Oecologia Australis
16(4): 782-796, Dezembro 2012
http://dx.doi.org/10.4257/oeco.2012.1604.05

MACROPHYTE STRUCTURE IN LOTIC-LENTIC HABITATS FROM BRAZILIAN PANTANAL

Gisele Catian[2], Flávia Maria Leme[2], Augusto Francener[2], Fábia Silva de Carvalho[2], Vitor Simão Galletti[3], Arnildo Pott[4], Vali Joana Pott[4], Edna Scremin-Dias[4] & Geraldo Alves Damasceno-Junior[4]*
[2]Master, Program in Plant Biology, Federal University of Mato Grosso do Sul, Center for Biological Sciences and Health, Biology Department. Cidade Universitária, s/nº – Caixa Postal: 549 – CEP: 79070-900, Campo Grande, MS, Brazil.
[3]Master, Program in Ecology and Conservation, Federal University of Mato Grosso do Sul, Center for Biological Sciences and Health, Biology Department. Cidade Universitária, s/nº – Caixa Postal: 549 – CEP: 79070-900, Campo Grande, MS, Brazil.
[4]Lecturer, Program in Plant Biology, Federal University of Mato Grosso do Sul, Center for Biological Sciences and Health, Biology Department. Cidade Universitária, s/nº – Caixa Postal: 549 – CEP: 79070-900, Campo Grande, MS, Brazil.
E-mail: gcatian@gmail.com*, flaviabotanica@gmail.com, augustofng@yahoo.com.br, fabinha-bio@hotmail.com, vitorsiga@gmail.com, arnildo.pott@gmail.com, vali.pott@gmail.com, edna-scremin.dias@ufms.br, geraldodamasceno@gmail.com

ABSTRACT
The goal of this study was to compare the vegetation structure of macrophytes in an anabranch-lake system. Sampling was carried out at flood in three types of aquatic vegetation, (wild-rice, floating meadow and *Polygonum* bank) in anabranch Bonfim (lotic) and in lake Mandioré (lentic) in plots along transects, to estimate the percent coverage and record life forms of species. We collected 59 species in 50 genera and 28 families. Fabaceae and Poaceae were the most representative and emergent plants predominated (62%). In the anabranch, with 48 species, *Polygonum acuminatum* and *Paspalum repens* (7%) were more frequent (8%); in the lake, with 39 species, the most frequent were *Polygonum ferrugineum* (7%) and *Hymenachne amplexicaulis* (9%). Both evaluated ecosystems have low floristic similarity (66.6%), which was repeated among the communities analyzed by environment: wild-rice (0.33%), *Polygonum* banks (0.37%); floating meadows (0.32%). The anabranch was richer and more diverse than the lake; wild-rice community was the most diverse compared to other ones in anabranch, while in the lake the *Polygonum* bank community was the most diverse. The life forms of species varied in relation to the environments (lotic and lentic) studied.
Keywords: anabranch; floating meadow; lake; vegetation structure; wild-rice.

RESUMO
ESTRUTURA DAS MACRÓFITAS EM AMBIENTES LÓTICO-LÊNTICO DO PANTANAL. O objetivo deste trabalho foi comparar a estrutura da vegetação de macrófitas em um sistema corixo-lagoa. A amostragem foi realizada na cheia, em três tipos de vegetação aquática, (arrozal, baceiro e banco de *Polygonum*), no Corixo Bonfim (lótico) e na Lagoa Mandioré (lêntico), em transectos com parcelas, para estimar a porcentagem de cobertura e registrar as formas de vida das espécies. Coletaram-se 59 espécies em 50 gêneros e 28 famílias. Fabaceae e Poaceae foram as mais representativas, e plantas emergentes predominaram (62%). No corixo, com 48 espécies, as mais freqüentes foram *Polygonum acuminatum* (8%) e *Paspalum repens* (7%); na lagoa, com 39 espécies, as mais freqüentes foram *Polygonum ferrugineum* (7%) e *Hymenachne amplexicaulis* (9%). Os dois ambientes avaliados apresentam baixa similaridade florística (66.6%), o que se repetiu entre as manchas analisadas por ambiente: arrozais (0.33%); bancos de *Polygonum* (0.37%); baceiros (0.32%). O corixo foi mais rico e diverso do que a lagoa, com o arrozal sendo o mais diverso em relação às demais manchas no corixo, enquanto na lagoa o banco de *Polygonum* foi o mais diverso. As formas de vida das espécies variaram em relação aos ambientes (lótico e lêntico) estudados.
Palavras-chave: arrozal; baceiro; corixo; estrutura da vegetação; lagoa.

RESUMEN

ESTRUCTURA DE LAS MACRÓFITAS EN AMBIENTES LÓTICOS-LÉNTICOS DEL PANTANAL. El objetivo de este trabajo fue comparar a estructura de la vegetación de macrófitas en un sistema brazo de rio – laguna. El muestreo fue realizado en la época de inundación, en tres tipos de vegetación acuática (arrozal, islas flotantes y banco de *Polygonum*), en el Corixo Bonfin (lótico-humedales construidos por el hombre) y en la Laguna Mandioré (léntico), en transectos con parcelas, para estimar el porcentaje de cobertura y registrar las formas de vida de las especies. Se colectaron 59 especies, en 50 géneros y 28 familias. Fabaceae y Poaceae fueron las más representativas, siendo las plantas emergentes las que predominaron (62%). En corixo con 48 especies, las más frecuentes fueron *Polygonum acuminatum* (8%) y *Paspalum repens* (7%); en la laguna con 39 especies, las más frecuentes fueron *Polygonum acuminatum* (8%) y *Paspalum repens* (7%). Los dos ambientes evaluados presentaron una baja similaridad florística (66.6%), lo que se repitió entre los lugares analizados por ambiente: Arrozales (0.33%), bancos de *Polygonum* (0.37%) y baceiros (0.32%). El corixo fue más rico y más diverso que la laguna, el arrozal fue el más diverso en relación a los demás lugares en el corixo; en cuanto a la laguna, el banco de *Polygonum* fue más diverso. Las formas de vida de las especies variaron en relación a los ambientes (lóticoy léntico) estudiados.

Palabras claves: arrozal; isla flotante; lago; estructura de la vegetación; laguna.

INTRODUCTION

Aquatic plant diversity vegetation is associated to diversity of habitats and to the flood pulse, thereafter wetland is favorable to the development of macrophytes of various life forms (Junk *et al.* 1989). The main lotic environments of occurrence of aquatic vegetation are rivers, meanders and anabranches, whereas the main lentic systems are lakes, ponds and floodable grasslands in the Pantanal.

Lakes are open depositional lentic environments submitted to water level oscillations and to influx-outflux of matter and organisms from lotic ecosystems, such as rivers or small water bodies interconnected with the main canals of the drainage basin, part of those larger systems, which influence flood dynamics (Cristofoletti 1981) and because of standing and shallow water in such type of habitat, the most common species are emergent macrophytes (Pott & Pott 2000).

Locally known as *corixos*, the anabranches are river arms linking large lakes to rivers and consist of channels formed in the rainy season, draining waters from grasslands, rivers and lakes, being temporary or permanent, connected through the floodplain during the flood (Da Silva & Figueiredo 1999). And lotic environments are running water systems, mainly fluvial systems, where materials contained in the fluxes are a mixture of particles of various origins, sizes and forms, mainly coming from water erosion on rocks and sediments (Cristofoletti 1981), plus being agent of propagule dispersion. The main life forms are free floating and free submerse macrophyte species (Pott & Pott 2000). In these habitats the current water tends to be a limitating and controlling factor, stronger than in lakes (lentic). Such differences determine specific and distinct features in dynamics and structure of communities which are adapted to the ecosystems (Margalef 1983).

During flooding, aquatic systems expand their areas, connecting rivers and plains, river and pond, lagoon and plain, and between the compartments of the plain, or from a combination of all these environments (Fantin-Cruz *et al*. 2009). Since the different levels of connectivity determine the transfer of matter and nutrients, and exchange between compartments of body fluid (Neiff 1996), depending of the extension and depth of water in the plain, and the spatial and temporal dynamics, the system can change between water storage system for transporting water, produced by horizontal flows (Fantin-Cruz *et al.* 2009).

Anabranches and lakes are an opportunity to study the occupation by aquatic macrophytes in lotic and lentic habitats, therefore during flood period one system is fed by another with water, but they have distinct characteristics of water flow and wind exposure, and anabranches may function as a main source of diaspores and propagules of aquatic plants for the lakes.

Macrophytes colonize to varying degrees most lotic and lentic ecosystems and provide increased spatial heterogeneity, creating habitats for many animals (Esteves & Camargo (1986), Weaver *et al.*1997), an increased stability of the littoral zone, protection of the banks (Sand-Jensen 1998) and also the retention of nutrients and pollutants (Carpenter & Lodge 1986, Gopal 1987). The distribution of species along several interrelated abiotic gradients make difficult for phytosociological approaches and determination of subunits in communities of macrophytes (Hutchinson 1975). Possibly for this reason, little is known about dynamics and community structure of aquatic macrophytes compared to phytosociological work undertaken on terrestrial ecosystems.

This paper aims to describe and compare the overall composition of macrophytes in lentic and lotic environments from the Pantanal floodplain. We tested the following hypothesis: there is low similarity between the environments, with different groups of dominant species according to characteristics of the water body (lentic or lotic). Based on that, we pursued to compare the assemblage structure of macrophytes in the anabranch-lake system on the western edge of Pantanal.

MATERIAL AND METHODS

The floristic survey was carried out during flood period, in areas under influence of the Paraguay River, specifically in Mandioré lake (117Km^2) and in anabranch Bonfim (22.62Km long), a canal through which water flows between the lake and the floodplain, in the municipality of Corumbá, State of Mato Grosso do Sul, near Amolar Mountains (18°00’59.99”S, 57°30’00.00”O). Anabranch Bonfim is a secondary canal or old river bed of the Paraguay River, which gives access to Mandioré lake (Figure 1).

The anabranch has variable width, between 60 and 120m, considered a lotic system surrounded by riparian forest and a few hills with seasonal forest and savanna (cerrado), whereas Mandioré Lake is an open environment, 20km long and 11km wide at its larger axes, limited by the Amolar Mountains at the West side, without natural barriers at the other sides, only floodplain covered by grasslands or forests.

The climate of the region is classified as Aw (Koeppen 1931), with a rainy period from October to March (mean annual rainfall of 1.100mm) and a drought period between April and September (Soriano *et al.* 2001), however local rain little influences river level. The flood regime is seasonal (Hamilton *et al.* 1996), monomodal, which lasts a few months and connect the river, water bodies and the plain.

The flood does not depend on local rainfall, which is rather low, however most of the water comes from the headwaters of Paraguay River, and due to the low north-south slope (2.5cm.km^{-1}) of the plain it spends four months or more to cross the entire Pantanal. The flood stabilization usually occurs in March and April, while the water of this river has slow flow too (Hamilton *et al.* 1996). Regional soils are planosols and eutrophic clays, plus neosols on sand banks and shores (Embrapa 1999, 2006).

Sampling points were chosen based on Landsat TM image and field inspection, aiming to visually represent the main physiognomies of aquatic vegetation on both studied water bodies. At both areas we sampled similar communities of aquatic plants named in the field as: wild-rice (locally known as *arrozal*), *Polygonum* bank, and floating meadow (locally known as *baceiro*). The wild-rice physiognomy is characterized by large communities of Poaceae, mainly from the genus *Oryza*, while the *Polygonum* bank has visual predominance of plants of this genus. The floating meadow is a floating islet of aquatic vegetation at various stages of succession, starting with a substrate made by living floating plants upon growing epiphytic aquatic macrophytes such as *Oxycaryum cubense* (Poepp. & Kunth) Palla (young floating meadow), or presenting floating organic soil, built up by dead organic matter, known as histosol – floating meadow in a more advanced stage of succession (Pott & Pott 2000, Pivari *et al.* 2008).

In Bonfim anabranch we sampled 87 plots of wild-rice (18º12’34.4”S, 57º26’18.6’’W), 38 plots of floating meadow and 51 plots of *Polygonum* bank (18˚13’21.5”S, 57˚28’5.9”W). In Mandioré lake we sampled 128 plots of wild-rice (18º11’25.6’’S, 57º30’6.8’’W), 32 plots of floating meadow (18º12’16.2’’S, 57º28’44.4’’W) and 107 plots of *Polygonum* bank (18º12’16.2”S, 57º28’44.4”W). All evaluated communities had approximately equivalent sizes.

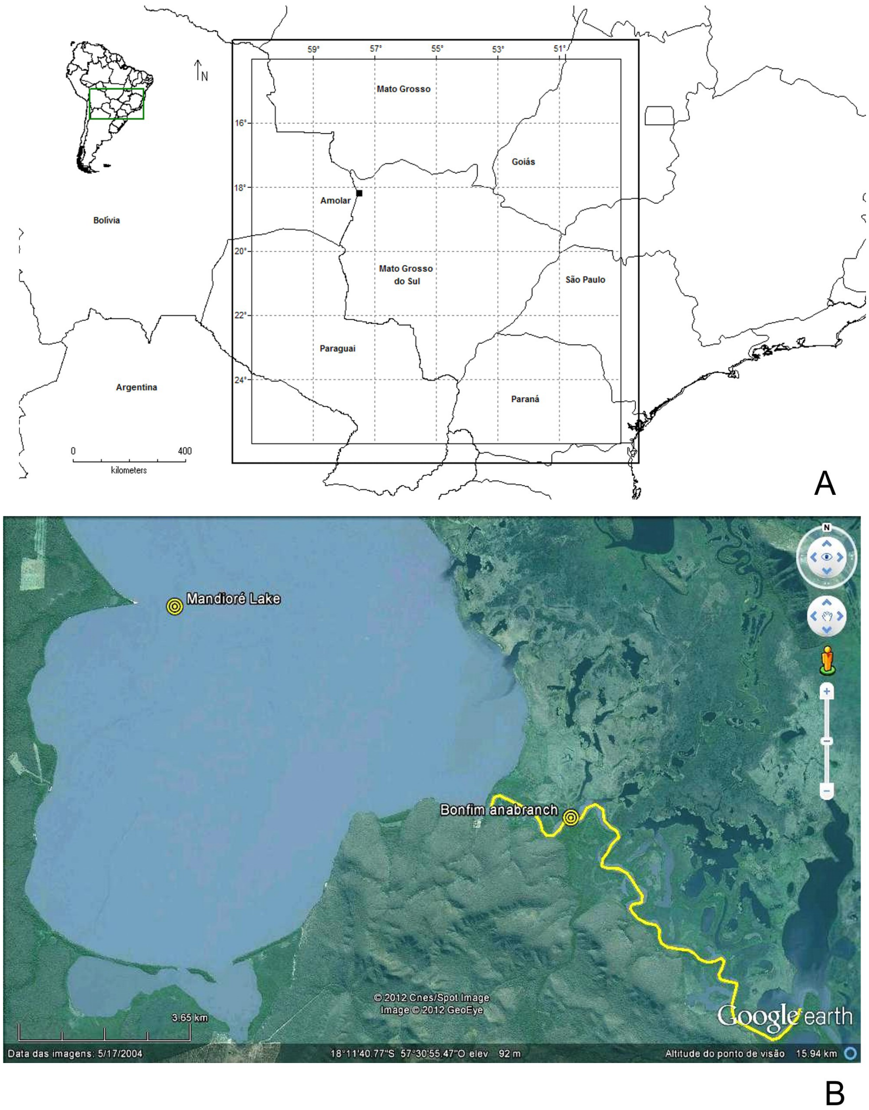

Figure 1. Western edge of Pantanal wetland in Brazil (A) and water bodies Mandioré lake and anabranch Bonfim (B) in the survey of aquatic macrophytes, on the Paraguay river floodplain, Pantanal wetland, Mato Grosso do Sul, at flood period, July/2009 (Google Earth 2011).
Figura 1. *Borda oeste da planície do Pantanal no Brasil (A) e corpos d'água lagoa Mandioré e corixo Bonfim (B) no levantamento de macrófitas aquáticas em área de influência da cheia no rio Paraguai, na planície do Pantanal, Mato Grosso do Sul, em período de inundação, Julho/2009.*

Data were gathered along transects entering the vegetation communities with a motor boat, placing plots (50 x 50cm quadrats) every 2m on both sides of the boat. In each quadrat we estimated percentage of cover for each species of vascular plant, according to Brower & Zar (1984), which is calculated by a perpendicular projection in relation to water, the plant canopy, which allows to estimate the percentage of the plot covered by each macrophyte species analyzed individually. We calculated relative frequency (RF, in %) and relative cover (RC, in %) of the species. We used an Importance Value (IV) which was considered as the sum of RF and RC per species (Damasceno-Junior & Pott 2011).

Botanical family nomenclature followed APG II – Angiosperm Phylogeny Group (2003) for angiosperms, and Kramer & Green (1990) for ferns, plus regional common names and information of occurrence. For the authors of the plant names, we consulted Brummitt & Powell (1992).

Life forms of the species occurring in each analyzed patch were classified according to Irgang *et al.* (1984) into: emergent, free floating, rooted floating, rooted submerse, free submerse and epiphyte and fertile specimens of all species or vegetative forms were collected and processed using herbarium techniques (Bridson & Formam 1992), and kept in the herbarium

CGMS at the Universidade Federal de Mato Grosso do Sul. Species were identified by comparison in the herbarium and through specialized bibliography (ex. Pott & Pott 1994, 2000), and some plants were sent to specialists to confirm identification.

To calculate similarity among water bodies we utilized Sörensen's index (Zar 1999) for all environments together and analyzed between similar environments. For diversity the index of Shannon-Wienner (H'), calculation was adapted according to Munhoz & Felfili (2006). A rarefaction curve was built utilizing the program Biodiversity Pro, Version 2 (Zar 1999). To compare the difference of life forms between environments (lotic and lentic) carried out analysis of variance (Two-way ANOVA).

RESULTS

For both sampled water bodies (anabranch and lake) we inventoried 59 species of aquatic macrophytes, within 50 genera and 28 families. Six species are ferns, one is a liverworth and the others are Angiospermae (Table 1). The most numerous families were Poaceae (11 spp.) and Fabaceae (9 spp.), representing 33.8% of the flora. The following genera presented two species each: *Aeschynomene*, *Eichhornia*, *Hymenachne*, *Ludwigia*, *Mimosa*, *Oryza*, *Panicum*, *Paspalum* and *Polygonum*. Emergent plants were the most representative life form with 62% of whole species, followed by free floating, epiphyte and rooted floating and the less represented group was free submerse with a single species in wild-rice of anabranch.

Table 1. Floristic composition of aquatic macrophytes and their life forms in Mandioré Lake (ML) and anabranch Bonfim (AB), on the Paraguay River floodplain, in the Pantanal, MS (July/2009). Sampled communities: Wr = wild-rice; PB = *Polygonum* bank and Fm = floating meadow.
Tabela 1. *Composição florística de macrófitas aquáticas e suas formas de vida na Lagoa Mandioré (ML) e no Corixo Bonfim (AB), em área sob influência da cheia no rio Paraguay, na planície do Pantanal, MS (Julho/2009). Comunidades amostradas: Wr = arrozal; PB = banco de Polygonum, e Fm = baceiro.*

Family/Species	Life form	AB	ML
Bryophyta			
RICCIACEAE			
Ricciocarpos natans (L.) Corda	Free-floating	Wr	PB; Fm
Monilophyta			
ADIANTACEAE			
Pityrogramma calomelanos (L.) Link	Epiphyte	Wr; Fm	_______
AZOLLACEAE			
Azolla filiculoides Lam.	Free-floating	Wr; PB; Fm	PB; Wr; Fm
MARSILEACEAE			
Marsilea crotophora D.M.Johnston	Rooted floating	Wr; PB; Fm	Fm
PARKERIACEAE			
Ceratopteris pteridoides (Hook.) Hieron.	Free-floating	PB	Wr
SALVINIACEAE			
Salvinia auriculata Aubl.	Free-floating	Wr; Fm	PB; Wr; Fm
Angiospermae			
ACANTHACEAE			
Justicia laevilinguis (Nees) Lindau	Emergent	Wr; Fm	PB
APOCYNACEAE			
Rhabdadenia madida (Vell.) Miers	Emergent	Wr; Fm	_______
Thevetia bicornuta Müll.Arg.	Emergent	Wr	_______
ARACEAE			

Continuation Table 1

Family/Species	**Life form**	**AB**	**ML**
Lemna aequinoctialis Welw.	Free-floating	Wr	PB; Fm
Pistia stratiotes L.	Free-floating	Wr; Fm	_______
Wolffiella welwitschii (Hegelm.) Monod	Free-floating	Wr; Fm	PB
ASTERACEAE			
Aspilia latissima Malme	Emergent	PB	_______
Enydra radicans (Willd.) Lack	Emergent	PB	_______
Eupatorium candolleanum Hook. & Arn.	Epiphyte	Wr; Fm	_______
Mikania micrantha Kunth	Emergent	Wr	PB
COMMELINACEAE			
Commelina schomburgkiana Klotzsch	Epiphyte	Wr; Fm	PB; Fm
CONVOLVULACEAE			
Aniseia martinicensis (Jacq.) Choisy	Emergent	Wr	_______
CURCUBITACEAE			
Cayaponia podantha Cogn.	Emergent	Wr; PB	PB; Fm
Melothria candolleana Cogn.	Epiphyte/emergent	Wr; PB	PB; Fm
CYPERACEAE			
Oxycaryum cubense (Poepp. & Kunth) Palla	Epiphyte	Wr; Fm	Fm
EUPHORBIACEAE			
Caperonia castaneifolia (L.) A.St.-Hil.	Emergent	Wr	_______
FABACEAE			
Faboideae			
Sesbania exasperata Kunth	Emergent	_______	Wr
Papilionoideae			
Aeschynomene rudis Benth.	Emergent	_______	BP; Wr
Aeschynomene sensitiva Sw.	Emergent	_______	Wr
Calopogonium caeruleum (Benth.) C.Wright	Emergent	_______	PB
Discolobium pulchellum Benth.	Emergent	Wr	______
Mimosoideae			
Mimosa adenocarpa Benth.	Emergent	_______	PB
Mimosa pellita Humb. & Bonpl. ex Willd.	Emergent	Wr	Wr
Neptunia plena (L.) Benth.	Emergent	Wr	______
Neptunia prostrata Baill.	Rooted floating	Fm	______
Vigna lasiocarpa (Mart. ex Benth.) Verdc.	Epiphyte/emergent	Wr; PB; Fm	PB; Fm
HYDROPHYLLACEAE			
Limnobium laevigatum (Humb. & Bonpl. ex Willd.) Heine	Free-floating	______	Fm
LENTIBULARIACEAE			
Utricularia hydrocarpa Vahl	Free-submerged	Wr	_______
MALVACEAE			
Melochia arenosa Benth.	Emergent	Wr	_______

Continuation Table 1

Family/Species	Life form	AB	ML
MELASTOMATACEAE			
Rhynchanthera novemnervia DC.	Emergent/emergent	Wr; Fm	_______
NYMPHAEACEAE			
Victoria amazonica (Poepp.) J.C.Sowerby	Rooted floating	_______	PB
ONAGRACEAE			
Ludwigia grandiflora (Michx.) Greuter & Burdet	Emergent	Wr	PB; Fm
Ludwigia helminthorriza (Mart.) H.Hara	Rooted floating	Wr; PB; Fm	PB; Wr; Fm
PHYLLANTHACEAE			
Phyllanthus fluitans Benth. ex Müll.Arg.	Free-floating	PB	PB; Fm
POACEAE			
Andropogon bicornis L.	Emergent/emergent	Wr; Fm	_______
Echinochloa polystachya (Kunth) Hitchc.	Emergent	Wr	PB
Hymenachne amplexicaulis (Rudge) Nees	Emergent	Wr; PB	PB; Wr; Fm
Hymenachne donacifolia (Raddi) Chase	Emergent	Wr	Wr
Leersia hexandra Sw.	Emergent	Wr; PB; Fm	PB; Wr
Oryza glumaepatula Steud.	Emergent	Wr	Wr
Oryza latifolia Desv.	Emergent	Wr; PB; Fm	Wr
Panicum dichotomiflorum Michx.	Emergent	_______	Wr
Panicum elephantipes Nees	Rooted floating	_______	Wr
Paspalum repens P.J.Bergius	Rooted floating	Wr; PB; Fm	PB; Wr; Fm
Paspalum wrightii Hitchc. & Chase.	Emergent	Wr	_______
POLYGONACEAE			
Polygonum acuminatum Kunth	Emergent	Wr; PB	PB
Polygonum ferrugineum Wedd.	Emergent	PB	PB; Wr
Ruprechtia brachysepala Meisn.	Emergent/emergent	Wr	_______
PONTEDERIACEAE			
Eichhornia azurea (Sw.) Kunth	Rooted floating	Fm	Fm
Eichhornia crassipes (Mart.) Solms	Free-floating	Wr; PB; Fm	PB; Wr; Fm
Pontederia rotundifolia L. f.	Rooted floating	Wr; PB; Fm	Wr; Fm
SPHENOCLEACEAE			
Sphenoclea zeylanica Gaertn.	Emergent	Wr; Fm	_______
VITACEAE			
Cissus spinosa Cambess.	Epiphyte/emergent	Wr; PB	PB

In Bonfim anabranch 47 species were found, distributed into 27 families and the richest ones were Poaceae (9 spp.), Fabaceae (5 spp.) and Asteraceae (4 spp.), while at Mandioré lake 39 species were identified, distributed into 20 families. The most numerous were Poaceae (9 spp.), Fabaceae (7 spp.) and Pontederiaceae (3 spp.) (Table 1). The number of species in anabranch and lake, respectively, was 29 and 19 for wild-rice; 19 and 25 for *Polygonum* banks and 23 and 18 for floating meadow.

Poaceae was the richest family in both wild-rice communities as well as in *Polygonum* banks, while Fabaceae also was the richest in the *Polygonum* bank into the lake. On the floating meadow in the anabranch Poaceae was again the richest family, whereas Pontederiaceae showed highest richness on the floating meadow in the lake.

The five species with highest IV at the wild-rice of the anabranch were *Polygonum acuminatum, Oryza latifolia*, *Echinochloa polystachya*, *Ricciocarpus natans* and *Cissus spinosa*, adding up 58% of the total IV for all species found on this patch (Figure 2A), while at the lake the five species with highest IV were *Hymenachne amplexicaulis*, *Oryza glumaepatula*, *Leersia hexandra*, *Eichhornia crassipes* and *Paspalum repens* adding up 78% of the IV for all species found at this wild-rice (Figure 2B).

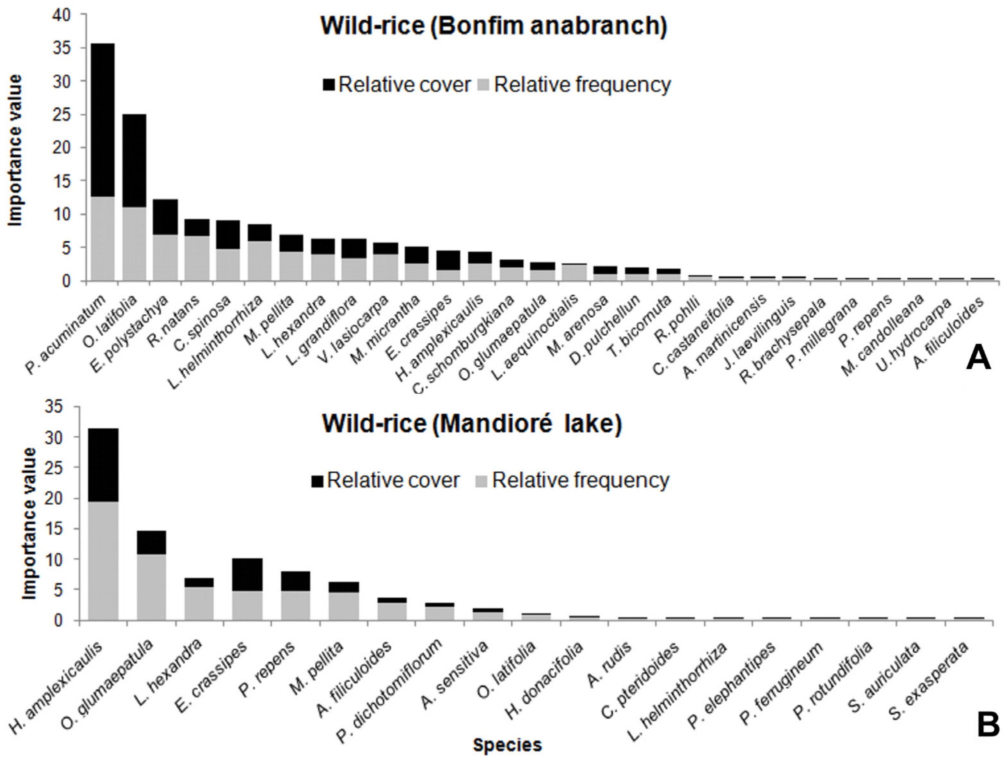

Figure 2. Most abundant aquatic macrophytes inventoried in wild-rice in anabranch Bonfim (A) and Mandioré lake (B), on the Paraguay river floodplain, Pantanal wetland, Mato Grosso do Sul, at flood period, July/2009.

Figura 2. *Espécies de macrófitas aquáticas mais abundantes inventariadas no arrozal do corixo Bonfim (A) e da lagoa Mandioré (B), em área de influência da cheia no rio Paraguai, na planície do Pantanal, Mato Grosso do Sul, em período de inundação, Julho/2009.*

On floating meadow in the anabranch (Figure 3A) the five species with highest IV were *Oxycaryum cubense*, *E. crassipes*, *M. crotophora* , *P. repens* and *Ludwigia helmintorrhiza* adding up 71% of the IV for all species found there, while at the lake (Figure 3B) the five species with highest IV were *Marsilea crotophora*, *Salvinia auriculata*, E*ichhornia crassipes*, *Vigna lasiocarpa* and *Azolla filiculoide*s and these species made up 71% of the IV for all species found at the floating meadow. At the *Polygonum* bank of the anabranch (Figure 4A) the five species which showed the highest IV were *P. acuminatum*, *Polygonum ferrugineum*, *Paspalum repens, E. crassipes* and *C. spinosa*, and these species added up 69% of the IV for all species found there while, at the lake (Figure 4B), the five species which presented the highest IV were *P. ferrugineum*, *Paspalum repens, E. crassipes, Azolla filiculoides* and *Echinochloa polystachya* (over 72% of the total IV) at this patch.

The most representative life form, with the highest number of species, is shown in Table 2. The emergent life form was the best represented in most analyzed communities, however epiphytes predominated in advanced stage at the floating meadow, while rooted floating prevailed in initial stage.

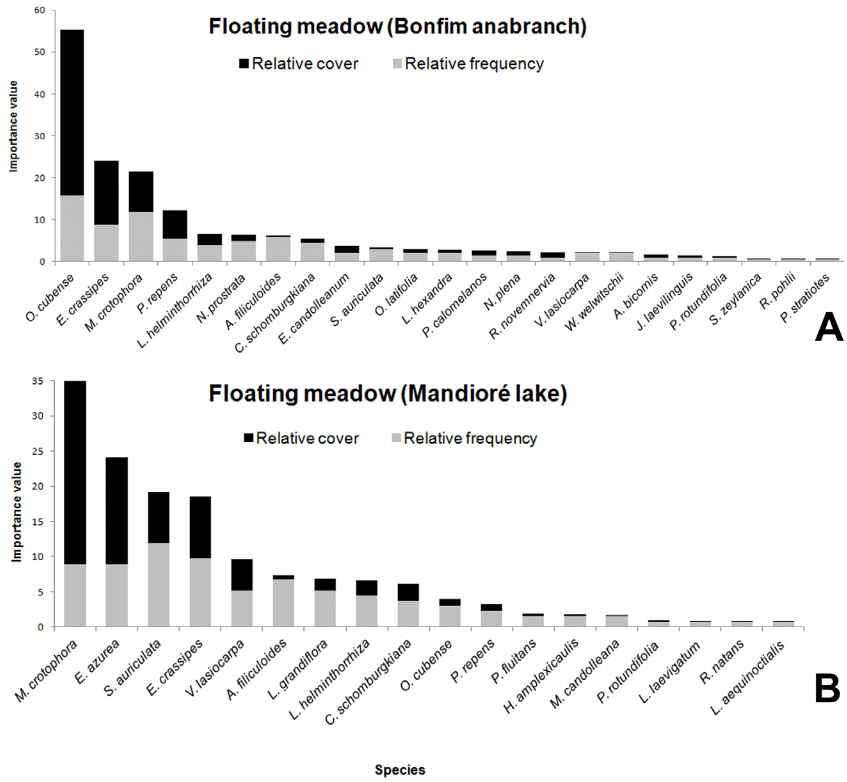

Figure 3. Most abundant aquatic macrophytes inventoried in floating meadow in anabranch Bonfim (A) an Mandioré lake (B), lake (B), on the Paraguay river floodplain, Pantanal wetland, Mato Grosso do Sul, at flood period, July/2009.

Figura 3. *Espécies de macrófitas aquáticas mais abundantes inventariadas no baceiro do corixo Bonfim (A) e da lagoa Mandioré (B), em área de influência da cheia no rio Paraguai, na planície do Pantanal, Mato Grosso do Sul, em período de inundação, Julho/2009.*Ique opublicaeque mori, P.

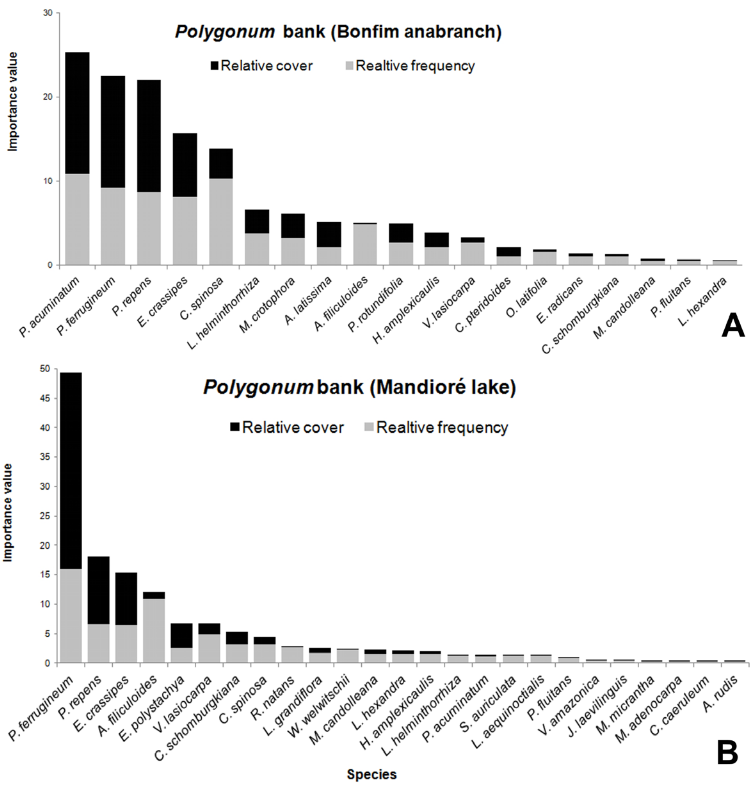

Figure 4. Most abundant aquatic macrophytes inventoried in *Polygonum* bank in anabranch Bonfim (A) and Mandioré lake (B), on the Paraguay river floodplain, Pantanal wetland, Mato Grosso do Sul, at flood period, July/2009.

Figura 4. *Espécies de macrófitas aquáticas mais abundantes inventariadas no banco de baceiro Polygonum do corixo Bonfim (A) e da lagoa Mandioré (B), em área de influência da cheia no rio Paraguai, na planície do Pantanal, Mato Grosso do Sul, em período de inundação, Julho/2009.*

Table 2. More frequent life forms (%) in the communities from anabranch Bonfim and Mandioré lake, on the Paraguay River floodplain, Pantanal, MS (July/2009). Sampled communities: Wr = wild-rice; PB = *Polygonum* bank and Fm = floating meadow.
Tabela 2. *Formas de vida mais frequentes (%) nas comunidades do Corixo Bonfim (B) e da Lagoa Mandioré (M), em área sob influência da cheia no rio Paraguai, na planície do Pantanal, MS (julho/2009). Comunidades amostradas: Wr = arrozal; PB = banco de Polygonum e Fm = baceiro.*

Life form	Wr B	Fm B	PB B	Wr M	Fm M	PB M
Epiphyte	1.50	50.69	0.69	0	5.04	4.23
Rooted floating	3.47	13.17	31.39	11.40	61.96	17.28
Free-floating	7.22	18.56	13.15	20.66	24.14	15.03
Emergent	79.55	6.09	48.6	67.83	2.68	59.01
Epiphyte/emergente	8.19	0.19	6.13	0	6.12	4.39
Free-submerged	0.01	0	0	0	0	0

The general Sørensen index for the species composition of both water bodies indicated that the two sites have low similarity for species (66.6%). This low similarity also occurred between the communities analyzed by site sampled: wild-rice (0.33%), *Polygonum* banks (0.37%); floating meadows (0.32%). The diversity index of Shannon (H') showed values of 2.41 and 1.04 for wild-rice in anabranch and lake; 2.20 for *Polygonum* bank in the anabranch and 1.74 in the lake; 1.84 for floating meadow in the anabranch and 1.92 for floating meadow in the lake. In general the richness patterns of the areas were similar except for wild-rice in the lake which had not enough samples to determine richness (Figure 5). The life forms of species varied in relation to the environments (lotic and lentic) studied (F_5= 38.716, p<0.001).

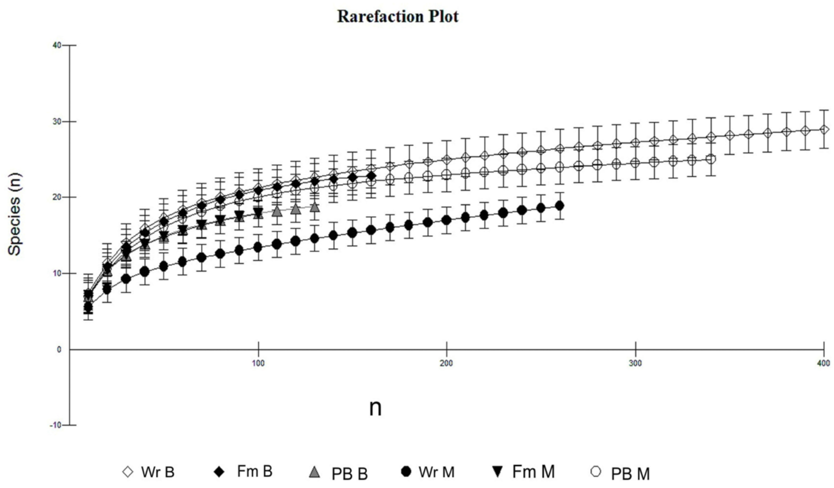

Figure 5. Rarefaction curve of the six sampled patches in the anabranch Bonfim and Mandioré lake: Wr (wild-rice), PB (*Polygonum* bank) and Fm (floating meadow) on the Paraguay river floodplain, Pantanal wetland, Mato Grosso do Sul, at flood period, July/2009.
Figura 5. *Curva de rarefação para as seis manchas amostradas no corixo Bonfim e na lagoa Mandioré: Wr (arrozal), PB (banco de Polygonum) e Fm (baceiro) em área de influência da cheia no rio Paraguai, na planície do Pantanal, Mato Grosso do Sul, em período de inundação, Julho/2009.*

DISCUSSION

Species richness of aquatic macrophytes in both areas is representative compared to values reported by Pott *et al*. (1989), 37 species in similar studie in the Pantanal. It represents 21% of all macrophytes listed in the Pantanal by Pott & Pott (2000). However, it is below those found by Irgang *et al*. (1984), 126 species, and Bove *et al*. (2003), 113 species. The species richness (47 spp.) recorded in the anabranch Bonfim is a little higher than that observed by Pott *et al*. (2011) in the anabranch Alegre (42 spp.) at the North part of the Pantanal.

Even with similar patterns of richness between most areas, we observe that communities have small values of equability because the number of species continued to grow with more samples, which reflects the dominance of some species in communities.

The anabranch Bonfim presented the highest richness and two of its most diverse communities were sampled. With the rise of water level, many adjacent wetlands become flooded, possibly recruiting seed banks and vegetative propagules, favoring the development of additional species. Moreover, the rise of water level creates new habitats providing greater spatial heterogeneity which also reflects positively on the diversity index, a process described also by Fernández-Aláez *et al.* (1999).

The majority of families (74%) presents a single species, indicating high local generic diversity. This is probably related to the cycles of seasonal floods besides producing several effects, such as changes in growth, morphology and physiology, can generate different patterns of richness and composition of plant assemblages.

The dominance (62%) of the emergent life form, predominantly in four of the six analyzed communities is associated with the fact that species of this group flourish in environments subject to seasonal flood, shallowness and resistance to decrease of water volume (Neves *et al.* 2006, Costa Neto *et al.* 2007).

WILD-RICE

The adjacent grasslands of the Pantanal are subject to periodic flooding, as we observed in both communities of wild-rice and in every hydrological stage (flood, drought) there are species adapted to seasonal environmental conditions. These floodplains generally present dominance of *Oryza* species, forming large communities of vegetation, in some places up to 5000ha.

The wild-rice of the anabranch presented more species than the wild-rice of the lake (29 and 19), probably because it was in the flowing, concentrating more floating species on its bed (9 to 4 in the lake) and also in large lakes there is usually little vegetation that may reflect the disadvantages of colonization of habitats with strong waves (Pott & Pott 2000), or fetch effect, observed in the lake.

At the wild-rice of the lake, *Hymenachne amplexicaulis* showed the highest IV (30%). Hydrophytes such as this species may increase or decrease depending on the intensity and duration of drought or flooding, occurring in areas under flood for long periods, tolerating up to 40 weeks at depths up to 1.2 m (Agriculture 2000), surviving to waves and keeping up with rising water (Pott & Pott 2000), through the process known as depth accommodation (Scremin-Dias 1999, 2009), whereby stems, leaves and flower stalks grow after the rise of the flood (Sculthorpe 1967). This species has a preference for flood, replacing the wild-rice in this season, what may explain the second highest IV for *O. glumaepatula*.

At the wild-rice of the anabranch, *O. latifolia* had the second highest IV, however the dominant species was *P. acuminatum* with IV of 35%. The occurrence of *O. latifolia* is mentioned in lakes and wetlands of Bolivia and Brazil (Pott & Pott 2000, Rosa *et al.* 2006) and dominance of wild species of rice on the community is favored by their propagation strategies and flood tolerance (Bertazzoni & Damasceno-Junior 2011). Schmitz *et al.* (2001) comment that the large lakes and floodplains along the Paraguay River allow the growth of *O. latifolia*, what differs from our finding, since this species occurred in the anabranch. As this species grows in a seasonal environment, its growth varies with the flood regime as the water level increases in the communities (Bertazzoni & Damasceno-Junior 2011).Thus, it is assumed that water level is a determining factor in predominance of specie in area, as well as the life cycle of the rice-field is strongly influenced by water regime of rivers. The same was observed by Rubin (1994) for *O. glumaepatula* and *O. grandiglumis* (Döll) Prod.

FLOATING MEADOWS

The variation in species number which occurred between floating meadows reflects the different stages of succession, as aquatic vegetation in more advanced stages of succession has higher complexity in several aspects, one of them is species richness (Neiff 1982). The difference among successional stages can also be responsible for the low floristic similarity (0.32%) we found between both floating meadows. Some species such as *Pityrogramma calomelanos* and *Rhynchanthera novemnervia,* expected for old floating meadows (Pott & Pott 2003, Pivari *et al.* 2008), were observed in the floating meadow of the anabranch.

Although *Oxycaryum cubense* has shown the highest IV at this point, this floating meadow is not in the initial phase due to the presence of other species typical of old floating meadow. This sedge is a species of young floating meadow, as it starts to grow on free floating plants (Pivari *et al.* 2008). So, we consider this floating island a transitional stage.

The floating meadow of the anabranch, because of its advanced stage with histosol of 10-50cm thick, has rooted species such as *O. cubense*, *Oryza latifolia*, *P. repens*, *L. hexandra* and epiphytes such as *V. lasiocarpa* and *C. schomburgkiana.* This community did not present emerging species, due to the presence of histosol, where epiphytic species predominate tolerant to flooding stress (Scremin-Dias *et al.* 1999) and emergent plants are commonly found in habitats constantly or temporarily flooded. Unlike the floating meadow of the lake, due to its early stage of accumulation, it showed a higher number of free floating species such as *E. azurea*, *L.aequinoctialis*, *Limnobium laevigatum*, *Phyllanthus fluitans* and *R. natans* on the floating meadow which does not present a histosol. The fern *M. crotophora* showed the highest IV in this communitie, because this species proliferates in mud during the flood season. According to Pott & Pott (2003), the plants belonging to this life form, such as *Salvinia*, *Eichhornia azurea*, *Limnobium laevigatum*, *Utricularia gibba* and *Pistia stratiotes* are found in early stages of floating meadows, then free floating species have characteristics such as small size, short root system, the leaves favor wind dispersal and the shoots released from the parent plant. These plants are easily driven in aquatic habitats by water and wind and can also grow mixed with other larger plants (Pitelli 2006). The growth of stolons is adapted to enable the species to follow variations of water level during the seasonal period (Neiff 2000).

POLYGONUM BANKS

Different species of *Polygonum* predominate in both analyzed *Polygonum* banks. Bini (1996) described the increase in phytomass of *Polygonum* sp. with the rise of water level in the floodplain of the Paraná River. Thomaz *et al*. (2004) also reported that the effect of environmental factors such as the increase of water level and temperature positively affect the growth of *P. ferrugineum*, whose factors may explain the dominant species of this genera found during the peak of flood in communities of the *Polygonum* bank sampled in the lake and anabranch in the present work.

Species of *Polygonum* are frequently found in wetlands (Souza & Lorenzi 2008). The abundant production of seeds and vegetative propagation by rooting in nodes, justify their presence in these habitats (Pott & Pott 2000).

Polygonum acuminatum showed the highest importance value (25%) in anabranch, followed by *P. ferrugineum* (22%), while *P. ferrugineum* was the most representative (49%) in the lake. Embrapa (2009) confirmed these species are very common at flooded grasslands such as the edge of anabranches and lakes with fertile sandy and clay soils. *Polygonum acuminatum* was observed at the state of Bahia, occurring along the banks of major rivers, while *P. ferrugineum* occurs mainly in lakes and ponds of clear water, as well as along rivers, streams and creeks (Melo 1996).

The *Polygonum* bank was richer in the lake, but less diverse than in the anabranch. The marginal areas of the lake are shallow environments, where the variation in water level is more intense than in other, reflecting the increase in species richness (Fortney *et al.* 2004). Furthermore, these areas constitute an interface between the aquatic and terrestrial environment, providing a heterogeneous habitat that often has a positive relationship with diversity (Barreto 1999).

Thus it was observed that although the floodplain systems during flood periods tend to homogenize the environment (Thomaz *et al.* 2007), it was not observed this fact for the analyzed environments in the hydrological phase, moreover, there is a significant relationship between forms of life and lentic and lotic environment. For Thomaz

(2002), macrophytes colonize in varying degrees, most ecosystems aquatic lotic and lentic. This fact is probably explained by the availability of resources each environment offers as well as abiotic characteristics, which reinforces the importance of studies that consider environmental characteristics. Moreover, occurs the process of succession in lentic environments, not only changing the species of macrophytes, but also the replacement of ecological groups over time (Thomaz 2002), and according the same author, this fact is evident especially when these changes occur in parallel with the increasing trophic status, which leads to the substitution of submerged species by floating and emerging species (Esteves 1998, Thomaz & Bini 1999).

CONCLUSIONS

The lentic and lotic environments showed low similarity, corroborating the hypothesis of the study, mainly because different species dominate communities of the same type, probably due to different environmental features of these communities, whose fact indicates the need for further studies to confirm whether the physicochemical parameters do influence distribution and composition of species in lentic and lotic environments.

ACKNOWLEDGMENTS: To the Graduate course in Plant Biology and to the research administration PROPP/UFMS for financing the field course; to the Brazilian agencies CAPES and CNPq for grants given to some of the authors; to ECOA for motor boat loan.

REFERENCES

AGRICULTURE AND RESOURCE MANAGEMENT COUNCIL OF AUSTRALIA AND NEW ZEALAND. 2000. Weeds of National Significance. *Hymenachne* (*Hymenachne amplexicaulis*) Strategic Plan. *National Weeds Strategy Executive Committee*. 26p.

APG (ANGIOSPERM PHYLOGENY GROUP) II. 2003. An update of the Angiosperm Phylogeny Group Classification for the orders and families of flowering plants: APG II. *Botanical Journal of the Linnean Society*, 141: 399-436. http://dx.doi.org/10.1046/j.1095-8339.2003.t01-1-00158.x

BARRETO, C.C. 1999. Heterogeneidade espacial do habitat e diversidade específica: implicações ecológicas e métodos de mensuração. *Oecologia Brasiliensis*, 7: 121-153.

BERTAZZONI, E.C. & DAMASCENO-JUNIOR, G.A. 2011. Aspectos da Biologia e Fenologia de *Oryza latifolia* Desv. (Poaceae) no Pantanal sul-mato-grossense. *Acta Botanica Brasilica*, 25: 476-486. http://dx.doi.org/10.1590/S0102-33062011000200023

BINI, L.M. 1996. Influence of flood pulse on the fitomass of three species of aquatic macrophytes in the Upper River Paraná floodplain. *Archives of Biology and Technology*, 39: 715-721.

BOVE, C.P.; GIL, A.S.B.; MOREIRA, C.B. & ANJOS, R.F.B. 2003. Hidrófitas fanerogâmicas de ecossistemas aquáticos temporários da planície costeira do Estado do Rio de Janeiro, Brasil. *Acta Botanica Brasilica*, 17: 119-135. http://dx.doi.org/10.1590/S0102-33062003000100009

BRIDSON, D. & FORMAM, L. 1992. *The Herbarium Handbook*. Royal Botanic Gardens, Richmond, VA. 346p.

BROWER, J.E. & ZAR, J.H. 1984. *Field and laboratory methods for general ecology*. Second edition. Wm. C. Brown, Dubuque, IA. 226p.

BRUMMITT, R.K. & POWELL, C.E. 1992. *Authors of plant names*. Royal Botanic Gardens: Richmond, VA. 732p.

CARPENTER, S.R. & LODGE, D.M. 1986. Effects of submersed macrophytes on ecosystem process. *Aquatic Botany*, 26: 341-370. http://dx.doi.org/10.1016/0304-3770(86)90031-8

COSTA NETO, S.V.; SENNA, C.S.F.; TOSTES, L.C.L. & SILVA, S.R.M. 2007. Macrófitas aquáticas das Regiões dos Lagos do Amapá, Brasil. *Revista Brasileira de Biociências*, 5: 618-620.

CRISTOFOLETTI, A. 1981. *Geomorfologia Fluvial. Canal Fluvial.* Vol.1. Edgard Blucher Ltda, São Paulo, SP. 313p.

DAMASCENO-JUNIOR, G.A. & POTT, A. 2011. Métodos de amostragem em estudos fitossociológicos sugeridos para o Pantanal. Pp. 295-323. *In*: J.M. FELFITI, P.V. EISENLOHR, M.M.R.F. MELO, L.A. ANDRADE, & J.A.A. MEIRA-NETO (orgs.). Fitossociologia no Brasil: Métodos e estudos de caso. Editora UFV, Viçosa, MG. Vol. 1. 558p.

DA SILVA, C.J. & FIGUEIREDO, D.M. 1999. Variação limnológica das baías de Chacororé e de Sinhá Mariana, Pantanal Mato-grossense, Mato Grosso (MT). *Revista Mato-Grossense de Geografia*, 3: 57-75.

EMBRAPA SOLOS (Empresa Brasileira de Pesquisa Agropecuária). 1999. *Sistema brasileiro de classificação de solos*. Embrapa-SPI, Brasília, DF; Embrapa Solos, Rio de Janeiro, RJ. 412p.

EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária). 2006. Centro Nacional e Pesquisa em Solos. *Sistema Brasileiro de Classificação de Solos*. Embrapa-SPI, Brasília; Embrapa-Solos, Rio de Janeiro, RJ. 306p.

EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária). 2009. Boletim de Pesquisa e Desenvolvimento 91 - *Floração de Espécies Apícolas no Pantanal Baseada em Informações de Herbário e Literatura*. Corumbá, MS. 44p.

ESTEVES, F.A. & CAMARGO, A.F.M. 1986. Sobre o papel das macrófitas aquáticas na estocagem e ciclagem de nutrientes. *Acta Limnologica Brasiliensia*, 1: 273-298.

ESTEVES, F.A. 1998. *Fundamentos de limnologia*. FINEP/ Interciência, Rio de Janeiro, RJ. 575p.

FANTIN-CRUZ, I.; GIRAD, P.; ZEILHOFER, P.; FILHO, F.M. & COLLISCHONN, W. 2009. Dinâmica da inundação e conectividade nos processos ecológicos do sítio de amostragem de longa duração-Pantanal. Pp.150-156. *In:* Anais do 2º Simpósio de Geotecnologias no Pantanal, Corumbá, 2009, Embrapa Informática Agropecuária/INPE.

FERNÁNDEZ-ALÁEZ, C.; FERNÁNDEZ-ALÁEZ, M. & BÉCARES, E. 1999. Influence of water level fluctuation on the structure and composition of the macrophyte vegetation in two small temporary lakes in the northwest of Spain. *Hydrobiologia*, 415: 155-162. http://dx.doi.org/10.1023/A:1003807905710

FORTNEY, R.H.; BENEDICT, M.; GOTTGENS, J.F.; WALTERS, T.L.; LEADY, B.S. & RENTCH, J. 2004. Aquatic plant community composition and distribution along an inundation gradient at two ecologically-distinct sites in the Pantanal region of Brazil. *Wetlands Ecology and Management*, 12: 575-585. http://dx.doi.org/10.1007/s11273-005-1763-0

GOPAL, B. 1987. *Waterhyacinth*. *Aquatic Plant Studies I.* Elsevier, Amsterdam, The Netherlands. 471p.

HAMILTON, S.K.; SIPPEL, S.J. & MELACK, J.M. 1996. Inundation patterns in the Pantanal wetland of South America determined from passive-microwave remote sensing. *Archives of Hydrobiology*, 137: 1-23.

HUTCHINSON, G.E. 1975. *A treatise on limnology: limnological botany*. Vol. 3. John Wiley and Sons, New York, NY. 660p.

IRGANG, B.E.; PEDRALLI, G. & WAECHTER, J.I. 1984. Macrófitos aquáticos da Estação Ecológica do Taim, Rio Grande do sul, Brasil. *Roessleria*, 6: 395-404.

JUNK, W.J.; BAYLEY, P.B. & SPARKS, R.B. 1989. The flood pulse concept in river-floodplain systems. *Canadian Species Published Fishies Aquatic Science*, 106: 110-127.

KOEPPEN, W. 1931. *Climatologia*. Fondo de Cultura Económica, Buenos Aires, BsAs. 338p.

KRAMER, K.U. & GREEN, P.S. 1990. *The families and genera of vascular plants, Pteridophytes and Gymnosperms.* First edition. Springer Verlag., New York, NY. 410p.

MARGALEF, R. 1983. *Limnologia*. Editora Omega, Barcelona, CJ. 1100p.

MELO, de E. 1996. O gênero *Polygonum* L. (Polygonaceae) no estado da Bahia, Brasil. *Sitientibus*, 14: 45-55.

MUNHOZ, C.B.R. & FELFILI, J.M. 2006. Fitossociologia do estrato herbáceo-subarbustivo de uma área de campo sujo no Distrito Federal, Brasil. *Acta Botanica Brasilica*, 20: 671-685. http://dx.doi.org/10.1590/S0102-33062006000300017

NEIFF, J.J. 1982. Esquema sucesional de la vegetacion en islas flotantes del chaco argentino. *Boletin Sociedad Argentina Botanica*, 21: 325-341.

NEIFF, J.J. 1996. Large rivers of South America: toward the new approach. *Verhandlungen des Internationalen Verein Limnologie*, 26: 167-180.

NEIFF, J.J. 2000. Diversity in some tropical wetland systems of South América. Pp. 1-32. *In*: B. GOPAL & W. JUNK (Eds.). Wetlands Biodiversity, Vol II. Backhuys Publishers, Leiden, The Netherlands. 60p.

NEVES, E.L.; LEITE, K.R.B.; FRANÇA, F. & MELO, E. 2006. Plantas aquáticas vasculares em uma lagoa de planície costeira no município de Candeias, Bahia, Brasil. *Sitientibus Série Ciências Biologicas*, 6: 24-29.

PITELLI, R.L. de C.M. 2006. Abordagens multivariadas no estudo da dinâmica de comunidades de macrófitas aquáticas. *Tese de Doutorado*. Universidade do Estado de São Paulo, Botucatu, SP. 60p.

PIVARI, M.O.D.; POTT, V.J. & POTT, A. 2008. Macrófitas aquáticas de ilhas flutuantes (baceiros) nas ilhas flutuantes (baceiros) nas sub-regiões do Abobral e Miranda, MS, Brasil. *Acta Botanica Brasilica*, 22: 559-567. http://dx.doi.org/10.1590/S0102-33062008000200023

POTT, V.J.; BUEBO, N.C.; PEREIRA, R.A.C.; SALIS, S.M. & VIEIRA, N.L. 1989. Distribuição de macrófitas aquáticas numa lagoa na fazenda Nhumirim, Nhecolândia, Pantanal, MS. *Acta Botanica Brasilica*, 2: 153-168. http://dx.doi.org/10.1590/S0102-33061989000300015

POTT, A. & POTT, V.J. 1994. *Plantas do Pantanal*. First edition. Embrapa, Brasília, DF. 320p.

POTT, V.J. & POTT, A. 2000. *Plantas aquáticas do Pantanal*. Embrapa, Brasília, DF. 404p.

POTT, V.J. & POTT, A. 2003. Dinâmica da vegetação aquática do Pantanal. Pp. 145-162. *In*: S.M. THOMAZ & L.M. BINI (eds.). Ecologia e manejo de macrófitas aquáticas. Editora da Universidade Estadual de Maringá, Maringá, PR. 341p.

POTT, V.J.; POTT, A.; LIMA, L.C.P.; MOREIRA, S.N. & OLIVEIRA, A.K.M. 2011. Plant diversity of the Pantanal wetland. *Brazilian Journal of Biology*, 71: 255-263, http://dx.doi.org/10.1590/S1519-69842011000200005

ROSA, M.S.; DOS SANTOS, P.P. & VEASEY, E.A. 2006. Caracterização agromorfológica interpopulacional em *Oryza glumaepatula*. *Bragantia*, 65: 1-10. http://dx.doi.org/10.1590/S0006-87052006000100002

RUBIM, M.A.L. 1994. A case study on life-history of wild rice – From germination to emergence of inflorescence. Pp. 38-42. *In*: H. MORISHIMA & P.S. MARTINS (eds.). Investigations of plant genetic c resources in the Amazon Basin with emphasis on the genus *Oryza*. Report of 1992/93 Amazon Project. Mishima: The Monbusho International Scientific Research Program.

SAND-JENSEN, K. 1998. Influence of submerged macrophytes on sediment composition and near-bed flow in lowland streams. *Freshwater Biology*, 39: 663-679. http://dx.doi.org/10.1046/j.1365-2427.1998.00316.x

SCHMITZ, P.I.; ROGGE, J.H.; BEBER, M.V. & ROSA, A.O. 2001. Arqueologia do Pantanal do Mato Grosso do Sul: Projeto Corumbá. Pp. 141-152. *In:* Pantanal 2000 – Encontro Internacional de Integração Técnico-Científica para o Desenvolvimento Sustentável do Cerrado e Pantanal, Corumbá, MS. Caderno de Resumos.

SCREMIN-DIAS, E. 1999. O retorno à origem aquática. Pp. 25-41. *In*: E. SCREMIN-DIAS, V.J. POTT & P.R. SOUZA (eds.). Nos Jardins Submersos da Bodoquena: guia para identificação de plantas aquáticas de Bonito. UFMS, Campo Grande, MS. 160p.

SCREMIN-DIAS, E. 2009. Tropical aquatic plants: morphoanatomical adaptations. Pp. 84-132. *In*: K. Del-Claro & Rico-Gray (orgs.). Encyclopedia of Tropical Biology and Conservation Management. EOLSS (www.eolss.net). First edition. UNESCO/EOLSS, Paris. Vol I.

SCULTHORPE, C.D. 1967. *The biology of aquatic vascular plants*. Eduard Arnold, London, Ont. 610p.

SORIANO, B.M.A.; CLARKE, R.T. & CATELLA, A.C. 2001. *Evolução da erosividade das cheias na bacia do rio Taquari*. Boletim de Pesquisa, n° 18. Embrapa Pantanal, Corumbá, MS. 18p.

SOUZA, V.C. & LORENZI, H. 2008. *Botânica sistemática: guia ilustrado para identificação das famílias de Angiospermas da flora brasileira, baseado em APG II*. Instituto Plantarum, Nova Odessa, SP. 640p.

THOMAZ, S.M. 2002. Fatores ecológicos associados à colonização e ao desenvolvimento de macrófitas aquáticas e desafios de manejo. *Planta Daninha*, 20: 21-33. http://dx.doi.org/10.1590/S0100-83582002000400003

THOMAZ, S.M. & BINI, L.M. 1999. Ecologia e manejo de macrófitas em reservatórios. *Acta Limnologica Brasiliensia*, 10: 103-116.

THOMAZ, S.M.; BINI, L.M.; PAGIORO, T.A.; MURPHY, K.J.; SANTOS, A.M. & SOUZA, D.C. 2004. Aquatic macrophytes: diversity, biomass and decomposition. Pp. 331-352. *In*: S.M. THOMAZ, A.A. AGOSTINHO & N.S. HAHN (eds.). The Upper Paraná River and its floodplain: Physical aspects, Ecology and Conservation. Backhuys Publishers, Leiden, The Netherlands. 393p.

THOMAZ, S.M.; BINI, L.M. & BOZELLI, R.L. 2007. Floods increase similarity among aquatic habitats in river-floodplain systems. *Hydrobiologia*, 579: 1-13. http://dx.doi.org/10.1007/s10750-006-0285-y

WEAVER, M.J.; MAGNUSON, J.J. & CLAYTON, M.K. 1997. Distribution of littoral fishes in structurally complex macrophytes. *Canadian Journal of Fisheries and Aquatic Sciences*, 54: 2277-2289.

ZAR, J.H. 1999. *Biostatistical Analysis*. Fourth edition. Prentice Hall, Upper Saddle River, NJ. plus appendices. 662p.

Submetido em 28/03/2012
Aceito em 29/10/2012