn & Keough, 2002). Variables with VIF > 10 (Naimi et al., 2014) were excluded only after evaluating their probable biological significance, and no excluded variable was considered biologically informative (Fidelis et al., 2019). Therefore, the physical parameters of depth, transparency, air temperature, water temperature, electrical conductivity, true color, total solids, dissolved solids, suspended solids and turbidity; the chemical parameters of pH, alkalinity, BOD, COD, DO, total N, Nitrate, total P, silica, redox, chloride; and the biological parameters of chlorophyll, coliforms, and *E. coli*, were selected. We also performed a Principal Component Analysis (PCA) on physical, chemical, and biological parameters, using the *prcomp* and *cmdscale* functions of the *vegan* package (Oksanen et al., 2022). This was done to reduce the dimensionality of selected parameters while conserving the variation that exists in all variables and species, that way we would have reduced values (PCA axes) for each type of parameter, facilitating the analysis and influence of each type of parameter on the community of macrophytes.

The influence of limnological parameters on richness, cover, and biomass of aquatic macrophytes was analyzed using Generalized Linear Mixed Models (GLMMs) with year of sampling as a random factor. For richness we used a Poisson distribution, for cover we used a beta distribution, and for fresh and dry biomass we used a gamma distribution, all with log link function. These distributions were selected considering the lowest values of the Aikaike and Bayesian information criteria calculated using the *fitdistrplus* package (Delignette-Muller & Dutang, 2015). First, we evaluated the influence of type of environment and hydroperiod on richness, cover, and fresh and dry biomass. Second, we analyzed the influence of limnological parameters considering hydroperiod and type of environment, using two models. The first model used the complete values of each parameter while the second model used reduced and classified values of physical, chemical and biological (PCA axes) to verify the influence of parameters individually and by type, including type of environment and hydroperiod. We used the *glmer* function from the *lme4* package (Bates & Maechler, 2010) for all models.

We investigated the influence of the composition and structure of surrounding vegetation (tree richness, abundance, average height, and basal area) on the richness, cover, and biomass of aquatic macrophytes in the types of environments, by building Generalized Linear Models (GLM) using same distributions mentioned above for the GLMMs. We used a GLM because we did not have the year or hydroperiod as a factor for the surrounding vegetation, only a single value for each sampling point. All models were performed using the function *glm* and the packages *MASS* (Ripley et al., 2022) and *vegan* (Oksanen et al., 2022).

Results

Floristics and structure

A total of 98 species belonging to 68 genera and 40 families were recorded and these are listed along with their authorship in Supplemental Table S2. The richest life forms were emergent (36 species) followed by amphibious (33), climbing (13), rooted submerged (7), free submerged (6), rooted floating (2), and free floating (2). *Eleocharis minima* appeared as emergent and rooted submerged in streams. Free floating and rooted species only occurred in lagoons and rivers, and free and rooted submerged species only in streams. Emergent plants in streams showed the highest richness (19), followed by amphibious species (18) in streams, and emergent species (18) in lagoons. Amphibious and emergent plants showed greater richness in periods of dry and receding water when compared to the flood period (Supplemental Table S2).

Diversity profiles showed that the diversity of lagoons and streams did not differ, with both being higher than that of rivers. For hydroperiods, the flood period had greater diversity than receding water and rising water periods, and the receding water period had greater diversity than the dry period. Considering both hydroperiod and environment type, diversity during the dry period cannot be distinguished from that of rising water and flood periods in lagoons. In streams and rivers, however, the diversity in the flood period did not differ from that of the dry season. In summary, the three types of environments presented similar diversity in the dry season. The diversity profiles of the environment types in each hydroperiod reinforced our previous notion that diversity does not differ among environment types during dry periods. Flood and receding water periods had similar profiles, during which lagoons and streams did not differ. All profiles showed that the diversity of aquatic macrophytes is related to environment and hydroperiod, despite the environments being connected (Fig. 2).

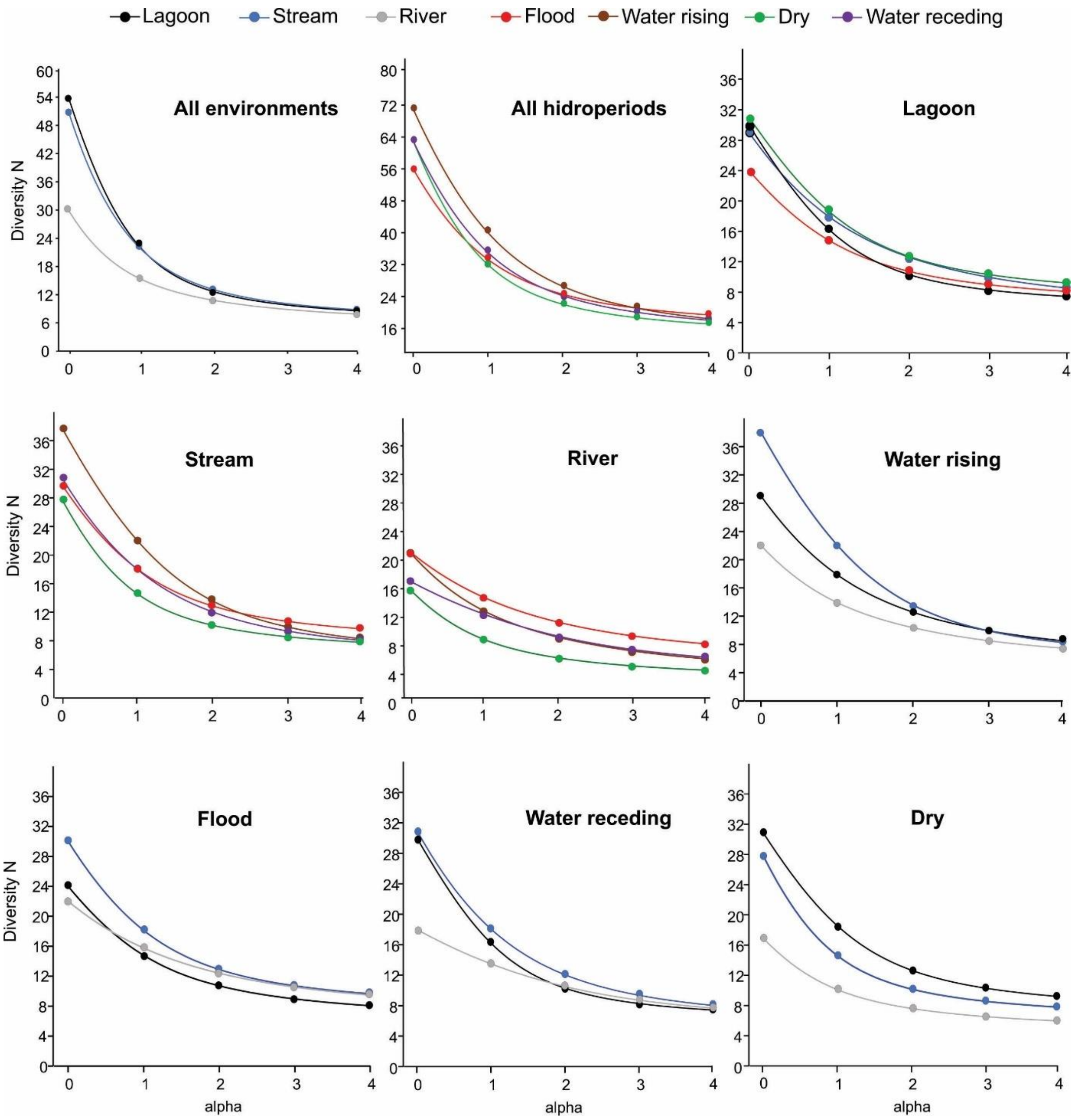

Fig. 2 Diversity profiles based on the exponential of the Renyi´s index of the macrophyte community, considering the hydroperiods, riverine environments, and their combinations in southern Amazonia. Profile values (H-alpha) when Diversity order parameter (alpha) = 0 provide information on species richness; alpha = 1 is the Shannon Diversity Index, and the profile value when alpha = 2 is the log Simpson Diversity Index (1/D).

The floristic similarity (Jaccard index) between lagoons and rivers was 40%, and both showed low similarity with streams (13%). Incorporating hydroperiod in the comparisons revealed high similarity between dry and receding water periods in all environments, and between flood and rising water periods in lagoons. In this sense, rivers and streams showed a similar pattern in relation to hydroperiod (Fig. 3A). Lagoons had 54 species (23 exclusive), streams had 51 (30 exclusive), and rivers had 31 (8 exclusive). Seventy-one species were recorded during rising water (one exclusive), 56 during flood (4 exclusive), 64 during receding water (10 exclusive), and 63 in the dry period (10 exclusive). Furthermore, 34 species occurred in all hydroperiods (Fig. 3B).

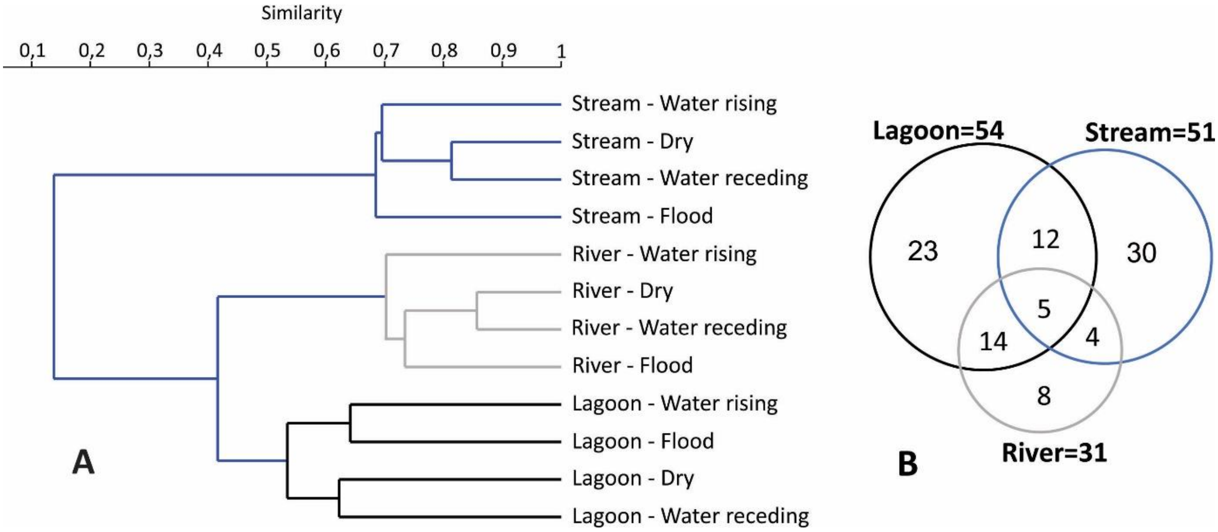

Fig. 3 A Cluster analysis (Sorensen similarity index) of the macrophyte community from riverine environments in southern Amazonia considering the hydroperiod. B Macrophyte species that are unique and shared between the three environments, and outside the circles is the total number of species from each environment.

Lagoons had seven indicator species, with emphasis on *Cyperus blepharoleptos* (IndVal = 0.500, P = 0.001) and *Polygonum acumninatum* (IndVal = 0.495, P = 0.001); rivers had three indicator species, *Cuphea melvilla* (Indval = 0.462, P = 0.002), *Sphenochlea zeylanica* (IndVal = 0.426, P = 0.002), and *Varronia polycephala* (Indval = 0.592, P = 0.001); and streams had 19 indicator species, especially *Montrichardia arborescens* (IndVal = 0.916, P = 0.001), *Aciotis acuminifolia* (IndVal = 0.489, P = 0.002), and *Eleocharis filiculmis* (Indval= 0.441, P = 0.001). Other species proved to be indicators of two environments together: lagoons and rivers had seven indicator species, especially *Mimosa pigra* (IndVal = 0.427, P = 0.003), *Cissus spinosa* (IndVal = 0.322, P = 0.026), and *Eichhornia crassipes* (IndVal=0.351, P=0.014); and rivers and streams had *Palicourea amplectens* (IndVal = 0.399, P = 0.008) as an indicator species. Hydroperiods did not present associated indicator species, however, considering environment and hydroperiod together revealed indicator species for some interactions, such as *Eleocharis minima* (IndVal = 0.445, P = 0.04) for flood period and streams (Table 1). The presence of emergent, amphibious, and climbing species is evident and representative of lagoons and rivers. Indicator species for streams had more types of life forms, with emergent, amphibious, climbing, and rooted submerged species. The presence of floating species (free and rooted) was observed to be an indicator of lagoons and rivers, and free submerged of rivers and streams. All rooted submerged species were indicators of streams. In the typical profile of the macrophyte community in different environment types we can observe the indicator species (Fig. 4).

Table 1 Indicator species of the macrophyte community in riverine environments of southern Amazonia, considering hydroperiods, types of environments, and their combinations. The symbol “x” represents the significant index at 95% significance level ($P < 0.05$). L: Lagoon, R: river, S: stream, WR: Water rising, D: Dry, F: Flood

Indicator species	L	R	S	L+R	R+S	R+WR	S+F	Live form
Aciotis acuminifolia	-	-	x	-	-	-	-	Emergent
Apalanthe granatensis	-	-	x	-	-	-	-	Rooted submerged
Calyptrocarya glomerulata	-	-	x	-	-	-	-	Amphibious
Ceratopteris thalictroides	-	-	x	-	-	-	-	Amphibious
Cissus spinosa	-	-	-	x	-	-	-	Climbers
Cuphea melvilla	-	x	-	-	-	-	-	Emergent
Cyperus blepharoleptos	x	-	-	-	-	-	-	Emergent
Eichhornia azurea	-	-	-	x	-	-	-	Rooted floating
Eichhornia crassipes	-	-	-	x	-	-	-	Free floating
Eleocharis elegans	-	-	x	-	-	-	-	Emergent
Eleocharis filiculmis	-	-	x	-	-	-	-	Emergent
Eleocharis minima	-	-	x	-	-	-	x	Rooted submerged
Fuirena umbellata	-	-	x	-	-	-	-	Emergent
Hymenachne amplexicaulis	x	-	-	-	-	-	-	Emergent
Ipomoea setifera	-	-	-	x	-	-	-	Climbers
Ludwigia octovalvis	-	-	x	-	-	-	-	Emergent
Mayaca fluviatilis	-	-	x	-	-	-	-	Rooted submerse
Mimosa pigra	-	-	-	x	-	-	-	Amphibious
Montrichardia arborescens	-	-	x	-	-	-	-	Emergent
Myriophyllum matogrossensis	-	-	x	-	-	-	-	Rooted submerged
Palicourea amplectens	-	-	-	-	x	-	-	Amphibiam
Polygonum acuminatum	x	-	-	-	-	-	-	Emergent
Rugoloa hylaeica	-	-	x	-	-	-	-	Emergent
Rugoloa pilosa	-	-	x	-	-	-	-	Emergent
Sphenoclea zeylanica	-	x	-	-	-	-	-	Amphibiam
Tonina fluviatilis	-	-	x	-	-	-	-	Rooted submerged
Varronia polycephala	-	x	-	-	-	-	-	Amphibiam

Influence of environment type and hydroperiod on the aquatic macrophyte community

Structural characteristics of the aquatic macrophyte community (richness, cover, biomass) were influenced by type of environment (lagoon, river, stream) and hydroperiod (rising water, receding water , dry, and flood) (Supplemental Table S3). Richness was significantly lower during the flood period in rivers (X = 4 ± SD = 2 ssp m^{-2}) when compared with lagoons (5 ± 3 spp m^{-2}) and streams (6 ± 4 spp m^{-2}). Cover was significantly higher during the flood period in rivers (25 ± 15% m^{-2}). Fresh biomass in streams (152 ± 48.5g m^{-2}) was significantly lower than that of lagoons (219.8 ± 48.5g m^{-2}) and rivers (278.5 ± 150.5 g m^{-2}) in all hydroperiods. The same pattern was found for dry biomass, where streams (25.5 ± 16.4g m^{-2}) were significantly lower than lagoons (41.7 ± 34.5 g m^{-2}) and rivers (49.7 ± 31.5 g m^{-2}) (Supplemental Table S4).

Influence of limnological parameters on the aquatic macrophyte community

The physical parameters that varied the most among environment types and hydroperiods were depth (coefficient of variation CV= 90%), transparency (CV = 50%), turbidity (CV = 50%), and true color (CV = 80%). The remaining physical parameters had coefficients of variation below 40%. Among chemical parameters, alkalinity, chloride, BOD, COD, organic N, and total P had coefficients of variation below between 60 – 70%, while the remaining chemical parameters had coefficients of variation below 30% variation. All biological parameters greater than 80% (Supplemental Table S5).

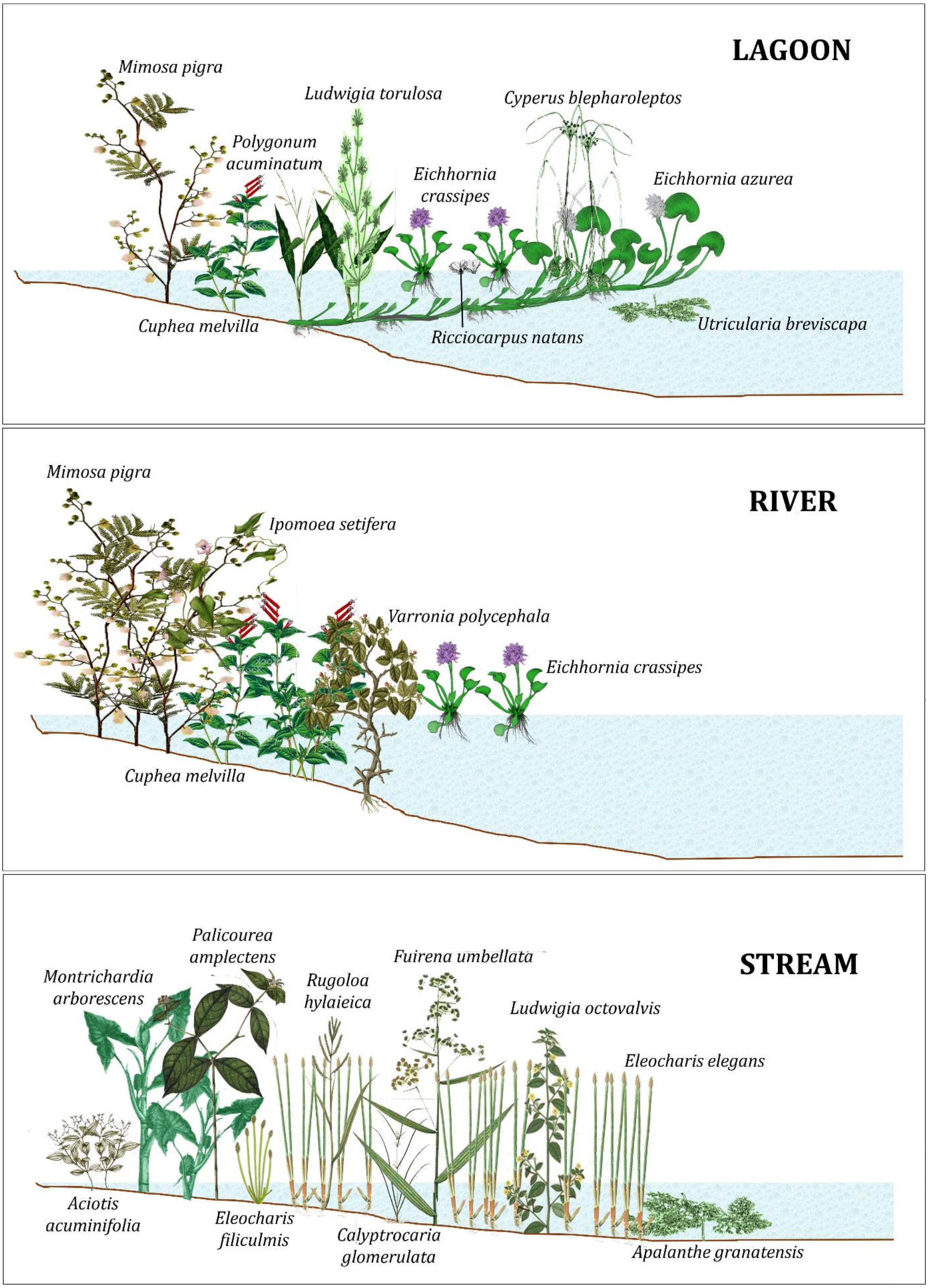

Fig. 4 Typical profile of the aquatic macrophyte community in riverine environments in southern Amazonia, based on the indicator species index

The aquatic macrophyte community was related in different ways to the types of limnological parameters (PCA axes) (Supplemental Table S6 and S7). Richness was positively related to physical limnological parameters in rivers (GLMM, $z = 2.135$, $P = 0.033$) and negatively related to them in streams (GLMM, $z = -2.310$, $P = 0.021$); richness was positively related to chemical parameters in streams (GLMM, $z = 2.310$, $P = 0.021$). Richness in relation to hydroperiod was positively related to physical and chemical parameters during flood (GLMM, $z = 3.380$, $P < 0.001$) and rising water (GLMM, $z = 2.674$, $P < 0.001$), respectively, and negatively with biological (GLMM, $z = -1.986$, $P = 0.047$) and physical (GLMM, $z = -2.523$, $P = 0.012$) parameters during rising water, and chemical parameters during flood (GLMM, z = -3.072, P = 0.002). Cover was positively related to physical parameters in rivers (GLMM, t=3.376, P=0.001), and to chemical parameters during rising water (GLMM, t = 2.607, P = 0.009). Fresh biomass was positively related to physical parameters (GLMM, t = 5.368, P < 0,001) and negatively to chemical parameters (GLMM, t = -2.299, P = 0.023) in rivers, and positively related to chemical parameters during rising water (GLMM, t = 2.631, P = 0.009). Dry biomass was positively related to physical parameters in rivers (GLMM, t = 2.562, P = 0.011), and positively to chemical parameters during rising water (GLMM, t = 1.893, P = 0.049) and water receding (GLMM, t = 1.740, P = 0.044) (Supplemental Table S8).

These relationships with the aquatic macrophytes community were also evidenced considering the limnological parameters individually (Supplemental Table S9). Thus, richness tended to increase significantly with increasing electrical conductivity (GLMM, z = 1.37, P = 0.041), water temperature (GLMM, z = 4.758, P = 0.049), transparency (GLMM, z = 4.214, P < 0.001) and silica concentration (GLMM, z = 4.758, P < 0.001). Still, richness tended to decrease with increasing air temperature (GLMM, z = -3.531, P < 0.001), DO (GLMM, z = -4.305, P < -0.001), and dissolved solids (GLMM, z = -4.813, P < 0.001), chloride (GLMM, z = -2.284, P = 0.022) and chlorophyll (GLMM, z = -2.141, P = 0.032). Cover tended to increase proportionally with air temperature (GLMM, t = 1.900, P = 0.049) and to decrease significantly with increasing total phosphorus concentration (GLMM, t = -2.145, P = 0.033). Fresh and dry biomass were significantly higher with increasing depth (GLMM, t = 3.830, P < 0.001, GLMM, t = 3.626, P < 0.001, respectivily) and air temperature (GLMM, t = 2.151, P = 0.033; GLMM, t = 2.485, P = 0.014, respectively), and decreased with increasing nitrate (GLMM, t = -1.747, P = 0.043; GLMM, t = -1.716, P = 0.052, respectively) and redox potential (GLM, t = -2.001, P = 0.047, GLMM, t = -1.775, P = 0.047, respectively)

Influence of surrounding vegetation on the aquatic macrophyte community

The surrounding arboreal vegetation differed descriptively among environment types. Lagoons had fewer tree species (X = 17 ± SD = 6 spp plot^{-1}) followed by streams (28 ± 5) and rivers (37 ± 9). Regarding tree abundances, lagoons had 19 ±7 ind. plot^{-1}, streams, 40 ± 5, and rivers, 41 ± 5. There was little variation in average height among environment types, with lagoons having 7 ± 0.5 m plot^{-1}, streams, 7 ± 1.3, and rivers, 7.5 ± 0.6. Tree basal area of the surrounding arboreal vegetation varied greatly, with lagoons having 0.38 ± 0.28 m^{2} plot^{-1}, rivers, 0.86 ± 0.59, and streams, 0.84 ± 0.42.

The surrounding vegetation also influenced the aquatic macrophyte community (Supplemental Table S10). Macrophyte richness in streams was negatively related to tree richness (GLM, z = -4.489, P < 0.0001) and tree height (GLM, z-value = -2.958, P = 0.003) and positively related to tree abundance (GLM, z-value = 3.601, P < 0.001). Macrophyte cover in rivers was negatively related to tree richness (GLM, t-value = -5.771, P = 0.004) and positively related to tree abundance (GLM, t-value = 5.520, P = 0.005). Cover in streams was negatively related to tree height

(GLM, t-value = -4.708 P = 0.009). Dry and fresh biomass in rivers were positively related to tree abundance (GLM, t-value = 4.076, P = 0.015; t-value = 4.040, P = 0.016), and negatively related to tree richness (GLM, t-value = -3.861, P = 0.018; t-value = -3.796, P = 0.019) (Fig. 5)

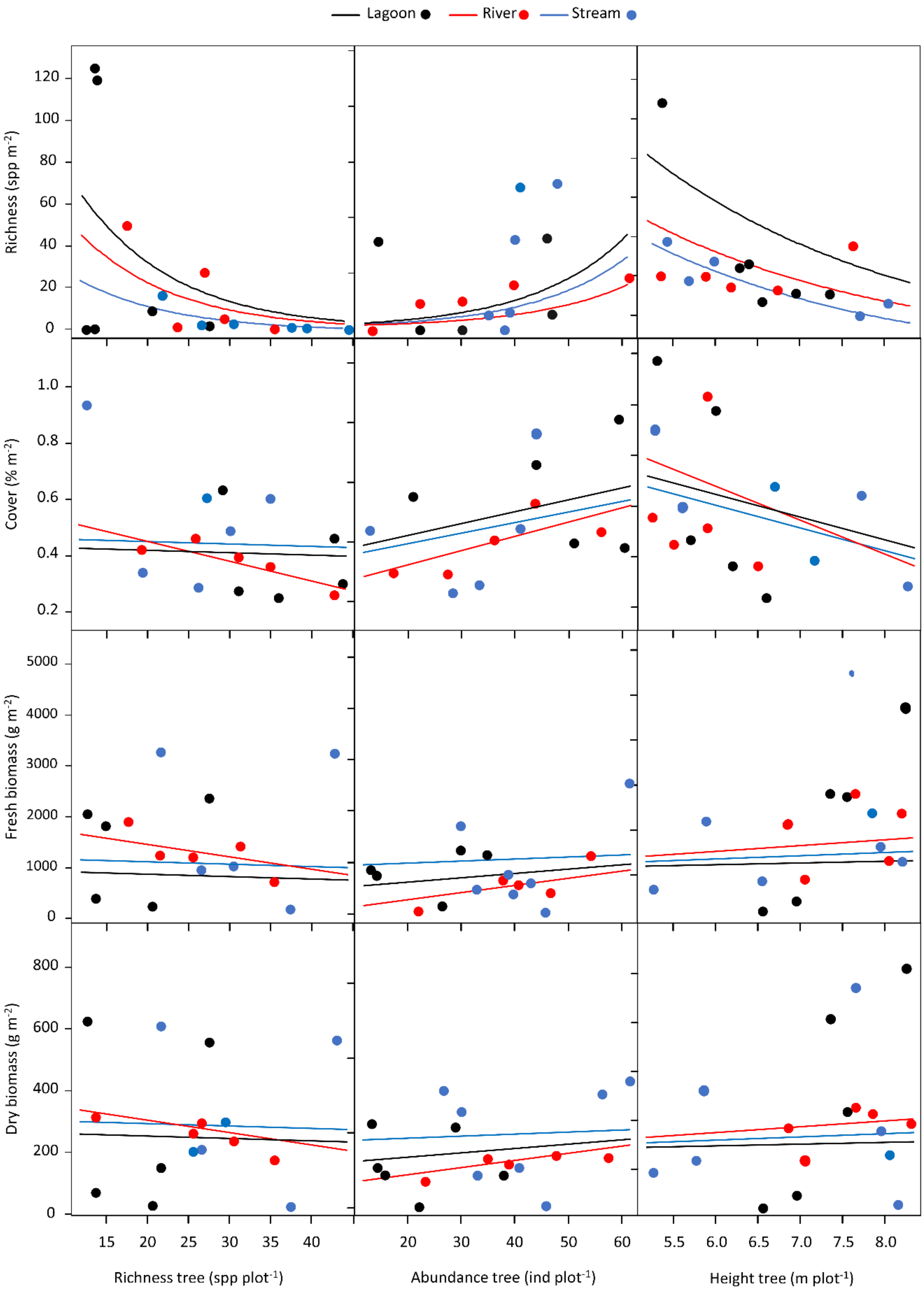

Fig. 5 Relationship of the structural characteristics of the surrounding vegetation with richness, cover, dry, and fresh biomass of the aquatic macrophyte community in riverine environments in southern Amazonia

Discussion

The results presented here show how macrophyte community structure and composition vary among riverine environments of the Tapajós river basin, and how the hydroperiod acts as a regulator of the heterogeneity of such communities in southern Amazonia. The greatest differences among environment types were observed in the dry period, which together with limnological characteristics, mainly physical and chemical, and the structure of the surrounding vegetation, dictated variation in the macrophyte community in the study area. The macrophyte species richness observed in the study area represented 14% of that recorded for southern Amazonia (Córdova et al., 2022), with the same representativeness of families, species, and life forms as in other regions and nearby phytogeographical domains (Pott et al., 2012, Piedade et al., 2018). Extensive floristic surveys are expected to detect more species than plot sampling, but only through the latter method can ecological relationships between plants and environment be captured (Alba et al., 2021). Macrophyte richness and diversity are driven by several factors, the size of the area being one of the most mentioned for several aquatic ecosystems (Murphy et al., 2003; Ferreira et al., 2011; Moura-Júnior et al., 2015; Moura-Júnior & Cotarelli, 2019; Oliveira et al., 2019). The area studied here in southern Amazonia covers more than 200 km of the main riverbed, in addition to the tributaries and adjacent lagoons, which promote this variety and environmental heterogeneity. The recorded richness may also be related to the location of the area in the Amazon-Cerrado transition. This region tends to accumulate a high floristic diversity that is often unique (Marimon et al., 2006; Maracahipes et al., 2015; Marques et al., 2020). The meeting of the two largest South American phytogeographic domains provides a great variety of habitats, which favors the permanent or temporary occurrence of various aquatic macrophytes (Córdova et al., 2022). This reinforces the idea that the floodplains of the Amazonas and Paraná rivers, which are included in these phytogeographic domains, are the most unique in terms of species composition, stressing the importance of preserving these ecosystems (Campos, 2021).

Despite the connection of environment types, only lagoons and rivers showed high floristic similarity, with the diversity of streams being more distinguishable. This pattern was apparent even when considering hydroperiods. There is a temporal influence on community composition of lagoons and rivers, since drier periods favor the occurrence of species that do not occur in flood periods (Lindholm et al., 2021). Thus, in southern Amazonia, the heterogeneity of riverine environments and climate variation, such as a more pronounced dry periods may contribute to these patterns of spatial/environmental and temporal variation in plant communities in the region. Spatial characteristics tend not to significantly influence species composition, with hydromorphological and limnological characteristics more often determining aquatic macrophyte community composition of streams (Mori et al., 2021).

The biodiversity profiles generated here showed that lagoons and streams had more similar and greater diversity than rivers, and the highest diversity is found during the rising water period, mainly because of the effect of greater species richness in streams, and of lagoons showing greater diversity in the dry period only. Therefore, by promoting the occurrence of amphibious, emerging and submerged species specific to each environment, dry increases heterogeneity among environments in this period (Petsch et al., 2021; Galvanese et al., 2022). In addition, variation in taxonomic composition is determined by environmental heterogeneity and temporal fluctuations in water levels of wetlands in the Neotropics unlike variation in cover and biomass. Variation in species richness usually differs from variation in structural characteristics (Pereto & Padial, 2021; Nascimento et al., 2022). This pattern shows the importance of considering the so-called seasonal homogenization, related to the flood, in studies with aquatic macrophyte communities (Petsch et al., 2021; Galvanese et al., 2022). The species richness of aquatic macrophytes was influenced by several environmental factors related at water characteristic, such as connectivity and heterogeneity (Hachoł et al., 2019). This was evidenced in the environmental differences principally physical , , found between streams, lagoons, and rivers in southern Amazonia. In this sense, physical limnological parameters were important in driving the occurrence of species in the macrophyte community, with electrical conductivity being a variable closely related to richness in all the studied riverine environment types, a pattern commonly found in connected wetlands (Marchetti & Scarabotti, 2016). On the other hand, suspended and dissolved solids reduced species richness in all environment types, as there are few life forms, mainly floating ones, that sequester and metabolize these elements and manage to develop in environments with this adverse characteristic (Singh et al., 2022; Wang et al., 2021).

The richness of the aquatic macrophyte community was influenced by physical (electrical conductivity, water temperature, transparency, air temperature and dissolved solids), chemical (silica concentration, chloride) and biological (chlorophyll) parameters, mainly in rivers and streams and in the rainy season (flood and rising water) (Sârbu et al., 2021). However, richness was also limited by chemical factors, such as DO, nitrate, potential redox and chloride, a common pattern in Neotropical floodplain systems (Campos, 2021). These characteristics of water bodies restrict the occurrence of species, since only some are adapted to conditions with an increase in these chemical properties (Campos, 2021; Singh et al., 2022; Pozzobom et al., 2021). Biological parameters, such as chlorophyll, are related to lower richness, especially at the beginning of the rainy season (rising water) where a few species occur. Since this biological parameter tends to decrease when more species interact, that is, common in environments with greater richness (Souza et al. , 2021).

Macrophyte extent and cover (area covered by macrophytes) responds to water characteristics differently depending on the type of environment and the phenophases of species (temporal characteristic) (Simão et al., 2021). In the present study, we were able to observe how cover was influenced by physical parameters of rivers and by the chemicals in rising water. In this sense, air temperature and total phosphorus mainly determined these relationships. The increase in air temperature and water depth in rivers in the rainy season can stimulate growth so that plants withstand the greater water pressure (Moura-Júnior et al., 2017; Morais et al., 2022). Air temperature is directly related to season, being higher in the summer, and also to the rainy season, flood and rising water (Li et al., 2020; Liu et al., 2021), which are the same characteristics of riverine environments in southern Amazonia. Phosphorus is often the limiting nutrient, or the nutrient that is most scarce, and thus limits growth in aquatic ecosystems, being mainly affected by the physical characteristics of the environment, and its effects are more evident in dry periods (Babur et al., 2021; Dubey et al., 2022). Macrophyte primary production tends to be maintained temporally, in response to an increase or turnover of species in riverine environments over the course of the year (Marchetti & Scarabotti, 2016). The differences in species composition found among the different hydroperiods in the region, especially in the hydroperiods intermediate to flood and dry, that is rising water and receding water, were influenced by chemical parameters in lagoons and streams and physical parameters in rivers. Amphibious, emergent, and climbing species tended to grow during the rising water period to reach adequate sizes that allow them to tolerate the flood season. High water level and depth mainly influence interspecific relationships, changing the concentration of nitrate and variation of redox potential, which are determinants for these species rooted on the banks of rivers (Li et al., 2020; Mori et al., 2021).

Primary production (represented by biomass) of aquatic macrophytes in southern Amazonia was found to be related to the structure and composition of the surrounding vegetation, with open vegetation favoring higher macrophyte productivity. Some riparian forests tend to have low tree cover, being almost similar to secondary formations (Esquivel-Muelbert et al., 2017). These openings in the canopy allow the entry of light (Souza & Martins, 2005), which may favor an increase in richness and cover of aquatic macrophytes in areas with less tree abundance. Therefore, floods also select for the few tree species that are adapted to this condition, which is why riparian forests present less diversity compared to other non-riparian environments (Wittmann, 2011). However, in broader areas with less influence from the water level, the density of trees increases because the areas remain flooded for a shorter time (Teixeira et al., 2008; Bao et al., 2017). So, a shorter flooding time facilitates the sporadic and strictly seasonal occurrence of fast-developing species, such as submerged and small floating species for example, and also facilitates an increase in cover by amphibious species, which are better adapted to the banks where they can take root more easily (Pivari et al., 2019).

Macrophyte primary production also depends on chemical characteristics that are related to soil fertility in the surrounding riparian forest, especially for rooted species (Silva et al., 2014; Yang et al., 2020). In addition, changes in the surrounding vegetation may be reflected in the aquatic macrophyte community since the aquatic environment is sensitive to changes in the surrounding environment. For instance, increased concentrations of suspended material and decreased dissolved oxygen were found to affect the development of submerged species (Bleich et al., 2014; Machado et al., 2015; Moi & Teixeira-de-Mello, 2022), as found in the different environment types sampled here. Macrophyte occurrence and primary production can be affected by global climate change, mainly anthropic related to the suppression of vegetation and use of riverine environments for human activities (Fearnside, 2019; Morais et al., 2022). All of these processes are widely operating in southern Amazonia (Maracahipes Santos et al., 2015; Marques et al., 2020). Thus, changes in the composition of the surrounding vegetation and in aquatic environments can influence the structure and ecological interactions of Amazonian aquatic macrophyte communities (Lobato-de Magalhães et al., 2021; Souza et al., 2021), and may even lead to their collapse. Changing the status of riverine environments can initiate a negative feedback loop affecting entire ecosystems (Pereira et al. 2021; Lind et al., 2022). Despite the patterns found, the interactions between macrophytes are complex and specific to the species and location in question. Therefore, a single landscape-scale model would not be appropriate to capture the processes that drive the distribution and abundance of macrophytes (Janauer et al., 2021; Singh et al., 2022)

From this study, which assessed interactions between aquatic macrophyte composition in space and time for a wide range of riverine environments in southern Amazonia, we conclude that the aquatic macrophyte community is subject to variation in type of aquatic environment, surrounding vegetation structure, hydroperiod, and limnological parameters. Streams showed more temporal stability (hydroperiods) with greater diversity in comparison to lagoons and rivers. The dry period represented a determining factor for differences in macrophyte composition and cover, increasing environmental differences within the community. Flooding acted by homogenizing the environment, yet at the same time it favored the development of all life forms. The relationship between macrophytes and the surrounding vegetation evidenced the interaction of the aquatic plant community with the non-aquatic environment, in which tree cover and diversity of tree species facilitates the development of aquatic macrophytes. Aquatic macrophyte richness was the component of the plant community most influenced by physical and chemical parameters, and was linked to environment type and hydroperiod. With our findings, we highlight the importance of surrounding vegetation and water quality for the macrophyte community, which is why the conservation of water resources and riparian forests is necessary to conserve the diversity and productivity of the aquatic macrophyte community in southern Amazonia.

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Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Milton Omar Cordova, Josiane Fernandes Keffer, Dienefe Rafaela Giacoppini and Cássia Beatriz Rodrigues Munhoz. The first draft of the manuscript was written by Milton Omar Cordova and all authors commented on previous versions of the manuscript. Later versions were corrected and commented on by Cássia Beatriz Rodrigues Munhoz. All authors read and approved the final manuscript.

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Data Availability All data generated or analyzed during this study are included in this article.

Declarations

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Supplemental Tables and Figures

Environmental and temporal variability of the aquatic macrophyte community in riverine environments in the southern Amazonia

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Supplemental Table S1. Excel spreadsheet of the richness, cover, fresh and dry biomass of aquatic macrophytes and physical, chemical, and biological limnological parameters riverine environments of southern Amazonia.
File in attachment

Supplemental Table S2. Cover, dry, and fresh biomass of the aquatic macrophyte community in riverine environments in southern Amazonia. L: lagoon, R: River, S: Stream, LF: Life forms: AB: amphibious, EM: emergent, FF: free floating, RF: rooted floating, FS: free submerged, RS: rooted submerged, CE: climber

Family/Specie	**LF**	**Flood**			**Water rising**			**Drought**			**Water receding**		
		L	**R**	**S**	**L**	**R**	**S**	**L**	**R**	**S**	**L**	**R**	**S**
ALISMATACEAE													

Helanthium bolivianum (Rusby) Lehtonen & Myllys	EM	-	-	-	-	-	-	x	-	-	-	-	-
APOCYNACEAE													
Rhabdadenia madida (Vell.) Miers	CL	-	-	-	-	x	-	-	-	-	-	-	-
Tabernaemontana siphilitica (L.f.) Leeuwenb.	AM	-	-	-	x	-	-	x	-	-	x	-	-
Tassadia berteroana (Spreng.) W.D.Stevens	CL	x	x	-	x	x	-	-	x	-	x	x	-
ARACEAE													
Montrichardia arborescens (L.) Schott	EM	-	-	x	-	-	x	-	-	x	-	-	x
Spathiphyllum gardneri Schott	EM	-	-	-	-	-	-	x	-	-	x	-	-
ASTERACEAE													
Mikania cordifolia (L.f.) Willd.	CL	-	x	-	x	x	-	x	x	-	-	-	-
Mikania micrantha Kunth	CL	x	x	x	x	x	x	-	x	x	x	x	x
BORAGINACEAE													
Heliotropium indicum L.	AM	-	-	-	x	-	-	-	-	-	-	-	-
Varronia polycephala Lam.	AM	-	x	-	-	x	-	-	x	-	-	x	-
CHARACEAE													
Nitella sp.	FS	-	-	x	-	-	-	x	-	-	-	-	-
CONVOLVULACEAE													
Ipomoea rubens Choisy	CL	-	x	x	-	x	-	-	x	-	x	x	-
Ipomoea setifera Poir.	CL	x	x	-	x	x	-	x	x	-	x	x	-
CUCURBITACEAE													
Cayaponia glandulosa (Poepp. & Endl.) Cogn.	CL	x	x	-	x	-	-	-	-	x	-	-	-
CYPERACEAE													
Calyptrocarya glomerulata (Brongn.) Urb.	AM	-	-	-	-	-	x	-	-	x	-	-	x
Cyperus blepharoleptos Steud.	EM	x	-	x	x	-	-	x	-	-	x	-	-
Cyperus brevifolius (Rottb.) Endl. ex Hassk.	AM	-	-	-	-	-	-	x	-	-	-	-	-

Cyperus luzulae (L.) Retz.	AM	-	-	x	-	-	x	-	-	-	-	-	x
Cyperus mundtii (Nees) Kunth	AM	-	-	-	-	-	x	-	-	-	-	-	-
Cyperus surinamensis Rottb.	EM	-	-	x	-	-	-	-	-	x	-	-	x
Diplacrum capitatum (Willd.) Boeckeler	EM	-	-	x	-	-	-	-	-	-	-	-	-
Eleocharis acutangula (Roxb.) Schult.	EM	-	-	x	-	-	x	-	-	-	-	-	-
Eleocharis capillacea Kunth	EM	-	-	-	-	-	-	x	-	-	x	-	-
Eleocharis elegans (Kunth) Roem. & Schult.	EM	-	-	x	-	-	x	-	-	x	-	-	x
Eleocharis filiculmis Kunth	EM	-	-	x	-	-	x	-	-	x	-	-	x
Eleocharis geniculata (L.) Roem. & Schult.	EM	-	-	-	-	-	x	-	-	x	-	-	x
Eleocharis mínima Kunth	RS	-	-	x	-	-	x	-	-	x	-	-	-
Fuirena umbellata Rottb.	EM	-	-	x	-	-	x	-	-	x	-	-	x
Rhynchospora cephalotes (L.) Vahl	CL	x	-	-	x	-	-	x	-	-	-	-	-
Rhynchospora comata (Link) Roem. & Schult.	EM	-	-	-	-	-	-	x	-	-	x	-	-
Scleria bracteata Cav.	AA	-	-	-	-	x	-	-	-	-	-	-	-
Scleria secans (L.) Urb.	AM	-	-	x	-	-	x	-	-	x	-	-	-
DILLENIACEAE													
Davilla nítida (Vahl) Kubitzki	CL	-	-	-	-	-	x	-	-	x	-	-	x
ERIOCAULACEAE													
Tonina fluviatilis Aubl.	RS	-	-	x	-	-	x	-	-	x	-	-	x
EUPHORBIACEAE													
Sapium glandulosum (L.) Morong	AM	-	-	-	-	-	-	-	-	-	x	-	-
FABACEAE													
Chamaecrista kunthiana (Schltdl. & Cham.) H.S.Irwin & Barneby	AM	-	-	-	-	-	x	-	-	-	x	-	-
Chamaecrista rotundifolia (Pers.) Greene	AM	-	-	-	-	-	x	-	-	-	-	-	-
Deguelia nitidula (Benth.) A.M.G.Azevedo & R.A.Camargo	CL	x	-	-	-	-	-	-	-	-	-	-	-

Mimosa pigra L.	AM	x	x	-	x	x	-	x	x	-	x	x	-
Sesbania virgata (Cav.) Poir.	AM	-	-	-	x	-	-	-	-	-	-	-	-
Vigna lasiocarpa (Mart. ex Benth.) Verdc.	CL	-	-	-	x	-	-	-	-	-	x	-	-
HALOGRACEAE													
Myriophyllum mattogrossensis Hoehne	RS	-	-	x	-	-	x	-	-	x	-	-	x
HYDROCHARITACEAE													
Apalanthe granatensis (Humb. & Bonpl.) Planch.	FS	-	-	x	-	-	x	-	-	x	-	-	x
Egeria najas Planch.	FS	-	-	x	-	-	x	-	-	x	-	-	x
LENTIBULARACEAE													
Utricularia breviscapa C.Wright ex Griseb.	FS	x	-	x	x	-	-	x	-	x	x	-	x
Utricularia foliosa L.	FR	x	-	-	-	-	-	-	-	-	-	-	-
Utricularia gibba L.	FS	-	-	-	x	-	-	-	-	x	-	-	x
LOGANIACEAE													
Chelonanthus alatus (Aubl.) Pulle	AM	-	-	-	-	-	-	x	-	-	-	-	-
Chelonanthus purpurascens (Aubl.) Struwe et al.	AA	-	-	-	-	-	-	-	-	-	-	x	-
Coutoubea racemosa G. Mey.	AM	-	-	-	-	-	-	-	-	x	-	-	-
LYTHRACEAE													
Cuphea melvilla Lindl.	EE	x	x	-	x	x	-	x	x	-	x	x	-
MALVACEAE													
Guazuma ulmifolia Lam.	AM	-	-	-	-	-	-	-	-	-	x	-	-
Hibiscus bifurcatus Cav.	AA	-	-	-	x	x	-	-	x	-	-	x	-
Urena lobata L.	AM	-	-	-	-	-	x	-	-	-	-	-	-
MAYACACEAE													
Mayaca fluviatilis Aubl.	RS	-	-	-	-	-	x	-	-	x	x	-	x
Mayaca sellowiana Kunth	RS	x	-	-	-	-	x	x	-	-	-	-	-

MELASTOMATACEAE													
Aciotis acuminifolia (Mart. ex DC.) Triana	EM	-	-	x	-	-	x	-	-	x	-	-	x
Clidemia bullosa DC.	AA	-	x	-	-	-	x	-	x	-	-	-	x
Clidemia capitellata (Bonpl.) D.Don	AM	-	-	-	-	-	-	-	-	x	-	-	x
Clidemia novemnervia (DC.) Triana	AM	-	-	-	-	-	x	-	-	-	-	-	-
NYMPHACEAE													
Nymphaea amazonum Mart. & Zucc.	RF	-	-	-	x	-	-	-	-	-	-	-	-
ONAGRACEAE							x						
Ludwigia decurrens Walter	EM	-	-	x	-	-	x	-	-	-	-	-	-
Ludwigia leptocarpa (Nutt.) H.Hara	EM	-	-	x	x	-	x	x	-	x	x	-	x
Ludwigia octovalvis (Jacq.) P.H.Raven	EM	-	-	x	-	-	x	-	-	x	-	-	x
Ludwigia peruviana (L.) H.Hara	EM	-	-	-	x	-	-	-	-	-	-	-	-
Ludwigia torulosa (Arn.) H.Hara	EM	-	-	-	x	-	-	x	-	-	x	-	-
PARKERIACEAE													
Ceratopteris thalictroides (L.) Brongn.	AM	-	-	x	-	-	x	-	-	x	-	-	x
PHYLLANTHACEAE													
Phyllanthus niruri L.	AM	x	-	-	-	-	-	x	-	-	-	-	-
PHYTOLACCACEAE													
Phytolacca cf. rivinoides Kunth & Bouché	EM	-	x	-	-	x	-	-	-	-	-	-	-
PLANTAGINACEAE													
Bacopa scabra (Benth.) Descole & Borsini	EM	-	-	x	-	-	x	x	-	x	-	-	x
POACEAE													
Digitaria ciliaris (Retz.) Koeler	EM	x	-	-	-	-	-	x	-	-	x	-	-
Echinochloa polystachya (Kunth) Hitchc.	EM	x	-	-	x	-	x	-	-	-	-	-	-
Echinodorus subalatus (Mart.) Griseb.	em	-	-	-	-	-	-	-	-	-	x	-	-

Hymenachne amplexicaulis (Rudge) Nees	EM	x	-	-	x	x	x	x	-	-	-	-	-
Luziola bahiensis (Steud.) Hitchc.	AM	-	-	-	-	-	x	-	-	-	x	-	-
Panicum olyroides Kunth	AM	x	x	x	x	x	x	-	-	-	-	-	x
Rugoloa hylaeica (Mez) Zuloaga	EM	-	x	x	-	-	x	-	-	x	-	-	x
Rugoloa pilosa (Sw.) Zuloaga	EM	-	x	x	-	-	x	-	-	-	-	-	x
Urochloa subquadripara (Trin.) R.D.Webster	AM	-	-	-	-	x	-	-	-	-	-	-	x
POLYGONACEAE								x					
Polygonum acuminatum Kunth	EM	x	x	-	x	x	-	x	x	-	x	x	-
Polygonum meisnerianum Cham.	EM	x	-	-	-	-	-	x	-	-	x	-	-
POLYPODIACEAE													
Cochlidium sp.	AM	-	-	-	-	-	-	-	-	-	-	-	x
PONTEDERIACEAE													
Eichhornia azurea (Sw.) Kunth	RF	x	x	-	x	x	-	x	x	-	x	x	-
Eichhornia crassipes (Mart.) Solms	FF	x	x	-	x	-	-	x	x	-	x	x	-
RICCIACEAE													
Ricciocarpos natans (L.) Corda	FF	x	x	-	x	-	-	-	-	-	-	-	-
RUBIACEAE													
Palicourea amplectens (Benth.) Delprete & J.H. Kirkbr.	AM	-	x	x	-	x	x	-	x	x	-	x	x
Psychotria anceps Kunth	AM	-	-	x	-	-	-	-	-	-	-	-	-
Sabicea aspera Aubl.	CL	-	x	-	-	x	-	-	-	-	-	x	-
SMILACACEAE													
Smilax rufescens Griseb.	CL	-	-	-	-	-	-	-	-	-	x	-	-
SOLANACEAE													
Solanum americanum Mill.	AM	-	-	-	-	x	-	x	-	-	x	x	-
Solanum paludosum Moric.	AM	-	-	-	-	-	-	-	x	x	-	x	-

SPHENOCLEACEAE													
Sphenoclea zeylanica Gaertn.	AM	-	x	-	-	x	-	-	x	-	-	x	-
URTICACEAE													
Urera baccifera (L.) Gaudich. ex Wedd.	AM	-	-	-	x	-	-	x	-	-	x	-	-
VERBENACEAE													
Lippia alba (Mill.) N.E.Br. ex Britton & P.Wilson	AM	-	-	-	-	-	-	x	-	-	-	-	-
Phyla betulifolia (Kunth) Greene	AM	x	-	-	-	-	-	x	-	-	-	-	-
VITACEAE													
Cissus spinosa Cambess.	CL	x	x	-	x	x	-	x	x	-	x	x	-
XYRIDACEAE													
Xyris jupicai Rich.	EM	-	-	-	-	-	x	-	-	-	-	-	x

Supplemental Table S3. Mean and standard deviation of richness (spp m^{-2}), cover (% m^{-2}), fresh and dry biomass (g m^{-2}) of aquatic macrophytes by type of environment and hydroperiods in southern Amazonia.

	Richness	Cover	Fresh biomass	Dry biomass
Lagoon	4.7 ± 3.1	15.5 ± 10.4	219.9 ± 239.0	41.7 ± 44.5
Dry	4.9 ± 3.2	15.6 ± 10.8	201.0 ± 198.4	51.7 ± 48.4
Flood	4.6 ± 2.7	13.8 ± 8.8	207.4 ± 174.4	31.1 ± 25.1
Water receding	4.3 ± 2.7	14.8 ± 11.6	261.3 ± 379.9	50.3 ± 67.4
Water rising	4.9 ± 4.1	17.7 ± 10.9	209.8 ± 155.6	33.5 ± 21.1
River	3.7 ± 2.5	19.4 ± 14.1	238.5 ± 254.2	49.7 ± 41.5
Dry	3.2 ± 2.0	17.3 ± 15.2	209.3 ± 228.3	57.2 ± 44.0
Flood	3.8 ± 2.2	24.8 ± 14.9	277.1 ± 265.3	38.8 ± 33.2
Water receding	3.5 ± 2.9	21.9 ± 15.0	317.4 ± 341.6	66.2 ± 55.1
Water rising	4.3 ± 2.9	13.6 ± 8.9	150.1 ± 124.9	36.4 ± 23.1
Stream	5.9 ± 4.9	13.1 ± 4.3	102.8 ± 55.3	25.5 ± 16.4
Dry	5.6 ± 4.6	13.5 ± 5.5	136.3 ± 78.2	37.4 ± 24.6
Flood	5.2 ± 3.9	12.6 ± 3.1	92.3 ± 51.1	21.2 ± 15.0
Water receding	5.9 ± 5.1	12.2 ± 2.0	95.6 ± 40.2	21.4 ± 6.3
Water rising	6.9 ± 5.9	14.0 ± 5.4	86.8 ± 28.4	22.0 ± 7.2

Supplemental Table S4. Generalized Linear Mixed Model of richness, cover, fresh and dry biomass of aquatic macrophytes among types of environments and hydroperiod in riverine environments in southern Amazonia. The symbol "*" indicates significant differences ($P < 0.05$)

	Estimate	Std.Error	z value	P value
Richness				
(Intercept)	159.601	0.116	13.729	<0.0001
Hydroperiod-Flood	-0.069	0.167	-0.418	0.676
Hydroperiod-Water receding	-0.129	0.169	-0.763	0.446
Hydroperiod-Water rising	-0.014	0.165	-0.082	0.934
Environment-River	-0.433	0.185	-2.336	0.019*
Environment-Stream	0.129	0.153	0.841	0.400
Hydroperiod-Flood : Environment-River	0.242	0.258	0.939	0.348
Hydroperiod-Water receding : Environment-River	0.229	0.262	0.873	0.382
Hydroperiod-Water rising : Environment-River	0.301	0.252	1.194	0.233
Hydroperiod-Flood : Environment-Stream	-0.013	0.221	-0.057	0.955
Hydroperiod-Water receding : Environment-Stream	0.187	0.219	0.854	0.393
Hydroperiod-Water rising : Environment-Stream	0.219	0.213	1.029	0.303
Cover				
(Intercept)	-1.832	0.190	-9.626	<0.0001

Hydroperiod-Flood	-0.082	0.269	-0.304	0.761
Hydroperiod-Water receding	-0.058	0.269	-0.216	0.829
Hydroperiod-Water rising	0.255	0.259	0.982	0.326
Environment-River	0.053	0.266	0.198	0.843
Environment-Stream	0.166	0.251	0.660	0.509
Hydroperiod-Flood : Environment-River	0.757	0.366	2.071	0.038*
Hydroperiod-Water receding : Environment-River	0.469	0.369	1.272	0.203
Hydroperiod-Water rising : Environment-River	-0.388	0.373	-1.041	0.298
Hydroperiod-Flood : Environment-Stream	0.037	0.358	0.105	0.917
Hydroperiod-Water receding : Environment-Stream	-0.008	0.358	-0.022	0.982
Hydroperiod-Water rising : Environment-Stream	-0.233	0.349	-0.666	0.506
Fresh biomass				
(Intercept)	201.003	51.254	3.922	0.001
Hydroperiod-Flood	6.397	72.484	0.088	0.929
Hydroperiod-Water receding	60.308	72.484	0.832	0.407
Hydroperiod-Water rising	8.827	72.484	0.122	0.903
Environment-River	8.271	72.484	0.114	0.909
Environment-Stream	-64.706	69.398	-0.932	0.049*
Hydroperiod-Flood : Environment-River	61.392	102.508	0.599	0.549
Hydroperiod-Water receding : Environment-River	47.792	102.508	0.466	0.642
Hydroperiod-Water rising : Environment-River	-67.991	102.508	-0.663	0.508
Hydroperiod-Flood : Environment-Stream	-50.430	98.144	-0.514	0.608
Hydroperiod-Water receding : Environment-Stream	-100.955	98.144	-1.029	0.305
Hydroperiod-Water rising : Environment-Stream	-58.294	98.144	-0.594	0.553
Dry biomass				
Hydroperiod-Flood	51.725	9.016	5.737	<0.0001
Hydroperiod-Water receding	-20.595	12.751	-1.615	0.108
Hydroperiod-Water rising	-1.475	12.751	-0.116	0.908
Environment-River	-18.219	12.751	-1.429	0.155
Environment-Stream	5.517	12.751	0.433	0.666
Hydroperiod-Flood : Environment-River	-14.369	12.208	-1.177	0.048*
Hydroperiod-Water receding : Environment-River	2.189	18.033	0.121	0.904
Hydroperiod-Water rising : Environment-River	10.478	18.033	0.581	0.562
Hydroperiod-Flood : Environment-Stream	-2.595	18.033	-0.144	0.886
Hydroperiod-Water receding : Environment-Stream	4.394	17.265	0.255	0.799
Hydroperiod-Water rising : Environment-Stream	-14.529	17.265	-0.842	0.401

Supplemental Table S5. Limnological parameters (physical, chemical and biological) in riverine environments in southern Amazonia. Mean ± Standard deviation.

LIMONOLOGICAL PARAMETERS	DROUGHT			FLOOD		
	Lagoon	**River**	**Stream**	**Lagoon**	**River**	**Stream**
Physicals						
Depth	3.25 ± 3.04	3.73 ± 3.08	0.98 ± 0.64	5.51 ± 4.93	4.47 ± 1.57	1.67 ± 0.72
Transparency	0.90 ± 0.55	1.45 ± 0.13	1.01 ± 0.49	0.84 ± 0.19	0.82 ± 0.28	0.93 ± 0.34
Air temperature	33.60 ± 1.12	31.60 ± 2.10	27.39 ± 3.79	30.59 ± 2.32	33.45 ± 1.16	28.58 ± 2.28
Water temperature	26.59 ± 2.03	25.86 ± 0.64	23.61 ± 1.48	27.71 ± 0.46	27.71 ± 0.51	25.97 ± 1.01
True color	24.60 ± 5.38	21.07 ± 3.38	32.56 ± 5.87	26.60 ± 9.75	33.53 ± 7.74	23.67 ± 3.55
Turbidity	9.92 ± 5.69	5.06 ± 0.72	4.76 ± 0.95	15.64 ± 8.81	26.98 ± 10.00	6.87 ± 4.26
Electrical conductivity	7.44 ± 4.27	8.57 ± 1.41	5.60 ± 0.71	10.99 ± 3.61	11.89 ± 2.82	5.66 ± 1.62
Total solids	13.27 ± 2.49	9.87 ± 0.30	9.33 ± 0.00	18.67 ± 2.32	20.27 ± 6.40	17.67 ± 3.23
Dissolved solids	9.27 ± 2.77	9.53 ± 1.04	7.33 ± 1.70	11.57 ± 4.19	11.37 ± 2.83	5.69 ± 1.31
Suspended solids	10.40 ± 0.89	10.00 ± 0.00	10.00 ± 0.00	12.93 ± 0.64	12.35 ± 1.51	14.03 ± 1.66
Chemicals						
pH	5.58 ± 0.70	5.98 ± 0.37	4.99 ± 0.34	6.27 ± 0.54	6.64 ± 0.30	5.59 ± 0.65
Alkalinity	1.30 ± 0.51	1.17 ± 0.44	0.67 ± 0.26	2.53 ± 2.18	4.57 ± 1.12	1.89 ± 0.74
Biological oxygen demand - BOD	1.90 ± 0.92	1.62 ± 0.72	1.07 ± 0.49	1.27 ± 0.88	0.59 ± 0.19	0.54 ± 0.10
Chemical oxygen demand - COD	5.60 ± 1.67	8.67 ± 6.83	8.39 ± 4.65	6.27 ± 3.05	4.80 ± 3.40	3.39 ± 0.85
Dissolved oxygen	7.21 ± 0.41	7.65 ± 0.32	7.05 ± 1.21	5.37 ± 1.85	6.23 ± 0.30	5.98 ± 0.64
Ammoniacal nitrogen	0.08 ± 0.00	0.08 ± 0.00	0.08 ± 0.00	0.08 ± 0.00	0.08 ± 0.00	0.08 ± 0.00
Nitrates	0.19 ± 0.02	0.17 ± 0.01	0.20 ± 0.02	0.26 ± 0.09	0.32 ± 0.05	0.25 ± 0.04
Organic nitrogen	0.35 ± 0.20	0.31 ± 0.27	0.50 ± 0.32	0.39 ± 0.18	0.28 ± 0.06	0.31 ± 0.09
Total nitrogen	0.57 ± 0.24	0.50 ± 0.29	0.87 ± 0.53	0.65 ± 0.08	0.59 ± 0.10	0.57 ± 0.09
Nitrites	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00

Kjeldahl nitrogen - NKT	062 ± 0.8	0.58 ± 0.25	0.92 ± 0.55	0.65 ± 0.08	065 ± 0.12	0.64 ± 0.11
Total phosphorus	0.11 ± 0.10	0.03 ± 0.03	0.07 ± 0.04	0.10 ± 0.06	0.07 ± 0.02	0.11 ± 0.03
Silica	7.97 ± 0.86	8.37 ± 0.38	8.68 ± 0.66	8.44 ± 1.54	9.56 ± 1.58	7.37 ± 0.67
Redox potential	216.23 ± 9.88	217.82 ± 16.77	218.26 ± 22.77	149.20 ± 37.72	134.15 ± 9.41	135.06 ± 11.25
Chloride	1.90 ± 1.20	1.07 ± 0.35	1.94 ± 0.76	1.77 ± 1.71	0.70 ± 0.18	1.06 ± 0.34
Biologicals						
Chlorophyll	2.40 ± 2.30	4.71 ± 3.17	1.90 ± 1.55	3.70 ± 2.06	2.20 ± 2.03	1.67 ± 1.48
Total coliforms	1573.1 ± 822.5	1340.1 ± 509.8	3308.5 ± 1577.9	2088.7 ± 700.0	3067.4 ± 740.8	5966.3 ± 4245.4
Escherichia coli	35.7 ± 62.0	15.9 ± 5.2	356.6 ± 315.6	60.1 ± 41.1	147.7 ± 37.9	766.1 ± 815.2

	WATER RESING			**WATER RECEDING**		
	Lagoon	**River**	**Stream**	**Lagoon**	**River**	**Stream**
Physicals						
Depth	2.52 ± 1.31	3.08 ± 1.04	1.38 ± 0.80	4.98 ± 3.84	6.43 ± 3.15	1.94 ± 0.81
Transparency	1.26 ± 0.19	1.05 ± 0.38	0.97 ± 0.37	1.02 ± 0.42	0.83 ± 0.11	1.70 ± 1.32
Air temperature	32.27 ± 2.60	30.73 ± 2.89	31.39 ± 2.34	28.21 ± 2.24	30.87 ± 1.86	29.84 ± 2.67
Water temperature	27.01 ± 0.54	27.24 ± 0.44	24.91 ± 0.25	27.53 ± 1.21	27.72 ± 0.43	25.39 ± 0.29
True color	17.33 ± 6.06	12.73 ± 2.52	21.50 ± 5.05	56.07 ± 30.90	46.67 ± 11.28	50.94 ± 13.07
Turbidity	6.25 ± 1.71	8.06 ± 4.73	5.59 ± 3.59	15.37 ± 14.02	16.17 ± 3.54	9.56 ± 3.76
Electrical conductivity	10.53 ± 3.40	10.29 ± 1.88	5.53 ± 1.76	11.27 ± 3.24	11.28 ± 2.00	7.89 ± 1.47
Total solids	13.80 ± 4.91	14.00 ± 5.04	11.06 ± 5.09	12.73 ± 4.91	13.47 ± 4.48	9.11 ± 0.54
Dissolved solids	11.07 ± 4.38	10.33 ± 1.89	5.39 ± 1.76	10.93 ± 3.49	9.53 ± 1.45	6.39 ± 1.67
Suspended solids	10.20 ± 0.45	10.27 ± 0.60	11.39 ± 3.40	10.40 ± 0.89	9.87 ± 0.30	10.00 ± 0.00
Chemicals						
pH	5.92 ± 0.55	6.28 ± 0.35	5.51 ± 0.57	6.10 ± 1.00	5.84 ± 0.24	5.22 ± 0.76
Alkalinity	1.17 ± 0.37	1.47 ± 0.18	1.39 ± 0.14	2.07 ± 0.72	1.87 ± 0.30	0.97 ± 0.27

Biological oxygen demand - BOD	2.78 ± 0.91	2.05 ± 0.92	2.08 ± 0.94	0.59 ± 0.19	0.92 ± 0.19	0.78 ± 0.35
Chemical oxygen demand - COD	15.53 ± 5.68	8.53 ± 3.86	8.22 ± 3.12	13.80 ± 2.28	9.87 ± 7.79	12.00 ± 4.15
Dissolved oxygen	6.04 ± 0.81	7.13 ± 0.46	6.83 ± 0.97	5.03 ± 0.98	6.24 ± 0.39	5.81 ± 0.81
Ammoniacal nitrogen	0.08 ± 0.00	0.08 ± 0.00	0.08 ± 0.00	0.08 ± 0.00	0.08 ± 0.00	0.08 ± 0.00
Nitrates	0.16 ± 0.04	0.16 ± 0.04	0.12 ± 0.01	0.31 ± 0.09	0.31 ± 0.04	0.26 ± 0.05
Organic nitrogen	0.73 ± 0.04	0.66 ± 0.47	0.33 ± 0.30	0.43 ± 0.10	0.50 ± 0.33	0.31 ± 0.08
Total nitrogen	0.92 ± 0.17	0.80 ± 0.49	0.40 ± 0.33	0.74 ± 0.07	0.77 ± 0.38	0.55 ± 0.07
Nitrites	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00
Kjeldahl nitrogen - NKT	0.98 ± 0.17	0.85 ± 0.39	0.42 ± 0.33	0.75 ± 0.06	0.81 ± 0.35	0.59 ± 0.05
Total phosphorus	0.19 ± 0.15	0.16 ± 0.12	0.11 ± 0.08	0.12 ± 0.14	0.09 ± 0.02	0.09 ± 0.11
Silica	8.59 ± 0.94	8.29 ± 0.97	8.38 ± 1.16	7.33 ± 1.57	7.48 ± 0.68	6.83 ± 0.40
Redox potential	157.65 ± 17.75	146.29 ± 20.49	169.28 ± 22.40	210.19 ± 19.36	227.99 ± 48.02	262.77 ± 16.55
Chloride	3.93 ± 1.55	3.27 ± 1.92	3.72 ± 1.50	3.10 ± 2.10	1.70 ± 1.19	3.06 ± 2.52
Biologicals						
Chlorophyll	2.62 ± 1.77	3.04 ± 2.10	0.60 ± 0.60	1.46 ± 1.10	3.14 ± 1.59	1.20 ± 0.88
Total coliforms	1815.3 ± 1449.8	3348.7 ± 1737.4	4610.9 ± 2964.6	4037.5 ± 4127.4	2596.9 ± 562.1	7447.8 ± 3015.6
Escherichia coli	63.6 ± 33.7	225.8 ± 182.3	477.4 ± 419.8	76.6 ± 41.4	101.1 ± 40.1	558.8 ± 383.9

Supplemental Table S6. Loadings PCA Axes of the limnological parameters in the community in riverine environments in southern Amazonia

Physical parameters

	PC1	PC2	PC3	PC4	PC5
Depth	0.427370	0.035394	0.280735	0.263414	-0.816321
Transparency	-0.104165	0.491456	0.765895	0.109386	0.276942
Air temperature	0.220271	0.557578	-0.101313	-0.757856	-0.147632
Water temperature	0.449269	0.248918	-0.321546	0.245782	0.241129
Electrical conductivity	0.268347	-0.551008	0.468977	-0.357809	0.161359
Total solids	0.431938	-0.055592	-0.085902	0.149551	0.130071
Dissolved solids	0.281421	-0.322569	0.372115	-0.248512	0.100452
Suspended solids	0.314313	0.096627	-0.365226	0.351258	0.159149
Turbidity	0.493412	-0.245353	-0.021522	-0.221125	0.183762
Standard deviation	17.344	11.311	10.101	0.8639	0.68908
Proportion of Variance	0.4298	0.1828	0.1458	0.1066	0.06783
Cumulative Proportion	0.4298	0.6125	0.7583	0.8649	0.93274

Chemical parameters

	PC1	PC2	PC3	PC4	PC5
pH	0.318563	-0.261615	0.115518	-0.187682	0.329219
Alkalinity	0.427047	0.101448	0.087866	-0.125006	0.063588
DBO	-0.147526	-0.437539	-0.224503	-0.020312	0.190801
DQO	-0.186906	-0.068713	0.435414	0.071027	0.544427
OD	-0.064674	-0.387014	-0.220696	-0.432541	-0.188809
Nitrate	0.237136	0.411395	0.328236	-0.180654	-0.045991
Organic nitrogen	-0.068190	-0.240594	0.366764	0.381531	-0.453464
Total phosphorus	0.150434	-0.065757	0.294859	0.350791	-0.218882
Silica	0.223447	-0.345625	0.077917	-0.100482	-0.363878
Redox potential	-0.337044	0.183339	0.253962	-0.316075	-0.011813
Chloride	-0.208964	-0.272618	0.106017	0.371266	0.280317
Standard deviation	19.436	15.324	12.567	11.912	104.476
Proportion of Variance	0.2698	0.1677	0.1128	0.1013	0.07797
Cumulative Proportion	0.2698	0.4376	0.5504	0.6517	0.72968

Biological parameters

	PC1	PC2	PC3
Chlorophyll	-0.479939	-0.868527	-0.123769
Total coliforms	0.632619	-0.244877	-0.734729
Escherichia coli	0.607824	-0.430925	0.666974
Standard deviation	14.251	0.8367	0.5188

Proportion of Variance	0.6769	0.2334	0.0897
Cumulative Proportion	0.6769	0.9103	10.000

Supplemental Table S7. Axes values of the PCA considering the limnological parameters community in riverine environments in southern Amazonia

Hydroperiod	Environment	Physical		Chemical		Biological	
		PCA1	PCA2	PCA1	PCA2	PCA1	PCA2
Flood	Lagoon1	-5.0889	2.0192	-71.693	-0.35603	-589.85	-133,36
Flood	Lagoon2	13.531	18.261	-49.722	0.34777	-951.06	-67,399
Flood	Lagoon3	4.8251	7.0254	-62.890	-4.9067	-1628.8	-66,411
Flood	Lagoon4	-4.7882	6.7172	23.350	-3.4974	-2300.0	-21,854
Flood	Lagoon5	-17.300	11.616	-31.690	2.6419	-1910.6	32,655
Flood	River1	-10.241	0.2405	-60.064	-5.1402	-345.89	-39,363
Flood	River2	13.114	17.335	-49.722	0.34777	-951.06	-67,399
Flood	River3	12.338	21.418	-51.843	-3.2303	-10.984	-113,93
Flood	River4	17.602	24.189	-40.978	1.3274	-1504.5	19,858
Flood	River5	9.1489	18.449	-65.499	-5.0852	344.78	-110,3
Flood	Stream1	-13.554	-1.5121	-41.409	-4.1354	-1.4300	183,21
Flood	Stream2	-5.9636	1.7196	-67.468	-2.841	6750.8	395,64
Flood	Stream3	-4.6506	-1.8615	-66.004	-3.3555	-682.16	24,693
Flood	Stream4	-9.7587	7.4741	-47.894	-3.9942	8691.9	1038,9
Flood	Stream5	-8.4987	-3.0934	-49.855	-5.1485	2120.9	23,511
Flood	Stream6	-6.0012	-4.4060	-43.851	-2.5955	-734.50	-92,649
Water rising	Lagoon1	18.317	-13.545	36.556	5.1763	7240.3	-864,51
Water rising	Lagoon2	57.102	-2.5523	33.079	1.106	-1014.7	-53,645
Water rising	Lagoon3	-2.3072	-4.5715	-4.072	8.8601	-2501.6	31,943
Water rising	Lagoon4	-9.0983	-2.6181	8.5846	4.2556	-2695.1	39,692
Water rising	Lagoon5	64.779	7.6491	39.246	2.6422	1293.7	-305,17
Water rising	River1	-2.3983	-1.901	90.958	10.554	-146.8	-138,13
Water rising	River2	30.009	-0.9212	52.032	2.133	-1467.7	-37,426
Water rising	River3	16.85	4.5057	46.242	-6.7528	-1071.2	11,048
Water rising	River4	20.654	3.2699	52.182	-5.4575	-1456.5	-9,1071
Water rising	River5	21.003	-1.9343	-39.63	-1.8427	-689.75	-133,34
Water rising	Stream1	4.8081	-9.291	51.887	-2.8816	5833.2	-266,35
Water rising	Stream2	34.735	-15.027	72.617	3.6437	6072.6	310,95
Water rising	Stream3	21.68	-9.8626	96.948	1.3476	3137.4	-390,55

Water rising	Stream4	25.093	-7.9991	61.421	0.9132	7018.6	-168,76
Water rising	Stream5	24.459	-7.6107	84.107	6.1215	-1089.3	285,55
Water rising	Stream6	-0.20676	-9.9689	84.178	-3.9375	2463.8	-326,65
Dry	Lagoon1	1.0323	-6.7086	44.963	-6.0878	-669.25	-45,557
Dry	Lagoon2	-10.024	-1.8594	20.673	-5.4985	-2858.1	37,733
Dry	Lagoon3	-4.7871	6.6212	23.35	-3.4974	-2300	-21,854
Dry	Lagoon4	-4.7871	6.6212	23.35	-3.4974	-2300	-21,854
Dry	Lagoon5	-11.632	1.667	29.899	-1.8429	-1830.2	-67,211
Dry	River1	-7.428	-6.3182	58.399	-5.8241	-2452.5	10,907
Dry	River2	-10.024	-1.8594	20.673	-5.4985	-2858.1	37,733
Dry	River3	-14.616	-2.056	32.42	1.6462	-2408.3	-2,295
Dry	River4	-8.9731	-2.7747	21.674	9.5315	-1702.7	-72,023
Dry	River5	-13.571	-0.9832	17.651	-6.0815	-1705	-75,203
Dry	Stream1	-3.7281	-9.3131	-5.6135	6.4689	-1930.8	898,36
Dry	Stream2	0.8507	-8.4881	32.628	-4.1814	1010.7	-8,5938
Dry	Stream3	-9.7784	-4.7805	50.474	-6.4732	1186.1	-186,38
Dry	Stream4	1.7735	-8.4761	13.353	0.0264	-1245.1	199,44
Dry	Stream5	5.1287	-10.348	40.876	-6.0128	-1714.2	172,36
Dry	Stream6	2.0487	-12.057	51.834	1.599	1297.2	-347,04
Water receding	Lagoon1	-5.6398	-5.9747	-11.695	4.9593	788.52	-244,79
Water receding	Lagoon2	-18.461	1.8129	-59.023	5.0056	-2447.5	49,908
Water receding	Lagoon3	-13.415	1.2374	-23.204	13.862	-2584.5	30,249
Water receding	Lagoon4	-13.415	1.2374	-23.205	13.912	-2584.5	30,249
Water receding	Lagoon5	-18.242	11.787	-31.69	2.6419	-1910.6	32,655
Water receding	River1	-20.298	-3.0323	-20.896	1.7988	-1158.2	-84,106
Water receding	River2	-18.461	1.8129	-59.023	5.0056	-2447.5	49,908
Water receding	River3	-19.119	5.0168	-18.666	-2.9224	1592.8	13,122
Water receding	River4	-10.937	12.746	-46.603	5.4411	1505.8	-3,2239
Water receding	River5	-19.125	5.3743	-61.48	-2.5846	-521.82	-39,716
Water receding	Stream1	-10.348	-8.4235	3.2183	-3.9298	586.28	22,141
Water receding	Stream2	-14.446	-5.3677	-33.025	4.2125	2824	-132,81
Water receding	Stream3	-17.397	-3.1352	-37.368	-0.05528	-604.05	-54,844
Water receding	Stream4	-11.512	-2.9346	-27.656	0.27344	6262.1	333,06
Water receding	Stream5	-0.4054	4.5572	-31.509	4.9954	-1078	524,62
Water receding	Stream6	-10.454	-8.8134	16.12	-3.6521	-1538.6	-26,254
variance (%)		**73.3**	**17.6**	**98.6**	**1.2**	**99.2**	**0.8**

Supplemental Table S8. Generalized Linear Mixed Model for comparison of richness, cover, fresh and dry biomass of aquatic macrophytes among in relation to type of limnological parameters, physical, chemical, and biological in riverine environments of southern Amazonia. The symbol "*" indicates significant differences ($P < 0.05$)

	RICHNESS				**COVER**			
Environment	**Estimate**	**Std. Error**	**z value**	**P value**	**Estimate**	**Std. Error**	**z value**	**P value**
Intercept	1.617	0.069	23.117	<0.001	-1.676	0.113	-14.799	<0.0001
Environment-River	-0.350	0.122	-2.869	0.004	-0.096	0.181	-0.535	0.593
Environment-Stream	-0.735	0.162	-4.553	<0.001*	-0.006	0.217	-0.026	0.979
Limnological Parameters-Biologicals	0.023	0.074	0.306	0.759	0.247	0.111	2.233	0.026
Limnological Parameters-Chemicals	-0.005	0.033	-0.143	0.887	-0.009	0.049	-0.202	0.840
Limnological Parameters-Physicals	-0.078	0.033	-2.349	0.019*	-0.025	0.049	-0.514	0.608
Environment-River : Limnological Parameters-Biologicals	0.061	0.137	0.443	0.658	-0.245	0.191	-1.279	0.201
Environment-Stream : Limnological Parameters-Biologicals	-0.071	0.091	-0.788	0.431	-0.219	0.129	-1.698	0.089
Environment-River : Limnological Parameters-Chemicals	0.050	0.061	0.822	0.411	-0.082	0.087	-0.942	0.346
Environment-Stream : Limnological Parameters-Chemicals	0.112	0.048	2.310	0.021*	0.027	0.080	0.342	0.733
Environment-River : Limnological Parameters-Physicals	0.154	0.072	2.135	0.033	0.343	0.102	3.376	0.001*
Environment-Stream : Limnological Parameters-Physicals	-0.504	0.077	-6.526	0,006	0.043	0.112	0.378	0.705
Hydroperiod	**Estimate**	**Std. Error**	**z value**	**P value**	**Estimate**	**Std. Error**	**z value**	**P value**
(Intercept)	1.361	0.127	10.724	<0.0001	-18132	0.185	-9.809	<0.0001
Hydroperiod-Flood	0.726	0.196	3.712	0.001*	0.058	0.319	0.182	0.855
Hydroperiod-Water receding	0.051	0.144	0.352	0.724	0.156	0.213	0.734	0.463
Hydroperiod-Water rising	0.237	0.145	1.635	0.102	-0.029	0.219	-0.131	0.896
Limnological Parameters-Biologicals	0.007	0.122	0.061	0.951	0.082	0.188	0.436	0.662
Limnological Parameters-Chemicals	0.112	0.068	1.656	0.098	-0.143	0.114	-1.248	0.212
Limnological Parameters-Physicals	-0.241	0.066	-3.658	0.001*	0.001	0.098	0.007	0.994

Hydroperiod-Flood : Limnological Parameters-Biologicals	-0.233	0.137	-1.694	0.090	-0.041	0.205	-0.200	0.841
Hydroperiod-Water receding : Limnological Parameters-Biologicals	-0.134	0.143	-0.936	0.349	-0.061	0.206	-0.293	0.769
Hydroperiod-Water rising : Limnological Parameters-Biologicals	-0.291	0.146	-1.986	0.047*	0.059	0.210	0.281	0.779
Hydroperiod-Flood : Limnological Parameters-Chemicals	-0.650	0.212	-3.072	0.002	0.241	0.256	0.942	0.346
Hydroperiod-Water receding : Limnological Parameters-Chemicals	-0.088	0.065	-1.356	0.175	0.146	0.121	1.202	0.229
Hydroperiod-Water rising : Limnological Parameters-Chemicals	0.356	0.133	2.674	0.008*	0.621	0.238	2.607	0.009*
Hydroperiod-Flood : Limnological Parameters-Physicals	0.261	0.077	3.380	0.001	0.047	0.115	0.413	0.679
Hydroperiod-Water receding : Limnological Parameters-Physicals	-0.013	0.082	-0.154	0.877	0.032	0.119	0.272	0.785
Hydroperiod-Water rising : Limnological Parameters-Physicals	-0.252	0.099	-2.523	0.012*	-0.195	0.151	-1.296	0.195
	FRESH BIOMASS				**DRY BIOMASS**			
Environment	**Estimate**	**Std. Error**	**t value**	**P value**	**Estimate**	**Std. Error**	**t value**	**P value**
Intercept	258.460	29.920	8.637	<0.0001	480.000	56.664	8.471	<0.0001
Environment-River	-125.080	46.580	-2.686	0.001*	-66.360	88.199	-0.752	0.453
Environment-Stream	-166.150	58.490	-2.841	0.005*	-221.700	110.763	-2.002	0.047*
Limnological Parameters-Biologicals	19.370	30.590	0.633	0.527	17.532	57.919	0.303	0.763
Limnological Parameters-Chemicals	24.210	13.340	1.814	0.071	0.757	25.266	0.299	0.765
Limnological Parameters-Physicals	-39.980	12.990	-3.078	0.002*	-61.571	24.601	-2.503	0.013*
Environment-River : Limnological Parameters-Biologicals	-90.360	51.940	-1.740	0.083	-103.27	98.345	-1.050	0.295
Environment-Stream : Limnological Parameters-Biologicals	-20.610	35.500	-0.581	0.562	-36.269	67.231	-0.539	0.590
Environment-River : Limnological Parameters-Chemicals	-52.430	22.810	-2.299	0.023*	-51.778	43.184	-1.199	0.232
Environment-Stream : Limnological Parameters-Chemicals	-20.750	21.540	-0.963	0.337	-11.976	40.795	-0.294	0.769
Environment-River : Limnological Parameters-Physicals	143.190	26.670	5.368	<0.001*	129.402	50.511	2.562	0.011*
Environment-Stream : Limnological Parameters-Physicals	31.090	30.340	1.024	0.307	55.743	57.460	0.970	0.333
Hydroperiod	**Estimate**	**Std. Error**	**t value**	**Pr(>|z|)**	**Estimate**	**Std. Error**	**t value**	**Pr(>|z|)**
(Intercept)	149.354	46.347	3.223	0.001	447.326	82.707	5.409	<0.0001

Hydroperiod-Flood	-60.540	88.826	-0.682	0.496	-258.440	158.512	-1.630	0.105
Hydroperiod-Water receding	100.312	55.633	1.803	0.073	50.612	99.279	0.510	0.611
Hydroperiod-Water rising	-33.101	56.393	-0.587	0.558	-185.390	100.634	-1.842	0.047
Limnological Parameters-Biologicals	-46.284	52.061	-0.889	0.375	-61.246	92.904	-0.659	0.511
Limnological Parameters-Chemicals	-24.469	27.415	-0.893	0.373	-53.826	48.923	-1.100	0.273
Limnological Parameters-Physicals	10.367	26.725	0.388	0.699	39.270	47.691	0.823	0.411
Hydroperiod-Flood : Limnological Parameters-Biologicals	34.748	57.047	0.609	0.543	40.399	101.802	0.397	0.692
Hydroperiod-Water receding : Limnological Parameters-Biologicals	26.181	57.704	0.454	0.651	0.219	102.975	0.021	0.983
Hydroperiod-Water rising : Limnological Parameters-Biologicals	23.030	59.762	0.385	0.700	50.358	106.647	0.472	0.637
Hydroperiod-Flood : Limnological Parameters-Chemicals	99.820	74.853	1.334	0.184	153.586	133.578	1.150	0.252
Hydroperiod-Water receding : Limnological Parameters-Chemicals	54.353	29.985	1.813	0.042*	93.081	53.510	1.740	0.043*
Hydroperiod-Water rising : Limnological Parameters-Chemicals	167.156	63.535	2.631	0.009*	214.684	113.380	1.893	0.049*
Hydroperiod-Flood : Limnological Parameters-Physicals	3.387	32.414	0.104	0.917	-39.982	57.844	-0.691	0.490
Hydroperiod-Water receding : Limnological Parameters-Physicals	15.359	32.892	0.467	0.641	17.510	58.696	0.298	0.766
Hydroperiod-Water rising : Limnological Parameters-Physicals	-74.448	42.974	-1.732	0.085	-98.097	76.689	-1.279	0.203

Supplemental Table S9. Generalized Linear Mixed Model for comparison of richness, cover, fresh and dry biomass of aquatic macrophytes among in relation to physical, chemical, and biological limnological parameters riverine environments of southern Amazonia. The symbol "*" indicates significant differences ($P < 0.05$)

	Estimate	Std. Error	z value	P value
Richness				
(Intercept)	3220.000	823.00	3.911	<0.001
Depth	21.200	16.200	1.310	0.190
Electrical Conductivity	25.300	6.439	1.370	0.041*
Transparency	35.300	8.390	4.214	<0.001
Air temperature	-36.300	10.300	-3.531	0.001*
Water temperature	54.500	27.600	1.972	0.048*
True color	0.344	2.670	0.129	0.897
Total solids	4.920	7.110	0.691	0.489
Dissolved solids	-78.000	16.200	-4.813	<0.001
Suspended solids	-24.500	16.600	-1.481	0.139
pH	-95.800	76.700	-1.248	0.212
Alkalinity	17.800	28.700	0.622	0.534
BOD	-71.700	41.500	-1.726	0.084
COD	-4.750	5.960	-0.797	0.426
OD	-158.000	36.700	-4.305	<0.001*
Total nitrogen	98.700	55.600	1.775	0.076
Nitrate	-2610.000	686.000	-3.804	<0.001*
Total phosphorus	298.000	323.000	0.921	0.357
Silica	131.000	27.500	4.758	<0.001
Redox potential	0.675	0.731	0.924	0.355
Chloride	-48.500	21.200	-2.284	0.022*
Chlorophyll	-38.200	17.800	-2.141	0.032*
Total coliforms	-0.032	0.025	-1.253	0.210
Escherichia coli	-0.056	0.066	-0.856	0.392
Cover				
(Intercept)	-3730.000	1170.000	-3.196	0.002
Depth	27.800	19.400	1.435	0.153
Electrical Condutivity	35.300	8.390	1.370	0.265
Transparency	-20.800	13.000	-1.598	0.112
Air temperature	27.300	14.400	1.900	0.049*
Water temperature	24.300	39.700	0.613	0.541
True color	1.060	3.060	0.345	0.731
Total solids	83.500	11.300	0.074	0.941
Dissolved solids	34.300	23.400	1.468	0.144

Suspended solids	-4.550	24.100	-0.189	0.850
pH	53.500	96.900	0.552	0.581
Alkalinity	-7.580	36.700	-0.207	0.837
BOD	17.800	56.600	0.314	0.754
COD	10.200	7.860	1.303	0.194
DO	-4.310	50.900	-0.085	0.933
Total nitrogen	-43.900	83.000	-0.529	0.598
Nitrate	-13.900	917.000	-0.015	0.988
Total phosphorus	-921.000	429.000	-2.145	0.033*
Silica	14.500	36.500	0.397	0.692
Redox potential	-0.761	1.010	-0.751	0.454
Chloride	35.900	27.900	1.285	0.201
Chlorophyll	10.200	23.100	0.443	0.658
Total coliforms	0.006	0.015	0.362	0.718
Escherichia coli	-0.014	0.060	-0.229	0.819
Fresh biomass				
(Intercept)	-5590.000	319000.000	-0.175	0.042
Depth	2390.000	6240.000	3.830	0.001*
Electrical Condutivity	635.300	898.390	1.370	0.281
Transparency	-1720.000	3290.000	-0.523	0.601
Air temperature	9400.000	4370.000	2.151	0.033
Water temperature	6200.000	10700.000	0.577	0.565
True color	675.000	923.000	0.731	0.466
Total solids	-1370.000	3040.000	-0.452	0.652
Dissolved solids	1490.000	6940.000	0.215	0.830
Suspended solids	2620.000	6830.000	0.384	0.702
pH	-20000.000	29700.000	-0.671	0.503
Alkalinity	-814.000	11500.000	-0.071	0.944
BOD	-5230.000	16900.000	-0.310	0.757
COD	2220.000	2330.000	0.952	0.343
DO	-10300.000	14900.000	-0.688	0.492
Total nitrogen	2,3500.000	25100.000	0.934	0.352
Nitrate	-479000.000	274000.000	-1.747	0.043*
Total phosphorus	-121000.000	119000.000	-1.017	0.311
Silica	3800.000	10900.000	0.349	0.728
Redox potential	-623.000	311.000	-2.001	0.047*
Chloride	11000.000	8650.000	1.270	0.206
Chlorophyll	3,610.000	6580.000	0.549	0.584
Total coliforms	0.158	486.000	0.033	0.974

Escherichia coli	-12.100	18.300	-0.659	0.511
Dry biomass				
(Intercept)	4480.000	56700.000	0.079	0.048
Depth	4020.000	1110.000	3.626	0.001*
Electrical Condutivity	265.300	8.390	1.370	0.458
Transparency	-182.000	585.000	-0.311	0.757
Air temperature	1930.000	777.000	2.485	0.014*
Water temperature	-557.000	1910.000	-0.292	0.771
True color	98.800	164.000	0.603	0.547
Total solids	-787.000	539.000	-1.459	0.147
Dissolved solids	1070.000	1230.000	0.864	0.389
Suspended solids	1250.000	1210.000	1.028	0.306
pH	-180.000	5280.000	-0.340	0.734
Alkalinity	-3600.000	2050.000	-1.759	0.080
BOD	-3150.000	3000.000	-1.048	0.296
COD	-55.000	414.000	-0.133	0.895
DO	1370.000	2650.000	0.517	0.606
Total nitrogen	3600.000	4470.000	0.805	0.422
Nitrate	-83600.000	48700.000	-1.716	0.042*
Total phosphorus	-4300.000	21100.000	-0.203	0.839
Silica	998.000	194.000	0.515	0.607
Redox potential	-98.100	55.300	-1.775	0.048*
Chloride	1910.000	1540.000	1.245	0.215
Chlorophyll	333.000	1170.000	0.285	0.776
Total coliforms	-0.520	0.864	-0.602	0.548
Escherichia coli	-3.740	325.000	-1.149	0.252

Supplemental Table S10. Generalized Linear Model of the structural characteristics of the surrounding vegetation with richness, cover, dry, and fresh biomass of the aquatic macrophyte community in riverine environments in southern Amazonia. The symbol "*" indicates significant differences (*P* < 0.05)

	Estimate	Std.Error	z value	P value
Richness				
(Intercept)	116.584	157.915	0.738	0.460
Environment-River	126.470	194.077	0.652	0.515
Environment-Stream	1422.114	504.002	2.822	0.005*
Surrounding vegetation-Tree richness	0.045	0.052	0.877	0.381
Surrounding vegetation-Tree abundance	-0.046	0.044	-1.050	0.294
Surrounding vegetation-Tree height	0.231	0.233	0.990	0.322
Environment-River : Surrounding vegetation-Tree richness	0.245	0.129	1.901	0.057
Environment-Stream : Surrounding vegetation-Tree richness	-0.342	0.076	-4.489	<0.0001*
Environment-River : Surrounding vegetation-Tree abundance	-0.170	0.095	-1.794	0.073
Environment-Stream : Surrounding vegetation-Tree abundance	0.181	0.050	3.601	0.001*
Environment-River : Surrounding vegetation-Tree height	-0.292	0.299	-0.974	0.329
Environment-Stream : Surrounding vegetation-Tree height	-160.248	0.541	-2.958	0.003*
Cover				
(Intercept)	-726.352	112.652	-6.448	0.003
Environment-River	376.498	126.445	2.978	0.041*
Environment-Stream	148.623	246.472	4.255	0.013*
Surrounding vegetation-Tree richness	0.051	0.033	1.538	0.198
Surrounding vegetation-Tree abundance	-0.037	0.028	-1.312	0.259
Surrounding vegetation-Tree height	0.939	0.165	5.714	0.005*
Environment-River : Surrounding vegetation-Tree richness	-0.433	0.075	-5.771	0.004*
Environment-Stream : Surrounding vegetation-Tree richness	-0.079	0.044	-1.813	0.144
Environment-River : Surrounding vegetation-Tree abundance	0.292	0.053	5.520	0.005*
Environment-Stream : Surrounding vegetation-Tree abundance	0.034	0.033	1.018	0.366
Environment-River : Surrounding vegetation-Tree height	-0.290	0.198	-1.466	0.216
Environment-Stream : Surrounding vegetation-Tree height	-130.387	0.277	-4.708	0.009*
Fresh Biomass				
(Intercept)	-5131.760	1749.590	-2.933	0.043
Environment-River	3055.920	1948.370	1.568	0.192
Environment-Stream	5430.520	3988.170	1.362	0.245
Surrounding vegetation-Tree richness	27.010	50.680	0.533	0.622
Surrounding vegetation-Tree abundance	-24.690	44.140	-0.559	0.606
Surrounding vegetation-Tree height	804.090	255.940	3.142	0.035*
Environment-River : Surrounding vegetation-Tree richness	-444.600	115.160	-3.861	0.018*

Environment-Stream : Surrounding vegetation-Tree richness	-45.530	69.260	-0.657	0.547
Environment-River : Surrounding vegetation-Tree abundance	334.220	82.000	4.076	0.015*
Environment-Stream : Surrounding vegetation-Tree abundance	31.860	52.150	0.611	0.574
Environment-River : Surrounding vegetation-Tree height	-323.680	303.340	-1.067	0.346
Environment-Stream : Surrounding vegetation-Tree height	-689.640	442.830	-1.557	0.194
Dry Biomass				
(Intercept)	-112.759	319.035	-3.534	0.024
Environment-River	856.954	355.282	2.412	0.073
Environment-Stream	1105.840	727.235	1.521	0.203
Surrounding vegetation-Tree richness	5.237	9.241	0.567	0.601
Surrounding vegetation-Tree abundance	-6.792	8.049	-0.844	0.446
Surrounding vegetation-Tree height	184.201	46.671	3.947	0.017*
Environment-River : Surrounding vegetation-Tree richness	-79.713	21.000	-3.796	0.019*
Environment-Stream : Surrounding vegetation-Tree richness	-7.322	12.629	-0.580	0.593
Environment-River : Surrounding vegetation-Tree abundance	60.405	14.952	4.040	0.016*
Environment-Stream : Surrounding vegetation-Tree abundance	7.827	9.510	0.823	0.457
Environment-River : Surrounding vegetation-Tree height	-99.326	55.313	-1.796	0.147
Environment-Stream : Surrounding vegetation-Tree height	-153.895	80.750	-1.906	0.129

CAPÍTULO III

Composições contrastantes de macrófitas aquáticas nas bacias hidrográficas do sul da Amazônia

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RESUMO

O sul da Amazônia apresenta uma complexidade ambiental que se reflete na alta diversidade de macrófitas aquáticas. Assim, nosso objetivo foi explicar as relações florísticas das macrófitas aquáticas entre bacias hidrográficas no sul da Amazônia, considerando a temporalidade dos ambientes e o tipo de vegetação. A área de estudo apresenta cinco bacias (nível 1), Tapajós, Xingu, Madeira, Araguaia e Alto Paraguai, com sub-bacias (nível 2) e microbacias (nível 3). A partir da lista de espécies produzida para o sul da Amazônia foi realizada uma busca de registros das espécies disponíveis na base de dados *speciesLink* e adicionadas informações de tipo de vegetação e bacia hidrográfica nos três níveis de divisão. As bacias Tapajós e Xingu apresentaram similaridade de 48%, e ambas tiveram 35% de similaridade com Madeira. A bacia do Araguaia apresentou menos de 10% de similaridade com o restante de bacias. A beta diversidade foi aumentando de bacias para microbacias, principalmente por troca/aumento (turnover) (Tapajós, Madeira, e Xingu), e perda (aninhamento) de espécies. Ambientes temporários diminuem a similaridade entre as bacias e dentro delas. Quando incluído o tipo de vegetação estas diferenças se mantem. As bacias hidrográficas da região sul da Amazônia possuem composição de macrófitas aquáticas distintas, com elevada troca de espécies, principalmente relacionados aos ambientes temporários, independentemente ao tipo de vegetação.

Palavras-chave: Bacia Amazônica, transição Cerrado-Amazônia, ambientes temporários

ABSTRACT

The southern Amazonia region presents an environmental complexity reflected in the high diversity of aquatic macrophytes (709 species). Therefore, our objective was to describe the floristic relationships of aquatic macrophytes among watersheds in the southern Amazonia. The study area comprises 5 basins, Tapajos, Xingu, Madeira, Araguaia, and Alto Paraguay (level 1), with sub-basins (level 2) and micro-basins (level 3). A search for species records described for the southern Amazon was conducted on the *speciesLink* platform, and information on vegetation type and watershed was added at three levels of division. The Tapajos and Xingu basins showed a similarity of 48%, and both had a 35% similarity with Madeira. Beta diversity increased from basins to micro-basins, mainly due to turnover (Tapajos, Madeira, and Xingu), and species loss (nesting). The Araguaia basin showed less than 10% similarity with the other basins. Temporary environments decrease similarity between and within basins. When vegetation type was included, these differences persisted. We conclude that the difference in aquatic macrophyte diversity in the southern Amazon basins is related to species turnover/increase, and primarily to the occurrence of species from temporary environments, regardless of vegetation type.

Keywords: Amazon Basin, Cerrado-Amazonia transition, temporary environments

INTRODUÇÃO

A Amazônia, o grande reservatório de água doce do mundo, carrega um dos mais altos níveis conhecidos de diversidade biológica, como mais de 50.000 espécies de plantas vasculares terrestres (Hubbell et al., 2009). Além disso, os ecossistemas de água doce, devido ao seu grande potencial são indicadores de preservação, importantes para manter a biodiversidade aquática global (Murphy et al. 2019). O sul da Amazônia apresenta uma grande extensão de transição entre dois grandes domínios fitogeográficos neotropicais, o Cerrado e Amazônia. Essa região ecotonal apresenta uma diversidade de habitats e tipos de vegetação, desde florestas densas, decíduas ou sempre verdes até formações savânicas (Marimon et al., 2006; Torello-Raventos et al., 2013). Devido à sua complexidade ambiental, a transição Cerrado-Amazônia possui uma elevada riqueza de espécies típicas da Amazônia, mas também compartilhadas com a Floresta Atlântica e o Cerrado (Marimon et al., 2006; Oliveira-Filho et al. 2017).

Estas áreas de ecótonos apresentam ampla oscilação na biodiversidade, assim como uma diferenciação e variação florística e estrutural em resposta às variações ambientais relacionadas à frequência de fogo, umidade do solo, geologia, edáfica e clima (Haidar et al., 2013; Souza & Eisenlohr, 2020). O sul da Amazônia apresenta uma alta biodiversidade de macrófitas aquáticas com mais de 700 espécies (Cordova et al. 2022). A região possui diversos tipos de áreas úmidas naturais, além de reservatórios artificiais associados a grandes hidroelétricas (Junk et al. 2020). Possui cinco grandes bacias hidrográficas, sendo três da região hidrografica Amazônica (Xingu, Tapajós e Madeira), uma da região hidrografica Tocantins-Araguaia e uma da região hidrográfica do Paraguai (IBGE 2014).

Diferentes ecossistemas aquáticos possuem composição, riqueza de espécies e proporções de formas de crescimento distintas, e todos os tipos de áreas úmidas contribuem para a riqueza de macrófitas de uma região (Matias et al. 2021). Na região amazônica, espécies de ambientes permanentes como rios, riachos e igarapés estão amplamente distribuídas no neotrópico, indicando ausência de barreiras para sua dispersão. Por outro lado, espécies de ambientes temporários (campos e campinaranas alagadas) dessas áreas têm distribuição mais restrita à Bacia Amazônica, provavelmente devido à localização desses ecossistemas em manchas isoladas na matriz da floresta amazônica (Lopes et al. 2021). Estudos vêm revelando padrões diferentes de ocorrência entre macrófitas em áreas úmidas, destacando a importância de considerar as diferenças fitoecológicas (relação ambiente e vegetação) (Trindade et al. 2018, Lopes et al. 2021).

As bacias hidrográficas são importantes no fornecimento de água doce, sedimentos, nutrientes e condições ambientais específicas que influenciam diretamente o crescimento e a distribuição das macrófitas. Tais bacias estão diretamente relacionadas ao regime hidrológico associado às variações sazonais, interação entre as chuvas, a topografia e a vegetação, assim como ao transporte de nutrientes e sedimentos (disponibilidade de nutrientes essenciais), à conectividade de hábitats que influencia na dispersão de sementes, esporos e propágulos; e aos impactos humanos (ex. desmatamento, agricultura e mineração) (Fares et al. 2021). O entendimento desses processos e da heterogeneidade ambiental relacionada às bacias é crucial para a conservação e a gestão sustentável desses importantes ecossistemas aquáticos (Nonato et al. 2021, Petri et al. 2023).

Os ecossistemas aquáticos continentais amazônicos estão passando por diversas variações e/ou alterações, diretamente relacionadas às mudanças climáticas, associadas a ações antrópicas afetando entre outros aspectos, os regimes de chuva que determinam a manutenção/criação de ambientes e/ou ecossistemas aquáticos, o que promove ou limita a ocorrência de macrófitas aquáticas, principalmente anfíbias e emergentes (Fares et al. 2020, Bomfim et al. 2023). Assim diferentes aspectos das comunidades de macrófitas (p.e. riqueza de espécies, composição, diversidade de formas de vida, etc.) devem ser considerados em estudos para preservação da Amazônia. (Fares et al. 2020, Vieira et al. 2023). Nesse sentido, ambientes degradados, em áreas com maior presença antrópica pode favorecer a ocorrência de diversas espécies e forma de vida de macrófitas aquáticas na Amazônia (Fares et al. 2021, Carmo et al. 2023).

No caso do sul da Amazônia, para plantas lenhosas, a variação florística é influenciada pelo ambiente, correspondendo a uma heterogeneidade ambiental relacionada principalmente à umidade do solo (Marques et al. 2020, Souza & Eisenlohr, 2020, Cupertino-Eisenlohr et al. 2021). No entanto, poucos trabalhos levantaram esses dados para ervas, sendo a maioria dos casos focados na Amazonia Central (Lopes et al. 2021). Por outro lado, em áreas de transição como o sul da Amazônia, a heterogeneidade ambiental está associada a confluência de diferentes bacias hidrográficas, inclusive aquelas de origem extra amazônica. A bacia do Xingu foi considerada como a mais representativa da diversidade dessa transição pela grande influência da região hidrografica do Araguaia-Tocantins (Marimon et al. 2006). Nesse sentido, nosso estudo pretende explicar as relações florísticas das macrófitas aquáticas entre as bacias hidrográficas do sul da Amazônia, considerando a temporalidade ou permanência dos ambientes aquáticos e do tipo de formação vegetal. Além disso, ao dividir as bacias em sub-bacias e microbacias esperamos encontrar diferenças na diversidade de macrófitas aquáticas. Esperamos que a temporalidade dos ambientes seja um fator determinante na ocorrência e diferenças florsiticas nas bacias hidrográficas, já que variações ambientais influenciam diretamente na ocorrência de espécies, inclusive em ambientes conectados (Cordova et al. 2023) independentemente do tipo de formação vegetal.

MATERIAL E MÉTODOS

Área de estudo

No Centro do Brasil o estado de Mato Grosso destaca-se por apresentar três domínios fitogeográficos (Amazônia, Cerrado e Pantanal), e uma flora diversa com grande potencial socioeconômico ambiental. No sul da Amazônia, norte de Mato Grosso, está a Floresta de Transição, a Floresta Estacional Perenifólia ou Floresta Estacional da borda sul-amazônica (Ivanauskas et al., 2004; Kunz et al., 2008), além de Campinaranas arbustivas e florestadas (Zappi et al, 2013, 2016). Situada em uma área de tensão ecológica entre o Cerrado e Amazônia (Marques et al. 2020), a região forma complexos mosaicos vegetacionais marcados por ecótonos e enclaves, tornando complicada a delimitação dos domínios fitogeográficos, e influenciando na circulação da biodiversidade (Morandi et al., 2016). A região é cortada por grandes rios e protegidas em áreas de preservação, como o Parque Estadual do Cristalino, a Estação Ecológica do Rio Ronuro, o Parque Estadual do Xingu entre outras. Na região norte, os rios Teles Pires e Juruena formam o grande rio Tapajós (Bacia do Tapajós), e conjuntamente com as bacias dos rios Xingu e Madeiras fazem parte da região hidrografica Amazônica. Além disso, apresenta porções da bacia do rio Alto Paraguai (região hidrográfica do rio Paraguai) e o rio Araguaia (região hidrografica Araguaia-Tocantins) (Figura 1).

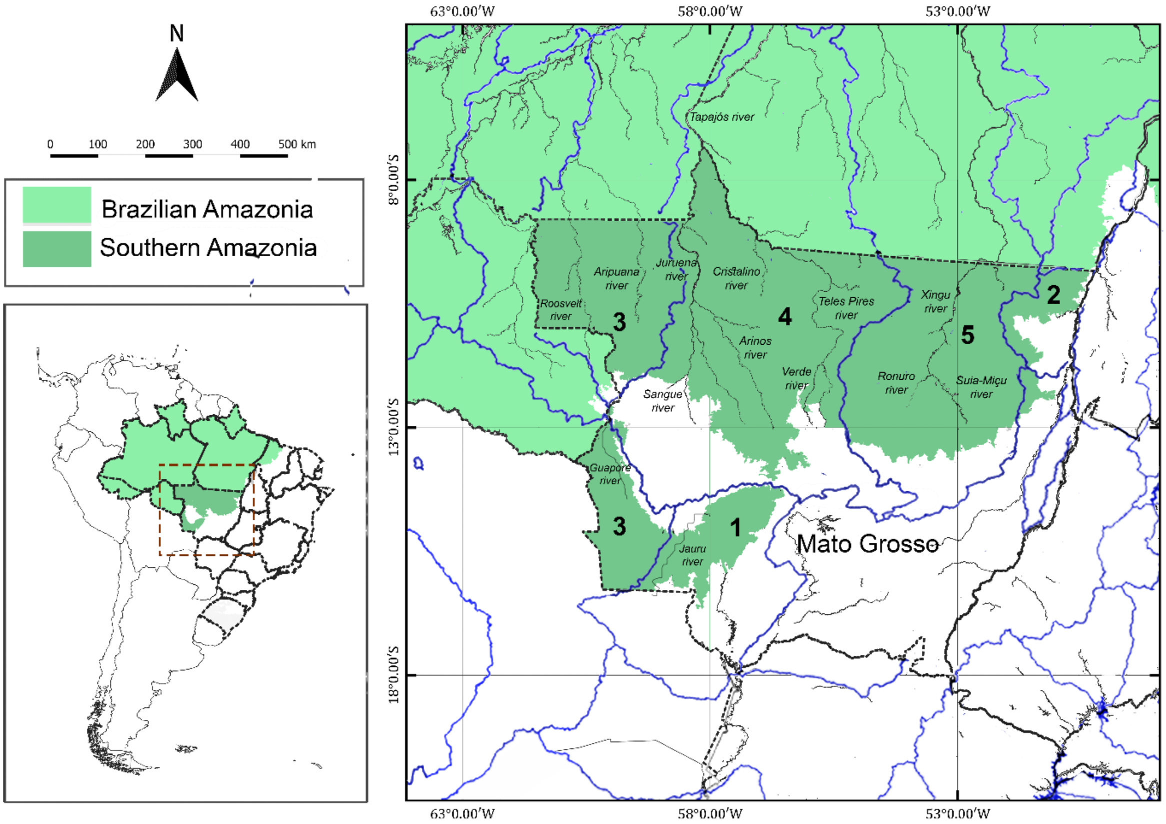

Figura 1. Área de estudo. Sul da Amazônia, Estado de Mato Grosso, Brasil. Linhas azuis limitam as bacias hidrográficas: 1. Alto Paraguai, 2. Araguaia, 3. Madeira, 4. Tapajós, 5. Xingu.

Coleta de dados

Para a construção do banco de dados utilizamos o conceito de macrófitas aquáticas sugerido pelo International Program of Biology (IBP), onde "macrófita aquática" é a denominação genérica (independentemente de aspectos taxonômicos) mais adequada para vegetais que habitam desde brejos até ambientes verdadeiramente aquáticos (Esteves, 1988).

Coleta em banco de dados

Para construção da lista de espécies aquáticas foi utilizada a lista de Cordova et al. (2022), Adicionalmente foram incorporados espécies e registros de coletas realizadas durante coletas de campo de 2015 a 2023 nas bacias amazônicas, Tapajós (Teles Pires, Cristalino, Juruena) e Xingu (Xingu e Ronuro), e Alto Paraguai (Rio Jauru) em diferentes épocas e períodos hidrológicos (seca, enchente, vazante e cheia). Identificamos as espécies consultando a literatura, taxonomistas e coleções de herbários. Os espécimes foram incorporados no acervo do Herbário Centro-Norte-Mato-Grossense (CNMT) do Acervo Biológico da Amazônia Meridional (ABAM) da Universidade Federal de Mato Grosso (Campus Sinop). Essa lista resultou em 20 espécies a mais da citadas por Córdova et al. 2022, contabilizado 729 espécies. Com a lista de espécies gerada buscamos outros registros georreferenciados de herbários disponíveis no *speciesLink* ((https://specieslink.net); outros bancos de dados como JABOT e GBIF não foram considerados por terem registros em outras coleções (duplicatas) disponíveis no *specieslink*. Além disso, outros registros dessas bases de dados foram excluídos por carecer de informações geográficas. Para ambas usamos os filtros "Pais: Brasil", "Estado: Mato Grosso" e "Tipo de Coleção: Botânica" e "Base de registro: Espécime preservado". Foi gerada uma planilha mesclada das bases de dados totalizando 9827 registros, contendo os registros com os nomes das espécies, localidades, coletores, número de coletor e coordenadas geográficas.

Processamento de dados

Foram considerados registros com identificação confirmada em nível de espécie por taxonomistas especialistas. Os demais registros na medida do possível, foram verificados consultando fichas de herbário e imagens disponíveis ou solicitadas aos herbários. O processamento do banco de dados foi realizado por etapas: (1) verificação da nomenclatura dos registros para descartar sinônimos, mantendo somente nomes científicos corretos e aceitos segundo a Lista de Espécies da Flora e Funga do Brasil, conferidos utilizando o pacote flora (Carvalho 2020) do R; (2) exclusão de registros duplicados, baseado principalmente no número de coletor quando presente, e na data e lugar de coleta no restante dos casos; (3) adição de coordenadas de registros não georreferenciados baseado na descrição do local de coleta usando o Google Maps; os registros sem essas informações foram excluídos; (4) foram incluídas as subespécies e variedades dentro da respectiva espécie; e (5) a descrição do local de coleta principalmente do ambiente (p.e: margem de rio, riacho, campo, lagoa, etc.), e vegetação (p.e. campinarana, floresta ciliar, floresta de galeria, etc.) foi útil para selecionar registros. As coordenadas geográficas foram verificadas na plataforma R através do pacote CoordinateCleaner função *clean_coordinates* (R version 3.6.2, Zizka et al. 2019); registros com problemas nas coordenadas foram corrigidas quando possível. Utilizamos coordenadas geográficas para circunscrever as bases de dados e registros de campo na Amazônia mato-grossense com auxílio do software QGIS 3.18.3 (Q-Gis.org 2020), de acordo com a delimitação dos domínios fitogeográficos brasileiros (IBGE 2010), excluindo registros de outros domínios fitogeográficos do estado (Cerrado e Pantanal).

Ao final obtivemos banco de dados com 729 espécies e 4953 ocorrências. A lista de espécies seguiu a classificação de famílias proposta pelo Angiosperm Phylogeny Group (APG IV 2016) para as angiospermas, Pteridophyte Phylogeny Group (PPG I 2016) para as samambaias e licófitas, e Goffinet e Buck (2004) para as briófitas. A classificação das formas de vida das espécies aquáticas seguiu Irgang e Gastal (1996) e Piedade et al. (2018), que é um esquema de classificação que incorpora a profundidade da água e o zoneamento horizontal das espécies dentro do ecossistema. Classificamos os ambientes em temporários (campo alagável, campinarana alagada, corredeira, etc.) e permanentes (rio, riacho, lagoa, etc.); e os tipos de vegetação utilizando a classificação no Flora e Funga do Brasil (Campinarana, Campo de Várzea, Floresta de Igapó, Floresta de Várzea, Campo limpo, Floresta Ciliar, Floresta de Galeria, Vegetação aquática e Vegetação sobre afloramentos rochosos). Obtivemos informações sobre domínio fitogeográfico do Flora e Funga do Brasil 2020.

Para classificar as divisões das bacias, usamos a estrutura HydroBASINS (www.hydrosheds.org/page/hydrobasins), um subconjunto do banco de dados HydroSHEDS. As sub-bacias HydroBASINS correspondem a um conjunto de camadas de polígonos vetorizados construídos com modelo digital de elevação, oferecendo 12 divisões de sub-bacias globais hierarquicamente aninhadas (Lehner & Grill 2013). Para padronizar na medida do possível o tamanho das sub bacias, combinamos três diferentes níveis de HydroBASINS para reter apenas sub-bacias maiores que 1.000 km^2 (Oberdorff et al. 2019). No nível 1 então as bacias Madeira, Tapajós, Xingu, Araguaia e Alto Paraguai, no nível 2 as bacias subdividas em sub-bacias, p.e. Teles Pires e Juruena dentro das bacias do Tapajós e o nível 3 as sub-bacias divididas em microbacias (p.e. Alto Teles Pires e Baixo Teles Pires dentro da sub-bacia do Teles Pires) (Tabela 1). Todas as etapas desta fase foram realizadas utilizando o software QGIS 3.18.3 (Q-Gis.org 2022).

Tabela 1. Bacias hidrográficas em suas divisões em três níveis segundo o HydroBasin no sul da Amazônia. A terminologia foi adaptada para facilitar e simplificar o uso e relações entre elas.

Bacia (Nível 1)	Sub-bacia (Nível 2)	Microbacia (Nível 3)
Região Hidrográfica Amazônica		
Rio Tapajós	Tapajós 1 - Rio Teles Pires – T1	T1.1; T1.2; T1.3
	Tapajós 2 - Rio Juruena - T2	T2.1; T2.2; T2.3; T2.4
Rio Xingu	Xingu 1 -Nascentes do Xingu – X1	X1.1; X1.2; X1.3; X1.4

	Xingu 2 - Alto Xingu – X2	X2.1
Rio Madeira	Madeira 1 – Aripuanã – M1	M1.1
Região Hidrográfica Araguaia-Tocantins		
Rio Araguaia	Araguaia 1 - Araguaia-Bananal – A1	A1.1; A1.2
Região Hidrográfica Paraguai		
Alto Paraguai	Alto Paraguai 1 - Jauru - AP1	AP1.1
	Alto Paraguai 2 – Paraguai – AP2	AP2.1; AP2.2

Análises de dados

Foram elaborados Perfis de Diversidade e Serie de Hill para comparar o nível 1 das bacias usando a função *renyi* do pacote *tidyverse* (Wickham et al. 2019). OS números de Hill permitem calcular a diversidade atribuindo pesos diferentes de acordo com a riqueza de espécies, já que cada abundância é elevada a um fator q proporcional à equabilidade. Foi realizada uma Análise de Cluster baseado na matriz de Similaridade de Simpson e o método UPGMA, por serem os mais adequados já que os dados são provenientes de diferentes amostragem e coletas, utilizando uma matriz de presença e ausência das espécies por bacias e sub-bacias (nível 1 e 2), com as funções *recluster.cons* e *recluster.boot* do pacote *recluster* (Dapporto et al., 2020). Além disso foi realizada uma Análise de Coordenadas Principais (PCoA) baseado em Similaridade de Simpson utilizando a ausência e presença de espécies pelo nível 3 das bacias e tipo de vegetação usando a funções *prcomp*, *vegdist*, e *cmdscale* do pacote *vegan* (Oksanen et al., 2022). O mesmo procedimento foi usado considerando o tipo de ambiente (temporário e permanente). Essa mesma matriz foi usada para determinar as espécies indicadoras de cada bacia, usando a matriz do nível 3, por médio do Indice de Espécies Indicadoras (IndVal) usando as funções do pacote *indicspecies*, *multipatt* (Dufrêne & Legendre, 1997), o argumento *r.g* foi utilizado para correção de amostras de diferentes tamanhos (Tichý and Chytrý 2006).

Foram utilizados o particionamento de diversidade beta de espécies proposto por Baselga (2010) e o particionamento de diversidade beta funcional desenvolvido por Villéger (2013) . Cada abordagem foi baseada em três coeficientes de dissimilaridade diferentes para vários locais: (1) coeficiente de Sørensen, uma medida da diversidade beta geral, (2) coeficiente de Simpson, uma medida de rotatividade sem influência das diferenças de riqueza, e (3) coeficiente de aninhamento, medindo aninhamento resultante de diferenças de riqueza (Baselga, 2010 ; Legendre, 2014).Para isso usamos as funções *beta.multi* e *beta.pair* do pacote *tidyverse* (Wickham et al. 2019) com as matrizes dos níveis 1, 2 e 3 (bacia, sub-bacias e microbacia). A presença e ausência de espécies foi organizada em uma matriz em intervalos de 1 grau para verificar a relação de riqueza de espécies com a latitude e longitude usando uma regressão linear simples, usando a função *lm* do pacote *vegan* (Oksanen et al., 2022). Todas as análises estatísticas foram realizadas na plataforma R (R version 4.3.2). Para evidenciar as áreas do sul da Amazônia com maior número de amostragens e com maiores lacunas de conhecimento foi construído um mapa de densidade de Kernel utilizando os registros de ocorrência com raio de influência de 25 km projetados sobre pixel de resolução (Q-Gis.org 2022)

RESULTADOS

Foi gerado um banco de dados de 4953 registros georrefenciados. Foram catalogadas 729 espécies de macrófitas aquáticas (5 briófitas, 33 samambaias e licófitas e 691 angiospermas), pertencentes a 299 gêneros (2 briófitas, 19 samambaias e licófitas, e 280 angiospermas) e 95 famílias (1 briófita, 13 samambaias e licófitas e 81 angiospermas). Na bacia do rio Tapajós ocorreram 75% (547 spp.) de todas as espécies registradas para o sul da Amazônia, seguida de Xingu (62%, 457 spp.), Madeira (45%, 332 spp.), Alto Paraguai (18%, 134) e Araguaia (7%, 48 spp.). Nesse sentido, Tapajós apresentou um maior número de espécies exclusivas (241 spp.), seguido por Xingu (39 spp.), Madeira (31 spp.), Alto Paraguai (14 spp.) e Araguaia (12 spp.). Além disso, Tapajós foi área com maior número de registros (67%). Os perfis de diversidade mostram que a diversidade pro bacia hidrografica são pouco comparáveis, inclusive ao aumentar os valores de q nos números de Hill (Figura 2).

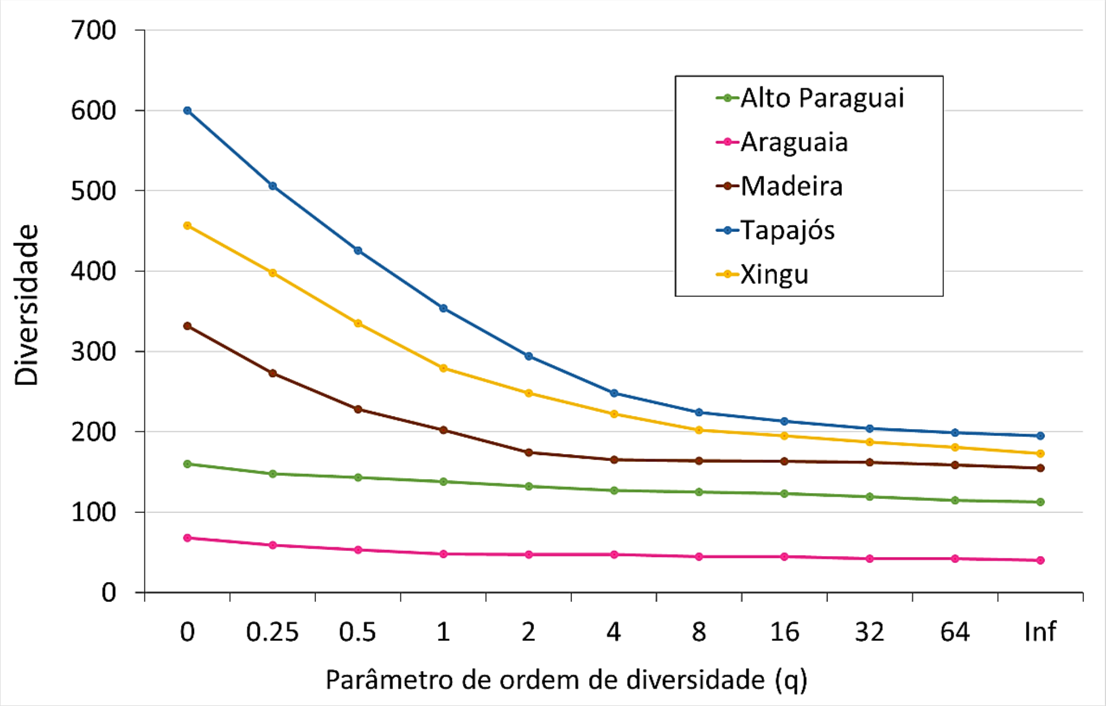

Figura 2. Serie de Hill e Perfis de Diversidade de macrófitas aquáticas por bacias hidrográficas (nível 1) no sul da Amazônia.

Em relação a distribuição geográfica, o maior número de espécies em cada sub-bacia ocorre tanto no domínio Cerrado como Amazônia (<50%). O Alto Paraguai, Xingu e Araguaia apresentou maior número de espécies com distribuição restrita ao Cerrado, 20, 27 e 39% respectivamente. Já a bacia do Tapajós e a do Madeira apresentaram as maiores percentagens de espécies restritas a Amazônia, 25 e 23% respectivamente.

Comparando a similaridade florística (Indice de Simpson) entre as bacias de nível 1, Tapajós e Xingu apresentaram uma similaridade de 48%, e ambas 35% de similaridade com Madeira. A bacia do Araguaia apresentou menos de 10% de similaridade com o restante de bacias (Figura 3).

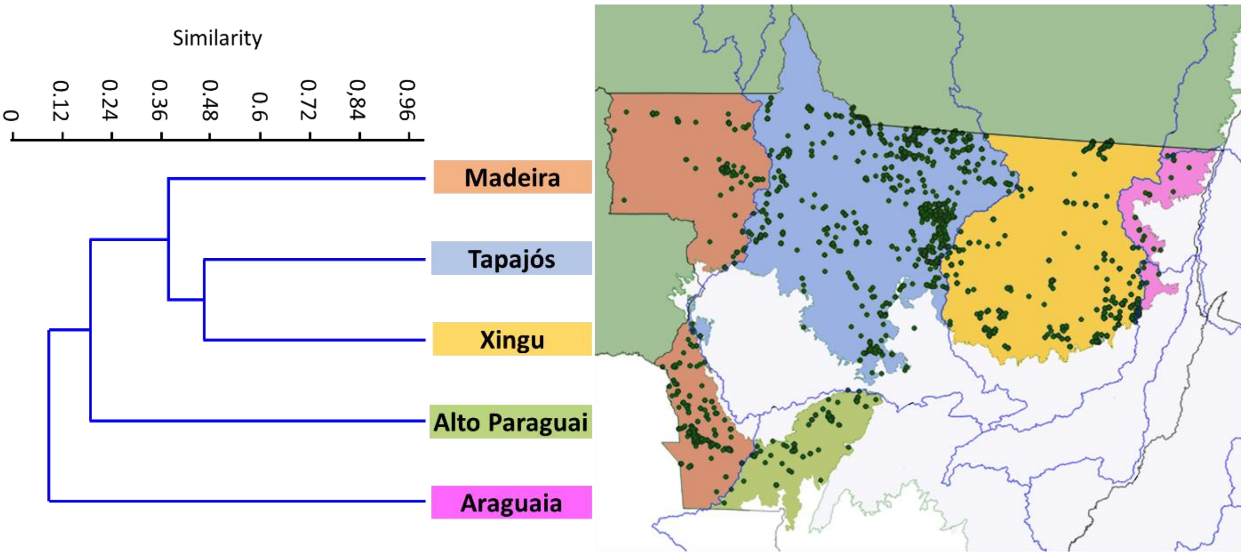

Figura 3. Análise de Agrupamento baseado na similaridade de Simpson de macrófitas aquáticas por bacias hidrográficas (Nível 1) no sul da Amazônia.

Considerando o nível 2 de bacias hidrográficas, as sub-bacias de Tapajós e Xingu continuam relacionadas, principalmente a Tapajós 1 e Xingu 1, e estas com a bacia Madeira 1. As diferenças ficaram maiores quando a bacias foram divididas em um segundo nível, o que mostra que existem espécies e/ou comunidades com ocorrência mais restrita a pequenas áreas. Além disso, ficou mais clara a relação entre as bacias da região amazônica (Figura 4).

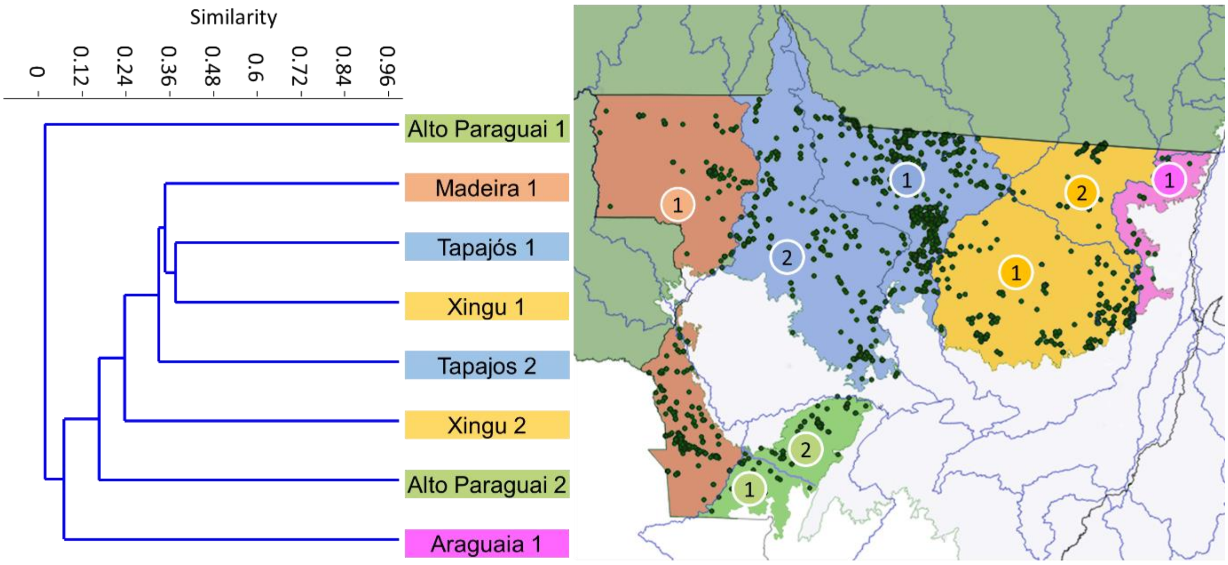

Figura 4. Análise de Agrupamento baseado na similaridade de Simpson de macrófitas aquáticas por sub-bacias hidrográficas (Nível 2) no sul da Amazônia

A beta diversidade nos diferentes níveis, bacias, sub-bacias e microbacias, mostrando uma alta diferença na composição de espécies (>70%) que se se intensifica quando dividida em sub-bacias e microbacias. Assim a diversidade beta total foi aumentando quanto maior era o nível de divisão das bacias. Por outro lado, ou aumento/troca (*turnover*) e diminuição (aninhamento) de espécies influenciaram de maneira diferente em cada nível. Nesse sentido, o *turnover* foi responsável pela alta diversidade beta em todos os níveis, sendo menos evidente nas bacias (0,4) e mais evidente nas microbacias (0,8) (Tabela 2). A diversidade beta reforça o fato que quanto mais analisamos as bacias em níveis menores mais diferenças podemos encontrar principalmente geradas por aumento/troca de espécies.

Tabela 2. Componentes da beta diversidade de macrófitas aquáticas entre bacias, sub-bacias e microbacias no sul da Amazônia. **Total:** Indice de Sorensen, **Turnover:** Indice de Simpson, **Aninhamento:** Diferença ente Sorensen e Simpson

	Total	**Turnover**	**Aninhamento**
Bacias	0.712	0.419	0.293
Sub-bacias	0.797	0.589	0.207
Microbacias	0.914	0.822	0.093

Analisando os componentes da diversidade beta par a par em cada nível das bacias (Figura 4), podemos observar como a Bacia do Araguaia mostrou uma perda de espécies em relação às outras bacias da região Amazônica (Tapajós, Xingu e Madeira) e uma troca de espécies com a bacia do Alto Paraguai. Quando comparadas as sub-bacias, observamos que o Alto Paraguai 1 apresentou a maior diversidade beta, principalmente por diminuição de espécies quando compradas com o restante de sub-bacias, à excepção da Araguaia 1 devido ao aumento/troca de espécies. Porém, de maneira geral o maior aporte para a diferença na diversidade beta foi turnover principalmente entre Xingu 2 com as sub-bacias do Tapajós e Madeira.

Esse fato também pode ser observado quando comparadas as microbacias, onde o turnover se destaca na diferença de diversidade entre as microbacias, principalmente as do Alto Paraguai e Araguaia que não fazem parte da região hidrográfica Amazônica. Além disso, podemos observar esse fato nas comparações das microbacias do Tapajós e Xingu (Figura 5).

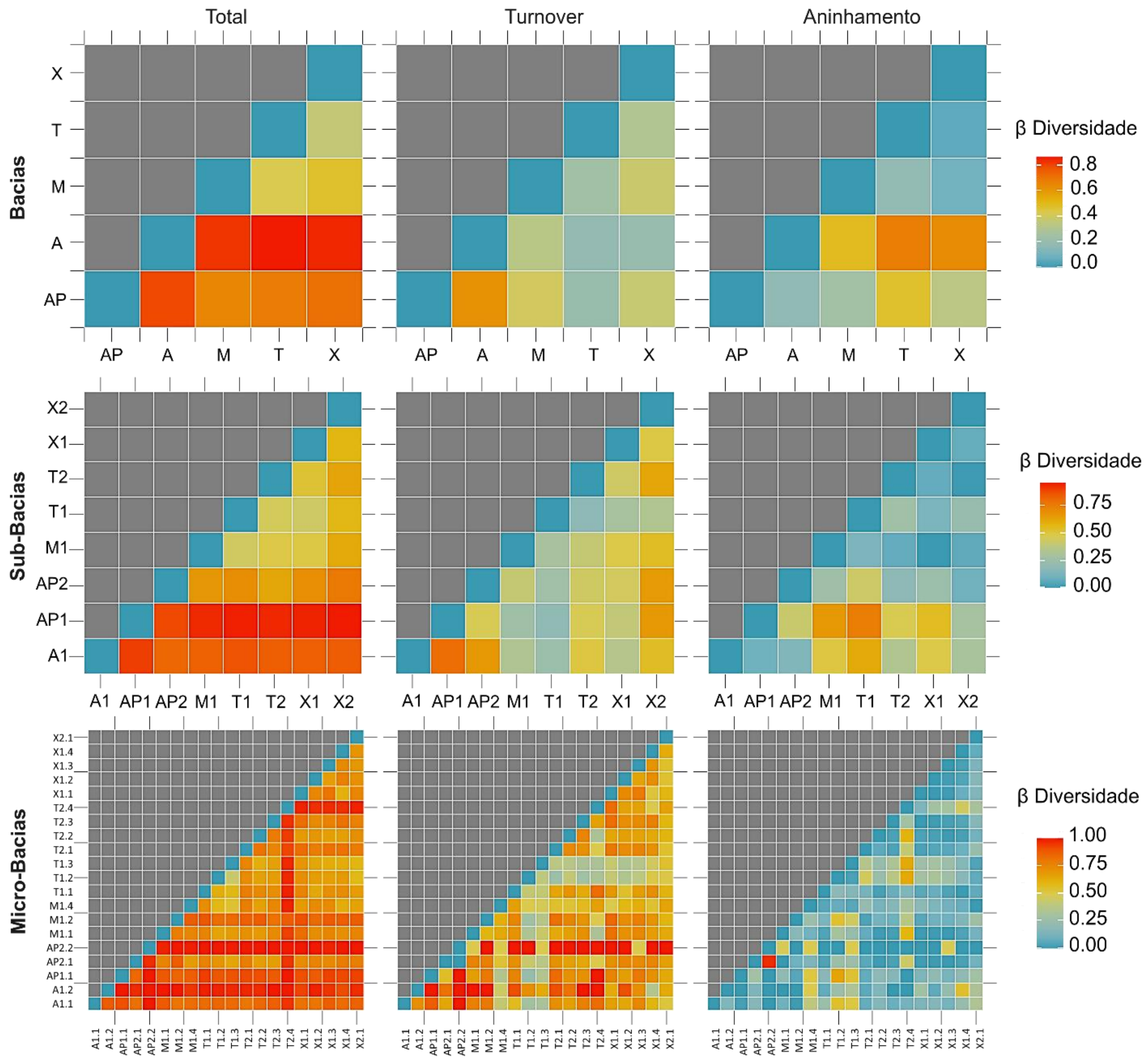

Figura 5. Componentes da beta (β) diversidade de macrófitas aquáticas entre bacias, sub-bacias e microbacias no sul da Amazônia. A: Araguaia, AP: Alto Paraguai, M: Madeira, T: Tapajós, X: Xingu.

Quando comparadas as bacias hidrográficas (nível 1) em relação ao tipo de ambiente, as macrófitas aquáticas mostraram um padrão característico. A ordenação multivariada (PCoA) mostrou que ambientes temporários tendem a mostrar maiores diferenças na composição de macrófitas aquáticas das bacias hidrográficas, já ambientes permanentes mostram um panorama contrário aumentando a similaridade entre as microbacias (nível 3) principalmente amazônicas (Tapajós, Madeira e Xingu) (Figura 6).

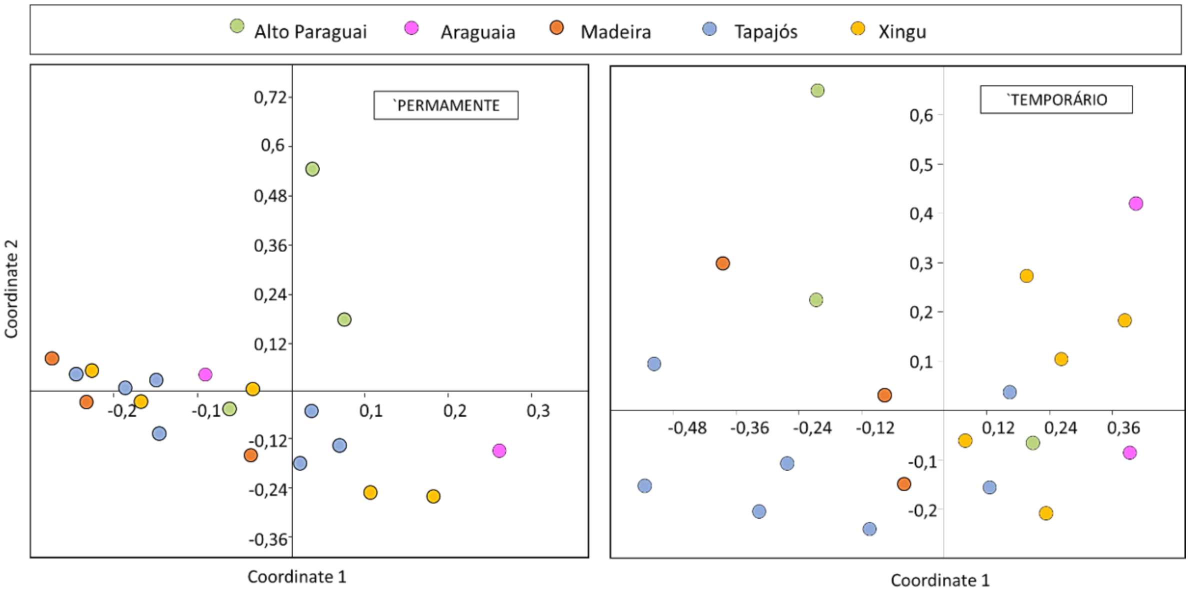

Figura 6. Análise de Coordenadas Principais- PCoA baseado na Similaridade de Simpson para macrófitas aquáticas por bacias hidrográficas considerando o tipo de ambiente, permanente (direita) e temporário (esquerda).

A ocorrência de espécies em ambientes temporários também mostrou diferenças dentro de cada bacia, demonstrando a importância dos ambientes aquáticos temporários na diversidade de macrófitas aquáticas (Figura 6). Nesse sentido, índice de espécies indicadoras de cada bacia mostrou que a maioria são próprias de ambientes temporários (50%) seguidas de permanentes (31%) e ambos os tipos (19%). Além disso, diferentes espécies de Podostemaceae (*Apinagia* spp, *Mourera* spp., *Lophogyne* spp.) aparecem como indicadoras de diferentes bacias, sendo que apresentam o mesmo ambiente em comum, as corredeiras (Tabela 3).

Tabela 3. Macrófitas aquáticas indicadoras para bacias hidrográficas no sul da Amazônia (Análise de especies indicadoras (IndVal). O símbolo “x” representa o índice de significância ao nível de significância de 95% (P < 0,05). AP: Alto Paraguai, A: Araguaia, M: Madeira, T: Tapajós, X: Xingu.

Espécie	AP	A	M	T	X	Tipo de ambiente
Abolboda poarchon					x	Temporário
Apinagia fluitans				x		Temporário
Apinagia membranacea					x	Temporário

Apinagia richardiana			x			Temporário
Azolla filiculoides				x		Permanente
Bacopa australis					x	Temporário
Bacopa caroliniana				x		Temporário/Permanente
Bacopa cochlearia					x	Temporário
Bacopa monnierioides	x					Temporário
Bacopa myriophylloides					x	Temporário
Bacopa stricta				x		Temporário
Borreria palustris				x		Temporário
Bulboltylis capillaris					x	Temporário
Cabomba caroliniana			x			Permanente
Cabomba haynesii					x	Temporário
Castelnavia pendulosa			x			Permanente
Ceratopteris thalictroides				x		Temporário/Permanente
Cuphea sessiliflora					x	Permanente
Cyclanthera carthagenensis				x		Permanente
Cyclanthera hystrix					x	Temporário/Permanente
Cyperus cornelii-ostenii					x	Temporário/Permanente
Cyperus giganteus	x					Temporário/Permanente
Drosera communis			x			Temporário
Echinodorus floribundus				x		Temporário
Echinodorus glaucus				x		Permanente
Echinodorus trialatus			x			Permanente
Egeria densa			x			Temporário
Eriocaulon altogibbosum				x		Temporário
Eriocaulon gibbosum			x			Temporário
Fimbristylis autumnalis					x	Permanente
Heteranthera multiflora					x	Permanente
Heteranthera zosterifolia			x			Temporário/Permanente
Hydrocleys parviflora	x					Temporário
Hydrolea elatior	x					Temporário/Permanente
Hyptis paludosa	x					Permanente
Ipomoea philomega				x		Permanente
Ipomoea subrevoluta					x	Temporário
Limnocharis flava				x		Temporário
Lindernia rotundifolia				x		Temporário
Lophogyne aripuanensis			x			Permanente
Ludwigia caparosa					x	Temporário
Ludwigia helminthorrhiza			x			Temporário
Ludwigia irwinii	x					Temporário
Ludwigia myrtifolia		x				Temporário
Ludwigia torulosa				x		Temporário/Permanente
Luziola bahiensis	x					Temporário
Mayaca longipes			x			Temporário
Mimosa sonnians					x	Temporário

Mourera weddeliana				x		Permanente
Myriophyllum mattogrossensis				x		Temporário
Noterophila crassipes					x	Permanente
Nymphaea gardneriana				x		Permanente
Nymphaea oxypetala			x			Temporário/Permanente
Polygonum hydropiperoides				x		Temporário
Potamogeton illinoensis			x			Temporário/Permanente
Rhynchospora emaciata				x		Temporário/Permanente
Rhynchospora hirta		x				Permanente
Ricciocarpos natans				x		Permanente
Salpinga secunda				x		Permanente
Salvinia biloba	x					Permanente
Spathiphyllum gartnerii				x		Temporário
Sphagnum subsecundum			x			Permanente
Sphenoclea zeylanica				x		Temporário/Permanente
Tassadia berteroana				x		Temporário/Permanente
Utricularia hydrocarpa					x	Temporário
Utricularia nigrescens			x			Temporário
Utricularia pusila					x	Permanente
Xanthosoma striatipes					x	Temporário
Xyris tortula					x	Temporário

Quando incluímos o tipo de vegetação na comparação entre bacias hidrográficas pudemos evidenciar algumas diferenças florísticas, principalmente naquelas de maior área como Xingu e Tapajós. Além disso é evidente a diferença florística dentro da bacia, sendo que cada tipo de vegetação apresenta suas particularidades independentes. Isso reforça que apesar de serem os mesmos tipos de formações vegetais a diversidade de espécies de macrófitas aquáticas são diferentes entre as bacias (Figura 7).

O registro e ocorrência de macrófitas aquáticas ainda apresenta lacunas no sul da Amazônia. Nesse sentido, existe uma relação positiva ($r^2 = 0,77$; $P = 0,012$) entre número de espécies e latitude, sendo que menores latitudes apresentam maior riqueza. Apesar das grandes bacias hidrográficas apresentam maior registros de coletas (Xingu e Tapajós) a maioria se concentra em formações florestais, como Florestas Ciliares e Floresta de Galeria e em campos alagáveis devido ao melhor acesso a essas áreas. Porém, a grande área da bacia do rio Madeira ainda apresenta lacunas evidentes que podem aumentam a distribuição, diversidade e ocorrência das macrófitas aquáticas no sul da Amazônia (Figura 8).

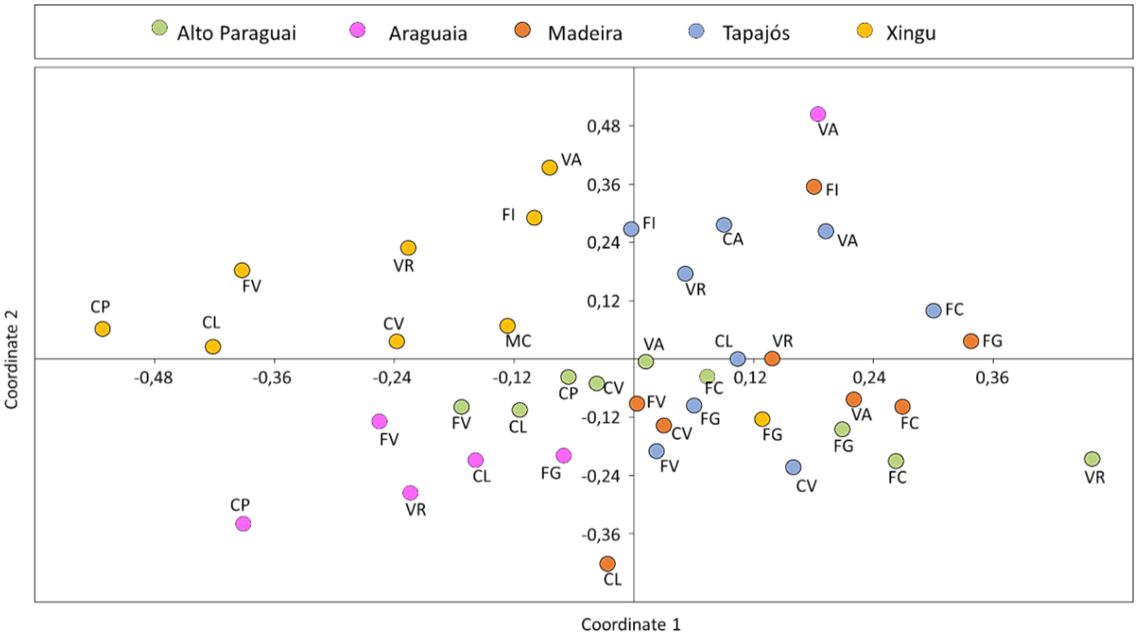

Figura 7. Análise de Coordenadas Principais- PCoA baseado na Similaridade de Simpson para macrófitas aquáticas por bacias hidrográficas considerando o tipo de vegetação. CP: Campinarana gramíneo-arbustiva, CL: campo alagável, CV: campo de várzea, FI: Floresta de igapó, FV: Floresta de Várzea, FC: Floresta Ciliar, FG: Floresta de Galeria, VA: Vegetação aquática, VR: Vegetação sobre afloramentos rochosos.

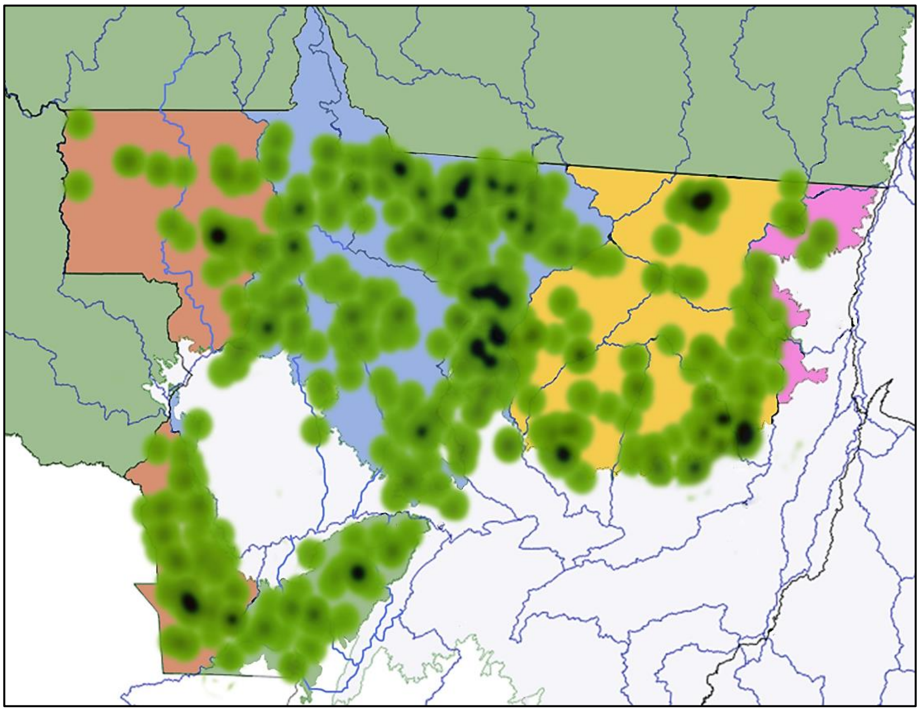

Figura 8. Mapa de Densidade de Kernel para registros de macrófitas aquáticas no sul da Amazônia. Áreas mais escuras indicam maior intensidade de ocorrência.

DISCUSSÃO

Este estudo contribuiu para a avaliação das macrófitas aquáticas na Amazônia, especialmente em regiões mais degradadas, como o arco de desmatamento (Fares et al 2021). A diversidade taxonômica encontrada a partir dos registros de macrófitas aquáticas no sul da Amazonia, e sua ocorrência em relação às bacias hidrográficas evidenciam o esperado para a região, relacionado à variedade de habitats (Piedade et al. 2016, Moura-Junior et al 2018, Córdova et al. 2023). A inclusão de bacias hidrográficas como fator importante na ocorrência de macrófitas aquáticas, deriva da localização da área de estudo, a qual apresenta áreas fora da Região Hidrográfica Amazônica (Bacia Amazônica) (IBGE 2014). Essas áreas fazem parte de grandes bacias relacionadas a outros domínios fitogeográficos brasileiros como Pantanal (Região Hidrográfica do Paraguai) e do Cerrado (Região Hidrográfica Araguaia-Tocantins). Assim, sua alta diversidade está relacionada a influência do contato com esses domínios, já que áreas de transição (ecótonos) representam áreas importantes de diversidade de macrófitas aquáticas, principalmente na região amazônica (Murphy et al. 2019).

As bacias hidrográficas no sul da Amazônia mostram diferenças florísticas de maior a menor escala, sendo que aumenta com a divisão das bacias em sub-bacias e microbacias. Assim, a relação florística com maior similaridade foi encontrada nas bacias do Xingue e Tapajós com maiores extensões no sul da Amazônia. Apesar disso, a divisão em sub-bacias ainda mostrou as diferenças por região hidrográfica (Amazônica, Paraguai e Araguaia-Tocantins). Nesse sentido foi possível observar que as bacias do alto Paraguai e do Araguaia consolidam suas diferenças nas menores escalas (sub-bacias e microbacias), comparadas com as bacias da região amazônica, demonstrando a importância da heterogeneidade e especificidade dos ambientes em escalas menores que pode levar a diferenças florísticas (Roleèek et al. 2007, Mori et al. 2021, Fu et al. 2023).

A heterogeneidade ambiental foi mais relacionada com a presença de ambientes temporários que favorecem as diferenças florísticas nas bacias hidrográficas, aumentando a diversidade de macrófitas aquáticas no sul da Amazônia. As espécies desses ambientes requerem condições temporais ambientais especificas, principalmente relacionadas aos períodos de chuva, quando eles se formam, como lagoas temporárias, ambientes alagados, afloramentos rochosos e arenosos, que na época da seca permanecem úmidos). Nesses ambientes temporários as formas de vida das espécies são majoritariamente emergentes e submersas de rápido desenvolvimento, que se adaptam em relação aos ciclos hidrológicos e nível da água das áreas úmidas (Piedade et al. 2018, Lindholm et al. 2020, Vieira et al. 2023). Por exemplo, em ambientes ribeirinhos nos períodos de seca ocorre substituição de espécies e de formas de vida (Córdova et al. 2023). Padrão semelhante pode ser encontrados nesses ambientes em condições de degradação, os quais experimentam mudança na umidade do solo por interferência humana independentemente da pluviosidade (Carmo et al. 2023, Fares et al 2021).

Ambientes permanentes como riachos, rios e igarapés, tendem a ter maior similaridade devido à sua ampla distribuição na região, já vegetação em ambientes temporários como campos e campinarana alagadas tendem a estar mais restritas e com diversidade mais restrita por causa das suas ocorrências limitadas à ocorrência sazonal desses ambientes, o que aumenta a variabilidade ambiental da região amazônica (Lopes et al. 2021). A maior similaridade presente em ambientes permanentes pode ser devido conexão que os mesmos apresentam, ao contrário do que acontece com os ambientes temporários (Trindade et al. 2019, Pozzobon et al. 2021), facilitando a dispersão das espécies ao longo das bacias. Apesar de serem os mesmos tipos de vegetação a condições espaciais das bacias hidrográficas levam a diferenças entre essas formações entre as diferentes bacias, fato que se deve possivelmente à origem ou nascentes das bacias (Marcusso et al. 2015). A compreensão do papel relativo dos fatores locais (sub-bacias e microbacias) e regionais na determinação dos padrões de diversidade de macrófitas pode ajudar os gestores a selecionar as estratégias de conservação mais adequadas para a preservação da biodiversidade, variando de acordo com a escala em foco (Fu et al. 2019).

A permanência ou temporalidade dos ambientes aquáticos nas bacias hidrográficas no sul da Amazonia determinou as diferenças na composição de macrófitas aquáticas . Este fato é um alerta de como mudanças climáticas que afetam principalmente o regime de chuvas, e os impactos de atividades humanas na Amazônia (Carvalho et al. 2020, Cano et al. 2022) podem afetar os ciclos de inundações e os ambientes temporários altamente associados a eles. Nesse sentido, na região de transição Cerrado-Amazônia que está inserida na área de estudo, é urgente conciliar a expansão agrícola e a proteção dos ecossistemas tropicais naturais, incluindo áreas úmidas (Marengo et al. 2022, Gomes et al. 2022)..

A diversidade de macrófitas nesta região segue padrões semelhantes a outras regiões brasileiras, especialmente os que avaliaram beta diversidade associada a bacia hidrográfica ou a alguma outra variável espacial. A diversidade nas bacias hidrográficas e a temporalidade dos ambientes levaram a uma alta diversidade de macrófitas aquáticas no sul da Amazônia. No entanto, ainda existem lacunas e deficiência na amostragem e registro deste grupo de plantas (Murphy et al. 2019, Cordova et al. 2022). A alta diversidade beta, atribuída ao aumento/troca de espécies (turnover) (Fu et al. 2019, Pozzobon et al. 2021), pressupõe que mais amostragens e registros em diferentes áreas e épocas tendem a aumentar a diversidade (Leibold et al. 2004, Oberdorff et al. 2019). Adicionalmente, o componente espacial, especialmente sobre o turnover de espécies, também pode indicar a influência de processos estocásticos, como a deriva genética e/ou limitações na dispersão que estruturam a mudança na composição de espécies de macrófitas nesses ambientes (Vieira et al. 2023). Somado a esse processo, os impactos de mudanças climáticas e atividades antrópicas podem ter contribuído para a diversidade beta da região (Carmo et al. 2023).

Concluímos que as diferenças na diversidade de macrófitas aquáticas nas bacias hidrográficas no sul da Amazônia está relacionada a alta troca de espécies, e principalmente temporalidade dos ambientes, independentemente do tipo de formação vegetal. Ambientes temporários devem ser considerados como um fator determinante em estudos de macrófitas aquáticas, por aportar espécies diferentes às encontradas em ambientes permanentes. Estas composições contrastantes revelam a importância de coletas e estudos no sul da Amazônia, focando em ambientes temporários e áreas pouco estudadas/coletadas. Além disso, demonstra a importância de conservação considerando a peculiaridade de cada área/bacia e a alta diversidade que pode abrigar, principalmente ante as mudanças climáticas relacionadas ao alto impacto antrópico característico no Sul da Amazônia.

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Material Suplementar

Macrófitas aquáticas por bacias e sub-bacias hidrográficas e por tipo de vegetação no sul da Amazônia. Bacias/Sub-bacias: AP: Alto Paraguai, A: Araguaia, M: Madeira, T: Tapajós, X: Xingu. Tipos de vegetação: CP: Campinarana gramíneo-arbustiva, CL: campo alagável, CV: campo de várzea, FI: Floresta de igapó, FV: Floresta de Várzea, FC: Floresta Ciliar, FG: Floresta de Galeria, VA: Vegetação aquática, VR: Vegetação sobre afloramentos rochosos.

GRUPO/FAMILIA/ESPÉCIE	**SUB-BACIAS**								**TIPOS DE VEGETAÇÃO**								
	AP1	**AP2**	**A1**	**M1**	**T1**	**T2**	**X1**	**X2**	**CN**	**CV**	**FI**	**FV**	**CL**	**FC**	**FG**	**VA**	**VR**
BRIÓFITAS																	
RICCIACEAE																	
Ricciocarpos natans (L.) Corda					1											1	
SPHAGNACEAE																	
Sphagnum palustre L.					1										1	1	
Sphagnum subsecundum Nees				1												1	
Sphagnum brasiliense Nees					1												1
SAMAMBAIAS E LICOFITAS																	
BLECHNACEAE																	
Neoblechnum brasiliense (Desv.) Gasper & V.A.O. Dittrich					1					1							
Telmatoblechnum serrulatum Rich.					1	1	1			1					1		
DENNSTAEDTIACEAE																	
Pteridium esculentum (Kaulf.) Maxon				1	1		1			1		1	1	1	1		
DRYOPTERIDACEAE																	
Cyclodium guianense (Klotzsch) van der Werff ex L.D.Gómez.					1											1	
Cyclodium meniscioides (Willd.) C.Presl	1			1	1	1	1			1		1	1	1	1		
GLEICHENIACEAE																	
Dicranopteris flexuosa (Schrad.) Underw.			1	1		1	1						1	1			
HYMENOPHYLLACEAE																	
Trichomanes crispum L.					1										1		
Trichomanes hostmannianum (Klotzsch) Kunze				1	1	1	1						1	1	1		
Trichomanes pinnatum Hedw.		1		1	1	1	1	1		1			1	1	1	1	

LINDSAEACEAE			1	1	1	1	1	1	1	1	1	1	1	
Lindsaea divaricata Klotzsch				1	1		1	1		1	1	1	1	
Lindsaea guainensis (Aubl.) Dryand.					1		1	1	1		1		1	
Lindsaea lancea (L.) Bedd.			1	1	1		1	1	1		1	1	1	
Lindsaea stricta (Sw.) Dryand.				1	1	1					1	1	1	
LOMARIOPSIDACEAE		1			1	1	1	1				1	1	
Cyclopeltis semicordata (Sw.) J.Sm.		1			1	1	1	1				1	1	
LYCOPODIACEAE	1	1		1	1	1	1	1	1	1	1	1	1	
Palhinhaea camporum (B. Øllg. & P.G. Windisch) Holub				1	1	1	1	1	1	1	1		1	
Palhinhaea cernua (L.) Franco & Vasc.	1	1		1	1	1	1	1	1		1	1	1	
LYGODIACEAE					1								1	
Lygodium volubile Sw.					1								1	
OPHIOGLOSSACEAE								1						1
Ophioglossum nudicaule L.f.								1						1
POLYPODIACEAE					1				1					
Cochlidium serrulatum (Sw.) L.E.Bishop					1				1					
PTERIDACEAE	1	1		1	11	1	1	1	11		1	1	1	1
Adiantopsis chlorophylla (Sw.) Fée	1										1			
Adiantum deflectens Mart.	1			1	1				1		1	1		1
Adiantum lucidum (Cav.) Sw.					1			1					1	
Ceratopteris pteridoides (Hook.) Hieron				1	1				1		1	1		
Ceratopteris thalictroides (L.) Brongn.					1	1					1		1	1
Pityrogramma calomelanos (L.) Link.	1	1		1	1	1	1	1	11		1	1	1	
SALVINIACEAE														
Azolla filiculoides Lam.					1					1				
Salvinia auriculata Aubl.				1	1						1	1	1	
Salvinia biloba Raddi		1											1	
THELYPTERIDACEAE														

Cyclosorus interruptus (Willd.) H. Ito				1	1		1		1				1	1	
Meniscium serratum (Cav.) Alston	1	1		1	1		1		1			1	1	1	
ANGIOSPERMAS															
ACANTHACEAE															
Hygrophila costata Nees							1	1							1
Justicia asclepiadea (Nees) Wassh. & C.Ezcurra					1	1	1					1	1	1	
Justicia laevilinguis (Nees) Lind.				1	1			1	1				1	1	1
Ruellia geminiflora Kunth					1	1	1					1			1
Ruellia jussieuoides Schltdl. & Cham.		1			1	1		1		1				1	1
ALISMATACEAE															
Echinodorus aschersonianus Graebn.							1					1			
Echinodorus floribundus (Seub.) Seub.					1									1	
Echinodorus glaucus Rataj					1								1		1
Echinodorus grandiflorus (Cham. & Schltdl.) Micheli.		1	1									1			
Echinodorus grisebachii Small				1	1							1			
Echinodorus lanceolatus Rataj					1		1	1				1	1	1	1
Echinodorus longipetalus Micheli.				1				1				1		1	
Echinodorus paniculatus Micheli				1	1		1				1	1		1	1
Echinodorus subalatus (Mart.) Griseb.				1	1	1	1					1	1	1	1
Echinodorus trialatus Fassett				1									1		
Helanthium bolivianum Rataj					1		1		1			1		1	
Helanthium tenellum (Mart.) Britton		1		1		1	1		1			1		1	
Hydrocleys nymphoides (Willd.) Buch.					1		1						1		
Hydrocleys parviflora Seub.		1											1		
Limnocharis flava (L.) Buchenau					1	1							1	1	1
Limnocharis laforesti Duchass. ex Griseb.		1			1			1	1			1		1	1
Sagittaria guayanensis Kunth		1		1	1	1		1	1			1	1	1	1
Sagittaria montevidensis Cham. & Chltdl.				1								1			
Sagittaria rhombifolia Cham.					1									1	

AMARANTHACEAE														
Alternanthera brasiliana (L.) Kuntze		1		1	1	1			1		1		1	1
Alternanthera dentata (Moench) Stuchlik ex R.E.Fr.						1								1
Alternanthera tenella Colla				1	1						1		1	
Amaranthus viridis L.							1						1	
Chamissoa altissima (Jacq.) Kunth			1	1	1	1				1	1	1	1	
Gomphrena celosioides Mart.		1							1				1	
Hebanthe eriantha (Poir.) Pedersen					1								1	
Pfaffia glomerata (Spreng.) Pedersen		1		1		1					1			
APIACEAE														
Eryngium ebracteatum Lam.				1	1	1	1		1			1		1
Eryngium elegans Cgam. & Schltdl.							1							1
APOCYNACEAE														
Allamanda cathartica L.						1						1	1	
Asclepias curassavica L.	1	1	1		1					1	1		1	
Funastrum clausum (Jacq.) Schltr.				1	1					1	1	1	1	1
Mandevilla clandestina J.F. Morales							1				1			
Mandevilla hirsuta (A.Rich.) K.Schum.				1	1	1	1			1	1	1	1	1
Mandevilla tenuifolia (J.C. Mikan) Woodson		1			1						1	1	1	
Prestonia quinquangularis (Jacq.) Spreng.					1			1				1		
Rhabdadenia madida (Vell.) Miers					1			1			1	1		1
Secondatia densiflora A.DC.		1	1	1	1	1	1				1	1	1	
Tabernaemontana siphilitica (L.f.) Leeuwenb.				1	1	1	1			1	1	1	1	1
Tassadia berteroana (Spreng.) W.D. Stevens					1						1	1		1
ARACEAE														
Anaphyllopsis cururuana A. Hay					1		1						1	
Montrichardia arborescens (L.) Schott					11		1		1	1	1	1	1	1
Pistia stratiotes L.				1		1						1	1	
Spathiphyllum gardneri Schott		1			1		1				1	1	1	1

Urospatha sagittifolia (Ridge) Schott	1	1		1	1	1	1	1				1	1	1	1		
Xanthosoma aristeguietae (G.S.Bunting) Madison					1		1						1	1			
Xanthosoma striatipes (Kunth & C.D.Bouché) Madison								1								1	
ARALIACEAE																	
Hydrocotyle leucocephala Cham. & Schltdl.					1										1		
ARECACEAE																	
Bactris hirta Mart.					1		1								1		
Bactris maraja Mart.				1	1	1							1	1	1	1	
Euterpe longibracteata Barb. Rodr.				1	1		1								1		
Mauritia flexuosa L.f.	1		1	1	1		1						1	1	1		1
Mauritiella aculeata (Kunth) Burret		1					1						1			1	
Mauritiella armata (Mart.) Burret			1	1	1		1		1				1	1	1		
ASTERACEAE																	
Ayapana amygdalina (Lam.) R.M.King & H.Rob.				1	1		1	1					1		1		
Conyza bonariensis (L.) Cronquist					1	1	1						1	1	1		
Eclipta prostrata (L.) L.				1	1	1							1	1	1		
Erechtites hieracifolius (L.) Raf. ex DC.				1	1	1	1			1			1	1	1	1	
Mikania congesta DC.						1		1						1	1		
Mikania cordifolia (L.f.) Willd.				1	1	1	1	1				1	1	1	1	1	
Mikania micrantha Kunth					1	1	1	1			1	1	1	1		1	
Orthopappus angustifolius (Sw.) Gleason		1			1	1	1	1			1	1	1		1	1	
Sphagneticola trilobata (L.) Pruski					1	1									1		
Tilesia baccata (L.f.) Pruski				1	11	1	1	1				1	11	1	1	1	
Vernonanthura brasiliana (L.) H.Rob.				1	1	1		1				1	1		1		
BIGNONIACEAE																	
Tanaecium pyramidatum (Rich.) L.G.Lohmann	1			1	1	1	1	1					1	1	1	1	
Tynanthus polyanthus (Bureau ex Baill.) Sandwith					1	1							1		1		1
BORAGINACEAE																	
Euploca filiformis (Lehm.) J.I.M.Melo & Semir				1	1		1					1	1	1		1	

Euploca parciflora (Mart.) J.I.M.Melo & Semir					1					1							
Heliotropium elongatum (Lehm.) Gürke					1								1		1		
Heliotropium indicum L.				1	1								1	1			
BROMELIACEAE																	
Aechmea bromeliifolia (Rudge) Baker				1	1	1	1						1	1	1		1
CABOMBACEAE																	
Cabomba caroliniana A.Gray				1									1				
Cabomba furcata Schult. & Schult. f.		1		1	1	1	1			1			1	1	1	1	
Cabomba haynesii Wiersema								1								1	
CAMPANULACEAE																	
Centropogon cornutus (L.) Druce		1		1	1	1							1	1	1	1	
Hippobroma longifolia (L.) G.Don					1								1				
CARYOPHYLLACEAE																	
Silene gallica L.								1								1	
CHLORANTHACEAE																	
Hedyosmum brasiliense Mart. ex Miq.	1	1		1	1		1						1	1	1		
COMBRETACEAE																	
Combretum fruticosum (Loefl.) Stuntz					1		1	1						1			
Combretum lanceolatum Pohl ex Eichler			1	1	1	1		1					1	1	1	1	
Combretum laxum Jacq.	1	1		1	1	1	1	1	1		1		1	1	1	1	
COMMELINACEAE																	
Commelina diffusa Burm.f.					1		1						1		1		
Commelina erecta L.		1			1	1							1				
Commelina longicaulis Jacq.				1	1	1					1			1	1		
Dichorisandra hexandra (Aubl.) C.B. Clarke				1	1		1	1				1	1	1	1		1
Floscopa glabrata (Kunth) Hassk.				1	1	1		1			1		1	1	1		
Floscopa peruviana Hassk. ex C.B. Clarke					1	1		1					1	1	1		
Murdannia engelsii M. Pell. & Faden					1								1	1	1		

Murdannia gardneri G. Brückn.				1							1				
Murdannia nudiflora (L.) Brenan				1		1					1	1			
Murdannia paraguariensis (C.B.Clarke) G.Brückn.				1							1				
Murdannia semifoliata (C.B.Clarke) G.Brückn.					1							1			
Tripogandra diuretica (Mart.) Handlos					1						1				
Convolvulaceae															
Aniseia martinicensis (Jacq.) Choisy			1	1										1	
Camonea umbellata (L.) Simges & Staples				1	1		1	1	1	1		1	1	1	
Cuscuta racemosa Mart.						1	1					1		1	
Ipomoea alba Choisy			1	1								1	1		
Ipomoea asarifolia (Desr.) Roem. & Schult.				1	1						1				
Ipomoea carnea Jacq.				1	1						1	1			
Ipomoea chiliantha Hallier f.							1		1						
Ipomoea goyazensis Gardner							1						1	1	
Ipomoea philomega (Vell.) House				1							1		1		
Ipomoea piresii O'Donell							1		1						
Ipomoea quamoclit L.			1	1		1		1			1		1		
Ipomoea rubens Choisy			1	1			1		1	1		1	1	1	
Ipomoea setifera Poir.				1		1					1	1	1	1	
Ipomoea squamosa Choisy			1	1	1						1	1	1		
Ipomoea subrevoluta Choisy							1					1			
Ipomoea triloba L.				1			1	1			1		1		
Operculina hamiltonii (G.Don) D.F.Austin & Staples				1		1					1				1
COSTACEAE															
Costus amazonicus (Loes.) J.F.Macbr.				1					1		1	1			
Costus arabicus L.	1		1	1	1	1	1				1	1	1		
Costus spiralis (Jacq.) Roscoe		1	1	1	1	1		1		1	1	1	1		
CUCURBITACEAE															
Cayaponia podantha Cogn.			1	1			1				1	1			

Cyclanthera carthagenensis (Jacq.) H Schaef. et S. S. Renner				1								1		
Cyclanthera hystrix (Gill.) Arn.							1				1			
CYPERACEAE														
Bulboltylis capillaris (L.) C.B. Clarke			1	1			1				1		1	1
Bulbostylis junciformis (Kunth) C.B. Clarke				1		1					1			
Bulbostylis truncata (Nees) M.T. Strong			1								1			
Calyptrocarya glomerulata (Brongn.) Urb.			1	1		1	1	1		1	1	1	1	1
Cyperus aggregatus (Willd.) Endl.				1			1	1			1	1		
Cyperus articulatus Rottb.			1								1			
Cyperus blepharoleptos Steud.			1	1	1			1			1	1	1	1
Cyperus brevifolius (Rottb.) Endl. ex Hassk.		1		1				1				1	1	
Cyperus chalaranthus J.Presl & C.Presl					1								1	
Cyperus cornelii-ostenii Kük						1					1			
Cyperus difformis L.		1									1			
Cyperus digitatus Rottb.						1					1			1
Cyperus esculentus L.		1		1		1	1	1				1	1	1
Cyperus flavescens (L.) Retz.		1		1				1			1			
Cyperus giganteus Vahl	1											1		
Cyperus haspan L.		1	1	1	1	1	1	1		1	1	1	1	1
Cyperus hermaphroditus (Jacq.) Standl.				1							1			
Cyperus hortensis (Salzm. ex Steud.) Dorr				1									1	
Cyperus incomtus Kunth				1				1						
Cyperus iria L.				1		1		1		1	1		1	
Cyperus lanceolatus Poir.				1				1						
Cyperus laxus Lam.				1		1				1	1	1	1	
Cyperus luzulae (L.) Retz.		1	1	1	1	1		1			1	1	1	1
Cyperus meyenianus Kunth				1							1			
Cyperus mundtii (Nees) Kunth				1		1								1
Cyperus odoratus L.		1		1					1		1		1	1

Cyperus rotundus L.	1				1								1	
Cyperus salzmannianus (Steud.) Bauters				1								1		
Cyperus schomburgkianus Nees				1							1			
Cyperus sellowianus (Kunth) T.Koyama						1					1	1		
Cyperus sesquiflorus (Torr.) Mattf. & Kük.			1	1				1			1			1
Cyperus sphacelatus Rottb.				1							1			
Cyperus surinamensis Rottb.			1	1	1	1	1	1			1		1	1
Diplacrum capitatum (Willd.) Boeckeler				1		1	1	1			1			1
Diplacrum guianensis (Nees) T. Koyama					1						1			
Diplasia karatifolia Rich. ex Pers.	1		1	1	1	1	1		1	1	1	1	1	1
Eleocharis acutangula (Roxb.)Schult.	1			1	1	1		1				1	1	1
Eleocharis amazonica C.B.Clarke				1										1
Eleocharis capillacea Kunth				1		1	1	1			1		1	1
Eleocharis elegans (Kunth) Roem. & Schult.				1	1	1	1	1		1	1	1	1	
Eleocharis filiculmis Kunth			1	1	1	1	1	1		1	1	1		1
Eleocharis geniculata (L.) Roem. &Schult.	1			1		1	1			1			1	1
Eleocharis interstincta (Vahl) Roem. & Schult.			1	1	1	1	1			1		1	1	1
Eleocharis minima Kunth	1		1	1	1	1		1		1	1	1	1	1
Eleocharis montana (Kunth) Roem. & Schult.							1	1						
Eleocharis nana Kunth				1		1							1	1
Eleocharis nigrescens (Nees) Kunth				1			1	1					1	
Eleocharis nudipes (Kunth) Palla	1						1						1	1
Eleocharis pachystyla (C.Wright) C.B.Clarke				1								1		
Eleocharis plicarhachis (Griseb.) Svenson				1									1	
Eleocharis retroflexa (Poir.) Urb.							1					1		
Fimbristylis aestivalis (Retz.) Vahl			1	1		1	1					1		1
Fimbristylis autumnalis (L.) Roem. & Schult.							1						1	
Fimbristylis complanata (Retz.) Link	1						1	1					1	
Fimbristylis cymosa R.Br.				1									1	

Fimbristylis dichotoma (L.) Vahl				1	1		1					1	1	1	1	
Fimbristylis littoralis (L.) Vahl	1		1	1	1		1		1			1		1	1	
Fimbristylis spadicea Rottb.				1								1		1		
Fuirena umbellata Rottb.	1			11	1	1			1			1	1	1	1	
Lagenocarpus rigidus (Kunth) Nees			1									1				
Rhynchanthera grandiflora (Aubl.) DC.				1				1								
Rhynchospora albiceps Kunth			1									1				
Rhynchospora amazonica Poepp. & Kunth			1	1			1		1				1			
Rhynchospora candida (Nees) Boeckeler				1								1				
Rhynchospora cephalotes (L.) Vahl	1	1	1	1	1	1	1		1	1		1	1	1	1	
Rhynchospora comata (Link) Roem. & Schult.				1	1	1						1		1	1	
Rhynchospora corymbosa (L.) Britton			1				1		1			1				
Rhynchospora eburnea Kral & W.W.Thomas				1								1				
Rhynchospora elatior Kunth							1	1	1			1				
Rhynchospora emaciata (Nees) Boeckeler					1								1			
Rhynchospora exaltata Kunth	1		1	1	1	1	1		1			1	1	1	1	1
Rhynchospora gigantea Link				1									1			
Rhynchospora globosa (Kunth) Roem. & Schult.			1	1	1	1						1		1		
Rhynchospora hassleri C.B.Clarke			1								1					
Rhynchospora hirta (Nees) Boeckeler		1									1					
Rhynchospora holoschoenoides (Rich.) Herter	1					1						1	1			
Rhynchospora marisculus Lindl. ex Nees				1			1					1				
Rhynchospora nervosa (Vahl) Boeckeler				1			1		1			1				
Rhynchospora reptans (Vahl) Boeckeler				1	1								1		1	
Rhynchospora rugosa (Vahl) Gale				1	1	1						1	1		1	
Rhynchospora tenuis Willd. ex Link			1									1				
Rhynchospora velutina (Kunth) Boeckeler						1	1			1	1	1				
Scleria bracteata Cav.	1			1		1						1	1	1		
Scleria distans Poir.							1					1				

Scleria gaertneri Raddi			1	1	1	1					1		1		
Scleria interrupta Rich.				1							1				
Scleria latifolia Sw.				1	1	1		1	1	1	1	1	1	1	
Scleria macrophylla J.Presl & C.Presl				1	1	1	1		1	1	1	1	1	1	
Scleria microcarpa Nees				1							1	1			
Scleria mitis P.J. Bergius						1	1				1			1	
Scleria secans (L.) Urb.			1	1	1	1					1	1	1		
DILLENIACEAE															
Davilla nitida (Vahl) Kubitzki	1	1	1	1	1	1	1				1	11	1		
Davilla rugosa Poir.			1	1	1	1	1	1			1	1	1	1	
DROSERACEAE															
Drosera cayennensis Sagot				1	1	1					1				
Drosera communis St. Hil.			1										1		
ERICACEAE															
Gaylussacia brasiliensis (Spreng.) Meisn.				1							1				
ERIOCAULACEAE															
Comanthera xeranthemoides (Bong.) L.R. Parra & Giul.		1	1	1		1				1	1		1		
Eriocaulon altogibbosum Ruhland ex Pilger				1							1				
Eriocaulon gibbosum Körn.			1											1	
Eriocaulon humboldtii Kunth		1	1		1		1			1	1		1		
Eriocaulon setaceum Kunth			1	1							1			1	
Leiothrix flavescens (Bong.) Ruhland				1			1	1			1	1			
Paepalanthus bifidus (Schrad.) Kunth				1								1			
Paepalanthus lamarckii Kunth				1		1					1		1	1	1
Syngonanthus caulescens Ruhland		1	1	1		1	1	1			1	1	1		1
Syngonanthus gracilis (Bong.) Ruhland				1	1	1	1			1	1			1	
Syngonanthus nitens Ruhland	1		1			1	1	1			1				
Tonina fluviatilis Aubl.			1	1	1	1				1	1	1	1	1	
ERYTHROXYLACEAE															

Erythroxylum anguifugum Mart.	1		1	1	1	1					1	1	1	1	
Erythroxylum deciduum A.St.-Hil.			1								1				
EUPHORBIACEAE															
Astraea lobata (L.) Klotzsch				1						1			1	1	1
Caperonia castaneifolia (L.) A.St.-Hil.			1			1		1			1		1		
Caperonia palustris (L.) A.St.-Hil.			1	1				1			1	1			
Croton trinitatis Millsp.				1		1				1	1		1	1	1
Dalechampia scandens L.			1	1	1	1				1	1				
Dalechampia tiliifolia Lam.			1	1		1				1	1				1
Euphorbia hyssopifolia L.			1	1		1				1	1	1	1		
FABACEAE															
Abrus fruticulosus Wight & Arn.				1	1			1			1		1		1
Aeschynomene americana L.	1		1	1	1						1		1		
Aeschynomene denticulata Rudd				1								1			
Aeschynomene fluminensis Vell.			1									1			
Aeschynomene sensitiva Sw.				1		1	1	1					1	1	
Bauhinia cupulata Benth.		1	1	1		1					1	1	1		
Bauhinia rufa (Bong.) Steud.			1	1	1						1	1	1		
Calliandra parviflora Benth.				1	1						1	1			
Calopogonium mucunoides Desv.	1	1		1	1	1	1					1	1		
Centrosema brasilianum (L.) Benth.	1			1							1		1		
Centrosema pubescens Benth.							1		1						
Chamaecrista desvauxii (Collad.) Killip			1	1	1	1	1	1		1	1	1	1	1	
Chamaecrista diphylla (L.) Greene			1	1	1	1	1				1				
Chamaecrista flexuosa (L.) Greene			1	1	1						1	1	1		
Chamaecrista hispidula (Vahl) H.S.Irwin & Barneby						1					1				
Chamaecrista kunthiana (Schltdl. & Cham.) H.S.Irwin & Barneby				1				1			1		1		
Chamaecrista nictitans (Benth.) H.S.Irwin & Barneby	1		1	1		1	1	1			1	1	1		
Chamaecrista ramosa (H.S.Irwin) H.S.Irwin & Barneby				1	1	1					1		1		

Chamaecrista rotundifolia (Pers.) Greene			1	1			1				1		1		
Clitoria guianensis (Aubl.) Benth.			1			1	1		1		1	1			
Crotalaria martiana (Windler & Skinner) Planchuelo						1					1				
Crotalaria micans Link			1	1		1	1		1	1	1				1
Crotalaria pallida Aiton		1		1	1					1			1		
Crotalaria pilosa Mill.							1	1	1	1	1				
Ctenodon brevipes (Benth.) D.B.O.S.Cardoso, P.L.R.Moraes & H.C.Lima				1			1								1
Ctenodon histrix (Poir.) D.B.O.S.Cardoso, P.L.R.Moraes & H.C.Lima			1	1	1	1	1		1		1	1	1		1
Ctenodon paniculatus (Willd. ex Vogel) D.B.O.S.Cardoso, P.L.R.Moraes & H.C.Lima			1	1		1	1		1		1		1		
Cymbosema roseum Benth.						1					1				
Deguelia nitidula (Benth.) A.M.G.Azevedo & R.A.Camargo				1	1	1					1		1	1	1
Desmodium barbatum (L.) Benth.			1	1	1	1	1			1	1	1	1		
Desmodium incanum DC.				1							1		1		
Dioclea virgata (Rich.) Amshoff			1	1	1	1	1			1	1	1	1		
Discolobium psoraleifolium Benth.			1											1	
Eriosema simplicifolium (Kunth) G. Don					1	1					1	1		1	
Indigofera hirsuta L.				1					1						
Indigofera suffruticosa Mill.			1		1					1			1		
Macropsychanthus grandiflorus (Mart. ex Benth.) L.P.Queiroz & Snak				1								1			
Macropsychanthus violaceus (Mart. ex Benth.) L.P.Queiroz & Snak				1	1	1					1	1	1	1	
Macroptilium gracile (Poepp. ex Benth.) Urb.				1							1				
Macroptilium lathyroides (L.) Urb.				1									1		
Mimosa debilis Humb. & Bonpl. ex Willd.	1	1	1	1	1		1		1	1	1	1	1	1	
Mimosa pigra L.			1	1		1					1	1	1	1	
Mimosa pudica L.			1	1		1			1		1	1	1		
Mimosa setosa Benth.			1	1	1	1							1		
Mimosa somnians Humb. & Bonpl.	1		1	1			1		1		1	1	1		
Neptunia oleracea Lour.				1						1					
Sacciolepis myuros (Lam.) Chase							1							1	

Senna obtusifolia (L.) H.S.Irwin & Barneby		1		1	1	1	1					1		1		
Senna occidentalis (L.) Link			1	1		1			1			1	1		1	
Senna quinquangulata (Rich.) H.S.Irwin & Barneby				1			1			1		1	1	1		
Senna silvestris (Vell.) H.S.Irwin & Barneby	1		1	1	1	1	1		1		1	1	1	1	1	1
Sesbania exasperata Kunth			1									1	1			
Stylosanthes grandifolia Mannetje							1							1		
Stylosanthes guianensis (Aubl.) Sw.	1		1	1	1	1						1		1		
Stylosanthes viscosa Sw.				1					1				1			
Vigna juruana (Harms) Verdc.				1									1	1		
Vigna lasiocarpa (Mart. ex Benth.) Verdc.			1	1									1	1		
Vigna unguiculata (L.) Walp.				1									1	1		
Zornia latifolia Sm.			1	1		1						1		1		
Zornia reticulata Sm.	1			1					1					1		
GENTIANACEAE																
Chelonanthus acutangulus (Ruiz & Pav.) Gilg							1		1							
Chelonanthus alatus (Aubl.) Maas	1		1	1	1	1	1				1	1		1	1	
Chelonanthus angustifolius (Kunth) Gilg							1							1		
Chelonanthus purpurascens (Aubl.) Struwe, S. Nilsson & V.A. Albert			1	1	1	1					1	1	1	1		
Chelonanthus viridiflorus (Mart.) Gilg					1	1	1				1	1	1			
Coutoubea ramosa Aubl.			1	1	1		1				1	1	1	1		
Coutoubea spicata Aubl.		1					1					1				
Curtia tenuifolia (Aubl.) Knobl.			1	1	1	1	1					1	1	1	1	
Schultesia brachyptera Cham.							1			1					1	
Schultesia guianensis (Aubl.) Malme			1	1					1			1		1		
GESNERIACEAE																
Drymonia coccinea (Aubl.) Wiehler			1	1	1					1		1	1	1		
Sinningia elatior (Kunth) Chautems				1			1					1				
HAEMODORACEAE																
Schiekia orinocensis (Kunth) Meisn.			1	1		1	1	1	1			1	1		1	1

HELICONIACEAE	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1
Heliconia acuminata L.C.Rich.					1	1	1	1			1			1	1	1	1
Heliconia angusta Vell.							1	1			1		1			1	
Heliconia marginata (Griggs) Pittier	1	1			1	1					1		1	1	1		
Heliconia psittacorum L.f.		1	1	1	1	1	1	1		1		1	1	1	1	1	
HYDROCHARITACEAE																	
Apalanthe granatensis (Bonpl.) Planch.					1		1			1			1	1		1	
Egeria densa (Rich.) Cesp.				1											1		
Egeria najas Planch.		1		1	1		1			1				1	1	1	
Hydrocleys nymphoides (Willd.) Buch.				1										1			
Limnobium laevigatum (Humb. & Bonpl. ex Willd.) Heine		1		1									1	1			
Ottelia brasiliensis (Planch.) Walp.				1			1						1	1			
HYDROLEACEAE																	
Hydrolea elatior Schott.		1														1	
Hydrolea spinosa L.			1	1	1								1	1			
HYPOXIDACEAE																	
Curculigo scorzonerifolia (Lam.) Baker							1						1				
IRIDACEAE																	
Cipura paludosa Aubl.		1			1			1		1			1	1	1		
Pseudotrimezia juncifolia Klatt					1								1				
Sisyrinchium vaginatum Spreng.							1									1	
LAMIACEAE																	
Cantinoa americana Mrt. ex Benth.					1					1			1	1			
Cantinoa carpinifolia (Benth.) Harley & J.F.B.Pastore				1								1			1		
Cantinoa mutabilis (Rich.) Harley & J.F.B.Pastore				1		1	1						1		1		
Cyanocephalus lanatus (Pohl ex Benth.) Harley & J.F.B.Pastore								1	1				1				
Hyptis atrorubens Poit.					1		1	1		1		1	1			1	
Hyptis brevipes Poit.				1	1	1				1			1		1		
Hyptis caespitosa A.St.-Hil. ex Benth.				1										1			

Hyptis campestris Harley & J.F.B.Pastore						1	1								1	
Hyptis conferta Pohl ex Benth.			1		1		1					1	1		1	
Hyptis lappacea Benth.							1								1	
Hyptis lorentziana O.Hoffm.				1	1	1						1		1	1	
Hyptis microphylla Pohl ex Benth.			1	1		1			1			1	1	1	1	
Hyptis paludosa St. Hil.	1											1				
Hyptis parkeri Benth.		1		1			1					1	1	1		
Hyptis recurvata Poit.			1	1		1	1					1	1		1	
Hyptis sinuata Pohl ex Benth.	1											1				
Marsypianthes chamaedrys (Vahl) Kuntze			1	1	1	1	1	1	1		1	1	1	1	1	
Mesosphaerum pectinatum (L.) Kuntze				1										1		
LAURACEAE																
Cassytha filiformis L.		1	1	1		1	1		1		1	1	1	1		
LENTIBULARIACEAE																
Genlisea filiformis A.St.-Hil.				1										1		
Utricularia adpressa Salzm. ex A.St.-Hil. & Girard				1												1
Utricularia amethystina Salzm. ex A.St.-Hil. & Girard				1	1	1	1					1	1	1	1	1
Utricularia breviscapa C. Wright ex Griseb.			1	1		1	1					1	1	1	1	
Utricularia chiribiquetensis A.St.-Hil. & Girard				1												1
Utricularia cucullata A.St.-Hil. & Girard				1					1							
Utricularia foliosa L.			1	1			1						1	1	1	
Utricularia gibba L.	1		1	1	1				1			1	1	1		
Utricularia guyanensis A.DC.						1					1					
Utricularia hydrocarpa Vahl.							1					1				
Utricularia neottioides A.St.-Hil. & Girard			1	1			1					1		1		
Utricularia nervosa G.Weber ex Benj.			1	1								1				1
Utricularia nigrescens Sylven			1										1			
Utricularia olivacea C.Wright ex Griseb.				1								1				
Utricularia poconensis Fromm			1										1			

Utricularia praelonga A.St.-Hil. & Girard							1							1	
Utricularia purpureocaerulea A.St.-Hil. & Girard							1								1
Utricularia pusilla Vahl	1			1		1						1			1
Utricularia simulans Kunth			1				1					1			1
Utricularia subulata L.				1	1	1						1	1	1	
Utricularia trichophylla Spruce ex Oliv.				1	1	1			1			1			
Utricularia triloba Benj.				1	1				1			1			
LINDERNIACEAE															
Lindernia crustacea (L.) F.Muell.				1	1		1		1			1	1	1	1
Lindernia rotundifolia (L.) Alston				1											1
Torenia thouarsii (Cham. & Schltdl.) Kuntze				1	1								1	1	
LOGANIACEAE															
Spigelia anthelmia L.	1		1	1	1				1			1		1	1
Spigelia scabra Cham. & Schltdl.				1											1
Strychnos erichsonii R.H.Schomb. ex Progel			1	1	1								1	1	
Strychnos peckii B.L.Rob.			1	1	1	1	1					1	1	1	1
Strychnos subcordata Spruce ex Benth.				1									1	1	1
LYTHRACEAE															
Ammannia auriculata Willd.	1													1	
Cuphea antisyphilitica Kunth			1	1	1	1	1				1	1	1		
Cuphea carthagenensis (Jacq.) J.F.Macbr.			1	1	1							1			1
Cuphea froesii Lourteig				1	1	1						1	1		1
Cuphea melvilla Lindl.	1	1	1	1	1	1	1					1	1	1	1
Cuphea micrantha Kunth			1	1		1					1	1		1	
Cuphea odonellii Lourteig			1			1	1		1			1			
Cuphea repens Koehne		1				1			1			1	1		
Cuphea retrorsicapilla Koehne		1		1		1	1	1			1	1		1	
Cuphea scolnikiae Lourteig			1	1		1	1				1	1		1	1
Cuphea sessiliflora A.St.-Hil.							1			1		1			

Cuphea sessilifolia Mart.						1	1	1				1	1			
Cuphea strigulosa Kunth				1		1							1		1	
MALPIGHIACEAE	1		1	1	1	1	1				1	1	1	1		
Diplopterys pubipetala (A.Juss.) W.R.Anderson & C.Cav.Davis	1		1	1	1	1	1				1	1	1	1		
MALVACEAE																
Byttneria divaricata K.Schum. & Hassl.			1	1										1		
Byttneria genistella Triana & Planch.			1	1		1						1	1	1		
Byttneria ramosissima Pohl						1						1				
Byttneria scabra L.	1								1							
Corchorus argutus Humb., Bonpl. & Kunth				1								1				
Corchorus hirtus L.						1						1				
Guazuma ulmifolia Lam.	1		1	1		1						1	1	1	1	
Helicteres guazumifolia Kunth	1		1	1		1	1				1	1	1	1	1	1
Hibiscus bifurcatus Cav.				1	1							1	1	1		
Hibiscus dimidiatus Schrank			1										1			
Hibiscus furcellatus Desr.					1	1						1	1			
Hibiscus sororius L.	1		1	1	1	1						1	1	1	1	1
Malvastrum coromandelianum Garcke	1			1								1		1	1	
Melochia graminifolia A.St.-Hil.							1					1				
Melochia villosa (Mill.) Fawc. & Rendle			1	1		1	1					1		1		
Sida acuta Burm.f.				1	1		1	1	1		1	1			1	
Sida rhmobifolia L.	1			1	1	1						1	1		1	
Sida setosa Mart.			1									1	1			
Sidastrum micranthum (A.St.-Hil.) Fryxell				1	1									1	1	
Urena lobata L.	1	1	1	1	1	1			1			1	1	1	1	
Waltheria indica L.	1	1	1	1	1	1						1	1	1	1	
MARANTACEAE																
Goeppertia capitata (Ruiz & Pav.) Borchs. & S.Suárez				1										1		
Goeppertia sellowii (Körn.) Borchs. & S.Suárez			1										1			

Ischnosiphon gracilis (Rudge) Körn.				1			1			1				1		
Monotagma laxum (Poepp. & Endl.) K.Schum.			1	1	1	1			1	1		1	1	1	1	
Thalia geniculata L.			1									1	1			
MAYACACEAE																
Mayaca fluviatilis Aubl.		1	1	1	1		1					1	1	1	1	
Mayaca kunthii Seub.			1	1								1			1	
Mayaca longipes Mart. ex Seub.			1											1		
Mayaca sellowiana Kunth			1	1		1	1				1	1	1	1	1	
MELASTOMATACEAE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Aciotis acuminifolia (Mart. ex DC.) Triana	1		1	1	1	1	1		1		1	1	1	1	1	
Aciotis indecora (Bonpl.) Triana			1	1	1								1	1	1	
Chaetogastra gracilis (Bonpl.) DC.					1							1				
Clidemia biserrata DC.						1	1	1	1						1	
Clidemia bullosa DC.				1	1	1						1	1	1	1	
Clidemia capitellata (Bonpl.) D.Don	1		1	1	1	1	1		1		1	1	1	1		
Clidemia hirta (L.) D.Don				1	1	1	1			1		1	1	1	1	
Desmoscelis villosa (Aubl.) Naudin			1	1	1	1	1		1			1	1	1	1	
Macairea radula (Bonpl.) DC.			1	1	1	1			1			1	1	1	1	
Miconia chamissois Naudin	1		1	1	1	1			1			1	1	1		
Miconia cinerascens Miq.				1										1		
Miconia ibaguensis (Bonpl.) Triana	1		1	1	1	1			1			1	1	1	1	
Miconia macrothyrsa Benth.			1		1							1				
Miconia prasina (Sw.) DC.			1	1	1	1	1					1	1	1		
Miconia pubipetala Miq.				1	1	1						1		1		
Miconia stenostachya DC.	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1
Noterophila crassipes (Naudin.) Kriebel & M.J.R.Rocha						1									1	
Noterophila limnobios (DC.) Triana	1		1			1						1	1	1	1	
Pterolepis repanda (DC.) Triana			1	1								1	1			
Rhynchanthera cordata DC.				1									1			

Rhynchanthera dichotoma (Desr.) DC.				1		1	1	1		1			1	1	
Rhynchanthera grandiflora (Aubl.) DC.		1	1	1			1				1		1	1	1
Rhynchanthera hispida Naud.			1		1								1		
Rhynchanthera novemnervia DC.	1		1	1	1			1			1	1	1		
Rhynchanthera serrulata Rich.				1			1	1			1				
Salpinga secunda Schrank & Mart. ex DC.				1					1				1	1	
Tibouchina aspera Aubl.			1			1					1			1	
Tibouchina gracilis (Bonpl.) Cogn.					1	1					1				
MENISPERMACEAE															
Cissampelos andromorpha DC.			1	1	1	1					1	1	1		
Cissampelos glaberrima A.St.-Hil.			1	1	1						1		1		
Odontocarya membranacea Barneby			1											1	
MENYANTHACEAE															
Nymphoides humboldtiana (L.) Kuntze			1										1		
MOLLUGINACEAE															
Glinus radaitus (Ruiz & Pav.) Rohrb.				1					1					1	
Mollugo verticillata L.				1		1					1		1		
NYMPHAEACEAE															
Nymphaea amazonum Mart. & Zucc.			1	1		1						1	1	1	
Nymphaea belophylla Trickett				1										1	
Nymphaea gardneriana Planch.				1	1						1		1	1	
Nymphaea oxypetala Planch.			1									1			
Nymphaea pulchella DC.						1							1		
OCHNACEAE															
Sauvagesia elata Benth.						1	1	1	1					1	
Sauvagesia erecta L.			1	1	1	1	1	1			1	1	1	1	1
Sauvagesia longifolia Eichler				1				1			1		1		
Sauvagesia racemosa A.St.-Hil.			1			1					1				
Sauvagesia sprengelii A.St.-Hil.						1					1				

ONAGRACEAE														
Ludwigia affinis (DC.) H.Hara			1	1							1	1	1	1
Ludwigia caparosa (Cambess.) H.Hara						1					1			
Ludwigia decurrens Walt.				1			1		1		1	1	1	1
Ludwigia densiflora (Micheli) H.Hara				1										1
Ludwigia elegans (Cambess.) H.Hara	1			1		1					1	1		
Ludwigia erecta (L.) H.Hara				1			1				1			1
Ludwigia filiformis (Micheli) Ramamoorthy							1							1
Ludwigia helminthorrhiza (Mart.) H.Hara			1										1	
Ludwigia hyssopifolia (G.Don) Exell				1	1		1	1	1		1		1	1
Ludwigia inclinata L.f.M.Gómez			1									1		
Ludwigia irwinii Ramamoorthy	1												1	
Ludwigia lagunae (Morong) H.Hara			1	1	1				1			1	1	
Ludwigia laruotteana (Cambess.) H.Hara						1					1			
Ludwigia leptocarpa (Nutt.) H.Hara	1		1	1	1	1			1	1	1	1	1	1
Ludwigia myrtifolia (Cambess.) H. Hara		1									1			
Ludwigia nervosa (Poir.) H.Hara	1	1	1	1	1	1			1	1	1	1	1	1
Ludwigia octovalvis (Jacq.) P.H.Raven	1		1	1	1	1	1		1	1	1	1	1	1
Ludwigia peruviana (L.) H. Hara						1				1				
Ludwigia rigida (Miq.) Sandwith			1	1			1				1	1		1
Ludwigia sedioides (Humb. & Bonpl.) H.Hara	1		1		1	1				1	1	1		1
Ludwigia sericea (Cambess.) H.Hara				1								1		
Ludwigia tomentosa (Cambess.) H.Hara	1		1	1	1	1			1		1	1	1	
Ludwigia torulosa (Arn.) H.Hara				1								1		1
ORCHIDACEAE														
Eulophia alta (L.) Fawc. & Rendle				1	1	1					1	1	1	
Habenaria gourlieana Hoehne					1							1		
Pteroglossa macrantha (Rchb.f.) Schltr.						1					1			1
OROBANCHACEAE														

Agalanis hispidula (Mart.) D'Arcy							1		1						
Agalinis glandulosa G.M.Barroso						1						1			
Buchnera integrifolia Larrañaga							1		1						
Buchnera palustris (Aubl.) Spreng.				1		1		1	1						
Buchnera rosea Kunth			1			1					1				
Esterhazya splendida J.C.Mikan						1					1				
Melasma melampyroides (Rich.) Pennell	1												1		
OXALIDACEAE															
Oxalis barrelieri L.				1							1				
PASSIFLORACEAE															
Passiflora acuminata DC.				1			1					1	1		
Passiflora alata Curtis	1	1		1							1	1	1		
Passiflora foetida L.			1	1							1		1		
Passiflora vespertilio L.				1	1						1			1	
PHYLLANTHACEAE															
Phyllanthus niruri L.				1	1	1					1		1	1	
Phyllanthus orbiculatus Rich.				1		1				1	1	1			1
Phyllanthus stipulatus (Raf.) G.L.Webster				1									1		
PHYTOLACCACEAE															
Phytolacca thyrsiflora Fenzl. ex J.A.Schmidt			1		1								1		
PIPERACEAE															
Piper caldense C.DC.			1									1			
Piper fuligineum Kunth	1		1	1		1				1	1		1	1	
PLANTAGINACEAE															
Bacopa arenaria (J.A.Schmidt) Edwall			1								1		1		
Bacopa australis V.C.Souza						1				1					
Bacopa caroliniana (Walter) B.L.Rob.				1									1		
Bacopa cochlearia (Huber) L.B.Sm.							1							1	
Bacopa gracilis (Benth.) Edwall			1	1			1		1		1		1		

Bacopa monnierioides (Cham.) B.L.Rob.	1													1		
Bacopa myriophylloides (Benth.) Wettst.						1						1				
Bacopa reflexa (Benth.) Edwall				1								1				
Bacopa salzmannii (Benth.) Wettst. ex Edwall			1	1		1	1		1		1	1			1	
Bacopa serpyllifolia (Benth.) Pennell				1	1									1	1	
Bacopa stricta (Benth.) Descole & Borsini				1	1				1			1		1		
Bacopa verticillata (Pennell & Gleason) Penne			1											1		
Conobea scoparioides (Cham. & Schltdl.) Benth.						1						1				
Myriophyllum mattogrossensis (Vahl) Blume				1					1							
Scoparia dulcis L.				1	1	1	1		1		1	1	1		1	
POACEAE																
Acroceras zizanioides (Kunth) Dandy	1		1	1			1					1	1		1	
Andropogon bicornis L.	1			1	1	1	1	1				1	1	1		
Andropogon hypogynus Hack.					1	1						1		1		
Andropogon leucostachyus Kunth				1		1	1				1	1	1			1
Andropogon pohlianus Hack.						1									1	
Andropogon selloanus (Hack.) Hack.	1		1		1	1					1	1		1		
Andropogon virgatus Desv. ex Ham.						1			1							
Anthaenantia lanata (Kunth) Benth.						1					1	1		1		
Arundinella hispida (Humb. & Bonpl. ex Willd.) Kuntze					1							1		1		
Axonopus aureus P.Beauv.			1		1	1	1					1		1		
Axonopus brasiliensis (Spreng.) Kuhlm			1		1	1	1				1	1		1		
Axonopus compressus (Sw.) P. Beauv.							1			1						
Axonopus eminens (Nees) G.A. Black							1	1								
Axonopus fissifolius (Raddi) Kuhlm.					1		1		1		1					
Axonopus leptostachyus (Flüggé) Hitchc.					1								1			
Axonopus longispicus (Döll) Kuhlm.							1		1							
Cenchrus echinatus L.	1		1	1	1							1	1	1		
Coix lacryma-jobi L.	1		1		1							1				

Cyphonanthus discrepans (Döll) Zuloaga & Morrone			1			1						1		1	
Digitaria ciliaris (Retz.) Koeler				1		1					1				1
Echinochloa colona (L.) Link				1	1									1	
Echinochloa crusgalli (L.) P.Beauv.	1			1					1			1			
Eleusine indica (L.) Gaertn.				1	1	1	1			1		1	1	1	
Eragrostis ciliaris (Kunth) Steud.					1	1						1			1
Eragrostis maypurensis (Kunth) Steud.	1		1			1						1		1	1
Eragrostis pilosa (L.) P.Beauv.						1	1				1	1			
Eragrostis rufescens Schrad. ex Schult.						1						1		1	
Homolepis aturensis (Kunth) Chase							1					1			
Hymenachne amplexicaulis (Rudge) Nees			1	1									1		1
Hymenachne donacifolia (Raddi) Chase			1	1									1	1	
Hymenachne grandis (Hitchc. & Chase) Zuloaga			1										1		
Hymenachne pernambucensis (Spreng.) Zuloaga				1											1
Hyparrhenia rufa (Nees) Stapf						1						1			
Imperata brasiliensis Trin.					1		1					1			
Isachne polygonoides (Lam.) Doll				1			1	1						1	1
Leersia hexandra Sw.			1	1			1						1	1	1
Leptochloa virgata Beauv.				1							1	1			
Loudetia flammida (Trin.) C.E. Hubb.			1			1						1		1	
Luziola bahiensis (Steud) Hitchc.	1											1			
Luziola spruceana Benth. ex Döll			1										1	1	
Megathyrsus maxima (Jacq.) B.K.Simon & S.W.L.Jacobs					1									1	
Melinis repens (Willd.) Zizka						1	1	1	1			1			
Mesosetum loliiforme (Hochst.) Chase			1			1						1			1
Oedochloa procurrens (Nees ex Trin.) Swallen		1	1	1	1	1	1					1			
Olyra ecaudata Döll				1	1	1				1	1			1	
Olyra longifolia Kunth				1	1								1		1
Oryza glumaepatula Steud.			1												1

Oryza grandiglumis (Döll) Prod.			1										1			
Otachyrium versicolor (Döll) Henrard							1					1	1			
Panicum dichotomiflorum Michx.			1			1						1	1			
Panicum millegrana Poir.				1		1	1							1		
Panicum olyroides Kunth				1									1			
Panicum repens L.						1									1	
Paratheria prostrata Grisebach						1						1				
Pariana campestris Aubl.				1		1				1		1		1	1	
Pariana radiciflora Sagot ex Döll			1	1						1	1		1	1		
Paspalidium geminatum (Hitchc. & Chase) Parodi			1										1			
Paspalum boscianum FlÃ¼ggé						1								1		
Paspalum conjugatum P.J.Bergius			1	1	1							1	1	1		
Paspalum conspersum Schrad	1			1		1						1	1			
Paspalum morichalense Davidse, Zuloaga & Filg.						1	1					1				
Paspalum orbiculatum Poir.					1							1				
Paspalum repens P.J. Bergius			1			1						1	1		1	
Paspalum virgatum L.			1	1	1							1	1	1		
Paspalum wrightii Hitchc. & Chase						1								1		
Raddiella esenbeckii (Steud.) C. E. Calderón & Soderstr.			1	1	1						1	1	1			
Rhynchospora eburnea Kral & W.W.Thomas							1		1							
Rugoloa hylaeica (Mez) Zuloaga				1		1	1		1			1	1	1	1	
Rugoloa pilosa (Sw.) Zuloaga		1	1	1	1	1			1			1	1	1	1	
Sacciolepis angustissima (Hochst. ex Steud.) Kuhlm						1					1					
Sacciolepis myuros (Lam.) Chase			1											1		
Setaria parviflora (Poir.) Kerguélen			1	1		1	1					1		1		
Steinchisma laxum (Sw.) Zuloaga				1		1			1			1		1		
Stephostachys mertensii (Roth) Zuloaga & Marrone				1		1	1		1		1			1		1
Trichanthecium cyanescens (Nees ex Trin.) Zuloaga & Morrone			1			1	1				1				1	
Trichanthecium machrisiana (Swallen) Zuloaga & Morrone				1				1					1			1

Trichanthecium nervosum (Lam.) Zuloaga & Morrone						1				1				
Urochloa mutica (Forssk.) T.Q.Nguyen				1	1		1		1		1		1	
PODOSTEMACEAE														
Apinagia fluitans P. Royen				1							1			1
Apinagia membranacea (Bong.) Tul.						1								1
Apinagia richardiana (Tul.) Engl.			1								1			
Apinagia riedelii (Bong.) Tul.	1		1								1	1		1
Castelnavia fluitans Tul. & Wedd.			1	1	1							1	1	1
Castelnavia multipartita Tul. & Wedd.			1	1	1						1	1		1
Castelnavia pendulosa (C.T. Philbrick & C.P. Bove) C.T. Philbrick & C.P. Bove			1								1			1
Castelnavia princeps Tul. & Wedd.	1				1									1
Lophogyne aripuanensis A.S.Tavares			1									1		
Lophogyne royenella Tul.			1	1	1						1	1	1	1
Mourera alcicornis (Tul.) P.Royen			1	1								1		1
Mourera aspera (Bong.) Tul.				1	1							1		
Mourera elegans (Tul.) Baillon			1	1	1							1	1	
Mourera monadelpha (Bong.) C.T. Philbrick & C.P. Bove				1							1			
Mourera weddeliana Tul.				1							1	1		
Tristicha trifaria (Bory ex Willd.) Spreng.	1		1	1							1	1	1	1
Weddellina squamulosa Tul.			1	1	1						1	1	1	1
POLYGALACEAE														
Senega adenophora (DC.) J.F.B.Pastore				1							1			
Senega gracilis (Kunth) J.F.B.Pastore		1				1				1	1			
Senega hygrophila (Kunth) J.F.B.Pastore		1	1			1			1		1			
Senega longicaulis (Kunth) J.F.B.Pastore		1	1			1	1	1		1	1			
Senega paniculata (L.) J.F.B.Pastore & J.R.Abbott						1					1			
Senega poaya (Mart.) J.F.B.Pastore					1	1					1	1	1	1
Senega tenuis (DC.) J.F.B.Pastore		1								1	1			
POLYGONACEAE														

Polygonum acuminatum Kunth				1			1			1	1	1
Polygonum ferrugineum Wedd.			1							1		
Polygonum hydropiperoides Michx.				1					1			
Polygonum meisnerianum Cham.				1		1						1
Polygonum punctatum Elliott			1	1	1				1	1		1
PONTEDERIACEAE												
Eichhornia azurea (Sw.) Kunth			1	1			1		1	1	1	1
Eichhornia crassipes (Mart.) Solms			1	1		1			1	1		1
Eichhornia diversifolia (Vahl) Urb.	1	1	1	1		1		1	1	1	1	1
Heteranthera multiflora (Griseb.) C.N.Horn							1					1
Heteranthera reniformis Ruiz & Pav.	1		1						1		1	
Heteranthera zosterifolia Mart.			1							1	1	
Pontederia cordata L.					1	1			1		1	1
Pontederia parviflora Alexander			1	1		1				1	1	1
Pontederia rotundifolia L.f.				1							1	
Pontederia subovata (Seub.) Lowden			1			1				1	1	
POTAMOGETONACEAE			1							1		
Potamogeton illinoensis Morong			1							1		
RAPATEACEAE												
Cephalostemon gracilis Poepp. & Endl.				1					1		1	
Rapatea paludosa Aubl.				1		1					1	
RUBIACEAE												
Borreria alata (Aubl.) DC.			1	1	1	1	1	1	1	1	1	
Borreria capitata (Ruiz & Pav.) DC.			1	1		1			1		1	
Borreria cupularis DC.							1				1	
Borreria flexuosa E.L. Cabral				1					1			
Borreria hyssopifolia (Willd. ex Roem. & Schult.) Bacigalupo & E.L.Cabral				1	1		1			1		1
Borreria latifolia (Aubl.) K.Schum.			1	1	1	1			1		1	1
Borreria multiflora (DC.) Bacigalupo & Cabral						1					1	

Borreria multiflora DC.	1										1					
Borreria ocymifolia (Roem. & Schult.) Bacigalupo & E.L.Cabral				1	1							1				1
Borreria ocymoides (Burm.f.) DC.				1									1			
Borreria palustris (Cham. & Schltdl.) Bacigalupo & E.L.Cabral				1										1		
Borreria pulchristipula (Bremek.) Bacigalupo & E.L.Cabral			1			1						1				
Borreria remota (Lam.) Bacigalupo & E.L.Cabral						1							1			
Borreria scabiosoides Cham. & Schltdl.				1						1						
Borreria schumannii Bacigalupo & E.L. Cabral							1					1				
Borreria verticillata (L.) G.Mey.			1	1		1	1				1	1				
Coccocypselum guianense (Aubl.) K.Schum.			1			1								1	1	
Declieuxia cordigera Müll.Arg.			1				1					1				
Diodia kuntzei K.Schum.			1		1									1		
Diodia macrophylla K.Schum.			1									1				
Duroia duckei Huber			1	1		1	1			1		1	1	1		
Palicourea amplectens (Benth.) Delprete & J.H. Kirkbr.				1		1	1			1	1	1	1	1	1	
Palicourea corymbifera (Mull.Arg.) Standl.			1	1		1					1	1	1	1		
Palicourea crocea (Sw.) Roem. & Schult.	1		1	1	1		1					1		1		
Palicourea grandifolia (Willd. ex Roem. & Schult.) Standl.				1	1	1							1	1		
Palicourea marcgravii A.St.-Hil.	1		1	1	1						1	1	1	1	1	1
Palicourea nitidella (Müll.Arg.) Standl.	1		1	1	1	1	1					1	1	1	1	
Perama hirsuta Aubl.			1	1		1					1	1		1	1	
Psychotria anceps Kunth		1		1		1	1					1	1	1		
Psychotria bahiensis DC.				1		1								1	1	
Psychotria capitata Ruiz & Pav.				1	1	1	1				1	1	1	1	1	
Retiniphyllum kuhlmannii Standl.				1	1			1				1	1			
Richardia brasiliensis Games	1													1		
Richardia grandiflora (Cham. & Schltdl.) Steud.						1						1				
Rudgea cornifolia (Kunth) Standl.			1			1	1				1	1	1		1	
Rudgea viburnoides (Cham.) Benth.	1		1	1	1	1					1	1	1	1		

Sabicea aspera Aubl.				1		1	1				1	1		1
Sipanea biflora (L.f.) Cham. & Schltdl.				1	1	1					1	1	1	1
Sipanea pratensis Aubl.	1		1	1	1					1			1	
Sipanea veris S.Moore	1			1	1	1				1		1	1	
Staelia virgata (Link ex Roem. & Schult.) K.Schum.					1		1				1	1		
Uncaria guianensis (Aubl.) J.F.Gmel.	1	1	1	1	1	1	1			1	1	1	1	1
SANTALACEAE														
Phoradendron platycaulon Eichler			1									1		
SMILACACEAE				1		1						1	1	1
Smilax polyantha Griseb.				1		1						1	1	1
SOLANACEAE														
Physalis angulata L.	1		1	1	1					1	1		1	
Solanum americanum Mill.			1	1	1		1				1	1	1	
Solanum anceps A.St-Hil.				1						1				
Solanum leucocarpon Dunal						1	1		1	1				
Solanum subinerme Jacq.				1		1					1	1	1	1
SPHENOCLEACEAE				1								1		
Sphenoclea zeylanica Gaertn.				1								1		
TURNERACEAE														
Piriqueta cistoides (L.) Griseb.			1	1	1	1	1			1	1	1	1	1
Turnera melochioides Cambess.				1				1						
Turnera orientalis (Urb.) Arbo							1		1		1			
TYPHACEAE														
Typha domingensis Pers.			1								1			
URTICACEAE														
Urera baccifera (L.) Gaudich. ex Weed.			1	1	1		1				1	1	1	1
VERBENACEAE														
Lantana camara L.			1	1							1	1	1	1

Lantana canescens Kunth				1			1	1				1	1	1	
Lantana trifolia L.				1	1		1	1				1			
Lippia alba (Mill.) N.E.Br.				1	1			1		1	1	1		1	
Phyla betulifolia (Kunth) Greene					1									1	
Stachytarpheta angustifolia (Mill.) Vahl				1	1		1		1			1		1	
Verbena litoralis Kunth				1							1				
VITACEAE															
Cissus erosa Rich.				1	1	1	1			1	1	1	1	1	
Cissus gongylodes (Baker) Planch.	1		1	1		1					1	1	1		
Cissus spinosa Cambess.				1	1			1	1		1	1		1	
Cissus verticillata (L.) Nicolson & C.E.Jarvis				1	1	1	1				1		1		
XYRIDACEAE															
Abolboda poarchon Seub.							1			1					
Abolboda pulchella Humb. & Bonpl.					1		1			1					
Xyris aquatica Idrobo & L.B. Sm.					1						1	1	1		
Xyris hymenachne Mart.				1	1			1		1	1	1			
Xyris jupicai Rich.		1	1	1	1	1	1		1	1	1	1	1	1	
Xyris lacerata Pohl ex Seub.					1		1				1				
Xyris macrocephala Vahl			1		1	1	1	1	1	1	1	1	1	1	
Xyris malmeana L.B.Sm.				1	1		1			1			1		
Xyris paraensis (Malme) L.B. Sm. & Downs						1							1		
Xyris savanensis Miq.		1		1		1	1	1		1	1		1	1	
Xyris stenocephala Malme					1										1
Xyris tortula Mart.								1	1						
ZINGIBERACEAE															
Hedychium coronarium J.Koening				1							1				

CONSIDERAÇÕES FINAIS

Estudos florísticos em áreas úmidas no Brasil são de extrema importância e vêm revelando um contínuo aumento de áreas de amostragem e de espécies. Assim, nossos achados contribuem para aumentar o volume de informações sobre áreas e ambientes amazônicos, e por consequência o conhecimento sobre as espécies de macrófitas aquáticas que ocorrem em áreas de ecótono, como o caso do sul da Amazônia. A alta diversidade, elevado grau de endemismo e ocorrência restrita de macrófitas no sul do Amazônia, tanto de espécies, famílias e formas de vida, foram registrados superando todas as expectativas, podendo claramente aumentar com novos estudos e inventários desenvolvidos na região.

Neste estudo também foi constatada a importância dos ambientes ribeirinhos na dinâmica dessas espécies. Assim, todos os padrões encontrados mostram como a comunidade de macrófitas aquáticas é tolerante e sensível ao mesmo tempo a variações temporais e ambientais que muitas vezes estão ligadas a mudanças climáticas e pressões antrópicas, sendo que impactos no entorno podem levar a mudanças drásticas dentro deste importante grupo de plantas e suas funções ecológicas nos rios amazônicos. Apesar dos padrões encontrados, as interações entre macrófitas são complexas, sendo específicas da espécie e do local. Com nosso estudo evidenciamos a importância da vegetação do entorno e qualidade da água na comunidade de macrófitas, razão pela qual a conservação do recurso hídrico e das florestas riparias se torna necessário para conservar a diversidade e produtividade da comunidade de macrófitas aquáticas na Amazônia.

Finalmente, a diferença na diversidade de macrófitas aquáticas nas bacias hidrográficas no sul da Amazônia e a elevada troca e aumento de espécies, principalmente em ambientes temporários, demonstra a importância de amostragens espaço-temporais. Além disso, é necessário que as características do ambiente de coleta sejam consideradas na descrição dos registros/estudos já que representam características importantes para estudos de distribuição, além de fornecer informações importantes para conservação de áreas úmidas no sul da Amazônia, mas também como indicadores de mudanças climáticas e dos impactos antrópicos que são frequentes na região, e que estão afetando toda a diversidade incluindo as macrófitas aquáticas.