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A SYNOPSIS OF ALISMATACEAE FROM THE SEMI-ARID REGION OF NORTHEASTERN BRAZIL[1]

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ABSTRACT - The Alismataceae (excluded Limnocharitaceae) comprises twelve genera of herbaceous aquatic plants. Only two of its genera (*Echinodorus* and *Sagittaria*) are native to the Neotropics. A survey of the species of Alismataceae confirmed the occurrence of four taxa of *Sagittaria* and eleven of *Echinodorus* from the semi-arid region of northeastern Brazil. Analytical keys to differentiate the genera and species are provided, as well as illustrations of their taxonomic characteristics and data on their geographical distribution. *Echinodorus macrocarpus* to be considered synonymous with *E. pubescens. Echinodorus reticulatus* is considered as a different species from *E. longipetalus*. There are five excluded taxa from the Brazilian semi-arid region: *E. grandiflorus*, *E. macrophyllus*, *E. martii, E. bolivianus*, and *E. decumbens*.

Keywords: *Echinodorus*. *Sagittaria*. Hydrophytes. Monocotyledons. Wetlands.

SINOPSE DE ALISMATACEAE DA REGIÃO SEMIÁRIDA DO NORDESTE DO BRASIL

RESUMO - A família Alismataceae (excluindo Limnocharitaceae) compreende doze gêneros de plantas herbáceas aquáticas. Apenas dois gêneros (*Echinodorus* e *Sagittaria*) são nativos da região Neotropical. O levantamento das espécies de Alismataceae confirmou a ocorrência de quatro *taxa* de *Sagittaria* e onze de *Echinodorus* para a região semi-árida do nordeste do Brasil. Chaves analíticas para gêneros e espécies são fornecidas, assim como ilustrações das características taxonômicas e dados de distribuição geográfica. *Echinodorus macrocarpus* foi considerado sinônimo de *E. pubescens. Echinodorus reticulatus* foi tratado como uma espécie distinta de *E. longipetalus*. Cinco *taxa* não foram confirmados para a região semi-árida brasileira: *E. grandiflorus*, *E. macrophyllus*, *E. martii, E. bolivianus* e *E. decumbens*.

Palavras-chave: *Echinodorus. Sagittaria*. Hidrófitos. Monocotiledôneas. Áreas alagadas

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INTRODUCTION

The family *Alismataceae* demonstrates subcosmopolitan distribution and comprises 12 genera (HAYNES et al., 1998). *Echinodorus* and *Sagittaria* are the only neotropical genera of this family, and they demonstrate the greatest species richness (FASSET, 1955; ROGERS, 1983).

There is a phytogeographical importance of the family *Alismataceae* in the new world because the large numbers of species present in tropical regions (principally in South America) (LOT; NOVELO, 1984). Haynes; Holm-Nielsen (1989) consider South America to be the primary center of diversity of the genus *Echinodorus*. This species diversity is very marked in Brazil, with *Echinodorus* being represented by 18 taxa, although *Sagittaria* has only six (HAYNES; HOLM-NIELSEN, 1994). The *Sagittaria* genus, on the other hand, demonstrates greater species diversity in the temperate regions of North America.

The phylogeny of *Echinodorus* genus was studied on the basis of morphological characters (LEHTONEN, 2006) and on the simultaneous cladistics analysis molecular and morphological data (LEHTONEN; MYLLYS, 2008). The results showed *Echinodorus* to be polyphyletic and none of the currently proposed infrageneric classifications of the genus were support in the light of phylogenetic studies. Feitoza et al. (2010) showed similar cytotaxonomic patterns between species of Alismataceae. The *Echinodorus* and *Sagittaria* species are characterized by a strongly bimodal karyotype, with 2n = 22 and karyotypic formula 2m + 20a.

The semi-arid region of northeastern Brazil is typified by alternating periods of drought and heavy rainfall in lowland areas, and species of *Echinodorus* and *Sagittaria* can be found in shallow lakes or marshes bordering both intermittent and perennial streams. A majority of these species are cryptophytes that have decentralized subterranean systems composed of rhizomes with perennial buds that can resist long periods of drought.

The present work presents a taxonomic synopsis of the species of *Alismataceae* (excluded Limnocharitaceae) found in wetlands throughout the semi-arid region of northeastern Brazil, with analytical keys to differentiate the genera and species as well as illustrations of their more specific taxonomic characteristics. There are few studies about the herbaceous flora from Brazilian semi-arid region (ANDRADE et al., 2009; PORTO et al., 2009). Especially on the aquatic ecosystems.

MATERIAL AND METHODS

The study region is located in northeastern Brazil, whose semi-arid region covers approximately 969.589,4 km^2 (MINISTÉRIO DA INTEGRAÇÃO NACIONAL, 2005) and comprises different regional rainfall regimes; with the rainy season extending from January to February in the western and southern sectors, and from March to April in the north. A BSh climate prevails and the average monthly temperature is 26-27^o during the dry season, with marked diurnal fluctuations (ANDRADE LIMA, 1981). Northeastern Brazilian semi-arid regions present saline aquatic ecosystems with low concentrations during the rain season.

Intermittent shallow lakes and streams are common in these semi-arid areas, and most aquatic ecosystems dry up completely for periods of from 3 to 9 months. The siliceous soil of the region is often highly impermeable (MALTCHICK et al., 1999).

The present work was based on the study of herbarium collections, observations and collections of plant populations in the field, and detailed morphological examination of plant structures. Catalogued specimens were examined in the following herbaria (acronyms follow HOLMGREN et al., 1990): AAU, ALCB, B, BM, BR, CEUL**,** COR, CR, EAC, F, GH, HRB, HST**,** HUEFS, IAN, ICN, INPA, IPA, K, MAC, MEXU, MICH, MO, NY, P, R, RB, S, SP, TEFH, U, UFMT, UNA, VEN. Current methods of collecting aquatic plants were used during sampling (see HAYNES, 1984; CESKA, 1986), and all collections were deposited at the EAC and ICN Herbaria. Only a small number of select herbarium collections are cited in the text, but the complete specimen list (579 were examined from northeastern Brazil) is available on request. All specimens cited were examined by the author. The taxonomic treatment followed Haynes; Holm-Nielsen (1994) and Lehtonen (2008).

RESULTS AND DISCUSSION

KEY TO THE GENENA

1. Monoecious flowers..... *Sagittaria*
1´.Dioecious flowers..... *Echinodorus*

KEY TO THE SPECIES OF *Echinodorus*

1. Plants slender, malleable; subterranean system centralized, uniform; inflorescence reduced, umbelliferous……..…...1. *E. tenellus*
1´. Plants thick, stiff; subterranean system decentralized, not uniform; inflorescence not umbelliferous...2
2. Flowers with 12 stamens…….……..3
2´. Flowers with more than twelve stamens…….……..7
3. Leaf lamina wide-ovate to ovate, base cordate, apex rounded to slightly retuse; petiole round in transversal section, glabrous; rhizome claviform; stamens with dorsal secretory structures……..……..2. *E. glandulosus*

3´. Leaf lamina ovate to elliptical-lanceolate, base attenuated, cuneiform or truncates, apex acute to obtuse; petiole never round in cross section, pubescent to glabrescent; rhizome fusiform to subfusiform; stamens without dorsal secretory structures……..……..4
4. Plants pubescent; petiole triangular in cross section…….…….....3. *E. pubescens*
4´. Plants glabrescent to glabrous, petiole pentagonal (rarely 3-sided) or semicircular in cross section……..5
5. Scape pentagonal or triangular in cross section, large wings ……..……..5. *E. palaefolius*
5'. Scape semicircular in cross section; without wings or narrow extension wings...……6. *E. subalatus*
7. Leaves ovate with cordate base, dorsal surface glabrescent to pubescent, 8-18 veins, venation campylodromous……..……..…8
7´. Leaf elliptical-lanceolate with base cuneiform to attenuated, surface glabrous, 5-7 veins, venation acrodromous……..……..9
8. Fruit obovate, leaf blade with secretory ducts not translucent……..…..6. *E. scaber*
8´. Fruit lanceolate, leaf blade with translucent secretory ducts, stippled marks…….……7. *E. floribundus*
9. Petiole semicircular in cross section, without wings; sepal triangular appressed to aggregated fruit; achene falcate, rostrum diminutive…. …….....…..... 8. *E. reticulatus*
9´. Petiole triangular in cross section, with wings; sepals ovate, reflexed on the aggregate fruit; achenes obovate, rostrum protruding……...10
10. Scape triangular in cross section with convex surfaces, ribbed; fruit glandular, glands discoid, from one to three.....…….....9. *E. lanceolatus*
10´. Scape triangular in cross section with concave surfaces; ribbed on only one surface; fruit without glands, or rarely with one discoid gland, diminutive when immature ..…....…….10. *E. paniculatus*

1. ***Echinodorus tenellus*** (Mart. ex Schlt. & Schult. F.) Buchenau (1868:2). Type: Brasil, Minas Gerais, Contendas, *Mart*. s.n. (lectype: M). Figure 1A.
SELECTED COLLECTIONS. BRAZIL. Bahia, Barra, lagoa marginal do rio Grande, 11 May 2003, *L.Q. Matias 401* (EAC); Pernambuco: Petrolina, área do Projeto Manejo Caatinga, June 1981, *Givaldo* s.n. (IPA 26341); Piauí: Parnaíba, lagoa Ilha de Santa Izabel, 4 Oct. 1973, *D.S.D. Araújo* 456 (RB).
NOTE. Populations of *E. tenellus* can easily be found in flooded lowlands and along the margins of lakes and the largest rivers in the semi-arid region (the São Francisco and Parnaíba rivers). Although this species characteristically inhabits perennial aquatic environments, these bodies of water often demonstrate large variations in their surface area during the dry season, and the species shows great morphological variations as well.
2. *Echinodorus glandulosus* Rataj (1969: 336). Type: Brasil, Pernambuco, Tapera, riacho Toró, jul 1921, *B. Pickel 64* (holotype: BRG *n.v.*; isotype: SP; paratype RB). Fig. 1B.
SELECTED COLLECTIONS. BRAZIL. Bahia, Feira de Santana, BA 52, estrada para Jaguará, L.P. Queiroz 1711 (HUEFS); Ceará State, Aiuaba, Estação Ecológica de Aiuaba, Açude do Letreiro, 8 May 2002, L.Q. Matias 350 (EAC), Paraíba: Itapororoca, fazenda Macacos, 11 May 1995, L.P. Félix 7097 (HST), Pernambuco: Gravatá, açude entre gravatá e Bezerros, 9 Nov. 1997, L.P. Félix 8996 (HST).
NOTE. *Echinodorus glandulosus* is endemic to northeastern Brazil, occurring in regions with long (seven to eight month) dry periods. Populations of *E. glandulosus* are commonly found in the southern and southwestern parts of Ceará State, and the paratype specimen came from this region.
3. *Echinodorus pubescens* (Mart.) Seub. *ex* Warm. (1872: 113). Type: Brasil, *Mart*. 143 (holotype: M). Figure 1C.
Echinodorus macrocarpus Rataj (1975: 69); **Synon.nov.** Type: Brasil, Ceará, Serra de Baturité, 4 aug 1938, *J. Eugênio* 227 (holotype: RB).
SELECTED COLLECTIONS. BRAZIL. Bahia**,** Rio de Contas, sudoeste de Jussiape, 26 March 1977, R.M. Harley et al. 20019 (U, IPA); Ceará, Aiuaba, lagoa da Casaca, 9 June 2002, L.Q.Matias 354 (EAC, ICN); Piauí, São Raimundo Nonato, lagoa Comprida, 13 April 2002, L.Q.Matias 321, 322, 323 (EAC, ICN).
NOTE. This species occurs in regions with dry periods lasting from five to seven months, and is frequently found in temporary lakes in lowland *caatinga* areas with silty soils that are rich in organic material. Rataj (1975) designated the collection *Eugênio* 227 (RB) as the type specimen of *E. macrocarpus* Rataj, placing it within the section *Paniculatii*. The holotype did not have flowers that could be analyzed. This specimen did have pubescent surfaces, and the fruits were similar to those found on the other specimens from northeastern Brazil. It was confirmed that none of the characteristics presented in the previous studies of Rataj (1975, 2004) were consistent with a distinct characterization of *E. macrocarpus*. As such, it is suggested that *E. macrocarpus* be synonymized with *E. pubescens*, as like as Matias (2007).
4. ***Echinodorus subalatus*** (Mart.) Griseb. (1866: 218). Type: Brasil, *Mart.* 150 (lectotype: M).
Figs. D, J, L
SELECTED COLLECTIONS. BRAZIL. Bahia, Cachoeira, Porto Castro Alves, Barragem Bananeiras, 7 July 1980, Scardino et al. 253 (ALCB, EAC, HUEFS, HRB, RB), Casa Nova, Porto, Rio São Francisco, 4 Aug 1939, Mendes s.n. (SP), Morro do Chapéu, Represa da fazenda Cardeal, 12 March 1996, R. Lima et al. 2299 (HUEFS, HRB); Ceará State, Granja, 17 July 2003, L.Q. Matias 481 (EAC, ICN), Senador Pompeu, Encantado, 6 May 2002, L. Q. Matias 343 (EAC, ICN); Minas Gerais State, Mu-

quém, rio Carinanha, afluente do São Francisco, 4 May 1912, A. Lutz 31 (R); Paraíba State, Brejo do Cruz, estrada para Catolé do Rocha, 20 April 2003, L.Q. Matias 329 (EAC, ICN), São Gonçalo, 22 April 1997, P. Lützelburg s.n. (IPA 43573); Pernambuco State, Arco Verde, 1 Aug. 1981, *G*. Cavalcanti s.n. (IPA 45394); Piauí State, Canto do Buriti, 11 April 2002, L.Q. Matias 320 (EAC, ICN); Rio Grande do Norte, José da Penha, fazenda Engenho Velho, 10 July 1984, A.C. Sarmento 795 (ALCB, HRB, RB); Açu, rio Açu, 11 July 1960, D. Andrade-Lima 3504 (IPA); Serra Negra, lagoa da serra, 22 April 2002, L.Q. Matias 333 (EAC, ICN).

NOTE. *Echinodorus subalatus* is very frequent in the semi-arid region and is encountered in many different types of aquatic environments, whether intermittent or not. This plant can assume quite reduced sizes (6-10 cm high) in regions with long dry periods (from 8 to 11 months).

5. ***Echinodorus palaefolius*** (Nees & Mart.) J.F. Macbr. (1931: 11). Type: Brasil, Minas Gerais, Felisberto Caldeira, jan 1817, *P.* Max Vidensis s.n. (holotype: BR). Figure 1M.

SELECTED COLLECTIONS. BRAZIL. Alagoas, Paulo Afonso, BR 110, entre Paulo Afonso e Jeremoabo, 7 June 1981, A. Mori et B. Boom 14242 (UNA); Bahia, Castro Alves, 6 June 1979, M.L. Seixa-Ribeiro s.n. (HUEFS 2201); Ceará, Aiuaba, Estação Ecológica de Aiuaba, rio umbuzeiro, 26 June 2003, L.Q. Matias 464 (EAC); Piauí, Macambira [Macambeira], May 1839, G. Gardner 2330 (BM, K); Paraíba; Juazeirinho, estrada em direção ao balneário, 27 April 2002, L.Q. Matias 341 (EAC, ICN); Pernambuco, Betânia, fazenda Cunhãns, 24 april 2002, L.Q. Matias 336, 337 (EAC, ICN).

NOTE. Populations of this species are mostly found in regions with a dry season that varies between seven and ten months. They inhabit shallow intermittent lakes or in small depressions in the *caatinga* (dryland) soil, forming thickets during the rainy season; predominantly on clay-humic soils. A subterranean system formed of rhizomes similar to those seen in *E. subalatus, E. pubescens*, and *E. glandulosus* allow these populations to survive unfavorable dry periods. Rataj (1971) described the variety *E. palaefolius* (Nees & Mart.) J.F. Macbr. var. *latifolius* (Micheli) Rataj as having "widely spherical" canaliculated petioles, and long pedicles. It was observed that the petioles of *E. palaefolius* demonstrate large variations in their shape (ranging from polygonal to semicircular), and that these variations could occur even in the same individual, thus making this characteristic impractical for use in classifying this variety.

6. ***Echinodorus scaber*** Rataj (1975: 62). Type: Guyana, Canje River, Oct 1887, *G.S. Jenman* 4310 (holótipo: K). Figure 1E.

SELECTED COLLECTIONS. BRAZIL. Bahia, Tabocas, Chapadão Ocidental, 5 km ao norte de Tabocas, 1 May 1980, R. M. Harley 21993 (SP); Paraíba, s.l., Jan 1935, H. Zenaide 91 (SP)**;** Piauí State, Macambira [Macambeira], May 1839, G. Gardner 2330 (BM, K).

NOTE. There is only one recorded collection from the *caatinga* region, from the extreme eastern sector of Piauí State. This locality is within the Ibiapaba Mountains - a region of the *caatinga* ecosystem with humid forests on higher slopes and *cerrado* (savanna) vegetation occupying the plateaus.

7**.** ***Echinodorus floribundus*** (Seub.) Seub. (1872:11 3). Type: Brazil, Gardner 1860 (Lectotype NY!, Isolectopype BM!, G, K, NY). Figure 1F

SELECTED COLLECTIONS. BRAZIL. Ceará, Crato, Aug 1838, G. Gardner 1860 (BM, P).

NOTE. ***Echinodorus floribundus*** is rare in the semi-arid region, and the collection specimen is old, coming from southern Ceará State.

8. ***Echinodorus reticulatus*** R.R. Haynes & Holm-Niels. (1986: 38). Type: Suriname, Sipaliwini, savanna area on Brazilian frontier, in great "Maurisie" forest, 1,5Km N of "4-Gebroeders" mts, 15 oct 968, F.H.F. Oldenburger, R. Norde & J.P. Schulz ON292 (holotype: NY; isotype: NY). Figure 1G.

SELECTED COLLECTIONS. BRAZIL. Bahia (*cf.*), Nov. 1974, D. Andrade Lima 7889 (IPA).

NOTE. Rataj (2004) synonymized *E. reticulatus* to *E. longipetalus* Micheli, arguing that *E. reticulatus* was merely a specimen demonstrating phenotypic variations (petioles larger than the bracts, wide leaves, and large flowers). Additionally, the author stated that although the unusual locality of the sample (Suriname) differs from the predominant geographical distribution of *E. longipetalus* (southwestern and central-western parts of South America) this was not sufficient motive to distinguish between these species. However, Haynes & Holm-Nielsen (1986) noted a striking difference between the pedicels of these plants, which reach ca. 4.5 cm in length in *E. reticulatus* but are always less than 1 cm long in *E. longipetalus*. Additionally, *E. reticulatus* has anthers with acuminate apices, differing from *E. longipetalus*, which has anthers with obtuse apices (HAYNES & HOLM-NIELSEN, 1994). For these reasons the synonymization was not accepted.

9. ***Echinodorus lanceolatus*** Rataj (1968: 38). Type: Brasil, São Paulo, *Burchell* 4158 (holotpe: BR, isotype: BR). Figure 1H.

SELECTED COLLECTIONS. BRAZIL. Bahia, Juazeiro, margem baixa do rio Salitre, campo dos cavalos, 8 July 1971, D. Andrade-Lima et al. 1211 (RB, IPA); Ceará, Granja, Olho d'água do Costa, povoado Santa Terezinha, 17 July 2004, L.Q. Matias 482 (EAC).

NOTE. This species occupies the margins of perennial rivers as well as swampy areas maintained by drainage from adjacent plateaus in the semi-arid region of northeastern Brazil, while other populations

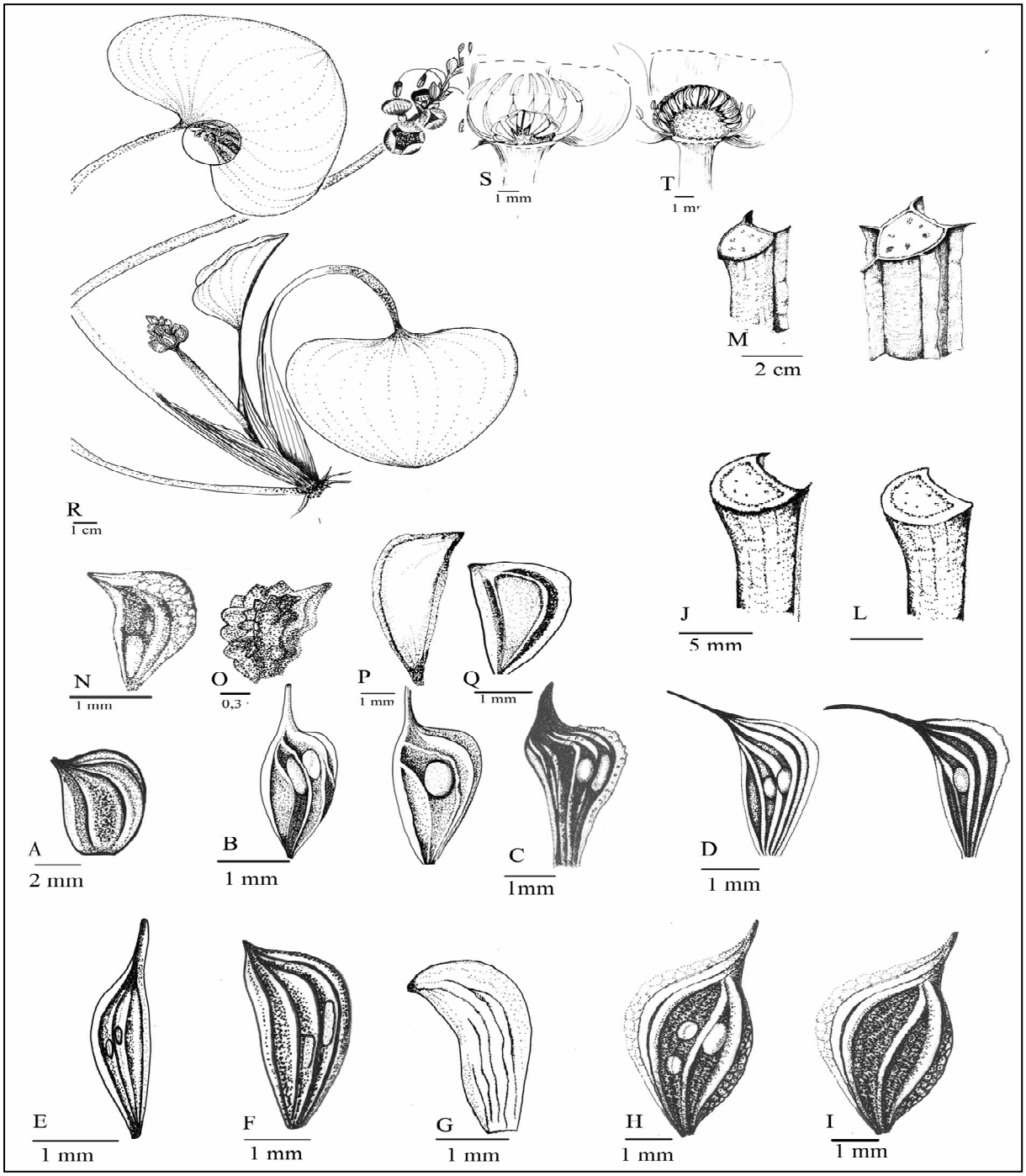

Figure 1. Diagnostic features of *Echinodorus* and *Sagittaria* species. **A.** Fruit of *E. tenellus* (L.Q. Matias 401, EAC), scale bar = 1mm); **B.** Fruits of *E. glandulosus* (L.Q. Matias 401, EAC), scale bar = 1mm; **C.** Fruit of *E. pubescens* (L.Q. Matias 323, EAC, ICN), scale bar = 1mm; **D.** Fruits of *E. subalatus* (P. Lützelburg s.n., IPA 43573), scale bar = 1mm; **E.** Fruit of *E. scaber* (G. Gardner 2330, BM, K), scale bar = 1mm; **F.** Fruit of *E. floribundus* (G. Gardner 1860, BM, P), scale bar = 1mm; **G.** Fruit of *E. reticulatus* (D. Andrade Lima 7889, IPA), scale bar = 1,8 mm; **H.** Fruit of *E. lanceolaus* (L.Q. Matias 482, EAC) , scale bar = 1mm; **I.** Fruit of *E. paniculatus* (L.Q. Matias 411, EAC), scale bar = 1mm; **J.** Distal end format of the scape of *E. subalatus* with two narrow wings (L.Q. Matias 343, EAC, ICN); scale bar = 5 mm; **L.** Distal end format of the scape of *E. subalatus* without wings (P. Lützelburg s.n., IPA 43573), scale bar = 5 mm; **M.** Distal end format of the scapes of *E. paleafolius* with two or five large wings (L.Q. Matias 336, EAC, ICN), scale bar = 2 cm; **N.** Fruit of *S. lancifolia* ssp. *lancifolia* (Lyra-Lemos et al 1321, MAC) with the basal oil gland and a smooth wings, scale bar = 1mm; **O.** Fruit of *S. guayanensis* ssp. *guayanensis* without the oil glands and with a muricate surface (L. Q. Matias 455, EAC, ICN), scale bar = 0,3 mm; **P.** Fruit of *S. rhombifolia* without the oil glands but with a narrow smooth wings (L. Q. Matias 406, EAC, ICN), scale bar = 1mm; **Q.** Fruit of *S. planitiana* without the oil glands but with a large smooth wings (Fernandes s.n., EAC 22996), scale bar = 1mm; **R.** Habit of *S. planitiana* (Fernandes s.n., EAC 22996) with a detail of trichomes on abaxial surface of leave, scale bar = 1cm; **S.** Male flower of *S. planitiana* with small and sterile carpels on the center (Fernandes s.n., EAC 22996), scale bar = 1mm; **T.** Female flower of *S. planitiana* with the whorl of stamina (Fernandes s.n., EAC 22996) , scale bar = 1mm.

can be found in estuaries and coastal lakes. Although Pansarin & Amaral (2005) synonymized this species to *E. paniculatus* Micheli, this synonymization was not considered in the present work - based on the fact that the anatomy of the scape of *E. lanceolatus* demonstrates a different pattern in cross-section than that of *E. paniculatus* (Matias et al. 2008). Additionally, the fruit gland of *E. paniculatus*, when present, is very diminutive and discoid (MATIAS 2007), differing greatly from the large fruit gland of *E. lanceolatus*.

10. ***Echinodorus paniculatus*** Micheli (1881: 3). Type: Guayana, R. *Schomburgk 220* (lectotype: K). Figure 1I.

SELECTED COLLECTIONS. BRAZIL. Bahia, Iraquara, estrada para Pratinha, lagoa do Parnaíba, 13 May 2004, L.Q. Matias 411 (EAC, ICN); Piauí, Pirapora, rio Pirangi, balneário, 23 May 2002, L.Q. Matias 362 (EAC).

NOTE. Populations of this species grow along river margins and in permanent lakes, or in ephemeral lakes that persist for reasonably long periods of time. Other populations can be found in estuaries and coastal lakes.

KEY TO THE SPECIES OF *Sagittaria*

1. Carpellate flowers with reflexed sepals; pedicels spreding to ascending in flower and fruit; coastal emersed plants from estuaries and lagoons…….....1. *S. lancifolia* ssp. *lancifolia*

1'.Carpellate flowers with adpressed sepals; pedicels spreding to ascending in flower and erect to recurved and inflated in fruit; mostly semi-arid emersed or floating plants from shallow lakes …… ……..……..2

2. Floating plants, achenes with muricate surface ... ……. 2. *S. guayanensis* ssp. *guayanensis*

2'. Emersed plants, achenes without muricate surface……..3

3. Leaves lanceo-elliptic to ovate, bracts conate at the base,
pistillate flowers without the whorl of stamina….. …….. 3. *S. rhombifolia*

3'. Leaves widely ovate to reniform, bracts separate,
pistillate flowers with the whorl of stamina …... …… 4. *S. planitiana*

1. ***Sagittaria lancifolia*** Linnaeus ssp. ***lancifolia*** (1759: 2). Type: Jamaica, Browne s.n. (Holotype LINN). Figure 1N.

SELECTED COLLECTIONS. BRAZIL.. Alagoas, Paiçabuçu, rio Marituba, 3 Nov. 1987, Lyra-Lemos et al. 1321 (MAC); Bahia, Itapicuru, Vila do Mosquete, fazenda Roçado, 24 Sept. 1993, Borges 40 (HRB).

NOTE. *S. lancifolia* ssp. *lancifolia* is an inhabitant of coastal wetlands. Although it has a wide range, it is rare in northeastern Brazil.

2. ***Sagittaria guayanensis*** ssp. ***guayanensis*** Kunth in Humboldt, Bonpland et Kunth (1816: 1). Type: Venezuela, Provincia Guayanensis, near to El Trapiche de Don Felix Farreras, Angostura, Jun 1800, F.W.H.A von Humboldt and A.J.A. Bonpland s.n. (Lectotype B). Figure 1O.

SELECTED COLLECTIONS. BRAZIL. Bahia, Bom Jesus da Lapa, 11 Feb 2000, Queiroz et al. 5889 (ALCB, UEFS); Ceará, Crateús, estrada para a Serra d'Almas, 25 March 2003, L.Q.Matias 455 (EAC, ICN); Pernambuco, Petrolina, 25 May 1983, Fortius 3441 (IPA); Rio Grande do Norte, Extremoz, 29 Oct 1917, A. Lutz 1335 (R).

NOTE. *S. guayanensis* ssp. *guayanensis* presents large morphological variations in its leaves, which may be associated with fluctuation in water levels due to local rainfall variations.

3. ***Sagittaria rhombifolia*** Chamisso (1835: 10). Type: Brasil, F. Sellow s.n. (lectotype E; isolectotype K, LE). Figure 1P.

SELECTED COLLECTIONS. BRAZIL. Bahia, Barra, Área de Proteção Ambiental Dunas e Veredas do São Francisco, 12 May 2004, L.Q.Matias 406 (EAC, ICN); Piauí, Cajazeiras [Cajazeiras do Piauí], Gardner 2737, Oct 1839 (BM)

NOTE. *S. rhombifolia* is a rare species from northeastern Brazil. It inhabits shallow lakes and quiet waterways at the transition zone between semi-arid and savannah regions, as well as lowlands in mountainous areas. S. *rhombifolia* demonstrates large morphological variations, especially of its leaves. The immersed leaves in populations from the northeast and from wetlands in Brazil showed elliptical lanceolate blades, while populations from meridional Brazil showed oval or rhombic leaves with attenuated bases.

4. ***Sagittaria planitiana*** G. Agostini (1970: 20). Type: Venezuelea: Edo. Portuguesa: marsh in llanos, just west of Guanare, alt. 180m, 25 Oct. 1966, Julian A. Steyermark et Marvin Rabe 96484 (holotype NY, isotype VEN, paratype: Venezuela: Edo. Guárico, Lagoon of Mesa de El Sombrero, in mud, 10 sep 1927, H. Pittier 12473). Figs. 1Q, 1R, 1S, 1T.

SELECTED COLLECTIONS. BRAZIL. Bahia, Barreiras, 24 Dec. 1954, Black 54-17752 (IAN); Ceará, Sobral, Estrada para Taperuaba, 15 June 1995, Fernandes s.n. (EAC 22996).

NOTE. Populations of *S. planitiana* occurring in northeastern South America demonstrated a prevalence of plants with reniform leaves and pubescent surfaces on the abaxial foliar faces, petioles, and scapes.

CONCLUSION

New occurrences of *E. lanceolatus, E. reticulatus*, *E. paniculatus*, *S. planitiana*, and *S. rhombifolia* were recorded for the semi-arid region.

The species of the semi-arid region demonstrate the following overall patterns of distribution: (a) species restricted to this semi-arid environment,

such as *E glandulosus, E. palifolius*, and *E. pubescens*; (b) species with neotropical distributions that are very common in shallow lakes in semi-arid regions, such as *E. subalatus* and *S. guayanensis* subsp. *guayanensis*; and (c) species occupying flooded areas in a larger range of environments with a humid tropical climate and that are restricted to specific habitats in the semi-arid region, such as *E. lanceolatus, E. reticulatus*, *E. tenellus*, *E. paniculatus*, *E. floribundus*, *E.scaber*, *S. planitiana*, and *S. rhombifolia*.

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