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First record of the aquatic plant *Echinodorus scaber* Rataj (Alismataceae) for the State of Maranhão, Northeastern Brazil

Primeiro registro da planta aquática *Echinodorus scaber* Rataj (Alismataceae) para o Estado do Maranhão, Nordeste do Brasil

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Abstract

Echinodorus is the second largest genus of the aquatic plant family Alismataceae, comprising 28 species, of which 24 occur in Brazil. This study represents the first record of *Echinodorus scaber* Rataj for the State of Maranhão, based on material collected in the Municipality of Brejo, eastern Maranhão. *Echinodorus scaber* shares morphological similarities with *E. macrophyllus* (Kunth) Micheli, but it can be distinguished by (I) a highly branched inflorescence, (II) scabrous peduncles and petioles covered by stellate trichomes, and (II) small flowers with reflexed petals. This new record of *E. scaber* contributes to a better understanding of this genus' diversity and distribution in Maranhão and underscores the necessity to broaden collection efforts for a better comprehension of the state's flooded zones. Comprehensive collection efforts, with a special focus on aquatic plants and in locations far from the state's main urban center, São Luís, may result in a significant knowledge increase of the flora, especially of the genus *Echinodorus*, which needs a broad taxonomic study. These recommendations may result in new records, range extensions, and species descriptions, contributing to the conservation of the aquatic environments of Maranhão.

Keywords: Alismatidae, aquatic macrophytes, Cerrado, taxonomy.

Resumo

Echinodorus é o segundo maior gênero da família de plantas aquáticas Alismataceae, compreendendo 28 espécies, 24 delas ocorrendo no Brasil. Este estudo representa o primeiro registro de *Echinodorus scaber* Rataj para o Estado do Maranhão, com base em material coletado no município de Brejo, leste do Maranhão. *Echinodorus scaber* compartilha semelhanças morfológicas com *E. macrophyllus* (Kunth) Micheli, mas pode ser distinguida por: (I) uma inflorescência altamente ramificada; (II) pedúnculos e pecíolos escabrosos recobertos por tricomas estrelados; e (II) flores pequenas com pétalas reflexas. Este novo registro de *E. scaber* contribui para uma melhor compreensão da diversidade e distribuição deste gênero no Maranhão e ressalta a necessidade de ampliar os esforços de coleta para uma maior compreensão das zonas inundadas do estado. Esforços de coleta abrangentes, com foco especial em plantas aquáticas e em locais distantes do principal centro urbano do estado, São Luís, poderá resultar em um aumento significativo do conhecimento da flora, especialmente do gênero *Echinodorus*, que necessita de amplo estudo taxonômico. Essas recomendações poderão resultar em novos registros, extensões de distribuição e novas descrições de espécies, contribuindo para a conservação dos ambientes aquáticos do Maranhão.

Palavras-chave: Alismatidae, macrófitas aquáticas, Cerrado, taxonomia.

1. Introduction

Echinodorus Rich. ex Engelm. is the second most specious genus within the aquatic family Alismataceae, currently including 28 species (Lehtonen, 2008). Most of them are found in the South American tropical regions, which are considered the genus center of diversity (Haynes and Holm-Nielsen, 1994). *Echinodorus* species include emergent and occasionally submerged aquatic herbs with predominantly emerged leaves and inflorescence (Haynes and Holm-Nielsen, 1986). Species of this genus are characterized by having long-petiolate leaves (with

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or without translucid markings on the blade), ribbed and glandular achenes (sometimes not glandular), and a subterranean system formed by rhizomes (Haynes and Holm-Nielsen, 1994).

In Brazil, the species of the genus are popularly known as *Chapéu-de-couro* (leather hat), a reference to the coriaceous consistency of their leaves (Pott and Pott, 2000). *Echinodorus* species are known to include ornamental species which are commonly present in water gardens and aquariums (Lehtonen and Falck, 2011). Additionally, the leaves of some species, e.g., *Echinodorus grandiflorus* (Cham. & Schltdl.) Micheli, are traditionally used within the country for the preparation of tea due to their diuretic properties and used to treat rheumatic diseases (Pott and Pott, 2000).

Echinodorus is represented in Brazil by 24 species, six of them endemic [*E. cylindricus* Rataj, *E. glandulosus* Rataj, *E. lanceolatus* Rataj, *E. major* (Micheli) Rataj, *E. palaefolius* (Ness & Mart.) J.F. Macbr., and *E. pubescens* (Mart.) Seub. ex Warm.], distributed across all phytogeographic domains and regions in the country. The genus is widely represented in the Amazon, Cerrado, and Atlantic Forest, with 10 species recorded for each domains. There is a total of 16 species in Northeastern Brazil, which represents 66% of the genus alpha diversity (Matias, 2023).

In Northeastern Brazil, two states are notable by comprising a high number of *Echinodorus* species in their territory: Bahia and Pernambuco, with 15 and nine species, respectively. Conversely, only four species of the genus are formally recorded in Maranhão State: *Echinodorus floribundus* (Seub.) Seub., *E. macrophyllus* (Kunth) Micheli, *E. paniculatus* Micheli, and *E. subalatus* (Mart.) Griseb. (Matias, 2023). This lower number is probably the result of the lack of extensive sampling efforts in Maranhão focusing on aquatic plants, even though the state is known for its great floristic potential, as evidenced by recent descriptions of new taxa (e.g., Guarçoni et al., 2020; Santos et al., 2020; Silva et al., 2023), and new occurrences (e.g., Ferreira et al., 2022; Pestana et al., 2022, 2023; Guarçoni and Marinho, 2023).

During a fieldwork conducted in the municipality of Brejo, eastern Maranhão, we sampled *Echinodorus scaber* Rataj for the first time in the State, increasing the number of known species to five. Photographs *in situ*, phenological and distribution data, taxonomic notes, morphological description, and an identification key for the species of the genus that occur in Maranhão State are provided here.

2. Material and Methods

2.1. Study area

The State of Maranhão is located in the northeastern region of Brazil, possessing an area of 331,983 km^2, and representing 3.9% of the national territory (IBGE, 2023). It is important to emphasize that Maranhão includes a transitional zone between the phytogeographic domains of Amazon (35%), Caatinga (1%) and Cerrado (64%), exhibiting climatic and phytogeographical characteristics typical of each one of these domains (Spinelli-Araújo et al., 2016; Figure 1). The local climate, according to Köppen's classification system, is classified as Aw, with a dry winter and rainy summer (Alvares et al., 2013). The average annual temperature variation is around 30 °C, and the annual rainfall is over 1,800 mm (UEMA, 2016).

2.2. Data collection

Samplings were conducted during field expeditions in January and August 2023 in the Municipality of Brejo, situated in eastern Maranhão, Brazil (Figure 1). According to Haynes (1984), the collected specimens were dried and deposited in the BMA and CCAA herbaria (acronym according to Thiers, 2023). Species identification was based on literature (Rataj, 1969; Haynes and Holm-Nielsen,

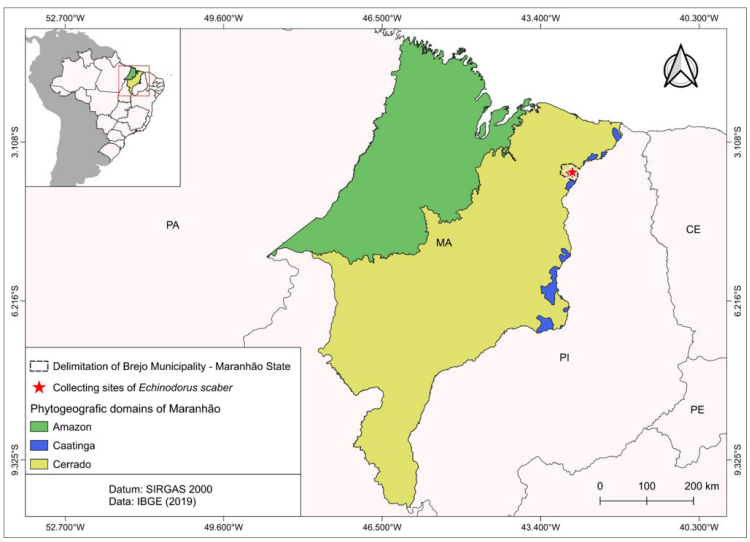

Figure 1. Map of the phytogeographic domains of the State of Maranhão, Northeastern Brazil, and the collecting sites of *Echinodorus scaber* in the Municipality of Brejo. Map preparation: M.C.A. Pestana.

1994; Lehtonen, 2008) and the descriptive terminology followed Beentje (2010).

Descriptions of *E. scaber* were based on the specimens collected in this study. Phenology data were obtained from exsiccate labels available online in the SpeciesLink database (CRIA, 2023) and from field observations. Information on geographical distribution was obtained from Matias (2023) and Plants of the World Online (POWO, 2023). The genus circumcision follows Lehtonen (2009), and the species name is in accordance with Matias (2023). The georeferenced records were obtained from the consulted database, as well as from the sites where specimens were sampled in this study. Only consistent and reliable coordinates were here considered. The map was created using the QGIS software (QGIS Development Team, 2021).

3. Results

Echinodorus scaber Rataj, Folia Geobot. Phytotax. 4: 438. 1969. **Type**: Guyana. Mounth of Canje River, Dec. 1887. *Jenman 4310* (holotype: K barcode 000098302 [digital image]!, isotype BRG) (Figures 2A and C).

≡ *Echinodorus macrophyllus* subsp. *scaber* (Rataj) R.R.Haynes & Holm-Niels., Brittonia 38: 331. 1986.

Species description: Aquatic herbs, up to 203 cm tall, emergent, perennial, peduncles and petiole scabrous, with stellate trichomes. Rhizome fusiform, 2-3 cm diam. Leaves emerged, long-petiolate, light green *in vivo*; petiole 10.5-42.4 cm long, cylindric; sheath 8.2-15.4 cm long; blades 10.2-23.3 × 5.2-16.3 cm, widely ovate, base cordate, apex obtuse, glabrous, margin undulate, coriaceous, glabrous; venation campilodromous, 10-13 veins, conspicuous, adaxially elevated; pellucid markings in blade absent. Inflorescence paniculate; peduncle 109.9-112.3 cm long, highly branched; 11-13 whorls, each 6-8 flowered; rachis 18.7-78.8 cm long, not winged, 10-13 whorls on the main axis; bracts 10.5-17.7 mm long, lanceolate, apex acuminate, glabrous, connate at base, 15-20 veins. Flowers long-pedicelate; pedicel 13-28 mm long, cylindric, erect, glabrous; sepals ovate, apex rounded, 20-30 veins, conspicuous, glabrous; petals 2.1-2.5 mm long, delicate, ovate, white, reflexed; stamens 15-17, filament ca. 2.3 mm long, glabrous, linear; anther 0.8-1.7 mm long, versatile; carpels 30-numerous. Achenes 2.8-3.5 × 0.8-1.9 mm, oblanceolate or fusiform, 3-6 ribbed, with 1-3 conspicuous glands; beak erect, 0.7-1.5 mm long. Seeds 1, ca. 1.15 mm long, oval, brown, surface reticulate (Figure 2).

Specimens examined: BRAZIL. MARANHÃO: Brejo, Quilombo Saco das Almas, Povoado Faveiro, 17-I-2023; fl.,

Figure 2. *Echinodorus scaber* found in Maranhão State, Northeastern Brazil: (A) Scabrous floral peduncle; (B) Detail of the flower and petal reflexed (white arrow); (C) Leaves; (D)Temporary pond where the species was collected in the study area. Photos: M.I. Silva (B) and M.C.A. Pestana (A, C, D).

fr., *Paiva, M. 47*, Oliveira, R., Pestana, M., Bastos, M., Silva, I. Júnior, E., Guarçoni, E. (BMA); *ibid*., Quilombo Saco das Almas, Povoado Criulis, 18-I-2023, fl., *Paiva, M. 68*, Oliveira, R., Pestana, M., Bastos, M., Silva, I. Júnior, E., Guarçoni, E. (BMA). *ibid*. 31-VIII-2023, fl., fr., *Paiva, M. 180*, Oliveira, R. (CCAA) (Figures 1 and 2).

Identification key for the *Echinodorus** species of the State of Maranhão, adapted from Matias (2023)

1. Blades widely ovate, base cordate, venation campilodromous 2
1'. Blades lanceolate or elliptical, base attenuate, venation acrodromous..... 4
2. Inflorescence peduncle and petiole scabrous; petals reflexed ..... *E. scaber*
2'. Inflorescence peduncle and petiole glabrous or glabrescent; petals not reflexed 3
3. Achene with 5-6 ribs and 1-2 glands ..... *E. floribundus*
3'. Achene with 2-4 ribs and 1-5 glands ... *E. macrophyllus*
4. Translucid markings in blade present forming lines; rachis winged ..... *E. subalatus*
4'. Translucid markings in blade absent; rachis not winged ..... *E. paniculatus*

*Additional information on the species of this genus with records for the State of Maranhão is presented in the Supplementary Material 1.

4. Discussion

Echinodorus scaber occurs in Argentina, Bolivia, Brazil, Colombia, Guyana, Paraguay, Peru, and Venezuela (POWO, 2023). It is recorded for all the Brazilian political regions, in the following federative units: Amazonas, Amapá, Pará, and Roraima (Northern Brazil); Goiás, Mato Grosso, and Mato Grosso do Sul (Central-Western Brazil); Minas Gerais, Rio de Janeiro and São Paulo (Southeastern Brazil); Paraná (Southern Brazil); Bahia and, as reported here, in Maranhão (Northeastern Brazil) for the first time, in the Cerrado phytogeographic domain (Figure 2). The geographic distribution of the species in South America is illustrated in Figure 3.

In Brazil, *Echinodorus scaber* occurs in wetlands in the Caatinga, Pantanal, Atlantic Forest, Cerrado, and in the Amazon phytogeographic domains (Matias, 2007, 2023). It is important to highlight that this species is rare in Northeastern Brazil herbaria collections, with only one record in Bahia previous to this study (Matias, 2023). This work provides the second record of the species to Northeastern Brazil region, as well as the first record for Maranhão.

In the Municipality of Brejo, the species is found either permanently or periodically in wet sandy soil, usually along the margins of streams and temporary ponds (see Figure 2). During the dry season, this species was not noticed, probably maintaining only a subterranean system formed by rhizomes that can persist for years and regrow during favorable conditions. At the study area, it was found flowering and fruiting in January and August. In other Brazilian regions, the species was collected with flowers from May to October (CRIA, 2023).

Echinodorus scaber can be identified by its highly branched panicle inflorescence, scabrous peduncles and petiole, with stellate trichomes (Figure 2A). From these latter characteristics, it derived its specific epithet: '*scaber*', from Latin, which means 'rough' or 'scabrous', referring to the densely scabrous peduncles and petioles. Moreover, the species has a peculiar flower, with small petals reflexed (Figure 2B), a character not found in other species of *Echinodorus* (Lehtonen, 2008).

Echinodorus scaber is commonly misidentified for *E. macrophyllus* (Kunth) Micheli, however, it differs from

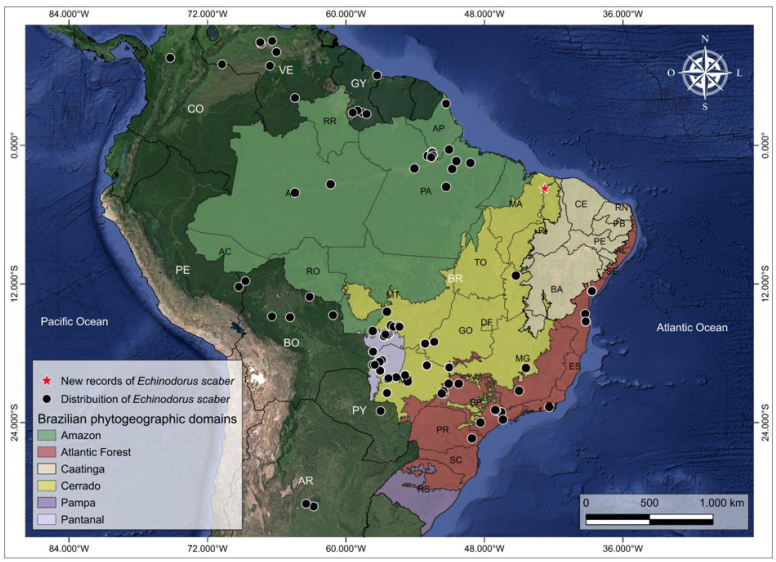

Figure 3. Geographic distribution of *Echinodorus scaber* in South America: Black circles indicate known distribution; Red star indicates the record in Maranhão State, Northeastern Brazil. AR: Argentina; BO - Bolivia; BR - Brazil; CO - Colombia; GY - Guyana; PE - Peru; PY - Paraguay; VE - Venezuela. Map preparation: M.C.A. Pestana.

this species by having scabrous peduncles (*vs.* glabrous to glabrescent), achenes with 3-6 ribs (*vs.* 2-4) and 1-3 glands (*vs.* 1-5), short petals, up to 2.5 mm long (*vs.* 12 mm), and androecium with 15-17 stamens (*vs.* 18-20). Furthermore, the inflorescence of *E. macrophyllus* usually exhibits vegetative proliferation (e.g., Canalli and Bove, 2017; Matias and Nascimento, 2022), a condition absent in the examined specimens of *E. scaber*.

Due to the morphological similarity to the species mentioned above, Haynes and Holm-Nielsen (1986, p. 331) proposed a new combination for *E. scaber*, suggesting it as a subspecies of *E. macrophyllus*, arguing that the differences between the two species were limited to size (were narrow) and shape of the achenes (were smaller), as Rataj (1969) described. The authors argued that the division into two species was not justified and that an approach at the infraspecific level would be more appropriate, as the narrow fruits were usually immature, while the mature fruits were larger and wider. Moreover, the authors noted that one of the achenes of *E. scaber* illustrated in the protologue (Rataj, 1969) exhibited all the characteristics of *E. macrophyllus*. This classification was followed until the phylogenetic work published by Lehtonen and Myllys (2008), who positioned *E. macrophyllus* and *E. macrophyllus* subsp. *scaber* (i.e., *E. scaber*) as different and not closely related species, despite the morphological similarities between them. This circumcision has been followed ever since.

This new record of *E. scaber* expands our understanding of this genus in Maranhão, as well as in Northeastern Brazil. However, it is notable that *Echinodorus* is clearly under-sampled in Maranhão, leading to a low richness compared to other States in Northeastern Brazil, such as Bahia and Pernambuco, which have 15 and nine recorded species, respectively (Matias, 2023). In addition, many herbaria containing collections of this genus from Maranhão have dubious identifications or are identified at genus level only. Given this situation, it is recommended that a specific taxonomic study be conducted on *Echinodorus* in Maranhão, along with increased collection efforts and a thorough review of its records in local herbaria.

Furthermore, from a botanical perspective, wetlands are among the least inventoried environments in Maranhão, and only recently it was the subject of more detailed studies (e.g., Silva and Fontes, 2018; Pestana et al., 2024). This lack of inventories and collection efforts contributes directly to the under-sampling of some groups of aquatic plants, such as *Echinodorus*. However, in general, the flora of wetlands has historically been neglected in floristic surveys, possibly due to the difficulties of collecting in swamp environments and the drying process, which requires greater care due to the humidity of the specimens (Haynes, 1984; Thomaz and Bini, 2003).

Hence, there is an urgent need to expand plant collection efforts in wetlands to enhance our understanding of Maranhão's flooded zones (Pestana et al., 2024). Conducting comprehensive collection efforts focusing on aquatic plants, especially in locations far from the Maranhão capital (the state's main urban center), São Luís, may result in a significant increase in knowledge of the flora, especially of the genus *Echinodorus*, which is clearly under-sampled in the State and needs a broad taxonomic study. These recommendations may result in new records, range extensions, and new species descriptions, contributing to the conservation of the aquatic environments of Maranhão.

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Supplementary Material

Supplementary material accompanies this paper.

Supplementary Material 1. Additional information obtained from Matias (2007, 2023) on the species of Echinodorus that occur in Maranhão.

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