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Aquatic macrophyte flora of coastal lakes in Santa Catarina, southern Brazil

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ABSTRACT – Aquatic macrophytes are representative flora elements of diverse wetland environments. They play several roles in aquatic ecosystems and are components of paramount importance in maintaining the dynamic and quality of these environments. For coastal lakes, where most aquatic macrophyte studies have been conducted, floristic surveys are continuously increasing, resulting in more knowledge about these species. This study sought to increase what is known about aquatic macrophytes by inventorying the biodiversity of these plants in three coastal lakes in the cities of Florianópolis (Lake Pequena), Imbituba (Lake Doce) and Araranguá (Lake Azul), Santa Catarina. A total of 112 aquatic macrophyte species were identified, including 76 species for Lake Pequena, 50 for Lake Doce and 52 for Lake Azul. Among the most representative families, Cyperaceae (24 species), Poaceae (10) and Onagraceae (eight) are notable.

Keywords: floristics, hydrophytes, lentic environments

RESUMO – **Flora de macrófitas aquáticas de lagos costeiros em Santa Catarina, sul do Brasil**. Macrófitas aquáticas são elementos vegetais representativas dos diversos ambientes alagados. Eles desempenham vários papéis em ecossistemas aquáticos, sendo os componentes de suma importância na manutenção da dinâmica e qualidade desses ambientes. Em lagoas costeiras, onde a maioria dos estudos ocorreu, os levantamentos florísticos desses grupos são continuamente crescentes, assim como o conhecimento sobre suas espécies. Nós procuramos incrementar mais informações sobre macrófitas aquáticas, reconhecendo a biodiversidade deste grupo para três lagoas costeiras de Santa Catarina, localizadas nas cidades de Florianópolis (Lagoa Pequena), Imbituba (Lagoa Doce) e Araranguá (Lago Azul). Um total de 112 espécies de macrófitas aquáticas foi identificado, sendo 76 espécies encontradas para Lagoa Pequena, 50 para Lagoa Doce e 52 para o Lago Azul. Entre as famílias mais representativas destes lagos, destacamos Cyperaceae com 24 espécies, seguido de Poaceae com 10 e Onagraceae com oito.

Palavras-chave: ambientes lênticos, florística, hidrófitas

INTRODUCTION

Freshwater lakes and ponds are defined as bodies of inland water without any direct communication with the sea (Esteves 2011). These landscapes fall among the most diverse ecosystems that establish connectivity between terrestrial and aquatic environments, and their extent is determined by the edge of the area permanently flooded or the limit of the area of influence of the water during flooding (Junk *et al*. 2014).

Frequently, lentic water bodies are referred to as final accumulators of allochthonous matter, since they continually receive input of sediment, water and organic matter from streams and adjacent areas (Esteves & Gonçalves 2011). These environmental conditions typically accommodate amphibious and aquatic flora commonly referred to as aquatic macrophytes.

Aquatic macrophytes are clearly adapted to lacustrine ecosystems, are associated with the shallow parts of ponds and lakes, generally establish themselves along shores and frequently form large populations (Burger 2000, Esteves & Caliman 2011).

Broadly defined, macrophytes are considered plants visible to the naked eye whose photosynthetic parts are permanently or for several months fully or partially submerged, or floating on the water surface, in fresh or brackish water (Irgang & Gastal Jr. 1996, Chambers *et al*. 2008, Rodrigues 2011, Thomaz & Esteves 2011).

We recognize that the use of a broad definition of macrophytes entails some problems in dealing with macrophyte communities because, for example, some species have adaptations that allow them to occupy more elevated wet areas, but not flooded and terrestrial areas, and some opportunistic species considered terrestrial may colonize flooded areas due to ecological plasticity (Keddy 2010, Thomaz & Esteves 2011). These aspects make the broad definition applied to macrophytes vague when addressing ecological responses of species to environmental factors, especially when dealing with amphibious species; due to this, ecologists often create narrower categories completely apart from macrophytes, such as marsh and helophyte species (Keddy 2010, Thomaz & Esteves 2011). However, the broad definition of macrophytes applied here reflects the vast majority of studies published in South America (e.g., Argentina: Neiff *et al*. 2000; Bolivia: Frey 1995; Brazil: Pedralli & Gonçalves 1997, Bove *et al*. 2003, Moura-Junior *et al*. 2013, 2015; Colombia: Rangel & Aguirre 1983; Schmidt-Mumm & Janauer 2014; Chile: Hauenstein *et al*. 1991, 1996, 2008, 2011; Venezuela: Colonnello 1995, Gordon 2000), which are concerned more with filling the "gaps" of biodiversity knowledge of macrophytes that have been reported (Thomaz & Bini 2003, Padial *et al*. 2008, Thomaz & Esteves 2011, Filho *et al*. 2014).

Representatives of aquatic macrophytes are in seven plant divisions, Spermatophytes, Pteridophytes, Bryophytes, Chlorophyta (especially order Charales), Cyanobacteria, Xantophytes and Rhodophyta (Chambers *et al*. 2008), and are classified by Pedralli (1990) into seven biological forms: rooted submersed, free submersed, rooted with floating leaves, free-floating, emergent, amphibious and epiphytic.

Macrophytes play various roles in aquatic ecosystems and are elements of paramount importance in maintaining the ecological balance of these environments (Cook *et al*. 1974, Irgang & Gastal Jr. 1996, Paz 1997, Amaral *et al*. 2008, Chambers *et al*. 2008). These organisms have several well-known ecological roles, such as serving as primary producers, participating in the cycling and storage of nutrients and the formation of organic debris, and acting as a filter during the input of allochthonous matter in a waterbody, and, thus, help control pollution and artificial eutrophication (Pott & Pott 2000). In addition, they serve as a food source and place of refuge for several species of vertebrates and invertebrates, and their presence can change the trophic interactions of the aquatic environment (Sánchez-Botero *et al*. 2007, Sagrario *et al*. 2009, Thomaz & Cunha 2010, Esteves 2011).

There have been several floristic surveys of aquatic macrophytes in the South Region of Brazil (Thomaz & Bini 2003, Pinheiro & Jardim 2015), which were mainly concentrated around coastal lakes. Coastal lakes border environments where human occupation and human activity are very intense (Thomaz 2002, Musyimi 2011), and are one of the most impacted environments in the world (Sala *et al*. 2001, Esteves *et al*. 2008), making it quite justifiable to be concerned about their biodiversity.

Floristic and ecological studies are fundamental to better understand macrophyte communities in coastal lakes and to subsidize conservation measures of these aquatic environments (Jayakumar *et al*. 2011). In Santa Catarina, works involving aquatic macrophytes are still scarce and include only a few floristic inventories or monitoring studies that include aquatic plants, such as Rambo (1949), Reitz (1961), Bresolin (1979), Falkenberg (1999), Zanette & Aguiar (2000), Tavares *et al*. (2004), Caris *et al*. (2007), Veiga (2010), Alves *et al*. (2011) and Magalhães *et al*. (2013).

In the present work, we present a floristic survey of macrophytes in three natural permanent coastal lakes located in south-central Santa Catarina.

MATERIAL AND METHODS

The three lakes in the study are located near the coast of Santa Catarina in the south-central part of the state (Fig. 1). Lake Pequena comprises an area of approximately 16.11 hectares and is in the Rio Tavares district in the municipality of Florianópolis (central point 27°39'23"S 48°28'43"W, 7 m a.s.l.). Lake Doce comprises 46.16 hectares and is in the Alto Arroio district in the municipality of Imbituba (central point 28°10'16"S 48°40'53"W, 10 m a.s.l.). Lake Azul comprises 120.26 hectares and is on the border of the municipalities of Araranguá and Balneário Arroio do Silva (central point 28°57'23"S 49°25'31"W, 12 m a.s.l.).

The freshwater lakes in the study are within the coastal vegetation of Santa Catarina, which formed five to seven thousand years ago (Soriano-Sierra *et al*. 2014). These lakes are surrounded by edaphic vegetation formations; although, the southern limit of Lake Azul is associated with dense lowland rain forest (IBGE 2012). All the lakes have residencies in their surroundings and these waterbodies are frequently used for recreation (and in the case of Lake Azul as a reservoir). Geological studies of southern Brazil indicate that the coastal strip in these areas experienced steady growth during the Quaternary period due to lifting or alluvial processes (Reitz 1961).

The aquatic vegetation of Lake Pequena, Lake Doce and Lake Azul was determined by intensive sampling during the summer of 2013 and spring of 2014, which is when the flowering period of aquatic vegetation is most intense. Most of the species found in the lakes were collected using the walking method (Filgueiras *et al*. 1994) along the shore; amphibious attire was used in shallower places. Some of the submerged aquatic species that were hard to reach were collected with a hook and for the deeper regions a boat was used to reach the species.

The botanical material was pressed, dried and deposited in FLOR (Mori *et al*. 1989). The species were identified using regional literature about aquatic macrophytes (Irgang & Gastal Jr. 1996, Paz 1997, Pott & Pott 2000, Amaral *et al*. 2008) and confirmed using taxonomic revisions of each genus. We consulted The Plant List (2013) and Flora do Brasil 2020 (in construction) databases to verify the correct names for the species surveyed. The classification systems used for angiosperms and monilophytes were APG IV (2016) and PPG I (2016), respectively. The biological forms of the macrophytes follow Pedralli (1990).

RESULTS AND DISCUSSION

The floristic survey of coastal lakes of Santa Catarina recorded 39 families, 65 genera and 112 species. *Ludwigia hyssopifolia* (G.Don) Exell is a new record for the state of Santa Catarina. Seventy-six species were recorded in Lake Pequena, 52 species in Lake Azul, and 50 species in Lake Doce (Table I).

The most representative botanical families were Cyperaceae (24 spp.), Poaceae (10 spp.) and Onagraceae

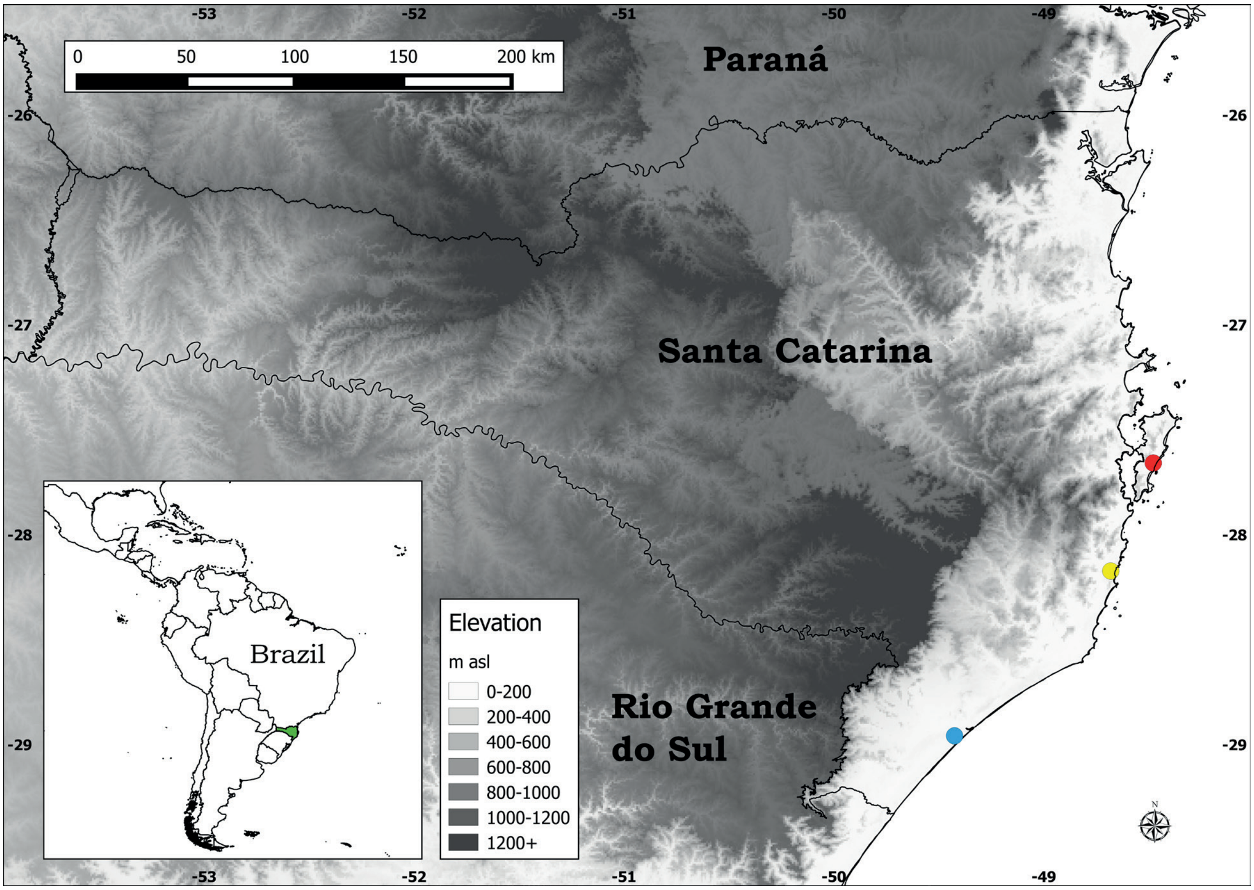

Fig. 1. Location of the lakes surveyed: Lake Pequena, Lake Doce and Lake Azul are indicated by a red, yellow and blue circle, respectively.

(eight spp.). The great richness of Cyperaceae in lentic environments of the Atlantic coast has been demonstrated by several studies, such as Zanette & Aguiar (2000), Stutz (2001), Bove *et al*. (2003), Matias *et al*. (2003), Paz & Bove (2007), Barros (2009), Alves *et al*. (2011), Valadares *et al*. (2011) and Pereira *et al*. (2012). The high frequency of Cyperaceae in aquatic environments is related to the large number of species in this family that are adapted to this condition, which includes around 30 genera and 3000 species (Cook *et al*. 1974). Moreover, species within Cyperaceae are anatomically adapted to a variety of moist environments, for example, aerenchyma in all organs of the plant, cell walls slightly lignified, epidermal cells with a thin cuticle, supporting tissues slightly or not developed at all and fewer vessel elements (Leite *et al*. 2009, 2012). Ecologically, Cyperaceae species in moist ecosystems have perennial habits, are highly efficient at vegetative propagation and tend to dominate these environments (Bove *et al*. 2003, Alves *et al*. 2011).

Poaceae are represented by seven genera, including typically aquatic taxa, such as species of *Luziola* Juss. *Ischaemum* L., *Panicum* L., *Steinchisma* Raf., *Trichanthecium* Zuloaga & Morrone and *Urochloa* P. Beauv. These genera belong to the most frequent taxonomic groups (tribes Oryzeae and Paniceae) in aquatic environments (Rua 2014). In addition to the typically aquatic species, a number of non-aquatic species that can occupy flooded areas (e.g. *Eragrostis* Wolf spp.) are also present (see Cook *et al*. 1974).

Onagraceae are represented only by the genus *Ludwigia* L. All the specimens encountered in this study belong to a group of species native to the Neotropics. These species were previously placed in *Jussiaea* L., are often found in subtropical regions, and have a center of distribution in Brazil (Munz 1947). The high representativeness of this genus in the sampled lakes is somehow associated with the fact that most species in sections *Myrtocarpus* (Munz) H. Hara and *Pterocaulon* Ramamoorthy are restricted to southeastern Brazil, Argentina, Uruguay and Paraguay (Ramamoorthy & Zardini 1987, Wagner *et al*. 2007). In addition, other species, such as *L. grandiflora* (Michx.) Greuter & Burdet, *L. hookeri* (Micheli) H.Hara, *L. leptocarpa* (Nutt.) *H.Hara* and *L. octovalvis* (Jacq.) P.H.Raven, are commonly found in the studied lakes, and some of them can be invasive weeds in wetlands and other wet areas (Wagner *et al*. 2007).

Among the species found in the lakes surveyed, *Drosera capillaris* Poir, *Utricularia tricolor* A.St.-Hil., *U. laxa* A.St.-Hil. & Girard, *U. gibba* L., *U. foliosa* L., *Rhabdadenia madida* Miers, *Eriocaulon modestum* Kunth, *Typha dominguensis* Pers., *Tibouchina asperior* Cogn., *Rhynchanthera cordata* DC., *Nymphoides indica* (L.) Kuntze, *Pontederia cordata* L., *Eichhornia crassipes* (Mart.) Solms, *Hydrolea spinosa* L., *Bacopa monnier*i

Table 1. List of families and species of aquatic macrophytes surveyed for each sampled lake, along with their biologic form, voucher and taxonomic work used for identification. LP = Lake Pequena, LA = Lake Azul, LD = Lake Doce. BF = Biologic form, Am = Amphibious, Em = Emergent, RS = Rooted Submersed, RL = Rooted with floating leaves, Ff = Free-floating, Ep = Epiphytes, FS = Free Submerged.

FAMILY	Species	LP	LA	LD	BF	Voucher	REFERENCES
Acanthaceae	*Hygrophila costata* Nees & T.Nees		x		Am	FLOR 53954	Wasshausen & Smith 1969
Alismataceae	*Helanthium tenellum* (Mart. ex Schult.f.) Britton	x	x		Am	FLOR 53950	Haynes & Holm-Nielsen 1994
Amaranthaceae	*Alternanthera philoxeroides* (Mart.) Griseb.	x	x	x	Am	FLOR 54529	Smith & Downs 1972
Apiaceae	*Centella asiatica* (L.) Urb.	x	x	x	Am	FLOR 54523	Mathias *et al.* 1972
Apocynaceae	*Oxypetalum pachyglossum* Decne.	x			Ep	FLOR 53986	Pereira *et al.* 2004
	Rhabdadenia madida Miers	x			Ep	FLOR 54048	Morales-Quirós 2009
Araliaceae	*Hydrocotyle bonariensis* Lam.	x	x	x	Am	FLOR 53936	Mathias *et al.* 1972
	Hydrocotyle leucocephala Cham. & Schltdl.			x	Am	FLOR 54080	Mathias *et al.* 1972
	Hydrocotyle ranunculoides L.f.			x	Fl	FLOR 54508	Mathias *et al.* 1972
Asteraceae	*Barrosoa betoniciformis* (DC.) R.M.King & H.Rob.	x			Am	FLOR 53980	Cabrera & Klein 1989
	Eclipta prostrata (L.) L.	x	x		Em	FLOR 54006	Mondin 2004
	Enydra sessilis DC.	x	x		Am	FLOR 54070	Lima *et al.* 2006b
	Pluchea oblongifolia DC.	x		x	Am	FLOR 53999	Freire *et al.* 2011
	Pluchea sagittalis (Lam.) Cabrera	x			Am	FLOR 54531	Freire *et al.* 2011
Blechnaceae	*Blechnum serrulatum* Rich.	x	x	x	Em	FLOR 53987	Sehnem 1968
Campanulaceae	*Lobelia hederacea* Cham.	x		x	Am	FLOR 53935	Fromm-Trinta & Santos 1989
Commelinaceae	*Commelina diffusa* Burm.f.	x		x	Am	FLOR 54076	Hassemer *et al.* 2016
	Commelina erecta L.	x			Am	FLOR 53992	Hassemer *et al.* 2016
Convolvulaceae	*Ipomoea tiliacea* Choisy	x			Ep	FLOR 54060	Ferreira 2009
Cyperaceae	*Bulbostylis capillaris* (L.) Kunth ex C.B.Clarke	x			Am	FLOR 51745	Ardissone 2013
	Cladium jamaicense Crantz		x	x	Em	FLOR 54005	Barros 1960
	Cyperus aggregatus Endl.	x			Am	FLOR 17137	Barros 1960
	Cyperus haspan L.	x		x	Em	FLOR 54043	Barros 1960
	Cyperus lanceolatus Poir.	x			Am	FLOR 50881	Barros 1960
	Cyperus mundulus Kunth	x			Am	FLOR 54056	Barros 1960
	Cyperus pohllii (Nees) Steud.	x			Am	FLOR 54527	Barros 1960
	Cyperus polystachyos Rottb.			x	Am	FLOR 33290	Barros 1960
	Cyperus prolixus Kunth	x			Am	FLOR 53926	Barros 1960
	Cyperus rigens J.Presl. & C. Presl.	x			Am	FLOR 54049	Barros 1960
	Eleocharis elongata Chapm.		x	x	Em	FLOR 54037	Trevisan 2009
	Eleocharis flavescens (Poir.) Urb.	x			Am	FLOR 54536	Trevisan 2009
	Eleocharis interstincta (Vahl) Roem. & Schult.	x	x	x	Em	FLOR 54074	Trevisan 2009
	Eleocharis laeviglumis R.Trevis. & Boldrini	x	x		Em	FLOR 54032	Trevisan 2009
	Eleocharis maculosa (Vahl) Roem. & Schult.		x	x	Em	FLOR 54016	Trevisan 2009

Table 1. Continuação

FAMILY	Species	LP	LA	LD	BF	Voucher	REFERENCES
	Eleocharis minima Kunth	x	x	x	RS	FLOR 53951	Trevisan 2009
	Fuirena robusta Kunth	x	x	x	Em	FLOR 54073	Barros 1960
	Rhynchospora brittonii Gale	x	x		Am	FLOR 54021	Guaglianone 1980
	Rhynchospora corymbosa (L.) Britton	x	x	x	Em	FLOR 54055	Guaglianone 2001
	Rhynchospora holoschoenoides (Rich.) Herter	x	x	x	Em	FLOR 53929	Guaglianone 1981
	Rhynchospora mariscul us Ness			x	Em	FLOR 54002	Guaglianone 1979
	Rhynchospora organensis C.B.Clarke			x	Am	FLOR 54075	Guaglianone 2001
	Rhynchospora tenuis Link			x	Am	FLOR 54045	Rocha & Luceño 2002
	Scleria distans Poir.	x			Am	FLOR 53982	Affonso *et al.* 2015
Droseraceae	*Drosera capillaris* Poir.		x		Am	FLOR 54017	Silva & Giulietti 1997
Eriocaulaceae	*Eriocaulon modestum* Kunth		x		Am	FLOR 54019	Moldenke & Smith 1976
Fabaceae	*Aeschynomene ciliata* Vogel		x		Am	FLOR 54068	Lima *et al.* 2006a
	Vigna luteola (Jacq.) Benth.	x			Ep	FLOR 53944	Snak *et al.* 2011
Haloragaceae	*Laurembergia tetrandra* Kanitz		x	x	Em	FLOR 54078	Fevereiro 1975
	Myriophyllum aquaticum (Vell.) Verdc.	x			RS	FLOR 59173	Fevereiro 1975
	Proserpinaca palustris L.		x		Em	FLOR 54008	Fevereiro 1975
Hydroleaceae	*Hydrolea spinosa* L.		x		Em	FLOR 54011	Flaster & Peixoto 1972
Juncaceae	*Juncus marginatus* Rostk.	x			Em	FLOR 53983	Barros 1962
	Juncus microcephalus Kunth	x		x	Am	FLOR 54001	Barros 1962
	Juncus scirpoides Lam.			x	Am	FLOR 54000	Barros 1962
Lamiaceae	*Hyptis inodora* Schrank	x	x	x	Em	FLOR 54064	Harley 1985
Lentibulariaceae	*Utricularia erectiflora* A.St.-Hil. & Girard			x	FS	FLOR 54028	Taylor 1980, 1989
	Utricularia foliosa L.		x		FS	FLOR 54009	Taylor 1980, 1989
	Uricularia gibba L.	x	x	x	RS	FLOR 54069	Taylor 1980, 1989
	Utricularia laxa A.St.-Hil. & Girard	x	x		RS	FLOR 54034	Taylor 1980, 1989
	Utricularia tricolor A.St.-Hil.			x	Am	FLOR 54083	Taylor 1980, 1989
Lythraceae	*Cuphea carthagenensis* (Jacq.) J.F.Macbr.	x	x		Em	FLOR 54007	Lourteig 1969
Malvaceae	*Hibiscus diversifolius* Jacq.	x			Em	FLOR 53943	Krapovickas & Fryxell 2004
Mayacaceae	*Mayaca fluviatilis* Aubl.	x	x	x	RS	FLOR 54051	Lourteig 1965
Melastomataceae	*Rhynchanthera cordata* DC.	x			Em	FLOR 54053	Wurdack 1962, Martins 2009
	Tibouchina asperior Cogn.			x	Em	FLOR 54003	Souza 1986
	Tibouchina urvilleana Cogn.	x		x	Am	FLOR 54029	Souza 1986
	Tibouchina versicolor Cogn.			x	Am	FLOR 54030	Souza 1986
Menyanthaceae	*Nymphoides indica* (L.) Kuntze	x	x		RL	FLOR 54052	Fabris & Klein 1971

Table 1. Continuação

FAMILY	Species	LP	LA	LD	BF	Voucher	REFERENCES
Nympheaceae	*Nymphaea amazonum* Mart. & Zucc.		x		RL	FLOR 53947	Wiersema 1987
	Nymphaea caerulea Savigny	x			RL	FLOR 53925	Conard 1905
	Nymphaea pulchella DC.		x		RL	FLOR 54522	Conard 1905, Wiersema 2008
Onagraceae	*Ludwigia grandiflora* (Michx.) Greuter & Burdet		x		Em	FLOR 53957	Munz 1947, Nesom & Kartesz 2000
	Ludwigia hookeri (Micheli) H.Hara		x		RS	FLOR 53975	Munz 1947
	Ludwigia hyssopifolia (G.Don) Exell			x	Em	FLOR 53970	Munz 1947
	Ludwigia leptocarpa (Nutt.) H.Hara	x	x	x	Em	FLOR 53948	Munz 1947
	Ludwigia longifolia (DC.) H.Hara	x		x	Am	FLOR 53971	Ramamoorthy & Zardini 1987
	Ludwigia multinervia (Hook. & Arn.) Ramamoorthy	x		x	Am	FLOR 53942	Ramamoorthy & Zardini 1987
	Ludwigia octovalvis (Jacq.) P.H.Raven	x	x		Am	FLOR 53959	Munz 1947
	Ludwigia peruviana (L.) H.Hara	x	x	x	Am	FLOR 54510	Ramamoorthy & Zardini 1987
Orchidaceae	*Habenaria inconspicua* Cogn.	x			Am	FLOR 54054	Hoehne 1940
	Habenaria parviflora Lindl.	x			Em	FLOR 53940	Hoehne 1940
	Habenaria repens Nutt.	x			Am	FLOR 54528	Hoehne 1940
Plantaginaceae	*Bacopa australis* V.C.Souza		x		Am	FLOR 54033	Souza & Giulietti 2009
	Bacopa monnieri (L.) Wettst.		x		Am	FLOR 54067	Souza & Giulietti 2009
Poaceae	*Eragrostis cataclasta* Nicora	x			Am	FLOR 53938	Ferreira & Zanin 2014
	Eragrostis paniciformis (A.Braun) Steud	x			Am	FLOR 54058	Ferreira & Zanin 2014
	Ischaemum minus J.Presl	x		x	Em	FLOR 53939	Neves & Zanin 2011
	Luziola peruviana J.F.Gmel.	x	x	x	Em	FLOR 53928	Longhi-Wagner *et al.* 2001
	Panicum aquaticum Poir.	x	x	x	Em	FLOR 53934	Guglieri & Longhi-Wagner 2000
	Panicum dichotomiflorum Michx.	x		x	Em	FLOR 54525	Guglieri & Longhi-Wagner 2000
	Steinchisma decipiens (Nees) W.V.Brown	x		x	Am	FLOR 54046	Guglieri & Longhi-Wagner 2000
	Steinchisma laxum (Sw.) Zuloaga	x			Am	FLOR 54535	Guglieri & Longhi-Wagner 2000
	Trichanthecium schwackeanum (Mez) Zuloaga & Morrone	x		x	Em	FLOR 54079	Guglieri & Longhi-Wagner 2000
	Urochloa arrecta (Hack. ex T.Durand & Schinz) Morrone & Zuloaga	x		x	Am	FLOR 53927	Smith *et al.* 1982; Morrone & Zuloaga 1992
Polygalaceae	*Polygala paniculata* L.		x		Am	FLOR 53949	Lüdtke *et al.* 2013
Polygonaceae	*Polygonum acuminatum* Kunth	x			Am	FLOR 54526	Pilz & Pereira 1988
	Polygonum hydropiperoides Michx.	x		x	Am	FLOR 54509	Pilz & Pereira 1988

Table 1. Continuação

FAMILY	Species	LP	LA	LD	BF	Voucher	REFERENCES
	Polygonum meisnerianum Cham. & Schltdl.			x	Am	FLOR 54077	Pilz & Pereira 1988
	Polygonum punctatum Elliott	x	x		Am	FLOR 54010	Pilz & Pereira 1988
	Rumex obtusifolius L.		x		Am	FLOR 54071	Caporal *et al.* 2011
Pontederiaceae	*Eichhornia crassipes* (Mart.) Solms.	x			Ff	FLOR 53977	Castellanos & Klein 1967, Pott & Pott 2000
	Pontederia cordata L.		x		Em	FLOR 54066	Castellanos & Klein 1967, Pott & Pott 2000
Rubiaceae	*Borreria palustris* (Cham. & Schltdl.) Bacigalupo & E.L.Cabral	x	x		Am	FLOR 54042	Delprete *et al.* 2005
	Coccocypselum campanuliflorum Cham. & Schltdl.	x			Am	FLOR 54041	Delprete *et al.* 2004
	Diodia saponariifolia (Cham. & Schltdl.) K.Schum.	x			Am	FLOR 54040	Delprete *et al.* 2004
	Oldenlandia salzmannii (DC.) Benth. & Hook.f. ex B.D.Jacks.		x		Am	FLOR 53955	Delprete *et al.* 2005
Salviniaceae	*Azolla filiculoides* Lam.	x	x		Ff	FLOR 54524	Evrard & Van Hove 2004
	Salvinia adnata Desv.	x	x		Ff	FLOR 54050	Forno 1983
Solanaceae	*Physalis pubescens* L.			x	Am	FLOR 53998	Soares *et al.* 2009
Thelypteridaceae	*Thelypteris interrupta* (Willd.) K.Iwats.		x		Em	FLOR 54063	Salino & Semir 2002
Typhaceae	*Typha domingensis* Pers.	x	x	x	Em	FLOR 54530	Reitz 1984
Xyridaceae	*Xyris jupicai* Rich.	x		x	Em	FLOR 54044	Smith & Downs 1965

(L.) Wettst., *Mayaca fluviatilis* Aubl. and *Myriophyllum aquaticum* (Vell.) Verdc. are notable and, according to Falkenberg (1999), are important elements of the wetland and pond flora of dunes and salt marshes. The same author also mentioned that *Tibouchina versicolor* Cogn., *T. urvilleana* Cogn., *Centella asiatica* (L.) Urb., *Hydrocotyle bonariensis* Lam. and *Vigna luteola* (Jacq.) Benth. are part of the floristic composition of the lakes and characteristic of the vegetation in dune and salt marsh plains, which demonstrates that a high proportion of species characteristic of the vegetation formation in the studied lakes is mainly related to the conservation of vegetation adjacent to the waterbodies.

Other species that occur in the studied areas, such as *Azolla filliculoides* Lam., *Alternanthera philoxeroides* (Mart.) Griseb., *Hydrocotyle ranunculoides* L.f., *Pluchea sagittalis* (Lam.) Cabrera, *Cladium jamaicense* Crantz, *Cyperus ligularis* L., *Eleocharis interstincta* (Vahl.) Roem. & Schult., *Fuirena robusta* Kunth, *Rhynchospora holoschoenoides* (Rich.) Herter, *Ludwigia octovalvis*, *L. longifolia* (DC.) H.Hara and *Luziola peruviana* J.F.Gmel., are identified by Soriano-Sierra *et al*. (2014) as typical elements of coastal lakes of Santa Catarina.

Among the biological forms of aquatic macrophytes (Pedralli 1990), for the species in the present study 52% are amphibious, 30% are emergent, 5.5% are rooted submerged, 4% are rooted with floating leaves, 3.5% are epiphytes, 3% are free-floating and 2% are free submerged.

The high percentage of amphibious species found in Lake Pequena, Lake Doce and Lake Azul is directly linked to the fact that these species occupy regions of the waterbody where the exchange between terrestrial and aquatic environments occurs. Thus, these species present the ability to adapt to both environments. Amphibious species show varying degrees of specialization to aquatic life, which can vary from species that tolerate only short periods of submersion to others that depend on water to complete their life cycle (Bloom *et al*. 1990). The latter species exhibit a synchronization of physiological events, such as quiescence, reproduction and growth, based on flooding events and the emergence of these plants (Robe & Griffiths 1998, Lytle & Poff. 2004, Akman *et al*. 2014). In addition, the water level along the waterbody margins fluctuates over the year, generating a range of different habitats, which is reflected in the high richness of amphibious plants (Fortney *et al*. 2004).

The predominance of amphibious species in lentic environments has been repeatedly reported in aquatic macrophyte checklists (Pedralli & Gonçalves 1997, Bove *et al*. 2003, Matias *et al*. 2003, Neves *et al*. 2006, Costa Neto *et al*. 2007, Paz & Bove 2007, Barros 2009, Alves *et al*. 2011, Moreira *et al*. 2011, Rolon *et al*. 2011, Araujo *et* *al*. 2012, Pereira *et al*. 2012, Mormul *et al*. 2013, Aona *et al*. 2015, Sabino *et al*. 2015), especially for coastal lakes.

Terrestrial species are sometimes present on the banks of the lakes, such as *Barrosoa betoniciformis* (DC.) R.M.King & H.Rob., *Tibouchina urvilleana*, *T. versicolor*, *Eragrostis cataclasta* Nicora, *E. paniciformis* (A.Braun) Steud., *Ipomoea tiliacea* Choisy and *Polygala paniculata* L. that are occasionally amphibious and resistant to flooding (Barros 2009, Alves *et al*. 2011). The occurrence of occasionally amphibious species is triggered by the amount of time the water level of the lake is low, which is when annual fast growing species begin to settle in the driest sediment that becomes inundated during periods of flooding.

Since the coastal lakes of this study contain freshwater and are located near the sea, where human occupation is more intense, they show different types of impacts that alter the dynamics of these ecosystems (Sala *et al*. 2001). These impacts result mainly from human settlement around the lakes where adjacent vegetation is converted into open spaces for recreation and grazing. Due to negligent use of these waterbodies, eutrophication processes and the continuous contribution of seedlings of non-indigenous species have resulted in the establishment and expansion of widespread weedy species, making the anthropic factor significantly responsible for the macrophyte composition in and around the lakes (Esteves *et al*. 2008, Musymi 2011, Thomas *et al*. 2015). The latter process favors the growth of weedy species that drastically alter the local composition, for example, *Urochloa arrecta* (Hack. ex T.Durand & Schinz) Morrone & Zuloaga, an African grass invasive in South America (Sendulsky 1978, Morrone & Zuloaga 1992).

Urochloa arrecta has a high tendency to spread and occupy wet soils, and its occurrence is relatively common in the coastal region Santa Catarina State. The species has been reported for the valleys of the Itajaí and Tubarão wetlands (Gava *et al*. 2010), Lake Sombrio (Lopes 2011), Lake Peri, in Florianópolis, and now for Lake Pequena and Lake Doce. Its occurrence in lakes appears to be linked to its initial propensity to become established on lake margins when the water level is low (Pott *et al*. 2011). It later spreads to deeper regions and adversely affects the richness and abundance of native species (Fernandes *et al*. 2013, Michelan *et al*. 2013). Therefore, preventive measures must focus on the security of the quality of the water and the biodiversity of coastal lakes (Bove *et al*. 2003), since these areas are under increasing environmental threat due to rising land values, real estate speculation, the creation of new allotments (legal urban advance) and the advancement of slums (illegal urban advance) (Hassemer *et al*. 2015).

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