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Aquatic macrophytes of six subtropical shallow lakes, Rio Grande, Rio Grande do Sul, Brazil

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Abstract: The aim of this study was to document the richness of aquatic macrophytes in six shallow lakes at Federal University of Rio Grande - FURG, Rio Grande, Rio Grande do Sul, Brazil. Qualitative surveys were carried out during 2008. Specimens were deposited at the university herbarium (HURG). We recorded 44 species belonging to 35 genera and 21 families. The majority of species were present all year. The family with highest diversity was Cyperaceae (eight species). Other studies have reported approximately 170 species for wetlands in the south of Brazil. This study documented approximately 25% of these species. The flora of the area should be preserved and monitored.

Introduction

Shallow lakes are complex ecosystems strongly influenced by physical, chemical and biological processes arising from the intense sediment-water interaction and the potential impact of aquatic vegetation (Scheffer 1998). Aquatic macrophytes play an important role in the structure and function of aquatic ecosystems (Chambers *et al.* 2008) and therefore participate in nutrient cycling, energy flow, and habitat heterogeneity (Wetzel 1993; Esteves 1998; Albertoni *et al.*, 2005).

Surveys of biological diversity in aquatic ecosystems are essential protective measures because they identify areas of major conservation value (Thomaz and Bini 2003). The high spatial variability of the macrophyte community is an important parameter to be considered in choosing these areas (Rolon *et al.* 2004). The Rio Grande do Sul coastal plain's low relief and the reduced depth of its water bodies give rise to common, diverse, and dense stands of macrophytes in the littoral zone of the area's lakes (Vieira and Rangel 1988; Albertoni *et al.* 2005). The current lack of updated information on species composition and on species' spatial and temporal distribution in different environments limits the establishment of guidelines for biodiversity conservation. The objective of this study was to extend current knowledge of aquatic vegetation in this region by surveying the aquatic macrophytes of six shallow lakes during a one-year period.

Materials and Methods

The city of Rio Grande (32°01'40" S, 52°05'40" W) is located in southern Brazil on the Rio Grande do Sul Coastal Plain. The coastal plain is characterized by low relief and absence of rivers. Streams and ponds constitute the hydrographic network (Vieira and Rangel 1988) (Figure 1).

The climate is humid subtropical (Cfa according to the Köppen classification). The winter and spring are characterized by intense humidity. The summer is dry. NE winds dominate for most of the year. In the autumn, and particularly in winter, S (mainly SE) winds become very important (Krusche *et al.* 2002).

The study was conducted in six aquatic environments located on the Carreiros campus of the Federal University of Rio Grande in an area of approximately 250 ha. The area has many small natural and artificial bodies of water. During periods of high rainfall, an extensive area remains flooded, and the soil is water saturated.

The lakes studied are permanent, small and shallow, reaching up to 3 m deep and 3 ha in size. These water bodies have different limnological characteristics (trophic status, dissolved status, dissolved oxygen concentrations, pH) (Albertoni *et al.* 2005; Marinho *et al.* 2009; Trindade *et al.* 2009), and these differences give rise to biological communities peculiar to each water body.

The samples were collected monthly from January to December 2008 using the methods in Pedralli (1990). In each lake, the species were recorded until samples stabilized (no further increase in species found, Filgueiras *et al.* 1994). The species found were photographed, collected for identification and mounting and deposited in the Herbarium of the Federal University of Rio Grande (HURG). The identification followed the taxonomic literature (Forno 1983; Cordazzo and Seelinger 1988, Cook 1990; Irgang and Gastal Jr. 1996; Cervi and Pott 1999; Gil and Bove 2007; Barros 1960). The species were arranged by family according to APG II - Angiosperm Phylogeny Group (2003). The verification of nomenclature and citation of authors of species found was carried out using the List of Species of Flora of Brazil (Forzza *et al.* 2010). The species were classified according to morphoecological group as follows: emergent (or amphibious), rooted with floating leaves, submerged rooted, free submerged and free floating (Esteves 1998).

The efficiency of sampling effort was quantified by using the species accumulation curve with 50 randomizations (Colwell 2009), with each monthly collection as the

sampling unit. To view the pattern of colonization, the species were classified using the following categories according to temporal frequency of occurrence: constant (present in 100% of collections); frequent (present in 99-50%), sporadic (present in 49-10%) and occasional (present in 9-1%) following Rolon *et al.* (2004).

Results and Discussion

A total of 43 species distributed across 35 genera and 21 families were recorded in the six shallow lakes of the Carreiros campus (Table 1). The species accumulation curve showed a tendency to stabilize and reached saturation in the final samples collected (Figure 4). This result indicates that the sampling effort was sufficient to quantify the macrophyte community on the Carreiros campus.

A few previous surveys of aquatic flora are available for this region. Pedralli *et al.* (1985) recorded 116 species in the city and its environments. Rocha and Costa (1988) found 21 species of macrophytes in a shallow lake. Approximately 24% and 43%, respectively, of the taxonomic inventories reported by these previous studies were also recorded in this study. The richness of taxa found in this study represents ca. 25% of the aquatic macrophytes listed by Rolon *et al.* (2004) for 146 wetlands in the state of Rio Grande do Sul. Therefore, although the scale of our environments is small, the high diversity of species recorded indicates the conservation importance of the area. The family Cyperaceae was most often represented in our samples. The eight species recorded represented a total of approximately 18.2% of all species found. Most of the recorded species (33 species) were constant in occurrence and present throughout the study period (Figure 2). The small variation in the number of observed species suggests that most of these species are perennials and can tolerate the environmental changes that occur, such as fluctuations in water levels and size of the systems. For example, during drought periods, species of the family Cyperaceae indicate the existence of temporary swamps (Bove *et al.* 2003).

Luziola peruviana (Poaceae) was the only species found in all six lakes and over the entire study period (Figure 3). This macrophyte is perennial, amphibious, rooted, with excellent regrowth, reproduction by seed and stolons, and vegetative growth throughout the year (Boldrini *et al.* 2005). According to Neiff (2000), the dominance of this species may reflect its amphibious adaptations, derived from stolon growth, that allow the plant to follow seasonal changes in the water level.

Among morphoecological groups, emergent and amphibious species were the most representative (28 species), followed by floating (seven species), submerged rooted (four species), submerged free (three species) and rooted with floating leaves (one species). The most representative species of amphibious and emergent macrophytes were also reported by several other authors from diverse aquatic systems (Irgang *et al.* 1984; Pott and Pott 1997; Matias *et al.* 2003; Bove *et al.* 2003; Rolon *et*

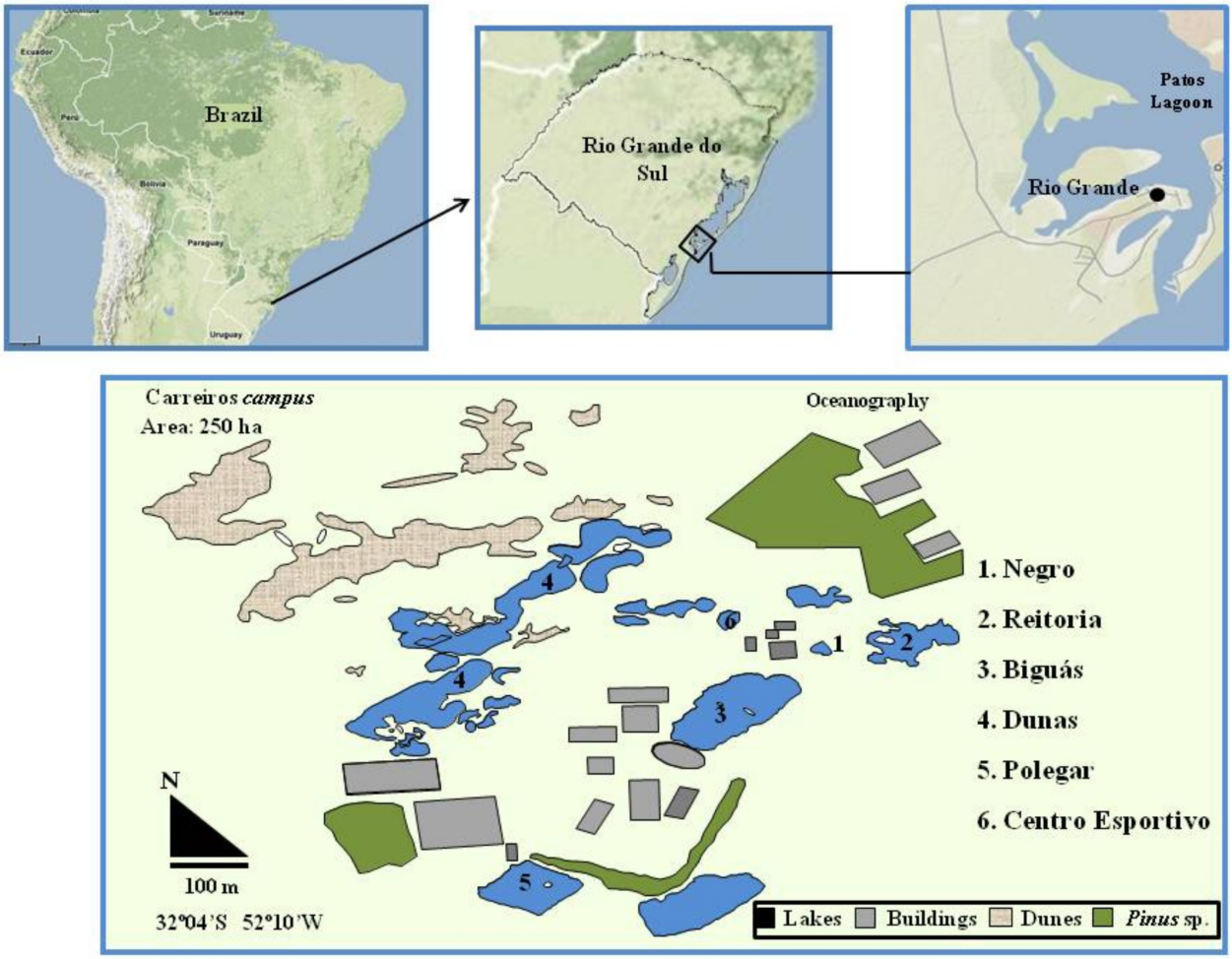

Figure 1. Map of study area showing the lakes sampled, located on Carrreiros campus, FURG, (Rio Grande, Rio Grande do Sul, Brazil).

al. 2004). Clearly, these species are well adapted to both aquatic and terrestrial environments (Junk and Piedade 1993).

Floristic surveys of all species are rarely reported. According to RØrslett (1991), survey findings may be affected by the areas and sampling periods included and by human intervention. Thus, some species may not have been recorded because they were in their vegetative state or had biennial life cycles. This observation suggests a need for future studies that focus on the ecological plasticity of these species.

In this study, we observed high diversity and low variation in the number of species throughout the year, which indicates that the studied area is in a good state of preservation. The fact that macrophyte communities play an important role in the maintenance and function of aquatic ecosystems in the region has strong implications for future research needs. There is a need to deepen and broaden the scope of floristic surveys as well as to focus on the preservation of native species and on maintaining the integrity of these ecosystems.

Figure 2. Perennial species in different seasons. *Typha domingensis*: A - summer (January) and B - Winter (June). *Scirpus giganteus*: C - Winter (June) and D - Spring (September).

Figure 3. *Luziola peruviana* present in the all lakes during all year.

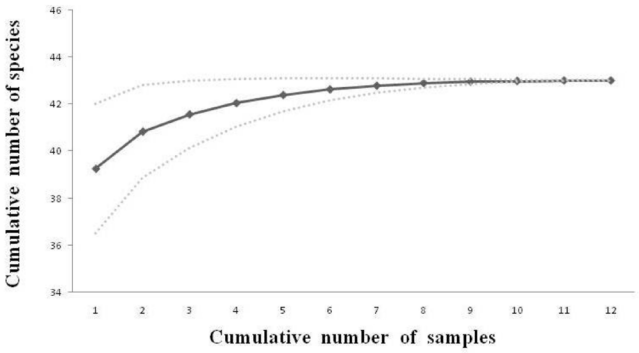

Figure 4. Species accumulation curve (solid line) and confidence intervals (dashed lines) Carreiros *campus.*

Table 1. List of species of macrophytes found in six shallow lakes at Carreiros campus in Rio Grande, Rio Grande do Sul, Brazil. Lakes: D – Dunas, P – Polegar. N – Negro, CE – Centro Esportivo e R – Reitoria. N° HURG = Number of herbarium deposit, FREQ= frequency of species.

FAMILY / SPECIES	MORPHO-ECOLOGY GROUP	LAKES	N° HURG	FREQ (%)
ALISMATACEAE				
Echinodorus tenellus (Mart.) Buchenau	emergent/amphibious	D, P	4299	25
Sagittaria montevidensis Cham. and Schltdl.	emergent/amphibious	D	-	100
AMARANTHACEAE				
Alternanthera philoxeroides (Mart.) Griseb.	emergent/amphibious	D, CE, R,N, B	4292	83
APIACEAE				
Centella asiatica (L.) Urb.	emergent/amphibious	D, P, CE, R, B	4298	100
ARACEAE				
Lemna valdiviana Phil.	free floating	D, N, CE	4462	92
Pistia stratiotes L.	free floating	D	-	33
Wolffia brasiliensis Wedd.	free floating	D, N	4294	33
Wolffiella oblonga (Phil.) Hegelm.	free submerged	D, N	4293	100
ARALIACEAE				
Hydrocotyle bonariensis Lam.	emergent/amphibious	D, P, CE, R, B	1160	100
Hydrocotyle ranunculoides L.f.	emergent	D, B	4295	100
ASTERACEAE				
Mikania periplocifolia Hook. and Arn.	amphibious	B	4114	100
Enydra anagallis Gardner	emergent/amphibious	D, CE, R, B	-	100
CABOMBACEAE				
Cabomba caroliniana A.Gray	submerged rooted	D	4458	75
CHARACEAE				
Chara sp.	submerged rooted	D, P	4291	100
Nitella sp.	submerged rooted	D	-	100
CYPERACEAE				
Androtrichum trigynum (Spreng.) H.Pfeiff.	emergent/amphibious	D, N	2104	100
Ascolepis brasiliensis (Kunth) Benth. *ex* C.B.Clarke	emergent/amphibious	B, D, R	-	100
Cyperus haspan L.	emergent/amphibious	P	4454	100
Cyperus odoratus L.	emergent/amphibious	CE, R, B	-	83
Cyperus rigens C.Presl	emergent/amphibious	D, N	4453	100
Pycreus polystachyos (Rottb.) P.Beauv.	emergent/amphibious	B	4455	100
Schoenoplectus californicus (C.A.Mey.) Soják	emergent/amphibious	D, P, B	-	100
Scirpus giganteus Kunth	emergent/amphibious	D	-	100
FABACEAE				
Erythrina crista-galli L.	emergent/amphibious	B		100
Vigna luteola (Jacq.) Benth.	emergent/amphibious	D, B		17
LENTIBULARIACEAE				
Utricularia breviscapa C.Wright *ex* Griseb.	free submerged	D, N, CE, R	4297	100
Utricularia gibba L.	free submerged	D, N, CE, R	2401	100
MENYANTHACEAE				
Nymphoides indica (L.) Kuntze	rooted with floating leaves	D, P, R	0789	100
ONAGRACEAE				
Ludwigia multinervia (Hook. and Arn.) Ramamoorthy	emergent/amphibious	D, CE, R	4324	100
Ludwigia hexapetala (Hook. and Arn.) Zardini *et al.*	emergent/amphibious	D, N, CE, R, B	4302	100
Ludwigia peploides (Kunth) P.H.Raven	emergent/amphibious	D, N, CE, R, B	1097	100
PLANTAGINACEAE				
Bacopa monnieri (L.) Pennell	emergent/amphibious	D, P, CE, R, B	-	100
POACEAE				
Luziola peruviana Juss. *ex* J.F.Gmel.	emergent/amphibious	D, P, N, CE, R, B	1214	100
POLYGONACEAE				
Polygonum ferrugineum Wedd.	emergent/amphibious	D, N, B	4461	100
Polygonum hydropiperoides Michx.	emergent/amphibious	D, N, R, B	2551	100
PONTEDERIACEAE				
Eichhornia crassipes (Mart.) Solms	free floating	CE, R	-	100
POTAMOGETONACEAE				
Potamogeton pectinatus L.	submerged rooted	D, CE	4296	100

Table 1. ***Continued.***

SALICACEAE			-	
Salix humboldtiana Willd.	emergent/amphibious	B	-	100
SALVINACEAE				
Azolla filiculoides Lam.	free floating	D, CE, N, R, B	4460	100
Salvinia herzogii de la Sota	free floating	D	4303	100
Salvinia minima Baker	free floating	D	-	100
TYPHACEAE				
Typha domingensis Pers.	emergent/amphibious	D	1209	100
XYRIDACEAE				
Xyris jupicai Rich.	emergent/amphibious	D, P, CE, R	-	83

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