



Original Papers

Alismataceae in humid subtropical areas in southern Brazil

Ana Paula Roschildt-da Silva^{1,3,5}, Ana Silvia Rolon² & Sonia Marisa Hefler^{1,4}

Abstract

Alismataceae is a family of aquatic or semi-aquatic plants with a wide distribution in humid areas, occurring in tropical, subtropical and temperate regions. Although Brazil accounts for 50% of the entire species diversity of this family, there are many gaps in knowledge of the species and their distribution, especially in the southern region of the country. This paper presents the study of Alismataceae species in the Biomes Pampa and Atlantic Forest of Rio Grande do Sul, highlighting taxonomic, ecological and distribution aspects. This study was based on the morphological analysis of specimens deposited in online data repositories and herbaria, as well as specimens collected in wetlands in the extreme south of Brazil. Ten taxa were registered for Rio Grande do Sul state: *Echinodorus grandiflorus*, *E. longiscapus*, *E. macrophyllus*, *E. reptilis*, *E. uruguayensis*, *Helanthium tenellum*, *Hydrocleys nymphoides*, *Sagittaria lancifolia*, *S. rhombifolia* and *S. montevidensis*. As a result of this study, an identification key for the taxa, morphological descriptions, images of the species and distribution maps are presented. Ecological and phenological data are also provided.

Key words: aquatic macrophytes, morphology, online repositories, South Region, taxonomic.

Resumo

Alismataceae é uma família de plantas aquáticas ou semiaquáticas com ampla distribuição em áreas úmidas, ocorrendo em regiões tropicais, subtropicais e temperadas. Embora o Brasil seja responsável por 50% de toda a diversidade da família, existem muitas lacunas no conhecimento das espécies e sua distribuição, principalmente na região sul do país. Este trabalho apresenta o estudo das espécies de Alismataceae nos Biomas Pampa e Mata Atlântica do Rio Grande do Sul, destacando aspectos taxonômicos, ecológicos e de distribuição. O estudo foi baseado na análise morfológica de espécimes depositados em repositórios de dados online e herbários, bem como espécimes coletados em áreas úmidas do extremo sul do Brasil. Foram registrados 10 táxons para o Rio Grande do Sul: *Echinodorus grandiflorus*, *E. longiscapus*, *E. macrophyllus*, *E. reptilis*, *E. uruguayensis*, *Helanthium tenellum*, *Hydrocleys nymphoides*, *Sagittaria lancifolia*, *S. rhombifolia* e *S. montevidensis*. Este estudo apresenta uma chave de identificação dos táxons, descrições morfológicas, imagens das espécies e mapas de distribuição. Dados ecológicos e fenológicos também são fornecidos.

Palavras-chave: macrófitas aquáticas, morfologia, repositórios on-line, Região Sul, taxonomia.

Introduction

The state of Rio Grande do Sul is classified as an environmental transition zone, where different ecological communities derived from two important biomes, the Pampa and Atlantic Forest, are in contact (IBGE 2004). Despite being

the smallest biome in Brazil, the Pampa has the greatest topographic and geological diversity in the south of the country (Ab'saber 2005). Within this complexity of environments, especially for Rio Grande do Sul, Fortes (1959) considered soil, relief and vegetation characteristics to classify the

¹ Universidade Federal do Rio Grande, Inst. Ciências Biológicas, Prog. Pós-graduação em Biologia de Ambientes Aquáticos Continentais, Campus Carreiros, Rio Grande, RS, Brasil.

² Universidade Federal do Rio Grande, Inst. Ciências Biológicas, Prog. Pós-graduação em Biologia de Ambientes Aquáticos Continentais, São Lourenço do Sul, RS, Brasil. ORCID: <<https://orcid.org/0000-0002-2168-2958>>.

³ ORCID: <<https://orcid.org/0000-0001-9907-0380>>.

⁴ ORCID: <<https://orcid.org/0000-0001-7985-3177>>.

⁵ Author for correspondence: annyroschildt@hotmail.com

state into 11 physiographic regions, of which seven (Litoral, Encosta do Sudeste, Depressão Central, Campanha, Missões and Planalto Médio) have all or at least part of their territory represented by the Pampa biome and four (Alto Uruguay, Campos de Cima da Serra, Encosta Inferior do Nordeste and Encosta Superior do Nordeste) belong mostly to the Atlantic Forest biome. Among these regions, the Litoral and Depressão Central stand out for gathering most of the natural wetlands in Rio Grande do Sul (Maltchik *et al.* 2003).

Wetlands are among the most productive and biologically diverse ecosystems in the world thanks to their efficient capture and conversion of solar energy, leading to up to eight times greater production of organic matter compared to cultivated fields. These environments provide several fundamental environmental services for the maintenance of local biodiversity and for the well-being of human populations, such as the control of river flows and floods, the stabilization of coastal regions, the retention of sediments and nutrients, shelter for several species, the recharge of underground aquifers, climate stability, and the reduction of pollutants in waters and associated watersheds (Maltchik 2003). In addition, most wetland environments are largely colonized by aquatic macrophytes and much of their biodiversity can be explained by the presence of this plant community (Mitsch & Gosselink 1993). Aquatic macrophytes are aquatic plants visible to the naked eye, which inhabit areas ranging from wetlands to truly aquatic environments. Their photosynthesizing parts are permanently or periodically functional, and they are either totally or partially submerged or floating in fresh or brackish water (Irgang & Gastal 1996).

Southern Brazil is home to the greatest diversity of aquatic macrophytes in the country (760 species), which may be a result of the great heterogeneity of habitats associated with wetlands in the region, among which we highlight lakes, lagoons, floodplains, wetlands and swamps (Oliveira *et al.* 2019). Among the three states of the southern region, Rio Grande do Sul has the highest diversity of aquatic macrophytes, with a total of 555 species (Oliveira *et al.* 2019), including more than 400 species cataloged on the coast (Irgang & Gastal 1996). Regarding floristic studies in aquatic ecosystems, Rio Grande do Sul also has the largest number of studies (RS; 57%), followed by Paraná (PR; 29%) and Santa Catarina (SC; 14%) (Oliveira *et al.* 2019).

Most taxonomy studies conducted in wetlands concentrate on the species richness of the Cyperaceae and Poaceae families (Keddy 2000; Sieben *et al.* 2010; Käfer *et al.* 2011). However, Cyperaceae and Poaceae occur in multiple terrestrial environments. There are families that are typical of aquatic environments and contribute high percentages of the plants living in aquatic conditions, such as Podostemaceae, Plantaginaceae, Eriocaulaceae, Lentibulariaceae, Isoetaceae and Alismataceae (Murphy *et al.* 2019).

Alismataceae is a family of aquatic or semi-aquatic plants, which are perennial or annual, most species of which occur in freshwater environments, slow or still, are rooted in muddy and soggy substrates, or floating in water, thus forming floating island associations (Haynes & Holm-Nielsen 1994). As the diagnostic characteristics, the family presents radial and trimeric flowers, numerous and free stamens, extrorse anthers, a superior ovary, emerged, submerged, or floating leaves, the presence of lactiferous, basal placentations, and generally achene fruit (Haynes *et al.* 1998). Recent studies involving phylogeny, molecular data and biogeographic analyses suggest that Alismataceae arose in the Neotropical, Western Palearctic and Afrotropical regions during the Cretaceous (Li *et al.* 2021). Intercontinental distribution occurs primarily through dispersal involving migration across land bridges and long-distance dispersal (Chen *et al.* 2012).

In Brazil, there are 40 species of Alismataceae, distributed in five genera: *Echinodorus* Rich. *ex* Engelm., *Helanthium* (Benth. & Hook. f.) Engelm. *ex* J.G.Sm, *Hydrocleys* Rich., *Limnocharis* Humb. & Bonpl. and *Sagittaria* Ruppius *ex* L. (Haynes *et al.* 1998; Matias 2022). Representatives of this family are naturally found in all biomes of Brazil, including the Amazon, Caatinga, Cerrado, Atlantic Forest, Pampa and Pantanal (Matias 2022).

For Rio Grande do Sul, there is reference to the occurrence of four genera (*Echinodorus*, *Helanthium*, *Hydrocleys* and *Sagittaria*); however, there is divergence in terms of specific richness. While Oliveira *et al.* (2019) and Rego (1988) cited only eight species, with Rego (1988) not including the genus *Hydrocleys*, which previously belonged to Limnocharitaceae, Matias (2022) points to the occurrence of 12 species.

For Alismataceae, although studies such as Haynes & Holm-Nilsen (1994), Rataj (1978) and Lehtonen (2006) have gathered many

essential characteristics for family recognition, the taxonomic classification and evolutionary history are still inconclusive (Li *et al.* 2021). Even though Cronquist (1981) historically considered Limnchariaceae as a family distinct from Alismataceae and this classification was recognized by APG II (2003), classifications such as those of Pichon (1946), Dahlgren *et al.* (1985), Judd *et al.* (2009), Lehtonen & Myllys (2008) and APG III (2009) accepted the three genera of Limncharitaceae, *Limncharis* Humb. & Bonpl., *Hydrocleys* Rich. and *Butomopsis* Kunth in Alismataceae, based on several morphological characteristics, among which the following should be mentioned: the presence of laticifers, hypogynous flowers, three or more carpels, and seeds with curved embryo. In addition to these characteristics, Furness & Banks (2010) indicated the presence of pantoporate and spinescent pollen grains as a morphological synapomorphy of the family. Thus, for this work, we following the classification adopted by the Flora and Funga of Brazil (Matias 2022) and by Plants of the World Online (Powo 2022).

In addition to phylogenetic divergences in accepting Alismataceae in a broader or narrower sense, there is also difficulty in identifying many species in the family, which leads to divergences in species delimitation and infrageneric classification. Many species, especially of the genus *Echinodorus* are difficult to delimit due to their phenotypic plasticity (Lehtonen 2006). Furthermore, new circumscriptions for *Echinodorus* have been proposed, such as accepting *Echinodorus berteroi* (Spreng.) Fassett as the only species for the genus, while the other 26 species would be included in a new genus, *Aquarius* Christenhusz & Byng (Lehtonen & Myllys 2008), because nuclear DNA analysis suggests that this species is often separated from the other species of the genus. However, a new study presented by Christenhusz *et al.* (2018), which was based on morphological features and nuclear and plastidial DNA analysis, supports the monophyly of *Echinodorus*, not accepting the circumscription previously proposed for the genus (Lehtonen & Myllys 2008) and which was adopted in subsequent publications (Lehtonen 2009a; Lehtonen & Falck 2011).

Although Brazil accounts for about 50% of the entire species diversity of the family (BGF 2015), there are many gaps in the knowledge of the species and their distribution. This is especially true for Rio Grande do Sul, where studies are restricted to Rego

(1988) for the family and Bevilacqua *et al.* (2001) for the genus *Echinodorus*. This justifies the need for updated information, given the advances in terms of taxonomic circumscription of the family. Thus, this study aimed to update the flora of the Alismataceae family in the state of Rio Grande. This work provides a taxonomic identification key, morphological descriptions, visual representations and taxonomic comments. Additionally, geographical distribution data and the conservation status of each species are made available.

Materials and Methods

Study area

The state of Rio Grande do Sul, located in the southern region of Brazil, has a land area of 281,707 km² (IBGE 2017). The region's climate is the temperate subtropical type, classified as humid mesothermal (Cfa- Köppen), with an average annual precipitation between 1,299 and 1,500 mm in the south and between 1,500 and 1,800 mm in the north. The average temperatures range from 15 to 18 °C, with lows as low as -10 °C and highs of 40 °C (Rio Grande do Sul 2022).

Data survey

The analyses of representatives of Alismataceae in Rio Grande do Sul, were obtained, in particular, through collection records from the following online data repositories: Global Biodiversity Information Facility-GBIF (2022), Brazilian Biodiversity Information System-SiBBR (2022), Re flora (2022) and SpeciesLink (2022). Specimens from the following herbaria, whose acronyms are according to Thiers (continuously updated), were consulted: BLA, CGMS, COR, CRI, ECT, ESA, ESA, FLOR, FUEL, FURB, HAS, HCF, HDCE, HPBR, HPL, HUCS, HVAT, IAP, ICN, INPA, K, LEB, MBM, MOBOT, MPUC and NYBG. In addition to these, specimens were also analyzed in situ at HURG and ex situ in herbaria in the State, whose specimens have not yet been indexed in the consulted repositories (HBEI, RSPF, HUIRB, HNIM and HERW). Information on the *obra pincipes* and type collections were accessed through the platforms IPNI (<<https://www.ipni.org/>>) and Tropicos (<<https://www.tropicos.org/home>>).

Field expeditions for plant collections were realized from November 2021 to March 2022, during spring and summer, in municipalities in the extreme south of Brazil, such as Rio Grande, Santa Vitória do Palmar, Jaguarão and Chuí. These

specimens were also included in the samples and analyses and deposited in the HURG herbarium.

Data from floristic studies previously conducted in the state of Rio Grande do Sul were also collected and analyzed. These studies provided information about the occurrence of Alismataceae family species in the region.

Data analysis

From the collection data, as well as morphological observations of the family for the state, the recognized species were grouped in tables and checked to enable duplicate records to be discarded (same specimen referenced in more than one database). Specimens whose taxonomic identification was unreliable (due to the absence of images, images that did not correspond to the family species or inconsistencies in the label description), whose place of occurrence was incorrect or absent, or even specimens from cultivars were not included in the analyses.

To georeference the locations of species records deposited in the repositories, the geographic coordinates informed on the collection labels were considered; when these were not available, the geoLoc tool (Reference Center for Environmental Information) and Google Maps were used to obtain the coordinates of the municipality seat. Similarly, when identifying incongruences between coordinates indicated on the labels and localities, the coordinate of the municipality seat or of some locality indicated on the label was used. If this was not possible, the material was not used as a reference point for localization. The specimens collected during the study period were georeferenced by the Android application As Minhas Coordenadas GPS (Ross 2022).

From the occurrence of the analyzed specimens, based on georeferenced data, distribution maps of the species were prepared for Rio Grande do Sul. The software Quantum GIS 3.16 was used to plot the data, considering the phytogeographic division between the Pampa biome and the Atlantic Forest biome (IBGE 2004) and the physiographic divisions proposed by Fortes (1959): Alto Uruguay, Campanha, Campos de Cima da Serra, Depressão Central, Encosta do Sudeste, Encosta Superior do Nordeste, Litoral, Missões, Planalto Médio and Serra do Sudeste. To prepare these maps, the following data sources were used: Pampa and Lagoons Review (IBGE 2015) and Water Mass Tract (ANA 2016) for the biomes; and Water Mass Tract and Watershed (ANA 2016), Municipal Mesh (IBGE 2020) and

Geographic Regions of the State of Rio Grande do Sul (IBGE 2017) for the physiographic regions.

For the descriptions, fertile specimens were selected from field collections and from digital images of herborized material available in the consulted repositories. For the latter, the selected specimens were those that allowed the analysis of macromorphological structures and/or showed extreme variation for each species analyzed. To perform the measurements on digital images, the image processing and analysis software ImageJ (Rasband 2022) was used. In the morphological descriptions, measurements were made of vegetative and reproductive structures that could be analyzed with this digital resource, following the terminology used by Pansarin & Amaral (2005). Reproductive structures that require a greater magnification for observation, such as anthers, carpels, fillets and stamens, were not included in the descriptions, due to their absence or the difficulty in analyzing the digital images (inadequate herborization or insufficient sharp magnification). Identification keys for the species of Rio Grande do Sul were also included, as was information related to ecological and phenological aspects based on information from the literature, labels from analyzed specimens, and field observations.

The selected material consisted of only one collection per municipality in Rio Grande do Sul. In cases where there was a reduced number of specimens or few images in online repositories, we chose to analyze additional material, which included specimens collected in bordering states (Santa Catarina and Paraná), as well as countries bordering Rio Grande do Sul (Uruguay). For *Echinodorus macrophyllus* (Kunth) Micheli, *Sagittaria lancifolia* L. and *Hydrocleys nymphoides* (Wild.) Buchenau, the additional material analyzed was from other states in Brazil. For *Echinodorus reptilis* Lehtonen, S., the type-material, the only sample located, was analyzed. Neither the additional material examined or the specimen-types consulted were used for morphological descriptions, but they were used for morphological comparisons and species confirmation, except for *E. reptilis*.

The plates with images of the taxa studied were made from photographs of specimens in the field during the collection expeditions or from images captured on the Web, selected from other studies and/or repositories and aimed to illustrate the habit, habitat, and vegetative and reproductive morphological structures characteristic of each species. The species *E. reptilis* was not included

in the plates due to the scarcity of reliable photographs.

For the conservation status of species, the National Center for Flora Conservation - CNCFlora (2022), State Decree No. 52,109, December 1, 2014 (SEMA 2014) and MMA Ordinance No. 148, June 7, 2022 (BRASIL 2022) were consulted. The databases consulted followed the Red List categories standardized by the IUCN (2022): Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Extinct in the Wild (EW), Extinct (EX), Data Deficient (DD) and Not Evaluated (NE).

Results and Discussion

A total of 1,025 records were analyzed (including online repositories, herbarium and collections). Of these, 210 were discarded because of duplicate records in the online repositories and 60 because of inconsistencies in identification or location. Thus, 755 records were considered for this study.

From the consulted bibliography, 10 floristic studies were found that reported the occurrence of Alismataceae species in the studied regions (Tab. 1). These studies indicated the presence of 5 species in Rio Grande do Sul, with *Sagittaria montevidensis* being the most frequently recorded in surveys. However, these occurrence data may be underestimated, as these studies only encompassed 5 of the 11 physiographic regions of the state, and most collections were limited to the Pampa region.

However, when analyzing studies with coverage for the entire territory of the state, the species richness was very close to that found in the present study, such as Rego (1988) and Oliveira *et al.* (2019), who cited eight species, and Matias (2022), who quoted 12 species. However, Rego (1988) did not mention *E. reptilis* or *E. macrophyllus*. The former was only recognized by Lethonem in 2008, and the latter was possibly omitted because there was no record of collection before 2000 for the state. Both species were accepted by Matias (2022) and recorded in the present study. In addition, *E.*

Table 1 – List of Alismataceae species recorded in floristic studies in Rio Grande do Sul state, Brazil.

Authors	Species	Municipality	Environment	Physiographic Region	Biome
Alves <i>et al.</i> 2013	<i>Sagittaria montevidensis</i>	Quarai	Countryside	Campanha	Pampa
Bertuzzi 2013	<i>Echinodorus longiscapus</i> <i>Sagittaria montevidensis</i>	Pelotas	Aquatic	Encosta do Sudeste	Pampa
Evaldt <i>et al.</i> 2013	<i>Echinodorus grandiflorus</i> <i>Sagittaria montevidensis</i>	Barra do Quarai	Steppic Savanna Park	Campanha	Pampa
Jacobi <i>et al.</i> 2013	<i>Helanthium tenellum</i> <i>Sagittaria montevidensis</i>	Rio Grande	Swamp	Litoral	Pampa
Demarco <i>et al.</i> 2019	<i>Sagittaria montevidensis</i>	Pelotas	Stream	Encosta do Sudeste	Pampa
Radaeski <i>et al.</i> 2014	<i>Echinodorus grandiflorus</i>	Barra do Quarai	Steppic Savanna Park	Campanha	Pampa
Rolon 2011	<i>Helanthium tenellum</i> <i>Echinodorus grandiflorus</i> <i>Sagittaria lancifolia</i>	Mostardas e Tavares	Wetlands	Litoral	Pampa
Spellmeier <i>et al.</i> 2009	<i>Sagittaria montevidensis</i>	Estrela	Swamp	Encosta Inferior do Nordeste	Atlantic Forest
Trindade <i>et al.</i> 2010	<i>Helanthium tenellum</i>	Rio Grande	Wetlands	Litoral	Pampa
Pereira <i>et al.</i> 2012	<i>Sagittaria Montevidensis</i> <i>Helanthium tenellum</i> <i>Sagittaria montevidensis</i>	Rio Grande	Wetlands	Litoral	Pampa

argentinesis Rataj, also mentioned by Rego (1988), is now accepted as a synonym of *E. grandiflorus* (Matias 2022; Powo 2022).

Oliveira *et al.* (2019) presented a compilation of several floristic studies, some of which involved searches for information in online repositories; the species mentioned include *Helanthium bolivianum* (Rusby) Lehtonen & Myllys and *Echinodorus floribundus* (Seub.) Seub. The former was not confirmed in the specimens analyzed in the present study, even though it is possible that it occurs, since there are records of the species in Santa Catarina and Paraná, states bordering Rio Grande do Sul. For the second species, only one specimen (V.J. Pott; A. Pott 9757, CGMS) was found in the state, which is, in fact, *E. grandiflorus*. *Echinodorus floribundus* is often mistakenly identified and even marketed under the name *E. grandiflorus*, but Lehtonen (2008) reported that the species is easily recognized by its size, usually greater than 1.5 m, and leaf blades with translucent dots, not dots or lines, as in closely related species (*E. longiscapus* and *E. grandiflorus*). In addition, the inflorescence of *E. floribundus* has many long, nearly horizontal branches, whereas there are few, short and nearly erect branches in *E. grandiflorus* (Lehtonen 2008).

There was also the citation of *E. lanceolatus* Rataj, *E. paniculatus* Micheli. and *E. aschersonianus* Graebner for the state (Matias 2022), which were not confirmed in the present study. The first one, after a revision of the Flora of Brazil by the author herself (L.Q. Matias 2022, personal communication), is no longer confirmed for the state, which also corroborates with CNCFlora (2022). *Echinodorus paniculatus* Micheli. which is the only record for Rio Grande do Sul (S.P. Hein; T.M. Clara, 5070, RBR), is another species,

probably *E. grandiflorus*, due to the oval leaf blade, with translucent marks and a cylindrical petiole, while *E. paniculatus* has lanceolate leaf blades, triangular petioles and the absence of translucent marks. Finally, the synonymization of *E. aschersonianus* Graebner, accepted by some authors (Holm-Nielsen 1994; Rataj 2004; Pansarim & Amaral 2005; Matias 2022), was confirmed after Lehtonen (2006) studied the type specimen (Osten 3249), observed herborized plants in the field and concluded that it was the submersed form of *E. uruguayensis*. Therefore, this was accepted as a synonym by authors such as Rego (1988), Lehtonen (2006) and Powo (2022) and was also accepted in the present study.

In addition to the situations reported, such as incorrect identifications and geographic inaccuracies, the analyses based on data from online repositories faced other difficulties, such as poorly collected and/or incorrectly herborized specimens, the absence of images for some records, and low-quality photographs. According to Maldonado *et al.* (2015), among these problems, the imprecision of geographic data most affects diversity patterns, overestimating richness in certain regions. Thus, to minimize these errors, unreliable information was discarded, and the search for georeferenced points was conducted based on information from the collection tags.

The analysis of morphological characteristics, especially of very small structures, was compromised for many specimens, either because of the low resolution of the images or because the specimens were poorly preserved and/or had floral parts missing. Even with these difficulties, many specimens allowed identification and data collection for morphological descriptions.

Key to identify Alismataceae taxa for Rio Grande do Sul

1. Dycline flowers.
 2. Petals white without macula at base; scape triangular; bracts ovolanceolate 8. *Sagittaria lancifolia*
 - 2'. Petals white with macula at base; scape cylindrical; bracts lanceolate.
 3. Rhizome cylindrical; blades sagitate, base sagitate; veins 14–20 9. *Sagittaria montevidensis*
 - 3'. Rhizome globose; blades lanceo-elliptic to oval, base attenuate; veins 7–8 10. *Sagittaria rhombifolia*
- 1'. Monocline flowers.
 4. Translucent markings present on leaf blades.
 5. Floating and submerged leaves; translucent line-like markings 5. *Echinodorus uruguayensis*

- 5'. Emerged leaves; translucent markings in the form of dots and lines.
- 6. Triangular petiole, decumbent inflorescence and lanceolate to elliptical blades 4. *Echinodorus reptilis*
- 6'. Cylindrical petiole, erect inflorescence and blades only oval.
- 7. Inflorescence mostly unbranched with <1 m height 2. *Echinodorus longiscapus*
- 7'. Inflorescence branched with >1 m height 1. *Echinodorus grandiflorus*
- 4'. Translucent markings absent on leaf blades.
- 8. White petals without macula.
- 9. Herbs 2.5–24 cm tall, blades linear, base attenuate 6. *Helanthium tenellum*
- 9'. Herbs 22–110 cm tall, blades oval, base cordate truncate 3. *Echinodorus macrophyllus*
- 8'. Yellow or light-yellow petals with yellow macula..... 7. *Hydrocleys nymphoides*

1. *Echinodorus grandiflorus* (Cham & Schltdl.)
Micheli Monogr. Phan. 3: 57. 1881.

Figs. 1a–d; 2a–b

Herbs perennial, 36–90 cm tall, glabrescent to glabrous. Rhizome fusiform, ca. 4 cm long. Leaves emerged, petiole cylindrical, 18–78 cm long, blades 10–25 × 4.5–22 cm, oval, apex rounded to obtuse, base cordate to subordate, rarely attenuate, veins 7–15, translucent markings in the form of lines and points. Inflorescence paniculate, glabrous, scape 57–80 × 0.3–0.7 cm, erect, occasionally with vegetative proliferations, cylindrical, triangular between verticils; verticils 5–25, with 4–24 flowers; bracts lanceolate, 0.5–4 cm long, glabrescent, apex acute. Flowers 3.5 × 4.8 cm dia, pedicels 1–5 cm long, sepals 4–9 × 4–6 mm. Fruit aquenium obovate, 1–3 × 1.5 mm.

Examined material: Arroio dos Ratos, 16.III.1985, *B. Irgang et al.* (ICN 96467). Barra do Quaraí, 14.V.1971, fl., *J.C. Lindeman et al.* (ICN 008434). Barra do Ribeiro, 6.XII.1967, fl. and fr., *B. Irgang & Z. Ceroni* 279 (ICN). Bom Jesus, 9.I.2005, fl., *R.A. Wasum* 2394 (HUCS). Cambará do Sul, 28.XI.1983, *S.A. Rego & M. Paiva* (RBR 5071). Campinas do Sul, 20.IX.1995, fl., *C.S. Zanchett* (HPBR 6093). Canela, 1.I.2007, fl., *C. Claudinei* (PACA-AGP 117650). Canguçu, 15.I.2002, fl., *Z. Leitzke* (PEL 22696). Canoas, 16.I.1932, fl., *B. Rambo* 269 (SP). Capão da Canoa, 4.XII.1992, (MPUC 12805). Capão do Leão, 6.I.2001, *S. Pesamosca* (PEL 25330). Caxias do Sul, 1.II.2000, fr., *L. Scur* 401 (MBM). Chuí, 14. XI.2021, fl. and fr., *A.P. Roschildt* 03 (HURG). Cidreira, 4.I.2012, fl., *L. Manzoni* (HUCS 38638). Dom Pedro de Alcântara, 1.XI.2010, *P.J.S. Silva Filho* 1686 (MPUC). Erechim, 26.X.1986, *I.P. Kochanski* (HPBR 1372). Esmeralda, 19.I.1996, fl. and fr., *J.A. Jarenkow* (PEL 3050). Farroupilha, 15.XI.1956, fr., *O.R. Camargo* 973 (PACA-AGP). Guaíba, 19.XII.2010, *N.I. Matzenbacher* (ICN 00043758). Jaguarão, 10.II.1938, fl., *B. Rambo* (PACA-AGP 2883). Maquiné, 16.IX.2001, fl., *G. Coelho de Souza* (ICN 126145). Marcelino Ramos, 28.XI.1993, fl., *A. Butzke* (HUCS 11854). Montenegro, 31.X.1945, fl., *Henz* 32535 (S). Mostardas, 9.I.2008, fl., *R. Meneghel*

91 (MBM). Nonoai, 1.III.1945, *B. Rambo* (PACA-AGP 28169). Nova Santa Rita, 19.XII.2017, fl., *V.L. Bittencourt* 150 (ICN). Osório, 12.IV.1981, fl. and fr., *A. Schwarzbald* 14 (ICN). Palmares do Sul, 1.XII.2003, *M.L. Abruzzi* 4372 (HAS). Passo Fundo, 20.X.1957, fl., *O.R. Camargo* 2236 (PACA-AGP). Pelotas, 19.XII.1892, fl., *C.A.M. Lindman* 939 (S). Pirapó, II.1989, fl., *R. Záchia* 31 (ICN). Porto Alegre, 13.I.1985, fl. and fr., *M. Sobral* 3700 (ICN). Rio Grande, 25.III.2022, fl. and fr., *A.P. Roschildt* 9 (HURG). Santa Cruz do Sul, 1.XI.1995, *S.M. Nunes* (MPUC 6255). Santa Maria, 1.III.1956, fl., *O.R. Camargo* 128 (PACA-AGP). Santa Vitória do Palmar, 26.II.1978, fl. and fr., *G. Martinelli* 4008 (RB). Santana da Boa Vista, 19.I.1996, fl. and fr., *J.A. Jarenkow et al.* (PEL 14953). Santiago, 2.XII.1998, *S. Bochi* (LEB 729461). Santo Antônio da Patrulha, 15.V.2015, *P.H. Schneider* (PACA-AGP 117857). São Francisco de Assis, 16.XII.2007, *E. Freitas* (LEB 2406). São Gabriel, 4.XI.1987, fl., *H. Longhi* 600 (ICN). São Jerônimo, 1.IX.1982, fl., *O. Bueno* 3576 (HAS). São João do Polêsine, 25.I.2000, fl. and fr., *R.A. Záchia et al.* 4210 (SMDDB). São Leopoldo, 19.XII.1961, *A. Sehnem* 7937 (PACA-AGP). São Lourenço do Sul, 3.III.2022, fl. and fr., *A.P. Roschildt* 7 (HURG). Sobradinho, 12.XII.1988, fl., *M.A. Durló* (HDCF 3950). Tapes, 1.XII.1980, *J. Goergem* (ICN 050190). Taquari, 14.XII.1957, *O.R. Camargo* (BLA 14720). Torres, 2.II.1984, fl., *A.S. Rego* 179 (ICN). Tramandaí, 30.III.1984, fl. and fr., *G. Pedralli & A.S. Rego* (ICN 110369). Triunfo, 28.III.1999, *J.M. Consoni* (PACA-AGP 91223). Tupanciretã, 28.I.1942, fl. and fr., *B. Rambo* (PACA-AGP 9415). Uruguaiana, IX.1985, fl., *G. Pedralli* (ICN 00043750). Viamão, 3.XII.1991, *C. Schlindwein* 1195 (UFP).

Echinodorus grandiflorus is a common species in Rio Grande do Sul found in the Pampa and Atlantic Forest (Fig. 2a), as well as in all physiographic regions of the state (Fig. 2b). It occurs in swamps, streams, the interior, and margins of rivers and lakes, preferentially in humid, flooded and clay soil. Specimens were also collected in sandy and brackish soil, a type of environment also mentioned by Pansarin & Amaral (2005). *Echinodorus grandiflorus* presents wide morphological variation, especially in leaf size

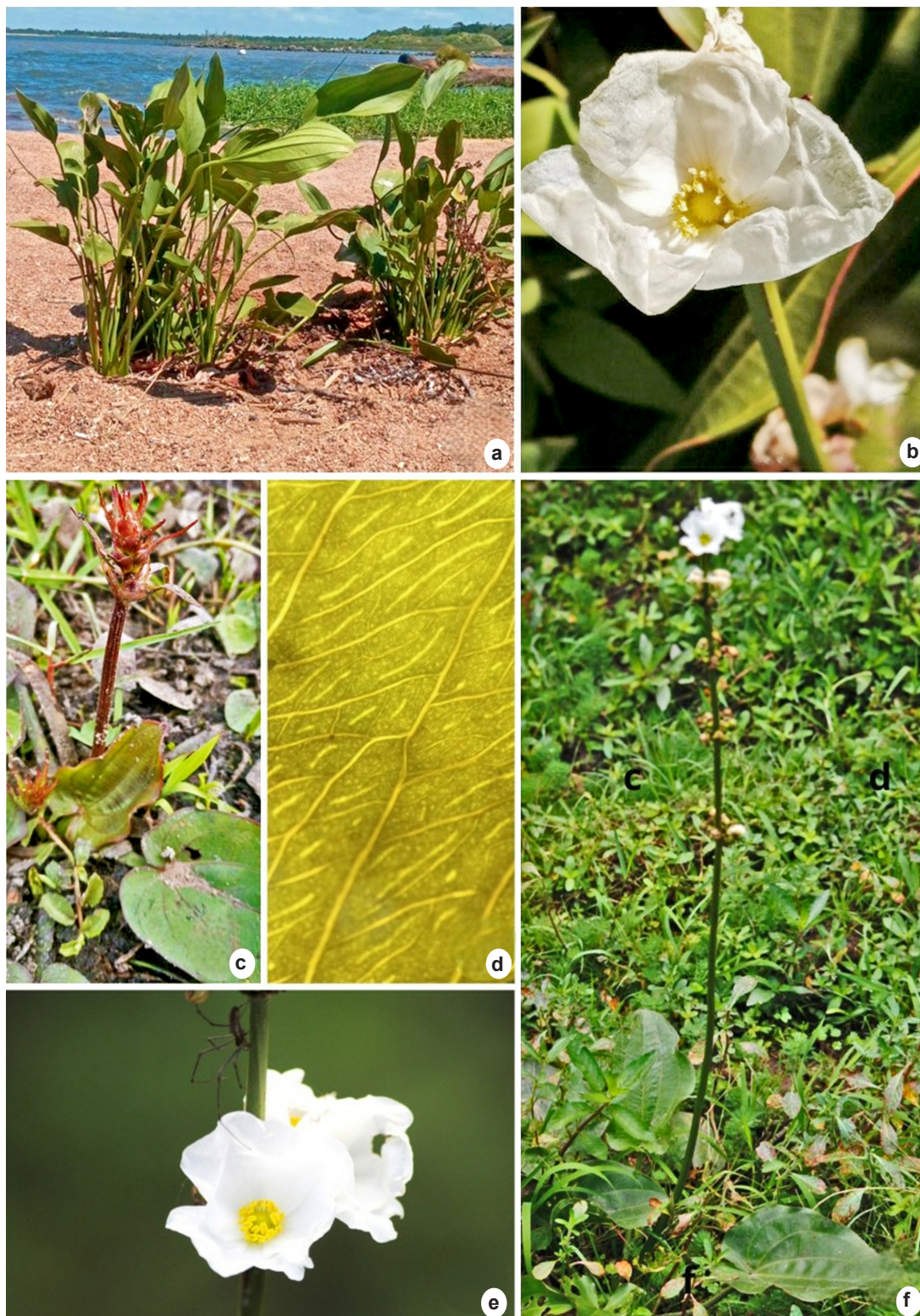


Figure 1 – a-d. *Echinodorus grandiflorus* – a. habit and habitat; b. flower; c. inflorescence apex at early stage, highlighting the reddish coloration; d. translucent markings seen under light microscope. e-f. *E. longiscapus* – e. flower; f. habit, highlighting the inflorescence without branches. (a-d. Roschildt 07; e-f. J. Tocce).

and shape, the number of veins, and inflorescence size. For Joaquim (2000), the rate of leaf growth and leaf area were influenced by soil moisture and shading, which was also observed in the specimens collected in this study. According to conservation status, the species was Not Evaluated (NE) by the

consulted sources (SEMA 2014; BRASIL 2022; CNCFlora 2022).

Echinodorus grandiflorus is widely used in folk medicine due to its anti-inflammatory, antioxidant (Marques *et al.* 2017) and antihypertensive (Prando *et al.* 2016) properties, as

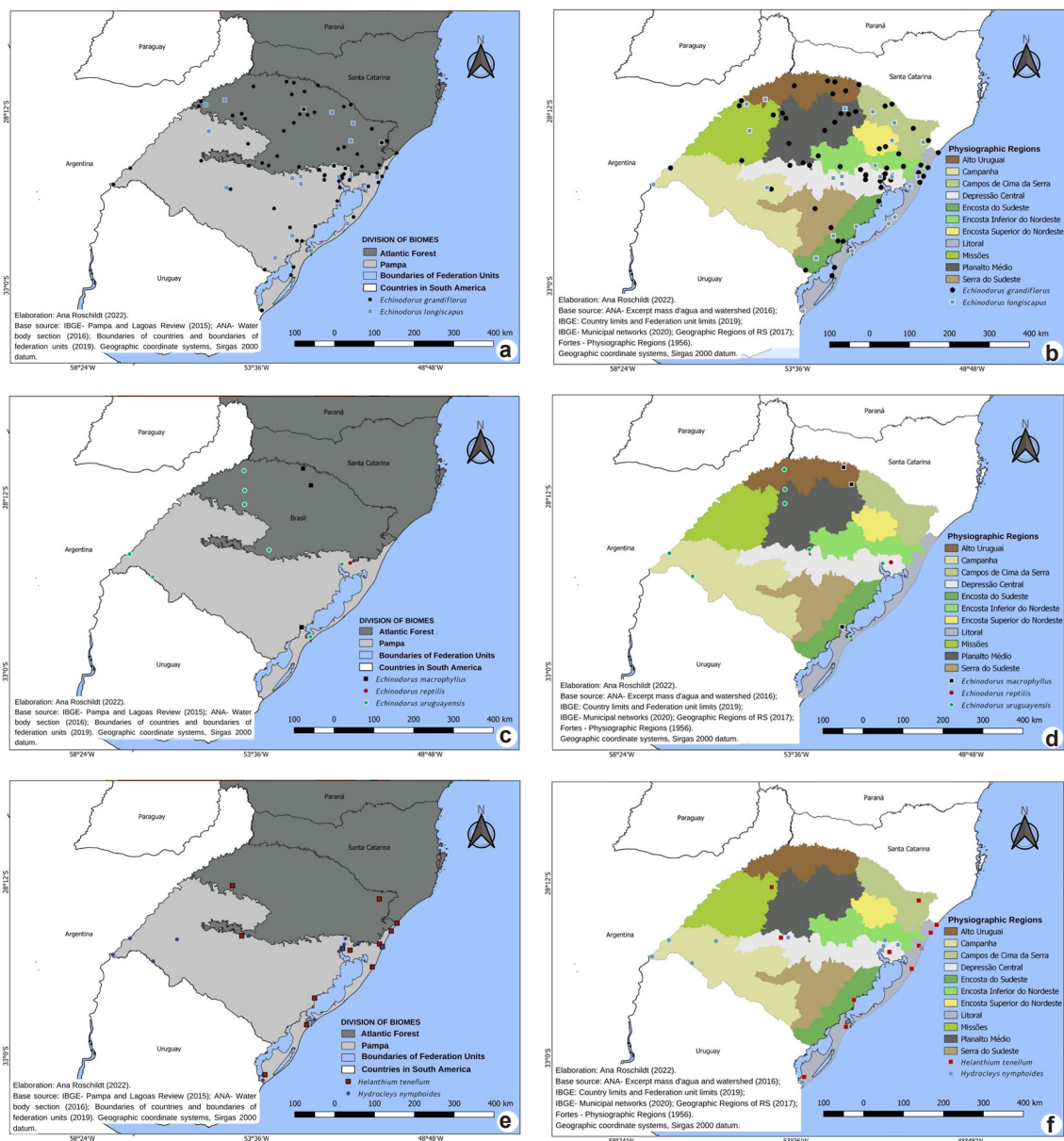


Figure 2 – a-f. Geographical distribution according to the biomes and physiographic regions of Rio Grande do Sul state, Brazil – a. *Echinodorus grandiflorus* and *E. longiscapus* according to the biomes; b. *Echinodorus grandiflorus* and *E. longiscapus* according to the physiographic regions; c. *Echinodorus macrophyllum*, *E. reptilis* and *E. uruguayensis* according to the biomes; d. *Echinodorus macrophyllum*, *E. reptilis* and *E. uruguayensis* according to the physiographic regions; e. *Helanthium tenellum* and *Hydrocleys nymphoides* according to the biomes; f. *Helanthium tenellum* and *Hydrocleys nymphoides* according to the physiographic regions.

well as for the manufacture of soft drinks in many regions of Brazil (Pimenta 2002; Brugiolo 2010).

Flowering and fruiting occur from September to May, from November to May in South America (Lehtonen 2008) and November to February in São Paulo (Pansarin & Amaral 2005).

The species popular names are “chapéu-de-couro” (Pott & Pott 2000), chá-de-campanha, chá-do-brejo, chá-de-pobre, chá-mineiro, congonha-do-brejo, erva-do-brejo and erva-do-pântano (Lorenzi & Matos 2002).

2. *Echinodorus longiscapus* Arechav. Anales Mus. Nac. Montevideo 4(1): 67-68, t. 2, 1903.

Figs. 1e-f; 2a-b

Herbs perennial, 13.8–58 cm tall, glabrescent to pubescent. Rhizome fusiform, 8–10 cm long. Leaves emersed, petiole cylindrical, 2.8–38 cm long, blades 3.6–20 × 2.8–15 cm, oval, apex rounded, base truncate to cordate, veins 5–13, translucent markings in the form of points and lines. Inflorescence racemose, rarely paniculate with some branching, glabrous to pubescent, scape 36–85.5 × 0.13–0.5 cm, erect, without vegetative proliferations, cylindrical, triangular between verticils; verticils 3–9, with 2–12 flowers; bracts lanceolate, 0.5–1 cm long, glabrescent, apex acute. Flowers 2–4 cm dia, pedicels 0.4–1.7 cm long, sepals ca. 5 × 2 mm. Fruit aquenium oblanceolate, ca. 2 × 0.7 mm.

Examined material: Arroio Grande, 16.XII.1999, fl., *A.P. Marques et al.* (PEL 2100). Barra do Quaraí, 31.III.2022, fl., *R.M. Senna et al.* 2288 (HAS). Bom Jesus, 13.I.1942, fl., *B. Rambo* (PACA-AGP 8572). Cambará do Sul, 28.XI.1983, *M. Paiva & A.S. Rego* 143 (ICN). Cerro Largo, XII.1948, *A. Sehnem* (HAS 92104). Esteio, 16.XI.1936, fl., *B. Rambo* (PACA-AGP 269). Gravataí, II.1983, fl., *T. Strehl* 548 (HAS). Guaíba, 10.I.1985, *D.B. Falkenberg & B. Irgang* (ICN 96460). Lagoa Vermelha, 14.XII.1966, *J. Lindeman* 3660 (MBM). Montenegro, 31.X.1945, fl., *E. Henz* (PACA-AGP 32532). Mostardas, 24.II.1984, *G. Pedralli et al.* (ICN 98501). Osório, XII.1953, fl. and fr., *J. Vidal* 4-395 (R). Palmares do Sul, I.2004, fl., *C. Mansan* 573 (HAS). Pantano Grande, 4.V.1984, *D.B. Falkenberg & A.S. Rego* 221 (ICN). Pelotas, 4.II.1950, fl. and fr., *A. Egydio & Teodoro* 62 (MBM). Porto Alegre, 20.XI.1974, fl., *S.M. Callegari* 199 (RB). Rio Grande, 4.XII.1983, *G. Pedralli & A.S. Rego* 152 (ICN). Rio Pardo, 23.IV.1983, *D.B. Falkenberg & M. Sobral* (ICN 098481). Santa Rosa, II.1947, fl., *A. Spies* (PACA-AGP 47320). São Francisco de Paula, XII.2005, fl., *R.M. Senna* 993 (HAS). São Gabriel, 5.IV.1984, fl. and fr., *D.B. Falkenberg* 244 (RBR). São Leopoldo, 16.III.1932, fl., *C. Orth* (PACA-AGP 33943). São Lourenço do Sul, 26.IV.2012, *C.L. Bonilha* 609 (ICN).

Tavares, 24.II.1984, *A.S. Rego et al.* 212 (ICN). Vacaria, 30.XII.1946, fl. and fr., *B. Rambo* (PACA-AGP 34578). **Additional material:** ARGENTINA. PROVÍNCIA DE CORRIENTES: Corrientes, I.XII.1970, *A. Krapovickas* 16763 (MBM).

Echinodorus longiscapus is morphologically similar to *E. floribundus* and *E. grandiflorus*. These species are often misidentified in herborized material. The species in question differs from the other two by its morphology and ecological preference, with *E. longiscapus* being the smallest species among them (0.5–1 m alt.), with oval leaves that are 5–20 cm long and glabrous to pubescent inflorescences that are mostly unbranched. *Echinodorus floribundus* is larger (1.5–3 m alt.), with oval leaves that are 20–40 cm long with pubescent inflorescences and many ramifications. *Echinodorus grandiflorus* is of intermediate size (1–1.5 m alt.), with leaves that are 10–25 cm long, glabrous inflorescences and few ramifications. Regarding ecological preference, although *E. grandiflorus* grows in permanently humid environments, *E. longiscapus* grows mainly in temporarily flooded depressions and *E. floribundus* can grow in humid depressions, flooded savannas and palm groves (*Mauritia flexuosa* L.f.) (Lehtonen 2008).

This species is very common in Rio Grande do Sul, occurring in the Pampa and Atlantic Forest (Fig. 2a), as well as in all physiographic regions except the Planalto Médio and the Serra do Sudeste (Fig. 2b). Rego (1988) presented it as the species with the widest distribution in the state; however, it was second in this study. *Echinodorus longiscapus* inhabits swampy forests, river and stream margins, humid fields, and swamps. The species also occurs in neighboring countries Uruguay and Argentina (Lehtonen 2008). According to Matias (2022), the species is restricted to the Pampa and Atlantic Forest, not occurring in northern Brazil. According to the conservation status, the species was Not Evaluated (NE) by the consulted sources (SEMA 2014; BRASIL 2022; CNCFlora 2022).

The species was collected with flowers from October to April in Rio Grande do Sul, while for South America, Lehtonen (2008) observed flowering from September to June.

The species popular name is “chapéu-de-couro” (Lorenzi & Matos 2002).

3. *Echinodorus macrophyllus* (Kunth) Micheli, Monogr. Phan. 3: 50, 1881. Figs. 2c-d; 3a-d

Herbs perennial, 22–110 cm tall, glabrous to glabrescent. Leaves emersed, petiole cylindrical, 19–45 cm long; blades 6–25 × 5–22 cm, ovate,

apex obtuse to rounded, base cordate to truncate, veins 8–13, without translucent markings. Inflorescence paniculate, scape 28–97 cm long, 3–4 mm wide, erect, without vegetative proliferations, cylindrical, triangular between verticils; verticils 6–17, with 3–10 flowers; bracts lanceolate, shorter than pedicels, 0.8–3.30 cm long, glabrescent, apex acute. Flowers 1.5–2.5 cm dia, pedicels 1.30–2.30 cm long, sepals 3–7 × 3–5 mm, ovate, glabrescent. Fruit aquenium oblanceolate, 2–3 × 1–2 mm.

Examined material: Aratiba, 20.V.2005, *P.C. Mohr* (HPBR 9435). Floriano Peixoto, 6.XI.2005, *I. Babicz* (HPBR 9621). Pelotas, II.2004, fl. and fr., *M. Couto* (ECT 0000022).

Additional material: BRAZIL. ESPÍRITO SANTO: Vitória, 15.VIII.2007, *O.J. Pereira & G. Lübe* 7498 (EAC). SÃO PAULO: Rio Grande da Serra, 14.XI.1994, *R. Simão-Bianchini* 596 (UEC). Ubatuba, 6.V.1990, *R. Romero et al.* 05 (UEC).

Echinodorus macrophyllus is frequently mistaken for *E. grandiflorus* due to morphological similarities, particularly in terms of leaf size and shape. The main characteristic to differentiate them is the absence of translucent markings on the leaf lamina in *E. macrophyllus*, a feature that is not easily visible to the naked eye. According to Matias (2022), another characteristic that differentiates the species is the presence of a fruit with a larger beak, prominent in the achenecetum, which was also observed in the materials analyzed in this study. This species is considered rare, with only three records for the state, being present in both biomes (Fig. 2c) and restricted to the Litoral and Alto Uruguai physiographic regions (Fig. 2d). The specimens analyzed lack data regarding the preferred habitats of the species for the state. According to Pott & Pott (2000), *E. macrophyllus* can be found in floodplains, floodable fields, marshes and temporary ponds. According to the conservation status, the species was Not Evaluated (NE) by the consulted sources (SEMA 2014; BRASIL 2022; CNCFlora 2022).

Flowering was observed from November to May, while Canalli & Bove (2017) reported flowering from September to December and April to August for southeast Brazil.

The species popular name is “chapéu-de-couro” (Lorenzi & Matos 2022).

4. *Echinodorus reptilis* Lehtonen Kew Bull. 63(4): 548–550, f. 7, map, 2008 [2009]! Fig. 2c-d

Herbs perennial, ca. 7.5 cm long, glabrous. Leaves emerged, petiole triangular, ca. 4 cm long,

blades 2–3 × 0.7–1.2 cm, lanceolate to elliptic, apex acute, base attenuate, veins 3, translucent markings in the form of dots and short lines. Inflorescence racemose, scape ca. 2 × 0.1 cm, decumbent, without vegetative proliferations, cylindrical to triangular; verticils 2, with 2–3 flowers; bracts lanceolate, much shorter than pedicels, up to 0.6 cm long, glabrous, apex acute. Flowers long petiolate ca. 2 cm dia, pedicels ca. 1.5 cm long, sepals ca. 5 × 3 mm, oval. Fruit aquenium oblanceolate, ca. 1.5 mm long, 0.5 mm wide.

Examined material: Porto Alegre, 2017, fl. and fr., *Remeck & Gernak* (BA,10961).

Echinodorus reptilis is distributed in southern Paraguay, northern/eastern Argentina and southern Brazil, has populations that occur only in river sandbanks, and a habitat that is generally not conducive to other species of the genus (Lehtonen 2008). For Brazil, populations of this species are reported only for Rio Grande do Sul, with only one known sample deposited in the BA Herbarium in Buenos Aires under the collection number BA 10961 (Remeck & Gernak), which was confirmed in this study. Thus, until now, its occurrence has been restricted to the Pampa (Fig. 2c), occurring only in the physiographic region Depressão Central (Fig. 2d). Phylogenetically, *E. reptilis* is close to *E. uruguayensis* (Lehtonen & Myllys 2008). While *E. uruguayensis* grows mainly in submerged conditions and eventually has emerged leaves, *E. reptilis* grows emerged and does not develop emerged leaves. In addition to the emerged growth form, the plant is of a small size and has a decumbent inflorescence with 2–3 verticils and only 2–5 flowers in each verticil, characteristics that Lehtonen (2008) considered to differentiate it from other *Echinodorus* species, which present a larger number of verticils and flowers. According to the conservation status, the species was Not Evaluated (NE) by the consulted sources (SEMA 2014; BRASIL 2022; CNCFlora 2022).

Flowering and fruit set occur from October to January (Lehtonen 2008).

5. *Echinodorus uruguayensis* Arechav. Anales Mus. Nac. Montevideo 4(1): 66–67, t. 2, 1902. = *Echinodorus aschersonianus* Graebn.

Figs. 2c-d; 3e-g

Herbs perennial, 15–63 cm tall, glabrous. Rhizome fusiform, long, ca. 16 cm long. Leaves floating or submerged, petiole cylindrical, 1–24 cm long; leaves floating, blades ca. 15.5 × 3.5–4 cm, elliptic to oval, rounded apex, attenuated base,

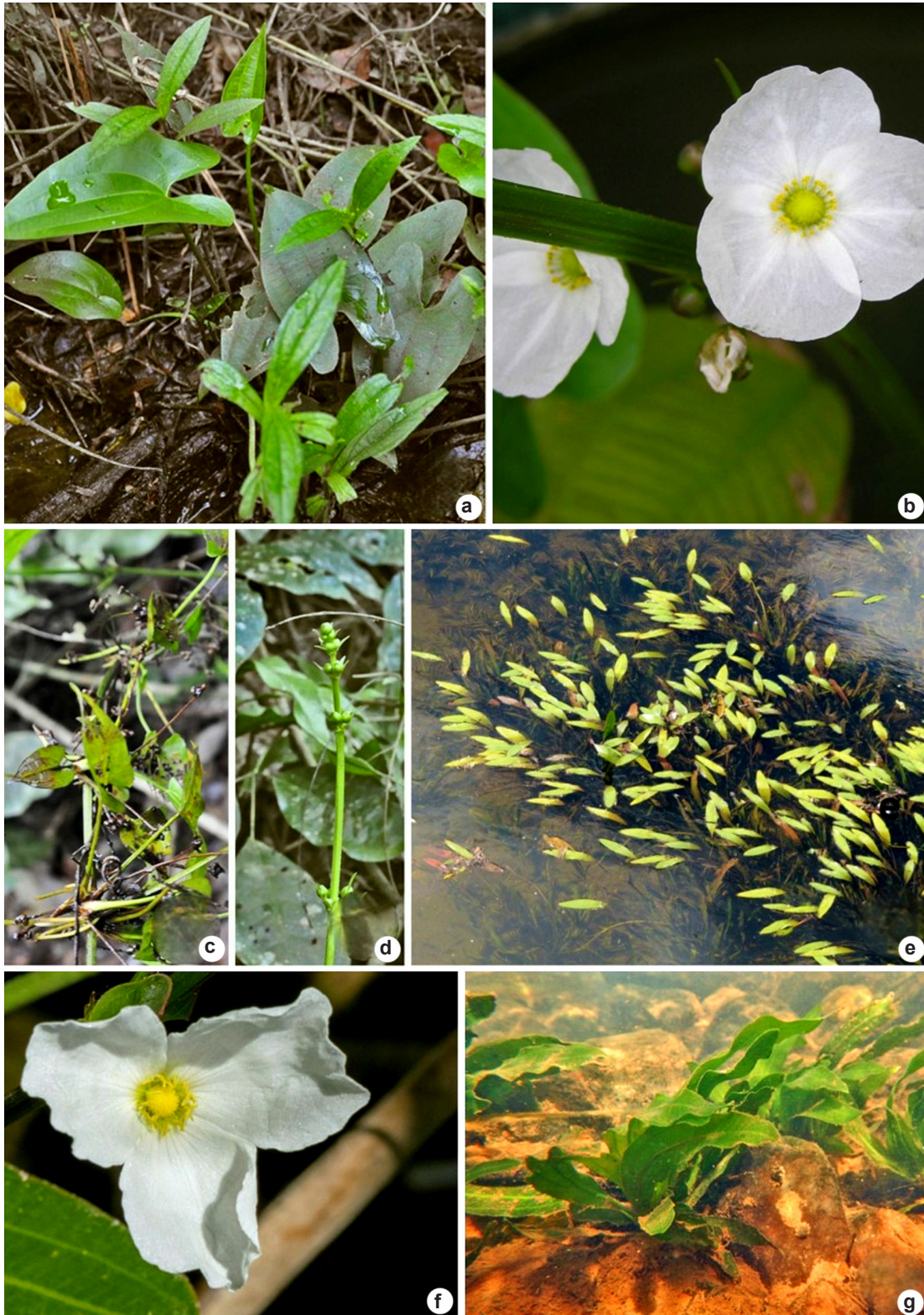


Figure 3 – a-d. *Echinodorus macrophyllus* – a. habit; b. flower; c. inflorescence with vegetative proliferations; d. inflorescence apex at early stage. e-g. *E. uruguayensis* – e. habit; f. flower; g. habitat of the submerged form, leaf blades evident. (a,c,d. Canalli 84; e. Lowe; f. Tosi; g. Schmitke).

veins 5, translucent line-like markings; submerged leaves, blades 5–15.5 × 0.6–2 cm, linear to lanceolate, acute to rounded apex, attenuated base, veins 3, translucent line-like markings present. Inflorescence cymose, scape 35–60 × 0.13–0.4 cm, erect to decumbent, often with vegetative proliferations, triangular; verticils 2–6, with 3–8 flowers; bracts lanceolate, 0.8–1.5 cm long, glabrous, long acuminate apex. Flowers 3.5–4.7 cm dia., pedicel 0.4–2.5 cm long, sepals ca. 7 × 4 mm, oval. Fruit aquenium oval to oblanceolate, 1.5–2 × 0.6–2 mm.

Examined material: Agudo, 12.XII.1988, fl., *M.A. Durló* (HDCF 3949). Ijuí, 28.XI.1953, fl., *J. Pivetta* 599 (PACA-AGP). Porto Alegre, 15.XII.1936, fl., *C. Orth* (PACA-AGP 32944). Quaraí, 1.1945, fl., *B. Rambo* (PACA-AGP 26330). Rio Grande, fl. and fr., (K 000098929). Três Passos, 1.1994, fl., *A.R. Schultz* 334 (ICN). Uruguiana, 14.I.1941, fl., *B. Rambo* (PACA-AGP 4201).

Additional material: BRAZIL. PARANÁ: Capitão Leônidas Marques, 10.IV.2004, *O.S. Ribas* 6230 (MBM). SANTA CATARINA: Riqueza, 10.XI.1984, *L.B. Smith* 13120 (NY). 16.X.1964, *L.B. Smith & R.M. Klein* 12591 (US).

This species stands out for presenting polymorphism related to the type of biological form, which presents linear lanceolate leaf blades when submerged and elliptic to ovate leaf blades when floating. The leaves can also acquire different colors, such as dark olive green, reddish brown or dark red, which according to Kasselman (2003), is a characteristic that classifies them as hybrids. *Echinodorus uruguayensis* is considered rare for Rio Grande do Sul due to the few records of collection thus far. In addition to the low number of records, all collections were made more than three decades ago, which could place this species in a threatened condition for the state. However, *E. uruguayensis* was Not Evaluated (NE) by the consulted sources (SEMA 2014; BRASIL 2022; CNCF flora 2022). *Echinodorus uruguayensis* does not occur in all phytogeographic domains of Brazil, being present only in the Pampa and Atlantic Forest (Matias 2022), which was confirmed in the present study (Fig. 2c). The species that was previously distributed in the physiographic regions of Alto Uruguai and Campanha (Rego 1988), now shows its expanded distribution, including the regions Depressão Central and Planalto Médio (Fig. 2d), preferentially in paludose areas. According to Lehtonen (2008), it can also inhabit small clear water rivers, rapids and other bodies with running

water. It is native to northern Argentina, eastern Chile, Uruguay, southern Brazil and Paraguay (Haynes & Holm-Nielsen 1994; Lehtonen 2008).

The material with flowers and fruit was collected from September to May.

6. *Helanthium tenellum* (Mart. ex Schult. f.) Britton Man. N. States (ed. 2) 54. 1905. = *Echinodorus tenellus* (Mart. ex Schult. f.) Buchenau. Figs. 2e–f; 4d–f

Herbs perennial, 2.5–24 cm tall, glabrous. Rhizome oblong, 0.1–0.5 cm dia. Leaves emerged, petiole cylindrical 0.2–6.5 cm long, blades 0.9–7 × 0.13–0.5, linear, apex acute, base attenuate, vein 1, translucent markings absent. Inflorescence paniculate, scape 4–18.5 × 0.4–0.5 cm, erect, without vegetative proliferations, triangular; verticils 1–4, with 2–9 flowers; bracts lanceolate, 0.1–0.3 cm, apex acute. Flowers ca. 1 cm dia, pedicel 0.5–3.8, sepals 1–3 mm long, ovate. Fruit aquenium obovate, ca. 1 × 1 mm.

Examined material: Bom Jesus, 15.XI.1989, fl., *B.M.T. Walter* (HCF 16236). Mostardas, 16.I.2018, fr., *V.L. Bittencourt* 289 (ICN). Osório, 22.IV.2015, fl. and fr., *C. Demeda* 43045 (HUCF). Porto Alegre, 7.XI.1950, fl., *A.R. Schultz* 771 (ICN). Rio Grande, 5.XII.1996, fl., *B. Irgang & C. Gastal* (HURG 1367). Santa Maria, 3.X.2018, fl., *R.G. Rolim* 17395 (SMDB). Santa Vitória do Palmar, 17.XII.1999, fl., *B.E. Irgang* 69 (ICN). Santo Ângelo, 11.X.1973, fl., *K. Hagelund* (ICN 6939). São Lourenço do Sul, 10.II.2018, *W. Mattenauer* (HURG 6164). Torres, II.1939, fl., *J. Vidal* (R 010068459). Tramandaí, 18.XII.1949, fl., *A.R. Schultz* 710 (ICN). Viamão, 15.III.2003, fl., *J. Paz* 84 (ICN).

Additional material: BRAZIL. RIO GRANDE DO SUL: Osório, 20.IV.2015, *F. Gonzatti* 1838 (HUCS). Torres, II.1939, *J. Vidal* (R010068459). SANTA CATARINA: Florianópolis, 19.XI.2014, *J.P.R. Ferreira & R. Trevisan* 662 (FLOR).

This species is distributed from the southeastern United States to Argentina (Pansarin & Amaral 2005). In Brazil, it has a wide distribution, with occurrence from the Amazon to southern Brazil (Pansarin & Amaral 2002; Matias 2022). In Rio Grande do Sul, most specimens were collected in the Pampa biome (Fig. 2e). Regarding physiographic regions, most records are restricted to the coast, which corroborates other floristic surveys (Tab. 1). There are also a small number of records for the regions Depressão Central, Campos de Cima da Serra, Encosta do Sudeste and Missões (Fig. 2f). In attempts at new collections, the species was no longer found in sites of historical records for

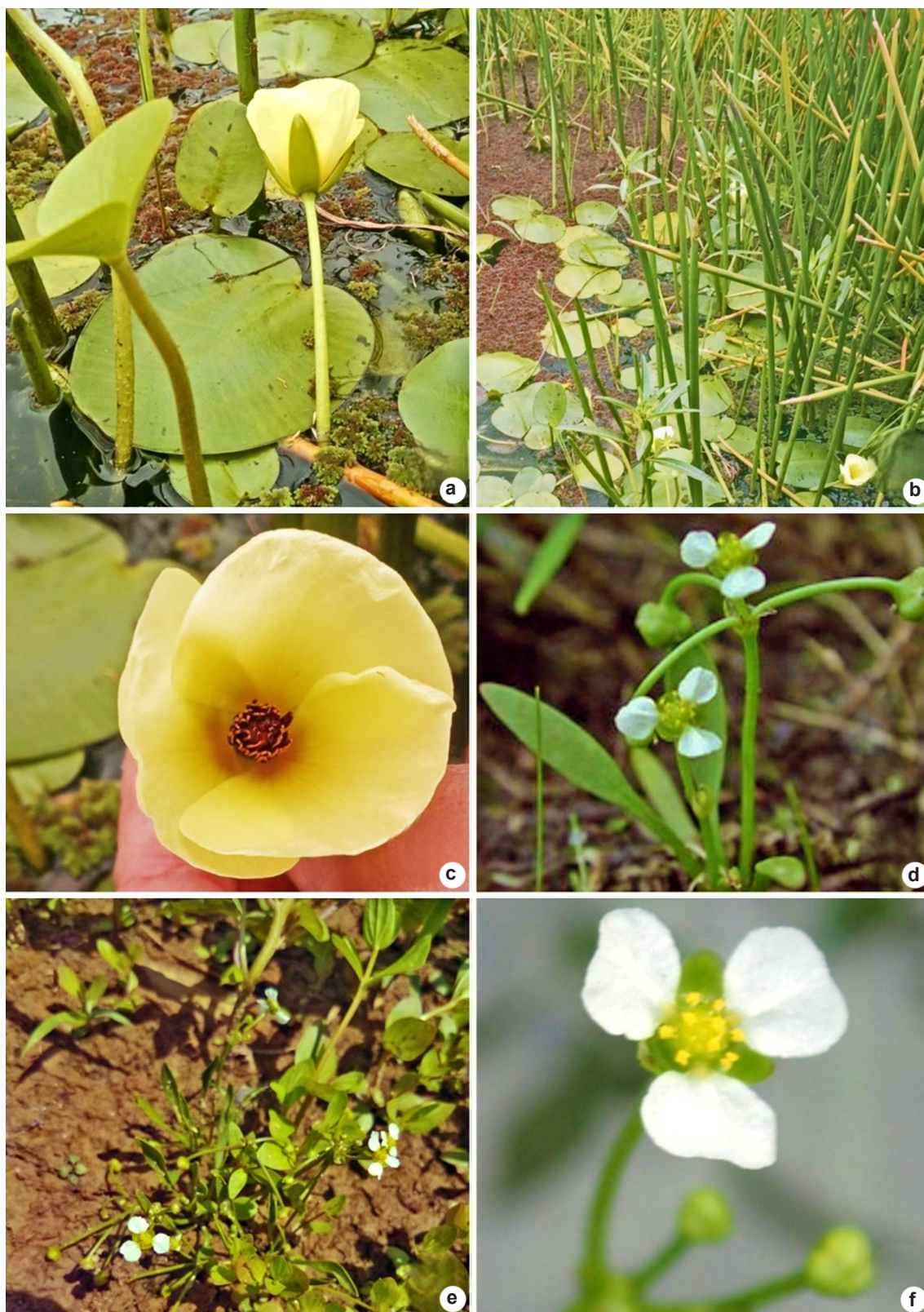


Figure 4 – a-c. *Hydrocleys nymphoides* – a. habit; b. habitat; c. flower. d-f. *Helanthium tenellum* – d. habit; e. habitat; f. flower. (a-c. Roschidt 10; d. Saulys; e. Wulker; f. Feaver).

this study. According to Scremin-Dias (2000), species collection in dry periods may be difficult because the plant can lose its parts areas and store starch in its roots during this season, which makes it able to develop new parts areas in rainy periods. *Helanthium tenellum* occurs mainly in swamps, ponds and streams. In addition to these environments, the species can be found in vazantes and floodable fields on sandy and silty soils (Pott & Pott 2000). According to the conservation status, the species was Not Evaluated (NE) by the consulted sources (SEMA 2014; BRASIL 2022; CNCFlora 2022).

Flowering seems to vary greatly by state. The species was collected with flowers between October and May in Rio Grande do Sul, between January and July in Rio de Janeiro (Canalli & Bove 2017), and between August and April in São Paulo (Pansarin & Amaral 2005).

The species popular names are “pygmy chain-sword”, “dwarf Amazonian sword plant” and “erva do pântano” (Haynes & Holm-Nielsen 1994; Pott & Pott 2000).

7. *Hydrocleys nymphoides* (Willd.) Buchenau, Index Crit. Butom. Alism. Juncag. 9, 1868.

Figs. 2e-f; 4a-c

Perennial herb, 15.5–40 cm tall. Rhizome globose 0.5–1 cm dia. Floating leaves, petiole 7–27 cm long, blade 3–5.6 × 2.5–5 cm, oval to rounded, apex rounded, base cordate, veins 5–7, no translucent markings. Inflorescence cymose, scape 16–30.5 × 0.2–0.5, floating, often with vegetative proliferations; 2–3 flowers; bracts elliptic, 2.6–3 cm long, apex obtuse. Flowers ca. 2.2 cm dia., pedicel 5.5–11 cm long, sepals ca. 1.8 × 0.5 mm, elliptic-lanceolate. Fruit follicle ca. 2.5 × 0.5 mm.

Examined material: Acrete, 24.XII.1981, fl., J. Stehmann & M. Sobral (ICN 89305). Barra do Quaraí, 17.XI.1984, fl., M. Sobral 3396 (RB). Canoas, 12.X.1930, fl., I. Augusto (ICN 8037). Chui, 8.I.2016, (Sisbio-Dibio 862470). Glorinha, 14.XII.1949, B. Rambo 44773 (P). Gravataí, 14. XII.1949, fl., B. Rambo (PACA-AGP 44773). Guaíba, 13.V.2012, N.I. Matzenbacher (HUCS 43227). Porto Alegre, 1922, fl. and fr., E. Schweiger (ICN 031086). Quaraí, 13.XII.1989, C. Schindwein (ICN 24719). Rio Grande, 25.III.2022, fl. and fr., A.P. Roscholdt 10 (HURG). Santa Maria, 1.V.1987, fl., B.E. Irgang & A. Alvarez Filho (MPUC 128088). Santa Vitória do Palmar, 9.I.2016, (PACA-AGP 862435). São Leopoldo, 10.XI.1934, fl. and fr., B. Rambo 1285 (ICN). Tramandaí, 8.III.1981, fl., M. Sobral & P. Brack 794 (ICN). Uruguaiana,

17.XI.1984, fl., M. Sobral 3396 (INPA). Viamão, IX.1974, fl. and fr., B. Irgang (ICN 027204).

Additional material: BRASIL. SÃO PAULO: Monte Mor, 15.III.1998, E.R. Pansarin *et al.* 156 (UEC).

Hydrocleys nymphoides is a species of Neotropical distribution, with occurrence from the south of the United States to northern Argentina (Haynes and Holm-Nielsen 1992). Although it occurs in all phytogeographic domains of Brazil (Matias 2022), most records for Rio Grande do Sul are concentrated in the Pampa biome (Fig. 2e), which may be related to the physiographic regions that make up this biome. Among these regions are the *Depressão Central* and the *Litoral*, which contain most of the wetlands of the state (Maltchik *et al.* 2003), as well as the Campanha region, which is located between the Uruguay and Ibicuí Rivers, two of the largest water bodies in Rio Grande do Sul (Fortes 1959). For the Atlantic Forest, records are restricted to the region of the Encosta Inferior do Nordeste (Fig. 2f), at the limit of the transition area between the two biomes. Historical collections indicate its occurrence in streams, swamps and ponds. According to studies for other states in Brazil, such as Pansarin & Amaral (2002) and Matias & Nascimento (2022), the species can also be found in swampy soils and periodically flooded floodplains. According to the conservation status, the species was Not Evaluated (NE) by the consulted sources (SEMA 2014; BRASIL 2022; CNCFlora 2022).

Recently several studies have shown that the species has high potential as an invasive plant, especially in wetlands and disturbed waterways. The plant, which is stoloniferous, can spread by fragments of its creeping stem, seedlings produced at the end of the growing season or seeds. Dispersal probably occurs by water currents, boats and machinery, waterfowl, and people (Kodala & Jobson 2018).

For Rio Grande do Sul, collections indicated flowering from November to May; however, for central-western Brazil, Pansarin & Amaral (2002) indicated that the species can eventually be found flowering throughout the year.

The species popular names are “water poppy” (Mobot 2022) and “lagartixa” (Pott & Pott 2000).

8. *Sagittaria lancifolia* L. Syst. Nat. (ed. 10) 2: 1270, 1759.

Figs. 5a-b; 6a-b

Herbs perennial, 29–88 cm tall, glabrous. Rhizome globose, ca. 4 cm dia. Emerged leaves, petiole cylindrical, 23.5–67 cm long, blade 3.7–21

× 0.7–5 cm, lanceolate to ovate, apex acuminate or acute, base attenuate, veins 5–6, translucent markings absent. Inflorescence paniculate or simple, scape 4.5–70 × 0.3–0.4 cm, erect, without vegetative proliferations, triangular; verticils 1–18, with 3–4 flowers; bracts ovate to lanceolate, 0.4–1.5 cm long, glabrous, acute apex. Flowers ca. 3 cm dia, pedicel 0.8–3 cm long, sepals 4–10 × 10–14 mm, oval. Fruit aquenium obovate, 2–3 × 1 mm.

Examined material: Rio Grande, 17.XII.1998, fl., *M. Perazzolo* (HURG 1763). Tramandaí, 13.I.1985, fl. and fr., *A. Rego 281* (ICN). Viamão, 2.I.2009, fl., *P.J.S. Silva Filho 925* (ICN).

Additional material: BRASIL. ALAGOAS: Feliz Deserto, 19.VIII.2006, *M.N. Rodrigues et al.* 1962 (MAC). Piaçabuçu, 13.VIII.1987, *G.L. Esteves et al.* 1909 (MAC). BAHIA: Nova Viçosa, 8.VII.1986, *G. Hatschbach 50738* (MBM). ESPÍRITO SANTO: Linhares, 19.III.2019, *A. Nepomuceno et al.* 746 (VIES). RIO DE JANEIRO: Quissamã, 6.VII.2005, *C.P. Bove & J. Paz* (R 205815).

In Brazil, *Sagittaria lancifolia* may have suffered a 30% reduction in populations over the

years and is currently classified as Vulnerable (VE) (BRASIL 2022; CNCFlora 2022). However, for Rio Grande do Sul, the species is classified as Endangered (NE) (SEMA 2014). According to CNCFlora (2022), most subpopulations of the species are located in Atlantic Forest habitats, but for Rio Grande do Sul, the records of the present study indicate that its distribution is restricted to the Pampa biome (Fig. 5a), occurring in the Litoral and Depressão Central physiographic regions (Fig. 5b). The present study indicates that most of the collections for the species were in coastal areas, corroborating other studies, such as Rego (1988) for the coast of Rio Grande do Sul, Matias & Nascimento (2022) for the coast of the state of Espírito Santo and Bogin (1955), and Kenner (2005) for the coast of the entire American continent. Although it is considered endemic in restinga areas (Pansarim & Amaral 2005), the records for this study showed that specimens were collected from artificial lakes, rivers and swamps. According to Matias (2022), there is no confirmed

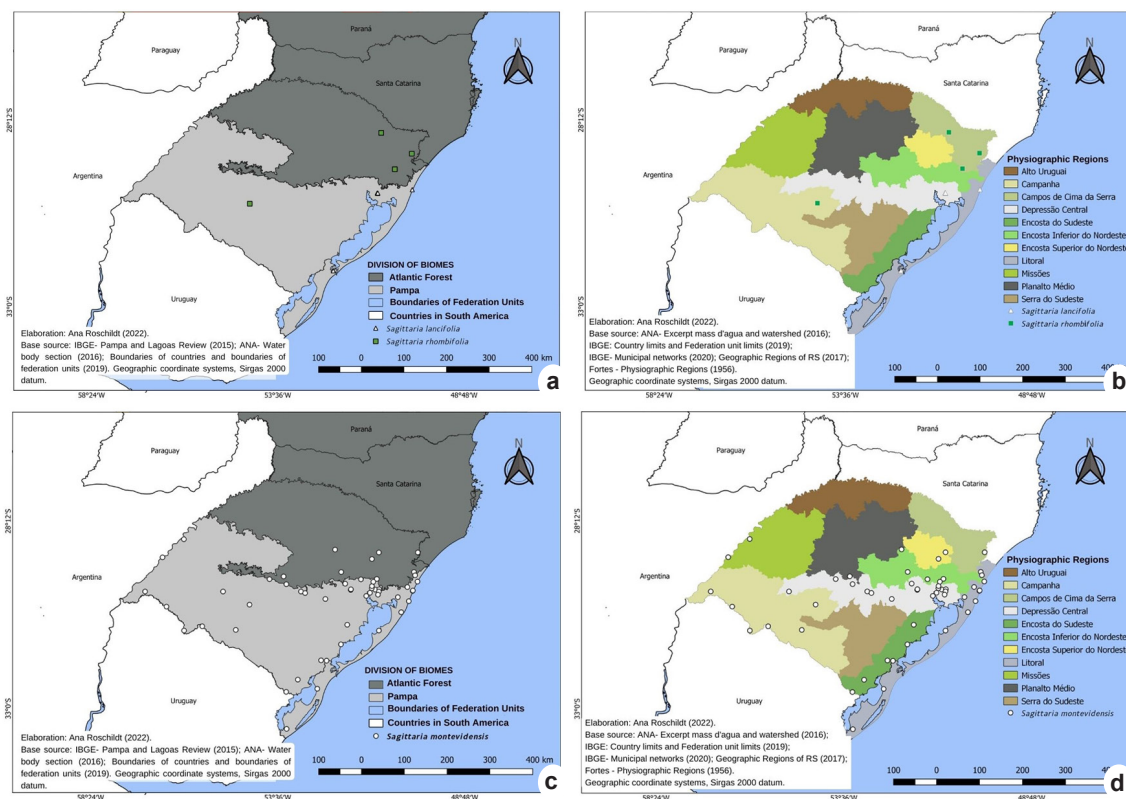


Figure 5 – a-d. Geographical distribution in Rio Grande do Sul state – a. *Sagittaria lancifolia* and *S. rhombifolia* according to the biomes; b. *Sagittaria lancifolia* and *S. rhombifolia* according to the physiographic regions. c. *Sagittaria montevidensis* according to the biomes; d. *Sagittaria montevidensis* according to the physiographic regions.



Figure 6 – a-b. *Sagittaria lancifolia* – b. habit; c. inflorescence. c. *Sagittaria rhombifolia* – c. habit, showing the decumbent inflorescences. d-f. *S. montevidensis* – d. habit; e. flower; f. rhizome with the presence of entomological galls. (a. Rouge; b-c. Tocce; d-f. Roschildt 06).

occurrence of the species for bordering states, such as Santa Catarina and Paraná, which was confirmed in the present study when additional material for the study area was consulted. Some of the material deposited in herbaria was wrongly identified, being confused with *Sagittaria montevidensis*. To differentiate them, the most evident characteristics are the shape of the leaf blade and the floral scape. *Sagittaria lancifolia* has lanceolate leaflets and a triangular floral scape, while *S. montevidensis* has sagittate leaflets and a cylindrical floral scape.

The specimens analyzed were collected with flowers in January and March, but according to Pansarim & Amaral (2005), they can be found blooming almost all year round.

The species popular names are “aguapé-de-folha-estreita” and “golfe” (Pott & Pott 2000).

9. *Sagittaria montevidensis* Cham. & Schltdl. Linnaea 2: 156, 1827. Figs. 5c-d; 6d-f

Perennial herb, 16–119 cm tall. Rhizome cylindrical, ca. 8 cm dia. Leaves emerged, rarely submerged, petiole 11–96 cm long; filodial leaves linear; leaf blade 3.4–37 × 0.5–22.5 cm, hastate to 1 sagittate, apex acute, base sagittate, veins 14–20, translucent markings absent. Inflorescence racemose or paniculate, scape 14–125 × 0.15–2 cm, erect, without vegetative proliferations, cylindrical; verticils 1–12, with 2–5 flowers; bracts lanceolate, 0.3–3 cm long, apex obtuse to rounded-acute. Flowers petiolate, ca. 3.5 cm dia., pedicels 1–4.8 cm long, sepals 5–9 × 2.5–4.5 mm, oval. Fruit aquenium oblong-lanceolate, 2.3–5 × 1.1–1.7 mm.

Examined material: Arroio Grande, 22.II.2022, fl and fr., *A. Roscholdt 06* (HURG). Balneário Pinhal, 16.XII.2011, fl., *E. Valduga 208* (HUCS). Cachoeira do Sul, 23.IV.1983, fl., *D.B. Falkenberg & M. Sobral s.n.* (ICN). Cachoeirinha, 10.IX.2004, fl., *J.R.V. Iganci 112* (PEL). Camaquã, 4.IV.1984, fl and fr., *S.A. Rego et al. 271* (RBR). Campo Bom, 1.IV.1975, fl., *L. Aguiar & C. Medaglia s.n.* (HAS 1551). Canela, 4.IV.1984, fl., *A.S. Rego s.n.* (ICN 96456). Canoas, 1.XII.1973, fl and fr., *K. Hagelund 7223* (ICN). Capão da Canoa, 23.I.1984, fl and fr., *A.S. Rego s.n.* (RBR 5112). Capão do Leão, 11.XI.2010, fl., *S. Pesamosca s.n.* (PEL 25331). Capivari do Sul, 14.V. 2002, fl., *E.N. Garcia 786* (ICN). Caxias do Sul, 7.XII.1988, fl., *R. Wasum s.n.* (US 1383125). Dom Pedrito 4.IV.1975, fl., *B. Irgang et al. s.n.* (ICN 027398). Esteio, 1.VI.1949, fl and fr., *B. Rambo 118* (US). Estrela, 8.IX.2006, fl., *J. Spellmeier 39* (HVAT). Gravataí, 1.III.1983, fl., *M. Neves 256* (HAS). Guaíba, 11.IV.1983, fl., *A.S. Rego s.n.* (ICN 96488). Ilópolis, 30.XI.2002, fl., *C. Gonçalves s.n.* (HVAT 1076). Imbé, 1.1967, fl., *K. Hagelund 5227* (ICN). Itaquí, 1.I.1943, fl., *H. Kleerekoper 31* (NY). Itati 28.II.1973, fl., *A.S. Rego*

s.n. (ICN198979). Jaguarão, 22.II.2022, fl and fr., *A.P. Roscholdt 04* (HURG). Livramento, 15.X.1971, fl., *A.S. Rego s.n.* (ICN 8571). Montenegro, 1.X.1977, fl and fr., *I. Ungaretti 767* (HAS). Osório, 17.IX.1983, *G. Pedralli & S.A. Rego 108* (ICN). Mostardas, 16.I.2018, fl., *V.L. Bittencourt 277* (ICN). Palmares do Sul, 7.I.1985, fl., *A.S. Rego 279* (ICN). Pântano Grande, 4.XII.1983, fl., *G. Pedralli 195* (ICN). Pelotas, 4.XII.1983, fl., *A.S. Rego et al. 160* (ICN). Porto Alegre, 29.XII.1966, fl., *J.C. Lindeman & H. Haas 29946* (MBM). Quaraí, 16.X.1983, fl., *A.S. Rego 118* (ICN). Restinga Seca, 12.X.1983, fl., *A.S. Rego 442* (ICN). Rio Grande, 3.III.2022, fl. and fr., *A.P. Roscholdt 08* (HURG). Santa Maria, 1.IV.2001, fl., *E.R. Salviani & H. Lorenzi 262* (HPL). Santa Vitória do Palmar, 14.XI.2021, fl. and fr., *A. Roscholdt 02* (HURG). Santana do Livramento, 10.XII.2008, fl. and fr., *F. Marchett 699* (HUCS). São Borja, 30.IX.1983, fl., *A.S. Rego et al. 113* (ICN). São Gabriel, 8.I.1969, fl., *A. Pott 181* (BLA). São Jerônimo, 1.IX.1982, fl., *R.L. Dutra 45* (HAS). São João do Polêsine, 30.IX.1954, fl., *F.R. Daniel 1277* (HRCB). São Leopoldo, 1.X.1941, fl. and fr., *J.E. Leite 440* (NYBG). São Lourenço do Sul, 15.XII.2002, fl and fr., *G. Heiden 236* (ECT). São Vicente do Sul, 29.XII.1976, fl., *A.S. Rego s.n.* (ICN). Tapes, 1.XII.1980, fl. and fr., *J. Georgem s.n.* (ICN 050191). Taquarí, 5.XII.1957, fl. *O.R. Camargo 2739* (PACA-AGP). Terra de Areia, 5.XII.1978, fl. and fr., *H. Longhi 626* (ICN). Torres, 9.XI.1983, fl. and fr., *A.S. Rego 134* (PEL). Tramandaí, 11.I.1984, fl., *A.S. Rego 096490*. Triunfo, 26.IX.1998, fl., *J.M. Consoni* (PACA-AGP 41194). Uruguaiana, 17.X.1987, fl., *W. Longhi* (ICN 043367). Viamão, 16.X.1983, fl., *A.S. Rego et al. 116* (ICN).

Sagittaria montevidensis is very common in the state, with records confirmed for the Pampa and Atlantic Forest (Fig. 5c). Previously, the species was cited for the regions Depressão Central, Litoral, Campanha, Missões and Serra do Sudeste (Rego 1988), but in this study, its range of occurrence was extended to all physiographic regions except Alto Uruguai (Fig. 5d). The species has characteristics of a competitive plant and adaptation to a wide ecological range, which allows it to inhabit flooded environments with different physicochemical characteristics (Cassol *et al.* 2008). This was verified in the present study, when its occurrence was found in streams, ponds, swamps, rice crops and drainage channels. This range of occurrence in different humid environments was also mentioned by Rego (1988). Furthermore, in sites that present a high concentration of organic matter, such as drainage channels, the species can reach up to 1.50 m in height, while in less eutrophicated sites, it can measure 20–60 cm in height. Although *S. montevidensis* is easily recognized in the field by the presence of decline flowers and sagittate leaves (Rego 1988), the great morphological

variability of the species causes it to be constantly misidentified. For example, Alves (2011) illustrated the habit and inflorescence of *E. grandiflorus* but used photos of *S. montevidensis*. Species *E. grandiflorus* and *S. montevidensis*, known as leather hat and false leather hat, respectively, have very similar phenotypic characteristics, but while *E. grandiflorus* has medicinal properties, no medicinal properties are yet known for *S. montevidensis* (Coelho *et al.* 2016). The presence of entomogenic galls on the plant root ends have been consistently observed (Fig. 6f), and according to Costa Lima (1956), they are produced by coleoptera of the species *Hypselus ater* Boheman. This insect, known as the aquatic curculionid, feeds and develops in different organs of aquatic plants in lentic environments (Spangler 1981). According to the conservation status, the species was Not Evaluated (NE) by the consulted sources (SEMA 2014; BRASIL 2022; CNCFlora 2022).

According to Rego (1988), its flowering and fruiting occurs from October to April; however, for the state, specimens were found flowering in all months of the year in the records and collections.

The species popular names are “aguapé-de-flecha” and “falso-chapéu-de-couro” (Demarco *et al.* 2019).

10. *Sagittaria rhombifolia* Cham. Linnaea 10: 219, 1835. Figs. 5a–b; 6c

Perennial herbs, 30–95 cm tall, glabrous to glabrescent. Rhizome globose, 2–2.5 cm dia. Leaves emersed or submersed, petiole 1–57 cm long; leaves emersed, 5.3–20 × 1.5–5.5 cm, lanceo-elliptic to ovate, apex acute to rounded, base attenuate, veins 7–8, translucent markings absent. Inflorescence racemose, scape 28–82 × 0.3–0.6 mm, erect, without vegetative proliferations, cylindrical; verticils 4–6, with 1–3 flowers; bracts lanceolate, 1–4.4 cm long, glabrous, apex acute to acuminate. Flowers long petiolate, ca. 4 cm dia, pedicel 1.7–3.2 cm long, sepals, 6–9 × 5–7 mm, elliptic. Fruit aquenium obovate, ca. 6 × 1.5 mm.

Examined material: Cambará do Sul, 28.XI.1983, fl., A. Rego & M. Paiva (ICN 098520). São Francisco de Paula, 27.X.1983, fl. and fr., A.S. Rego (ICN 96478). São Gabriel, VI.2008, fl. and fr., C.V.S. Gastal (EAC 43596). Vacaria, 30.XII.1946, fl., B. Rambo (PACA-AGP 34577). **Additional material:** ARGENTINA. Corrientes, 28.III.1975, M.M. Arbo *et al.* 943 (MBM). BRASIL. SANTA CATARINA: Lages, 3.XII.1956, L.B. Smith 8137 (NY). Porto União, 19.XII.1956, L. Smith & R. Reitz (US 2655227).

This species is distributed from Central America to South America, from southern Costa Rica to Argentina (Matias & Irgang 2006). In Brazil, it occurs from northern Amazonia to the south of the country (Pansarin & Amaral 2005; Matias 2022). For Rio Grande do Sul, there are few records of species collection, and its occurrence is restricted to the physiographic regions of Campanha and Campos de Cima da Serra (Fig. 5b). The species was classified by CNCFlora (2022) as Least Concern (LC). However, according to the other sources consulted, the species was Not Evaluated (NE) (SEMA 2014; BRASIL 2022). We believe that *S. rhombifolia* may be classified as endangered in a future analysis since few specimens have been collected, with no records of collections for more than 12 years for the state. Records show its occurrence in rivers, paludose areas and urban areas. According to Hall & Gil (2016), it also occurs in canga formations, margins and interiors of permanent ponds, marshes, and flooded swampy fields. *Sagittaria rhombifolia* presents a wide leaf variation, which correlates with its ecological type; it presents sessile and linear leaves when submerged and longipeciolate, usually rhombiform, leaves with an acute apex and acute to rounded base when emersed (Durigan *et al.* 2018). This variation in leaf morphology was confirmed in the specimens analyzed for the present study.

It was collected flowering in June, October, November and December in the state of Rio Grande do Sul. Data divergent from that recorded by Pansarin & Amaral (2005) found specimens flowering only in December and January in the state of Rio de Janeiro.

The species popular names are “lagartixa” (Pott & Pott 2000), “golfo” and “golfe” (Matias & Irgang 2006).

Regarding the bibliographic survey, floristic studies in Rio Grande do Sul indicate the presence of five species from the Alismataceae family, with *Sagittaria montevidensis* being the most common. However, species richness might be underestimated due to the regional focus of the studies. Comprehensive studies corroborated similar findings, with the present study identifying *Echinodorus reptilis* and *Echinodorus macrophyllus*, previously omitted, and clarifying the synonymy of *Echinodorus argentinensis*.

Although the quality of data from online repositories is being improved, there is still a need

for advances in the quality of materials and available data, especially location data and geographic coordinates, as well as adequate collection and herborization and images with good resolution.

Although there was already a taxonomic revision for the family (Rego 1988) in Rio Grande do Sul, there were many gaps and information to be updated. The present work showed important issues to be discussed, such as a lower number of species confirmation for the state, in relation to previous studies, which is probably related to misidentification and recent circumscriptions for the family. In addition, it expanded and addressed new aspects related to the distribution, ecology and phenology of the species, as well as provided an updated key for species identification.

The present study also presents the amplification of the distribution of Alismataceae species in new geographical domains, namely the Encosta Inferior do Nordeste, Encosta Superior do Nordeste and Planalto Médio, which had no occurrence records in previous studies (Rego 1988). Thus, we can confirm the wide distribution of Alismataceae for Rio Grande do Sul, with occurrence in all physiographic regions.

Regarding the conservation status, most of the species have not been evaluated, with the need for this evaluation following the standards of the IUCN because there are indications that there are other species with some degree of threat, in addition to those indicated in this study.

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Data availability statement

In accordance with Open Science communication practices, the authors inform that all data are available within the manuscript.

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