Aquatic macrophyte diversity of the Pantanal wetland and upper basin

Pott, VJ.[a]**, Pott, A.*[a]*, Lima, LCP.*[b]*, Moreira, SN.*[a] *and Oliveira, AKM.*[c]

[a]Programa de Pós-graduação em Biologia Vegetal, Departamento de Biologia, Universidade Federal de Mato Grosso do Sul – UFMS, CP 549, CEP 79070-900, Campo Grande, MS, Brazil

[b]Programa de Pós-graduação em Botânica, Universidade Estadual de Feira de Santana – UEFS, Av. Transnordestina, s/n, CEP 44036-900, Feira de Santana, BA, Brazil

[c]Programa de Pós-graduação em Meio Ambiente e Desenvolvimento Regional, Universidade Anhanguera – Uniderp, Rua Alexandre Herculano, 1400, Jardim Veraneio, CEP 79037-280, Campo Grande, MS, Brazil

*e-mail: vali.pott@gmail.com

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(With 1 figure)

Abstract

This is a short review of the state of the art concerning diversity of aquatic macrophytes and the main aquatic vegetation types in the Brazilian Pantanal wetland and upper watershed. There are *ca.* 280 species of aquatic macrophytes on the Pantanal floodplain, with scarce endemism. On the upper watershed, *Cerrado* wetlands (*veredas*) and limestone springs have a distinct flora from the Pantanal, with twice the species richness. As a representative case of aquatic habitats influenced by river flood, some primary data are presented for the Pantanal Matogrossense National Park and associated Acurizal Preserve, analysing the floristic similarity among aquatic vegetation types. We comment on problems of conservation and observe that *Panicum elephantipes* Nees is one of the few natives to compete with the invasive *Urochloa arrecta* (Hack. ex T. Durand & Schinz) Morrone & Zuloaga.

Keywords: flora, aquatic plants, floodplain, savanna, vereda.

Diversidade de macrófitas aquáticas do Pantanal e alta bacia

Resumo

Esta é uma breve revisão sobre o estado do conhecimento sobre as macrófitas aquáticas e os principais tipos de vegetação do Pantanal brasileiro e da alta bacia. A flora da planície inundável é de aproximadamente 280 espécies, com escasso endemismo. Na alta bacia, as áreas úmidas do Cerrado (veredas) e nascentes em calcário têm flora distinta do Pantanal, com o dobro da riqueza de espécies. Como um caso representativo de ambientes aquáticos influenciados por inundação fluvial, são apresentados alguns dados primários do Parque Nacional do Pantanal mato-grossense e da Reserva Acurizal associada, analisando-se a similaridade florística entre tipos de vegetação aquática e comentando-se os problemas de conservação na região, onde foi observado que a espécie *Panicum elephantipes* Nees é uma das poucas nativas que competem com a invasora *Urochloa arrecta* (Hack. ex T. Durand & Schinz) Morrone & Zuloaga.

Palavras-chave: flora, plantas aquáticas, campo úmido, savana, vereda.

1. Introduction

The first botanical reports on aquatic plants of the Pantanal come from European naturalists who crossed the region, as summarised by Sampaio (1916). Foremost among Brazilian botanists was the pioneering Hoehne (1923), who collected in the Pantanal, looking closely at aquatic plants, many of them mentioned in his book (Hoehne, 1948).

Then a gap occurred up until the last two decades, when local botanists started to give some information on the regional flora (e.g. Pott and Pott, 1994, 1997). Various surveys on aquatic macrophytes of the sandy Pantanal, flooded by rain, have been previously reported (e.g., Pott et al., 1999). Some as yet unpublished data on the Pantanal Matogrossense National Park are presented, gathered by the authors and extracted from the Rapid Ecological Assessment-Botany report (Pott et al., 2001), as a representative case of aquatic vegetation influenced by river flood.

2. Results and Discussion

2.1. Flora

Diversity of aquatic macrophytes in the Pantanal varies from the smallest (*Wolffia brasiliensis* Wedd.) to the largest hydrophyte, *Victoria amazonica* (Poepp.) Sowerby. There are at least 280 species of aquatic macrophytes in the Pantanal (Pott, 2008), most of them shown in the identification manual by Pott and Pott (2000), considering various degrees of dependence on water. The most numerous families are Poaceae (26), Cyperaceae (19), Fabaceae (15), Onagraceae (15) and Pontederiaceae (12), and the best represented genera are *Ludwigia* (15), *Bacopa* (12), *Utricularia* (11), *Nymphaea* (7), and *Polygonum* (7) (Pott and Pott, 2000; Pott, 2008).

Taxonomic work on aquatic plants in the Pantanal is as yet restricted to a few groups, such as Nymphaeaceae (Pott, 1998), Araceae-Lemnoideae (Pott and Cervi, 1999), *Aeschynomene* (Lima et al., 2006), and some genera have been reviewed on a Brazilian scale, such as *Panicum* (Guglieri and Longhi-Wagner, 2004). World-wide reviews such as *Utricularia* by Taylor (1989) are also very useful.

Research on macrophyte vegetation has been carried out mainly in floristics. It is often concentrated on a few spots, e.g., Pott et al. (1989, 1999) at Nhumirim ranch (Nhecolândia), Costa (2004) at Santa Emília ranch (Aquidauana), Nunes da Cunha et al. (2000) at Pirizal (Poconé) and other areas of Poconé (Prado et al., 1994; Schessl, 1999).

Cerrado wetlands (*veredas*) on the upper watershed and close by headwaters of the Paraná basin have a richer flora, with at least 574 species (Pott, 2008), twice the species richness found in the Pantanal. The flora of limestone springs on the Bodoquena upland is not very diverse but forms attractive underwater gardens (Pott, 1999).

Many aquatic plants which occur in the Pantanal are elements of wide distribution, in common with wetlands in other neotropical phytogeographic provinces, such as Amazonia and the Paraná basin. *Veredas* contain many additional Poaceae, Cyperaceae, Melastomataceae, etc., in common with other wet grasslands of South America.

There are floristic dissimilarities between the plain and the upper watershed (Pott, 2008), for example, in the crystalline streams of Bonito (Bodoquena range) grows *Potamogeton illinoensis* Morong (Pott, 1999), not yet found in the Pantanal, whereas the giant waterlily *V. amazonica* has exclusive occurrence in oxbow lakes of the lower floodplain (Pott, 2008). Also unique in Mato Grosso do Sul is the wetland sawgrass *Cladium jamaicense* Crantz (Pott, 2008), with *Chara rusbyana* M. Howe covering gaps, on organic soil upon sedimentary calcium carbonate. However, floristic similarity of the Pantanal with wet grasslands of the upper basin increases towards the *Cerrado* uplands, on the eastern sandy soil, with species in common such as *Drosera sessilifolia* A. St.-Hil., *Echinodorus grandiflorus* (Cham. & Schltdl.) Micheli, *Xanthosoma striatipes* (Kunth & Bouché) Mad., etc. Nevertheless, the grass-sedge community of *Mauritia* (*M. flexuosa* L. f.) palm wetlands in the headwaters and along *cerrado* streams of the upper basin is quite distinct from this palm formation on the plain (Pott, 2008), where it only occurs along a few rivers (Aquidauana and Taquari) (Silva et al., 2000) and is associated with species of seasonally flooded grassland or riparian scrub quite different from *veredas*.

Often there are large areas with assemblages dominated by a single macrophyte, such as species of *Oryza* and *Polygonum*, generally with strong vegetative propagation, or various communities may occur within a short distance. Some hydrophytes survive the dry season as dormant rhizomes, which is the case of *Echinodorus* spp., *Eleocharis* spp., *Nymphaea* spp., *Sagittaria* spp.. These are therefore among the first to reappear in the wet season, while others grow from seeds (*Ludwigia* spp.) and spores (*Salvinia*), and many use both vegetative and reproductive strategies. Year-round water level may vary up to 7 m in the river system, while fluctuation is much less in non-coalescent isolated ponds and most areas flooded only by rain. Flood cycles can be drawn from daily records taken by the Navy since 1900 at the hydrometric station at Ladário.

Some species are associated with lotic habitats, such as *Ludwigia inclinata* (L. f.) P.H. Raven, *Nymphaea oxypetala* Planch., but more often with lentic environments, while some occur in both, like *Eichhornia azurea* (Sw.) Kunth. Most sub-regions do not have lakes and ponds, and therefore have quite a monotonous landscape, compared to Nhecolândia, Rio Negro (part of Aquidauana) and Abobral, which present high diversity of habitats, such as brackish and fresh water ponds, seasonal streams, floodplain channels and ancient river beds (“corixos”) and anabranches. Brackish ponds (“salinas”) are poor in macrophyte species, where only *Paspalum vaginatum* Sw. and charophytes occur. Along the Serra do Amolar there are large lakes (Vermelha, Uberaba, Mandioré, Gaíva, etc.), with aquatic vegetation restricted to shores and wind-sheltered inlets.

2.1.1. Endemic and rare species

The Pantanal is a Quaternary floodplain, geologically recent (Holocene), so very few endemic species occur, none of them aquatic. However, the endemic peanut *Arachis vallsii* Krapov. & W.C. Greg. can be considered aquatic, as it grows in 40 cm flooded mud under *Copernicia alba* Morong, on the floodplain of Lake Baía Negra and in a few other clayey spots, where it flowers and sets fruit, with the advantage of its long hollow peg and stem, characteristic structures of aquatics. A few species are quite rare or show very restricted occurrence, such as *Nymphaea belophylla* Trickett, *Eichhornia diversifolia* (Vahl) Urb., *Oryza grandiglumis* (Döll) Prod., found near the Paraguay River in Cáceres, *Discolobium psoraleaefolium* Benth., collected only on the eastern part of the alluvial fan of the Taquari River. For instance, *Eulophia alta* (L.) Fawc. & Rendl. has been found on an old floating island, *Xanthosoma aristiguietae* (Bunting) M. Madison, on the margins of the Miranda River to where rooting stems could have been carried in pre-Columbian times as a medicinal plant.

2.2. Life forms

Aquatic macrophytes have been grouped according to their life form, into submerged, free floating, rooted floating, emergent and amphibious (Irgang et al., 1984), and epiphyte (Tur, 1972). Usually life form zoning occurs according to water depth: amphibians on the littoral, emergents on the shallow belts, and others in the deeper zones (Pott et al., 1989).

2.3. Types of aquatic habitats and main vegetation types

According to Silva et al. (2007), there is a total of 2,557 km^2 of open water in the dry season of the Pantanal, considering only that with a vegetation-free surface. However, the flooded area varies from 7 to 70% of the Pantanal, so at high flood it may reach 110,000 km^2, according to Hamilton et al. (1996), who used radar images, so also taking into account floating aquatics.

Floating mats ("camalote") and floating meadows ("baceiro", "batume") are both found in permanent water bodies such as ponds, lakes, canals, oxbows and rivers. The floating aquatic "batume" was defined by Da Silva (1984). Floating mats are attached banks of floating macrophytes, or they may not be anchored, so that they float downriver or may be driven by wind; the main species of these are the water hyacinths *Eichhornia crassipes* (Mart.) Solms and *E. azurea* (Sw.) Kunth, then both can be uprooted and become free-floating. On top of them and on free-floating aquatic plants (water lettuce, *Pistia stratiotes* L., water fern *Salvinia auriculata* Aubl.), *Oxycaryum cubense* (Poepp. & Kunth) Palla starts to grow, with densely entangled long hollow roots and rhizomes, and gradually the floating mats become floating meadows, with denser vegetation, made up mainly of *Eleocharis plicarhachis* (Griseb.) Svenson, rooted on histosol, as long as the pond does not dry (Pivari et al., 2008). Histosol is a sort of organic soil made of decomposing plants (Neiff, 1978). As the floating meadow ages, the histosol thickens up to more than 1 m, allowing humans to walk on it, as we have already done with a group of 10 people. This floating vegetation is most frequent in the Western zones, in the sub-regions of Abobral and Cáceres and along the Paraguay, Cuiabá, Negro, Miranda and Nabileque Rivers. The cover of bursedge, *O. cubense*, mats can be distinguished on Landsat and SPOT images (Abdon et al., 1998).

Swamps ("brejos") or permanently flooded or waterlogged areas are not as common as the rather misleading toponym Pantanal (= swampland) may suggest, and are confined to wetter places and those with fine sediments, near rivers, such as the Negro (sub-region Aquidauana), which overflows and disappears into a wide swamp, and parts of the sub-regions of Abobral, Paraguay and Poconé. Also, lately the increasingly flooded Taquari delta has become a swamp, due to silting of the river bed and consequent permanent overflow (Pott and Pott, 2005). It contains grasses and sedges, often with some becoming dominant such as giant sedge *Cyperus giganteus* Vahl ("pirizal"), *Ipomoea carnea* var. *fistulosa* (Mart. ex Choisy) D.F. Austin ("algodoal"), fireflag *Thalia geniculata* L. ("caetezal") and cat-tail *Typha domingensis* Pers. ("taboal"), growing in swampy areas or temporary ponds. Cat-tail tends to increase in disturbed flooded areas and artificial ponds (borrow pits and dredged water holes for cattle), while *Rhynchospora trispicata* (Nees) Steud. and *Scleria variegata* (Nees) Steud. are very frequently found.

2.4. Annual cycle

Aquatic plants respond well to the flood dynamics. Many shallowly flooded grasslands dry up and the seasonal aquatics disappear, among them even perennials, such as *Pontederia parviflora* Alexander and *Sagittaria guayanensis* Kunth, as do small annuals like *Bacopa* spp. and *Echinodorus tenellus* (Mart.) Buch. A difference is that in the Pantanal there is a stronger wet and dry cycle, whereas on the upper watershed the flood pulse is much lower, even where there is 50-100% more rainfall. Here soils remain waterlogged or with a high water table all year round, fed by ground water in the dry season, flowing over an impermeable layer of laterite, making the water ferruginous, or over basalt or sandstone. Plant distribution in *cerrado* wet grassland and *vereda* is related to ground-water level (Meirelles et al., 2002), yet in the Pantanal the water table may fall below 2 m in the dry season, hence above-ground water level in the wet is a more important factor. In parts of the Pantanal, these changes in the dry and aquatic phases are more pronounced, reflected in a high proportion of opportunistic therophytes (Schessl, 1999), on intermediate ground between floodless and deep flooded stretches. *Vereda* soils are more organic and peaty, acting like a water storing sponge. These soils are organosoils and gleysoils (Ramos et al., 2006). The soils in the Pantanal, even though hydromorphic too, vary from pure sand to heavy clay, but due to the very flat landscape, in the dry period the water table reaches the surface only in depressed parts, for example in ponds and water courses.

2.5. Dynamics

Aquatic vegetation in the Pantanal changes over time, starting with free-floating plants such as *Salvinia* spp., *Pistia stratiotes*, and *Limnobium laevigatum* (Humb. & Bonpl. ex Willd.) Heine, which become colonised by the epiphyte *Oxycaryum cubense* (Pott and Pott, 2003) and later by *Eleocharis plicarhachis* (Pivari et al., 2008). In more permanent ponds and oxbow lakes, aquatic vegetation tends to advance to a later stage of floating meadow, building up a floating organic soil (histosol) (Neiff, 1978, 1982), which supports shrubs such as *Ludwigia nervosa* (Poir.) Hara and *Rhynchanthera novemnervia* DC. (Pivari et al., 2008) and even treelets, e.g. *Cecropia pachystachya* Trécul and *Tabebuia insignis* (Miq.) Sandw., until the pond eventually dries up and the floating meadow dies, and the process resumes in a new flood cycle (Pott and Pott, 2003). Nitrophilous terrestrial plants also appear, such as *Erechtites hieracifolia* (L.) Raf. ex DC., and the weedy tanner-grass *Urochloa arrecta* (Hack. ex T. Durand & Schinz) Morrone & Zuloaga thrives on this organic substratum. Often the floating meadow is not attached, as an island, and moves

around by wind, sometimes becoming stranded on the shore and decaying, recovering only if the water rises in time; it can be carried downstream and block a channel mouth or end up in the river, losing pieces due to collisions (banks, logs) or storms (1 m waves), and finally disintegrating.

2.6. Indicator species

In the Pantanal, dominance of free-floating plants (*Pistia*, *Salvinia*) indicates that the water body has dried off or the aquatic vegetation was removed by another disturbance. In the highlands, dense populations of *Echinodorus macrophyllus* (Kunth) Micheli, and *Urospatha sagittifolia* (Rudge) Schott indicate disturbed wetland, usually occurring near roads and on silted *veredas* (Pott and Pott, 2003), while *Xanthosoma striatipes* tends to increase under grazing. The submerged *Ottelia brasiliensis* Planch. increases in dammed streams.

3. Pantanal Matogrossense National Park

As a case study, some original data extracted from the unpublished report are presented about the National Park, gathered by the authors in the year 2001. So far, there is no published work on the aquatic vegetation of this Park and the adjacent Acurizal Preserve.

Seventeen sampling sites considered representative of the aquatic habitats (Table 1) were established, inspected by boat, or some on foot in the dry period, and plants were recorded at high and low waters. Plant specimens were collected, and are kept at the CGMS (UFMS) Herbarium. Plots were not measured and varied in area.

To obtain the floristic similarity among sampling sites of aquatic vegetation the Jaccard coefficient was used (Figure 1); this is recommended for presence/absence data (Krebs, 1989). In addition, cluster analysis was performed using the Unweighed Pair Group Method with Arithmetic Mean (UPGMA) (Kent and Coker, 1992).

3.1. Types of aquatic habitats

The types of aquatic habitats and vegetation sampled were river, "corixo" (anabranch, oxbow), floating meadow, lake, pond, seasonal channel ("vazante"), backswamp and incoming stream.

The Alegre and Caracará Rivers are anabranches which run in a cutoff channel from the Cuiabá River to lake Baía dos Burros and other similar large open waters. The lakes show little aquatic vegetation cover, due to waves.

3.2. Flora

The floristic survey of various habitats at 17 sampling sites in the Park showed 135 species of aquatic macrophytes, nearly half the total number for the whole Pantanal. The most numerous families were Poaceae (15), Cyperaceae (10), Fabaceae (13), Onagraceae (9), Asteraceae (5), Convolvulaceae (5) and Euphorbiaceae (5), and the best represented genera were *Ludwigia* (13), *Cyperus* (10), *Ipomoea* (6), *Panicum* (6), *Aeschynomene* (5), *Eleocharis* (5), *Utricularia* (5) and *Polygonum* (5). These families and genera are typical of the Pantanal aquatic flora (Pott and Pott, 2000).

3.3. Life forms

The life forms are all present, albeit submerged, and some rooted floating plants are not common in the Park. It is surprising that not a single species of *Nymphaea* was detected, even though it is so easy to spot, and that seven

Table 1. Types of aquatic habitats and vegetation sampled in Pantanal Matogrossense National Park and Acurizal Preserve, Pantanal wetland, Brazil.

Sites	Abbreviation	Coordinates S, W	Habitat
Acurizal Preserve	AP-1	17° 48' 31.3" and 57° 34' 34.8"	Seasonal stream
Acurizal Preserve	AP-2	17° 48.47.5"and 57° 33' 36.9"	Oxbow lake (shallow)
Baía Acurizal	BA-1	17° 49' 51.8"and 57° 34' 55.4"	Connected large oxbow
Baía Caracará	BC-1	17° 51.32" and 57° 26.86"	Delta lake
Baía Caracará	BC-2	17° 51.71" and 57° 26.23"	Delta lake
Baía dos Burros	BB-1	17° 50' 23.7" and 57° 23' 48.7"	Closed oxbow
Baía dos Burros	BB-2	17° 49' 19.6" and 57° 22.57.5"	Oxbow lake
Córrego Retiro	CR-1	17° 50' 29.8" and 57° 33' 35.4	Incoming stream
Córrego Zé Dias	CZ-1	17° 52.06" and 57° 30.09"	Bay of stream
River Cuiabá	RI-1	17° 51' 08.3" and 57° 24' 51.5"	Backswamp
Park houses	PH-1	17° 50' 45.4" and 57° 24' 12.3"	Pond
Park houses	PH-2	17° 50' 44.7" and 57° 24' 12.4"	Backswamp
River Alegre	AL-1	17° 37' 46" and 57° 24' 46"	Anabranch
River Araminho	AR-1	17° 44.05" and 57° 32.48"	Old river bed
River Araminho	AR-2	17° 43.65" and 57° 32.37"	Backswamp
River Caracará	RC-1	17° 43.22" and 57° 20.59"	Anabranch
River Caracará	RC-2	17° 43.97" and 57° 19.81"	Anabranch

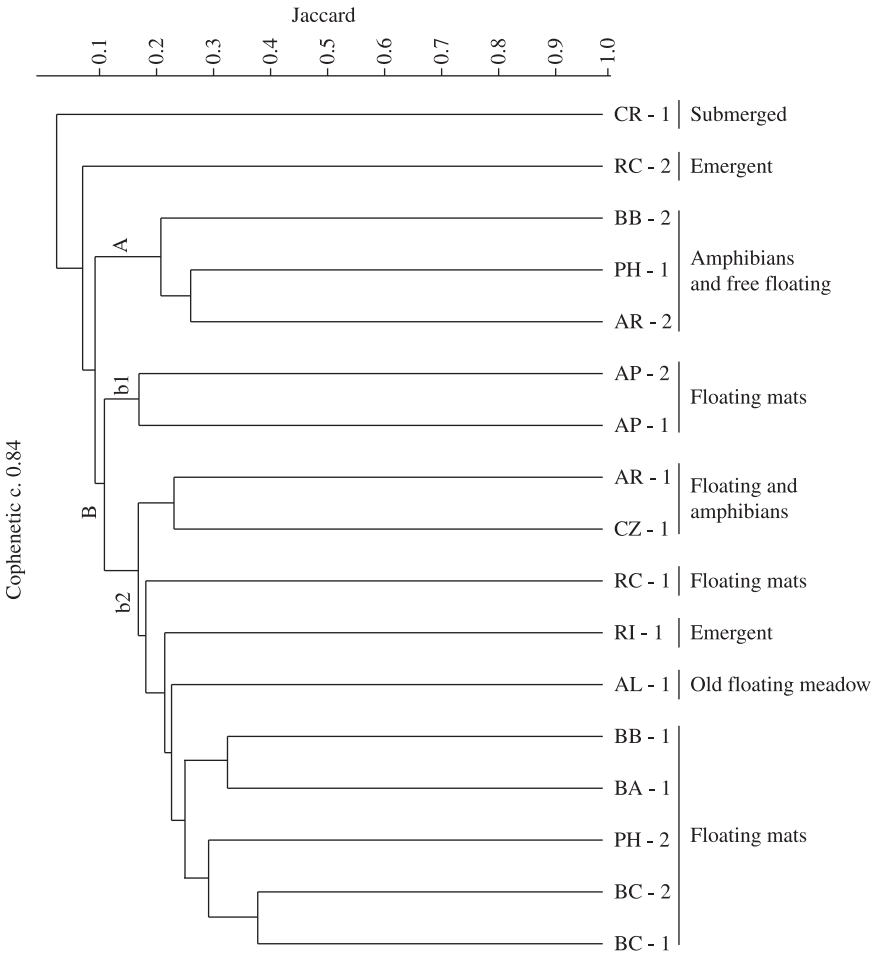

Figure 1. Dendrogram of floristic similarity among sampling sites of aquatic vegetation, grouped (separate vertical line on the right) according to their main habits, of Pantanal Matogrossense National Park and Acurizal Preserve, Pantanal wetland, Brazil. See Table 1 for names of sampling sites, coordinates and types of habitat.

species are found elsewhere in the Pantanal. Their absence is attributed to the low transparency of the water not allowing the young leaves to rise to the surface, although their relative *Victoria* succeeds in this. The turbid water would also explain the low number (five) of submerged species, four of them exclusive to the clear stream (CR-1) coming from the hill.

3.4. Main aquatic communities

Along rivers and streams there is a clear zoning of vegetation, seasonally dynamic: rooted floating mat (*Eichhornia azurea*, *Paspalum repens* Berg., *Panicum elephantipes* Nees) near the bank, then a sequence of emergent plants along the riverside, such as *Panicum dichotomiflorum* Michx. and *Paspalum fasciculatum* Willd. on the levee, oxbows and backswamps with free floating and emergent macrophytes, floating mats and floating meadows, and swamp of *Aspilia latissima* Malme. Thickets of this 1-2 m shrub, often mixed with *Polygonum acuminatum* Kunth, *Ipomoea carnea* Jacq. var. *fistulosa* (Mart. ex Choisy) D.A. Austin, and *Cissus spinosa* Cambess. are an intermediate stage between the aquatic vegetation and early successional phases of riparian forest, held back by flood and eventual wildfires. Well developed floating meadows occur on both sides of the anabranch Alegre River (AL-1), with treelets of *Tabebuia insignis* (Miq.) Sandw.), invaded by tanner-grass *U. arrecta*, while large emergent plants dominate in the anabranch Caracará River (RC-2) until further upstream becoming blocked by floating meadows. A typical oxbow lake (BB-1) is one connected to the Baía dos Burros lake, with free-floating plants and dead matter being colonised by the epiphytic *Oxycaryum cubense* plus dense mats of this sedge. Araminho River (AR) is an active old river bed, connected to the Paraguay River and anastomosed with its own oxbows.

3.5. Species richness

Species richness (Table 2) increases in wave-protected smaller water bodies and the older floating islands hold the highest number of species. On the floating meadow of the backswamp near the Park houses (PH-2) 45 species were found, nearly as many as on a floating meadow of

Table 2. Species richness, exclusive and common species at sampling sites of aquatic vegetation of the Pantanal Matogrossense National Park and Acurizal Preserve, Pantanal wetland, Brazil (meaning of site names with coordinates is given in Table 1). Common: present in ≥ 7 habitats.

Sites	Richness	Species	
		Exclusive	Common
PH-2	45	3	14
AL-1	42	10	12
BC-2	40	0	15
BC-1	34	1	13
AR-2	34	9	7
CZ-1	27	4	11
BA-1	25	1	13
RI-1	23	1	9
AR-1	22	1	8
BB-1	21	0	11
PH-1	21	2	5
RC-1	19	0	7
C-2	13	1	2
BB-2	13	0	5
AP-1	12	2	5
AP-2	11	1	5

the anabranch Alegre River (AL-1) with 42, each with one third of the aquatic floristic richness. The lowest richness was found in two sites (AP-1 and 2) on floating mats of the Paraguay River, at Acurizal Preserve, with 12 and 11 species, respectively.

3.6. Floristic similarity

Floristic similarity among sampled sites is shown in Figure 1. Cophenetic correlation explains 84% of the data. Two groups are shown in the dendrogram, A and B, with low similarity (15%). Group A joined sites AR-2, BB-2 and PH-1, which are the *Aspilia latissima* backswamps, with 25% similarity for the first two and 30% for the third site. Two other sites stand out, CR-1 and RC-2, with low similarity, below 10%; CR-1 is Córrego Retiro creek, with crystalline water from the hills, showing submerged species (*Utricularia breviscapa* Wright ex Griseb., *U. hydrocarpa* Vahl, and *Egeria najas* Planch.) and *Ludwigia sedoides* (Bonpl.) Hara, absent in the other sampled sites, whereas RC-2 is an extensive bank of large emergent plants (*A. latissima*, *I. carnea*, *Polygonum* spp.). Group B was divided in two subgroups, *b1* which linked AP-1 and AP-2, with 18% similarity, and *b2* which joins sites AR-1, CZ-1, RC-1, RI-1, AL-1, BB-1, BA-1, PH-2, BC-2, and BC-1, at different similarity levels (18 to 38%). Groupings tend to show a sequence from floating mats (BB-1, BA-1, PH-2, BC-1 and 2) to inland sites farther from the Paraguay River. The floating meadows stayed apart due to the advanced succession stage of AL-1 compared to RC-2, though both are on anabranches.

3.7. Frequency and cover

Cover was visually estimated (in 1 m^2 quadrats) for the main species per sampling site. The most frequent species and also showing the highest cover is *Polygonum acuminatum*, followed by *Eichhornia crassipes* with the second highest frequency, while *E. azurea* is the second in cover; the fourth in cover is *Oxycaryum cubense* (Table 3). So, only four species add to nearly half (46.7%) of the overall cover of the sampled aquatic vegetation. Next in frequency are *Vigna lasiocarpa*, *Hymenachne amplexicaulis*, *Mimosa pigra*, *Oxycaryum cubense*, *Aspilia latissima*, *Salvinia auriculata* and *Paspalum repens*.

Even though *Victoria amazonica* is impressive in the landscape, it is not frequent in the study area and its population (Araminho River) was seen only during the flood period. This giant water-lily is very competitive and tends to dominate other plants, expanding its 1-2 m diameter leaves with their strong symmetric frame of ironwork-like nerves, until a single individual can cover up to 20 m^2. Associated species such as *E. azurea* and *Paspalum repens* recolonise available space during the low water season.

Near the inselberg Morro do Caracará the large populations of native rice *Oryza latifolia* Desv. and *O. glumaepatula* Steud. represent important germplasm, so the Park has a role in *in situ* conservation. At low water, the flood-grown culms lie down, and are then often taken over by *Hymenachne amplexicalis* and *Leersia hexandra*, until their regrowth from nodes when the flood returns.

Lake Gaíva does not present macrophytes, only algae, indicated by the green colour of the water and the organic sediment, and by filaments on the shore.

4. Use and Conservation

Domestic animals, particularly horses, feed on aquatic plants, mainly grasses and sedges (Pott and Pott, 2004; Alho, 2008a,b). However, cows are usually removed from deep flooded areas or they spontaneously move to less flooded ground. Nevertheless, cattle remain year-round in rain-flooded zones, where they overgraze and trample waterlogged short soft grasslands around ponds and drainage lines. Buffaloes are known for damaging aquatic habitats. For instance, Pott et al. (1999) found 18 aquatic plant species in a pond with buffaloes, while 2 years after the removal of the animals the richness increased to 38 species. Fortunately buffalo are not liked by traditional ranchers, as they are difficult to manage and tend to become feral in this extensive type of husbandry, otherwise aquatic vegetation could be severely damaged, as has occurred in the Amapá wetlands in Amazonia. However, new owners have started to introduce buffalo again, as well as goats, both of which present a threat to the Pantanal.

Wildfire reaching dry beds is deleterious to hydrophytes with exposed buds, while it enhances seed germination of

Table 3. Frequency and mean cover of the main aquatic macrophytes of Pantanal Matogrossense National Park and Acurizal Preserve, Pantanal wetland, Brazil.

Species	Frequency (%)	Mean cover (%)
Aspilia latissima Malme	58.82	3.53
Urochloa arrecta (Hack. ex T. Durand & Schinz) Morrone & Zuloaga	29.41	3.53
Cayaponia podantha Cogn.	29.41	1.12
Discolobium pulchellum Benth.	41.18	0.41
Echinochloa polystachya (Kunth) Hitchc.	29.41	0.18
Eichhornia azurea (Sw.) Kunth	**58.82**	**11.24**
Eichhornia crassipes (Mart.) Solms	**64.71**	**12.24**
Eleocharis minima Kunth	17.65	4.62
Hydrocotyle ranunculoides L.f.	29.41	-
Hymenachne amplexicaulis (Rudge) Nees	47.06	0.65
Ipomoea carnea v. *fistulosa* (Mart. ex Choisy) Austin	35.29	3.70
Leersia hexandra Sw.	41.18	2.59
Lemna aequinoctialis Welw.	29.41	-
Lippia alba (Mill.) N.E. Br.	35.29	0.76
Ludwigia helminthorrhiza (Mart.) Hara	41.18	-
Ludwigia leptocarpa (Nutt.) Hara	29.41	1.12
Ludwigia nervosa (Poir.) Hara	35.29	-
Melochia arenosa Benth.	41.18	2.47
Mimosa pigra L.	47.06	1.24
Oxycaryum cubense (Poepp.& Kunth)Lye	47.06	**9.06**
Panicum elephantipes Nees	41.18	2.24
Paspalum repens Berg.	47.06	3.59
Pfaffia glomerata (Spreng.) Pedersen	29.41	0.41
Pistia stratiotes L.	29.41	-
Polygonum acuminatum Kunth	**76.47**	**14.18**
Polygonum ferrugineum Wedd.	35.29	3.88
Pontederia parviflora Alex.	41.18	-
Rhabdadenia madida Miers	35.29	0.24
Salvinia auriculata Aubl.	47.06	1.94
Vigna lasiocarpa (Benth.) Verdc.	**58.82**	-

weedy *Mimosa* spp. and *Sesbania virgata* (Cav.) Pers., shrubs which tolerate flooding and compete with other aquatic plants (Pott and Pott, 2003). Yet rhizomatous macrophytes such as *Canna glauca* L., *Cyperus giganteus* Vahl, *Eleocharis* spp., *Thalia geniculata* and *Typha domingensis* can survive and tend to become dominant (*op. cit.*).

Few exotic aquatic plants have invaded the Pantanal. One is *Sphenoclea zeylanica* Gaertn. (Sphenocleaceae, formely Campanulaceae), but it is restricted to the Paraguay River floodplain (Pott and Pott, 2000), even in undisturbed sites such as the National Park. Two introduced grasses have become weeds, torpedo-grass *Panicum repens* L. is spreading in sandy areas and tanner-grass *Urochloa arrecta* on clay (Pott and Pott, 2003). The latter is a real threat to aquatic vegetation diversity, propagated by seed, stolon, rhizome, or any fragment, carried by flood flow, taking over other aquatic plants, as is already happening in the Pantanal National Park, where we observed that the vigorous stoloniferous *Panicum elephantipes* is one of the only native grasses to match the competition.

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