

# Taxonomy and distribution of *Sagittaria* (Alismataceae) in north-eastern Brazil

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Received 11 January 2005; received in revised form 5 September 2005; accepted 29 September 2005

## Abstract

The family Alismataceae comprises 12 genera of herbaceous aquatic plants. There are only two genera that are naturally found in Neotropical regions: *Echinodorus* and *Sagittaria*. This study examines the species of *Sagittaria* from north-eastern Brazil, a region that is characterized by a semiarid climate and intermittent aquatic ecosystems. Four taxa have been identified: *S. guayanensis* subsp. *guayanensis*, *S. rhombifolia*, *S. lancifolia* subsp. *lancifolia* and *S. planitiana*. Full descriptions, observations, geographic distributions, illustrations and a species key are presented.

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**Keywords:** Alismataceae; Arrowhead; North-eastern Brazil; *Sagittaria*; Semiarid region

## 1. Introduction

The genus *Sagittaria* belongs to the cosmopolitan aquatic family Alismataceae, with most of its species occurring in the New World (Cook, 1996; Haynes et al., 1998), predominantly in North America (Lot and Novelo, 1992).

Specialists have not yet been able to estimate the total number of species. However, Haynes and Hellquist (2004) found 24 North American species, and Haynes and Holm-Nielsen (1994) described 14 from the neotropics.

Haynes and Holm-Nielsen (1994) described six Brazilian taxa. *S. sprucei* Micheli is endemic to Amazonia; *S. montevidensis* Chamisso and Schlectendal subsp. *montevidensis* is found in both southern and central regions of the country; *S. lancifolia* L. subsp. *lancifolia* is found along the coast. *S. rhombifolia* Chamisso and *S. guayanensis* Kunth subsp. *guayanensis* are pan-American species. *S. planitiana* Agostini is a rare species, represented by some populations in central Brazil.

A semiarid climate predominates in north-eastern Brazil, and botanical studies on aquatic plant in that region are

infrequent. Semiarid shallow lakes are non-spatially defined ecosystems, which differ from their surroundings by the presence of surface water and the development of aquatic communities that are strictly linked to it. They are predominantly epigenic and have two hydrologic disturbance agents: flood and drought (Maltchik et al., 1999; Maltchik and Pedro, 2000). Additionally, in northern and eastern Brazil coastline wetlands such as estuaries and lagoons predominate. All these aquatic environments show Alismataceae species in their plant communities.

The purpose of the present study was to characterize the species of the genus *Sagittaria* that occur in north-eastern Brazil where habitats, climate and environmental dynamics are quite different from those in Central and North American regions, where the genus presents more diversification.

## 2. Materials and methods

The study region was located in north-eastern Brazil, where the semiarid region occupies approximately 834,666 km<sup>2</sup> large and extends from 2°54' to 17°21'S and 45°00' to 35°00'W. To the east, the semiarid region meets the Coastal Rain Forest and the Mesophytic Semideciduous Forests form an ecotone. The northern areas vary from a narrow coastal belt of psammophytic vegetation to areas where the semiarid vegetation reaches to the shoreline. To the west, the semiarid region encounters savanna

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vegetation (Andrade-Lima, 1981). There are different regional rainfall regimes, and the rainy season extends from January to February in the western and southern region, and from March to April in the northern region. A BSh climate prevails, and during the dry season the average monthly temperature is 26–27 °C, with great diurnal variation (Andrade, 1972).

The semiarid lakes are shallow, ca. 0.5–2 m deep, and the accumulated waters originate from direct precipitation and runoff. The substrate impermeability generally originates from its siliceous nature (Maltchik et al., 1999). The water level decreases during the dry season, and most shallow lakes dry up for a period of from 3 to 9 months. The water level changes are heavily dependent on annual average rainfall.

Sampling was carried out during the rainy season in the north-eastern region of Brazil from March to July, 2002–2003. Current methods of collecting aquatic plants (Haynes, 1984) were used during the sampling. The base map was from IBGE (1988). All plants were deposited at EAC and ICN Herbaria. Specimen descriptions are restricted to the material collected in north-eastern Brazil. Only the representative material has been listed and the complete list of exsiccates is available on request.

### 3. Results

*Sagittaria* Linnaeus. Sp. Pl. 2: 993. 1753; type: *Sagittaria sagittifolia* Linnaeus.

Aquatic plants, perennials or annuals, monoecious or andromonoecious, glabrous or pubescent, submerged, floating or immersed herbs with milky latex. Underground system formed by roots and corms or rhizomes, rarely stolons along the substrate surface. Submerged leaves phyllodial linear or elliptic-lanceolate, parallelodromous, glabrous, apex acute, base attenuate, sessile; floating leaves ovate or sagittate, campylodromous, glabrous, membranous, apex acute or obtuse, base attenuate or cordate, petiolate; immersed leaves ovate, sagittate or lanceo-elliptic, campylodromous, glabrous or pubescent, cartaceous or coriaceous, apex acute to rounded, base attenuate, cuneate, reniform, sagittate, or rounded; petiole terete or triquetrous. Inflorescence racemose or paniculiform, rarely umbelliform; peduncle terete or triangular, erect, decumbent or floating, glabrous or pubescent at the distal end, rachis terete or triquetrous, erect, decumbent or floating, glabrous or pubescent; bracts ovate or lanceo-elliptic, parallelodromous, membranaceous, chartaceous to coriaceous, surface smooth or ornate, hyaline margin, apex acute to obtuse, free or connate at the base; whorls with two to three flowers. Flowers monoclinous or mostly declinous, and the inflorescence shows staminate flowers above and carpellate below; pedicels spreading or ascending, carpellate flowers often thickened and recurved in fruit; sepals three, concave, elliptic or ovate, membranous or coriaceous, persistent, those of the staminate flowers reflexed, those of the carpellate flowers adpressed or reflexed; petals three, clawed or not, mostly deciduous, generally with pale colours of white or pink with yellow or purple spots occasionally present at the base. Staminate flowers with a spirally whorl of sterile carpels occasionally present; stamens whorled mostly numerous; filaments linear or dilated at

the base, glabrous or pubescent; anthers bilocular, linear or orbicular, baxifixed. Carpellate flowers with the spirally whorls of numerous carpels arranged in a crowded, mostly spherical head on a dome-shaped receptacle; carpels distinct, one ovule, a monocyclic whorl of stamens rarely present. Achenes flattened, winged, beak lateral or terminal, surface smooth or ornate, glands occasionally present. Seeds campylotropous, erect.

Bogin (1955) recognized *Lophocarpus* (Durand, 1888) as a subgenus of *Sagittaria*, which is characterized by carpellate flowers generally present on adpressed sepals, with recurved pedicels expanding in fruit and with whorls of stamens occasionally present. The subgenus *Lophocarpus* is represented by species from pan-tropical or warm-temperate regions. The north-eastern Brazil displays three taxa: *S. guayanensis* subsp. *guayanensis*, *S. rhombifolia* and *S. planitiana*, *S. lancifolia* subsp. *lancifolia* was included in the subgenus *Sagittaria*, with mostly north-temperate species, occasionally extending to the tropics in marsh areas.

Key to the *Sagittaria* taxa in north-eastern Brazil Fig. 1.

#### 1. *S. lancifolia* subsp. *lancifolia*

1a. Carpellate flowers with reflexed sepals; pedicels spreading to ascending in flower and achenecetum; coastal emerged plants from estuaries and lagoons.

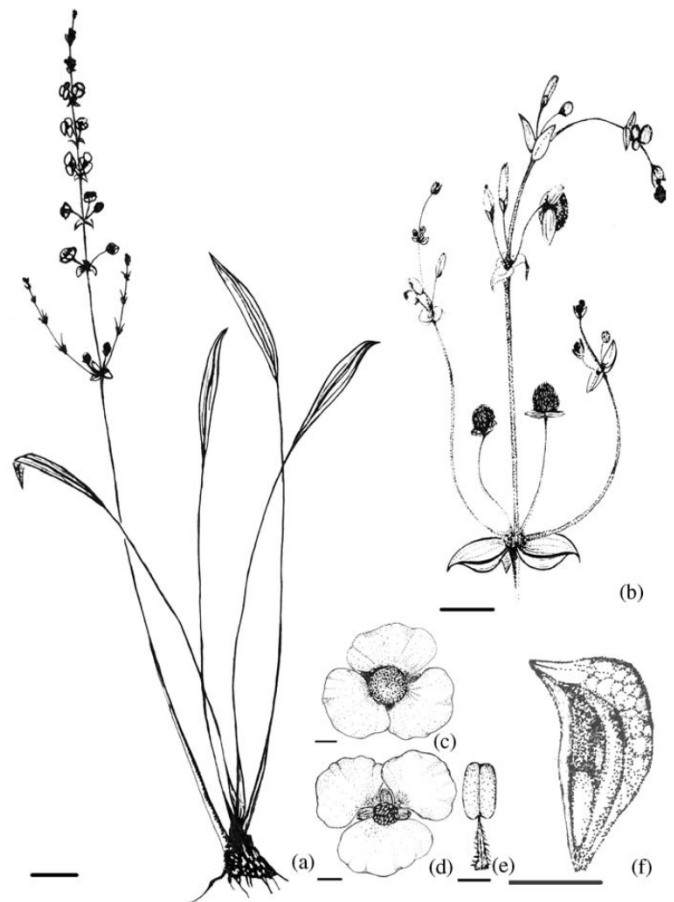


Fig. 1. *Sagittaria lancifolia* L. subsp. *lancifolia*: (a) habit, bars = 5 cm; (b) details of inflorescence, bars = 1 cm; (c) carpellate flower, bars = 4 mm; (d) staminate flower, bars = 4 mm; (e) stamen, bars = 1 mm; (f) fruit, bars = 1 mm.



- 1b. Carpellate flowers with adpressed sepals; pedicels spreading to ascending in flower and erect to recurved and inflated in achenecetum; mostly semi-arid emersed or floating plants from shallow lakes.
2. *S. guayanensis* subsp. *guayanensis*
- 2a. Floating plants, achenes with tuberculate surface.
- 2b. Emersed plants, achenes without tuberculate surface.
3. *S. rhombifolia*
- 3a. Leaves lanceo-elliptic to ovate, bracts conate at the base, carpellate flowers without the whorl of sterile stamina.
- 3b. Leaves widely ovate to reniform, bracts free, carpellate flowers with the whorl of sterile stamina.
4. *S. planitiana*

3.1. *Sagittaria lancifolia* L. subsp. *lancifolia*, *Syst. Nat.*, ed. 10, 2: 1270. 1759

Type: Jamaica, *Browne s.n.* (Holotype LINN 1124/6 *non vidi*); Fig. 1.

Herbs perennial, 85–104 cm tall, emersed, glabrous. Rhizomes globose, 3–5.5 cm diameter. Leaves emersed lanceo-elliptic to ovate, 12.5–16 cm long, 1–1.5 cm wide, chartaceous, 6 veined, campylodromous, apex acuminate, base attenuate; petiole terete, 31–45 cm long, 0.6–0.8 cm diameter, glabrous; sheath 15–22 cm long. Inflorescence paniculiformis, erect; peduncle triangular at the distal end, 38–55 cm long, 0.4–0.8 cm diameter, glabrous; rachis terete, 23–34 cm long, glabrous, 5–9 whorls; 2–3 flowers in whorl; staminate bracts ovate, 5–15 mm long, 4–8 mm wide, 10–12 veined, coriaceous, glabrous, apex acute, base free; carpellate bracts ovate, 5–13 mm long, 4–8 mm wide, 14–16 veined, coriaceous, glabrous, apex acute, base connate. Staminate flowers with spreading pedicels; pedicels terete, 25–34 mm long, 1–2 mm diameter, glabrous; sepals ovate, reflexed, concave, 6–8 mm long, 4–5 mm wide, smooth, 12–16 veined; petals ovate, 5–16 mm long, 5–15 mm wide, clawed, white; stamina 20–26; filaments terete, 3.5–4 mm long, pubescent; anthers linear, 2–2.5 mm long, apex obtuse; whorl of sterile carpels absent. Carpellate flowers with spreading pedicels; pedicels terete, 13–25 mm long, 1.5–2 mm diameter, glabrous; sepals ovate, reflexed, concave, 10–11 mm long, 10–12 mm wide, 14–16 veined, smooth; petals ovate, 5–16 mm long, 5–14 mm wide, clawed, petals white; whorl of sterile stamina absent. Achenecetum, 10–15 mm diameter; persistent sepals reflexed. Achenes obovate, 2.5–3.2 mm long, ca. 1 mm wide, surface smooth, winged, keeled; beak erect lateral, ca. 0.5 mm long; secretory structures presented at dorsal wing. Seeds 0.6–1 mm long, yellowish-brown.

3.1.1. Well-established local names: *golfe*, *aguapé-de-folha-estreita*

*Sagittaria lancifolia* subsp. *lancifolia* occurs from south-eastern North America (Haynes and Holm-Nielsen, 1994) to South Brazil (Almeida Rego, 1988), as an inhabitant of coastal wetlands. Although it has a wide range, it is rare in north-eastern Brazil (Fig. 5).

*Sagittaria lancifolia* subsp. *lancifolia* differs from the others species of *Sagittaria* from north-eastern Brazil in having free,

narrow-ovate conic bracts at carpellate and staminate flowers, and inflorescences whose first verticil is usually ramified, constituting a panicle-like inflorescence. These are erect plants, reaching more than 2 m (Bogin, 1955; Haynes and Holm-Nielsen, 1994), but they are not encountered in north-eastern Brazil.

3.1.2. *Specimens examined*

Brazil: Alagoas—Paçabuçu, rio Marituba, 3 Nov 1987, *Lyra-Lemos et al.*, 1321 (MAC); Paçabuçu, Ponta da Terra, margens do rio Marituba, Vila do Mosquete, fazenda Roçado, 13 Oct 1987, *Esteves et al.*, 1909 (MAC); Paçabuçu, Ponta da Terra, margens do rio Marituba, 17 Nov 1987, *Esteves et al.*, 1959 (MAC); Penedo, Marituba de Baixo, rio Marituba, 4 Apr 1986, *Esteves et al.*, 1831 (MAC); Penedo, Marituba de Cima, rio Marituba, 4 Apr 1986, *Esteves et al.*, 1832 (MAC); Penedo, rio Marituba, 15 Dec 1985, *Lyra Lemos et Pinheiro* 1069 (MAC). Bahia: Alcobaça, estrada de Alcobaça a Prado, 16 Feb 1977, *Harley*, 17998 (IPA, RB); Alcobaça, estrada de Alcobaça a Caravelas, 14 Oct 1972, *Santos s.n.* (SP 161832); Itapicuru, Vila do Mosquete, fazenda Roçado, 24 Sep 1993, *Borges* 40 (HRB); Valença, estrada de Valença a Guaibin, 22 May 1975, *Santos s.n.* (SP 161832). SERGIPE: Ilha das Flores, 22 Oct 1974, *Fonseca s.n.* (RB 172991).

3.2. *Sagittaria guayanensis* Kunth subsp. *guayanensis*, *Nov. Gen. Sp.* 1: 250. 1816

Type: Venezuela, Provincia Guayanensis, prople El Trapiche de Don Felix Farreras et Urbem, Angostura, Jun 1800, *F.W.H.A von Humboldt* and *A.J.A. Bonpland s.n.* (Lectotype B-W 17559 *non vidi*); Fig. 2.

Herbs perennial, 10–57 cm tall, submerged or floating, glabrescent. Corms terete, 2.4–3.5 cm diameter. Leaves submerged or floating; submerged leaves not seen; floating leaves ovate to widely elliptic, 2.5–16.5 cm long, 2–8 cm wide, membranous, 10–12 veined, campylodromous, apex acute to rounded, base cordate to rounded; petiole triquetrous, 5–62 cm long, 0.2–0.5 cm diameter, pubescent with simple trichomes;

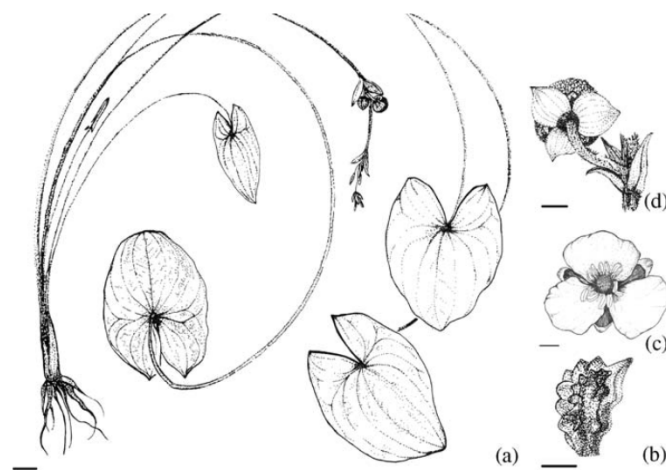


Fig. 2. *Sagittaria guayanensis* Kunth subsp. *guayanensis*: (a) habit, bars = 1.6 cm; (b) carpellate flower, bars = 1 mm; (c) staminate flower, bars = 1 mm and (d) fruit, bars = 0.3 mm.



sheath 4.5–7 cm long. Inflorescence racemose, floating; peduncle terete, 45–56 cm long, 0.5–0.7 cm diameter, pubescent; rachis terete, 4–9 cm long, pubescent, 5–7 whorls, 2–3 flowers at whorls, the lower whorls with carpellate flowers and staminate flowers at the upper whorls; staminate bracts lanceolate, 5–6 mm long, 3–4 mm wide, 12–14 veined, membranous, glabrous, apex acute, base free; carpellate bracts lanceolate, 6–10 mm long, 8–9 mm wide, 7–9 veined, membranous, glabrous, apex acute, base free. Staminate flowers with spreading to erect pedicels; pedicels terete, 6–9 mm long, 0.3–1 mm diameter, pubescent; sepals ovate, adpressed, concave, ca. 5 mm long, ca. 6 mm wide, smooth, 20–29 veined; petals ovate, ca. 6 mm long, ca. 5 mm wide, clawed, white with yellow spots at base; stamina 12; filaments terete, ca. 3 mm long, glabrous; anthers linear, ca. 3 mm long, apex acute; whorl of sterile carpels present. Carpellate flowers with spreading to erect pedicels; pedicels terete, 15–16 mm long, pubescent; sepals ovate, adpressed, concave, 10–11 mm long, 10–12 mm wide, 28–35 veined, smooth; petals ovate, 8–10 mm long, 5–8 mm wide, clawed; whorl of stamina present. Acheneecetum, ca. 15 mm diameter; persistent sepals adpressed, erect. Achenes obovate, ca. 3 mm long, ca. 2 mm wide, surface tuberculate, wings absent, keeled; beak erect lateral, 0.5–1 mm long, secretory structures absent. Seeds ca. 1 mm long, yellowish-brown.

### 3.2.1. Well-established local names: golfe, pataca

*S. guayanensis* subsp. *guayanensis* is a neotropical taxon and a frequent inhabitant of wetlands from south-eastern United States to northern Argentina (Bogin, 1955). This species occurs in shallow lakes near the mountains, the floodplains of the great rivers and the coastal wetlands of Brazil (Fig. 5).

*S. guayanensis* subsp. *guayanensis* presented a wide variation in foliar morphological that may be associated with fluctuations in local rainfall. This relationship was observed by Guimarães (1999) in populations of *S. guayanensis guayanensis* in Brazilian wetlands, and was also pointed out by Bogin (1955).

The holotype at P reported by Kunth has not been located (Haynes and Holm-Nielsen, 1994), neither has the fragment of the holotype at MO reported by Bogin (1955) (Gituru et al., 2002). Lot and Novelo (1994) described the specimens at Willdenow Herbarium as holotypes from their examination of the B–W microfiche at MEXU. Both Bogin (*loc cit.*) and Rataj (1972) claimed the type at B had probably been destroyed during World War II. Rataj *vide* the neotype: Suriname, Hostman 870 (TCD *non vidi*) with isoneotypes (LE, W, *non vidi*).

### 3.2.2. Specimens examined

Brazil: Alagoas—Paiçabuçu, Pontal do Peba, 6 Jul 1982, Rocha 568 (MAC); Paiçabuçu, Ponta da Terra, 13 Oct 1987, Esteves et al., 1862 (MAC). Ceará: Crateús, estrada para a Serra d'Almas, 25 Mar 2003, L.Q. Matias 455 (EAC, ICN). Bahia: Bom Jesus da Lapa, 11 Feb 2000, Queiroz et al. 5889 (ALCB, UEFS); Formosa do Rio Preto, brejo, 24 Apr 2000, França 3259 (ALCB); Coração de Maria, estrada para Retiro, 22 Sep 1995, França 1360 (UEFS); Iaçú, estrada para Itaeté, 11 Feb 1997, Harley et al. 5494 (HRB, ALCB); Itaberaba, rio Paraguaçu, 4 Jun 1995, França 1213 (UEFS); vila de Morrinhos, lagoa do

Piranha, 4 May 1912, A. Lutz 38 (R); Rio de Contas, vila de Rio de Contas, rio Brumado, 25 Mar 1977, Harley et al. 19986 (IPA). Pernambuco: Petrolina, 25 May 1983, Fortius 3441 (IPA); Petrolina, estrada de Petrolina para Afrânio, 19 Apr 1971, Heringer et al. 180 (R, RB); Riachuelo, Mar 1912, Lüettzelburg 1743 (RB). Maranhão: Anapurus, 28 Jun 1972, Sucre 9415 (RB); Porto Franco, 4 Apr 1970, Eiten et Eiten 10176 (SP). Piauí: São João do Pirangi, lagoa São José, 1913, Lüettzelburg 188 (IPA); Valença do Piauí, estrada de Valença para Elesbão Veloso, 7 Feb 1974, Camargo de Abreu 13 (SP). Rio Grande do Norte: Extremoz, 29 Oct 1917, A. Lutz 1335 (R).

### 3.3. *Sagittaria rhombifolia* Cham., *Linnaea* 10: 219. 1835

Type: Brazil, F. Sellow *s.n.* (lectotype E!; isotype *vide* Rataj (1972) K, LE *non vidi*); Fig. 3.

Perennial herb, 40–62 cm tall, emersed, glabrous to glabrescent. Rhizomes globose, 2–2.5 cm diameter. Leaves emersed or submersed; leaves submerged ovate, 8–14.5 cm long, 4–5.5 cm wide, membranous, 10 veined, apex acute, base

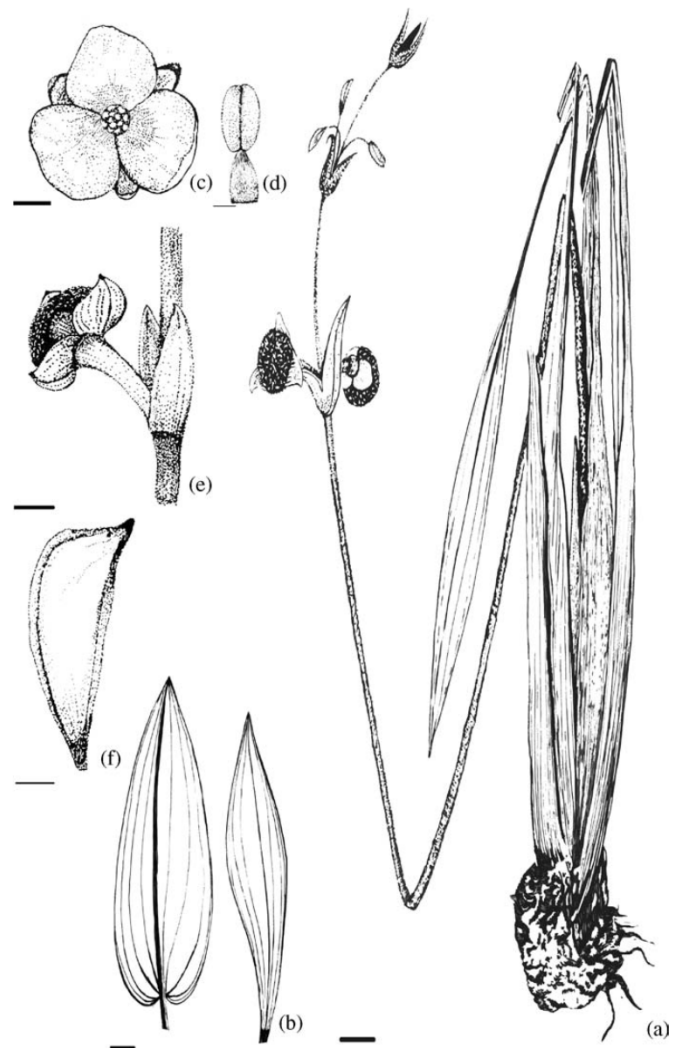


Fig. 3. *Sagittaria rhombifolia* Cham.: (a) habit, bars = 1 cm; (b) forms of emersed leaves, bars = 1 cm; (c) staminate flower, bars = 1 mm; (d) stamen, bars = 1 mm; (e) carpellate flower, bars = 1 mm; (f) fruit, bars = 1 mm.





cordate; leaves emersed lanceo-elliptic to ovate, 12–21 cm long, 2–7.5 cm wide, coriaceous, 6–8 veined, apex acute, base attenuate; petiole terete, 27–38 cm long, 0.5–0.8 cm diameter, glabrous; sheath 14–18 cm long. Inflorescence racemose, erect; peduncle terete, 42–55 cm long, 0.5–0.8 cm diameter, glabrous; rachis terete, 7–21 cm long, glabrous, 3–7 whorls; 2–3 flowers at the whorls; staminate bracts lanceolate, 10–35 mm long, 6–10 mm wide, 20–26 veined, coriaceous, glabrous, apex acuminate to acute, base connate; carpellate bracts ovate to lanceolate, 20–45 mm long, 6–10 mm wide, 24–32 veined, coriaceous, glabrous, apex acute to acuminate, base connate. Staminate flowers with spreading pedicels; pedicels terete, 35–40 mm long, 0.8–1 mm diameter, glabrous; sepals ovate, adpressed, concave, 4–6 mm long, 11–14 mm wide, smooth, 15–28 veined; petals ovate, 18–20 mm long, 6–8 mm wide, clawed, white with yellow spots at base; stamina 8–11; filaments conical, 2–2.5 mm long, glabrous; anthers linear, 3 mm long, apex obtuse; whorl of sterile carpels absent. Carpellate flowers with erect to spreading pedicels; pedicels terete, expanded in fruit, 20–35 mm long, 3–6 mm diameter, glabrous; sepals elliptic, adpressed, concave, 6–10 mm long, 5–8 mm wide, 36–42 veined, smooth; petals ovate, 6–10 mm long, 5–8 mm wide, clawed, white with yellow spot at the base; whorl of sterile stamina absent. Achenecetum, 1–1.5 cm diameter; persistent sepals adpressed, erect. Achenes obovate, 5–8 mm long, 2–3 mm wide, surface smooth, 2 wings, keeled; beak erect lateral, 1–1.5 mm long, secretory structures absent. Seeds 2–3 mm long, brownish.

### 3.3.1. Well-established local names: *golfe*, *golfo*

*S. rhombifolia* occurs from Central to South America (Bogin, 1955). It is a rare species from north-eastern Brazil and inhabits shallow lakes and quiet waterways at the transition zone between semiarid and savannah regions (Fig. 5). It is also found in the lowlands near mountains.

*S. rhombifolia* is characterized by large morphological variations (mainly foliar). Rataj (1970) observed these variations in populations occurring in southern South America. This variation was manifested in oval submerged leaves with a cordiform base [e.g. *Queiroz 2103* (HUEFS), *Irwin et al. 14746, 14745* (NY)], a foliar type that is quite different from that normally cited for this species (linear submersed leaves) (Bogin, 1955; Haynes and Holm-Nielsen, 1994). On the other hand, a cordiform limbus is not frequent, but has been reported for floating leaves (Bogin, 1955). Emersed inflorescences were erect, differing from the decumbent position encountered in specimens studied by Guimarães (1999) from the wetlands in Mato Grosso State. The emersed leaves in the populations analysed from north-eastern Brazilian wetlands presented an elliptical lanceolate limbus, differing from populations from southern Brazil with either oval or rhombic leaves with attenuated bases [e.g. *Almeida-Rego 122* (ICN), *Baptista s.n.* (ICN 2521), *Smith et Klein 8137* (NY)].

### 3.3.2. Specimens examined

Brazil: Bahia—Barra, Área de proteção Ambiental Dunas e Veredas do São Francisco, 12 May 2004, L.Q. Matias 406

(EAC, ICN); Barreiras, 2 Nov 1987, rio Cachorro, *Queiroz et al. 2103* (UEFS); Barreiras, 150 km SW, rio Piau, 13 Apr 1966, *Irwin et al. 14755, 14746* (NY); Mucugê, fazenda Ourici, 27 Nov 1986, *Ferreira et al. 405* (HRB); Mucugê, Estrada para Contendas do Sincorá, 30 Oct 1978, *Martinelli 5485* (RB). PIAUÍ: Cajazeiras [current name: Cajazeiras do Piauí], *Gardner 2737*, Oct 1839 (BM).

### 3.3.3. Additional specimens examined

Brazil: Pará—Mauná, Ilha de Marajó, fazenda Menino Deus, rio Paracauary, 20 Feb 1950, Black & Engelhard 50-8924 (IAN). SANTA CATARINA: Lajes, rio Cavieiras, 3 Oct 1956, *Smith et Klein 8137* (NY). Rio Grande do Sul: São Francisco de Paula, Tainhas, 8 Jun 1960, *Baptista s.n.* (ICN 2521); São Francisco de Paula, Tainhas, 27 Jan 1985, *Almeida-Rego et al. 122, 123* (ICN).

### 3.4. *Sagittaria planitiana* G. Agostini, *Phytologia* 20: 1. 1970

Type: Venezuela: Edo. Portuguesa: marsh in llanos, just west of Guanare, elev. alt. 180 m, 25 Oct 1966, *Julian A. Steyermark et Marvin Rabe 96484* (Holotype NY *non vidi*, Isotype VEN!, image of NY!). Paratype: Venezuela: Edo. Guárico, Lagoon of Mesa de El Sombrero, in mud, 10 Sep 1927, *H. Pittier 12473* (NY *non vidi*). (<http://www.image.nybg.org/herim/0300/v-30-00311499big.jpg>); Fig. 4.

Perennial herbs, 20–45 cm tall, emersed, pubescent. Corms terete, 2–3 cm diameter. Emersed leaves widely ovate to reniform, 3.5–9 cm long, 4–13 cm wide, chartaceous, 12–19 veined, apex rounded, base cordate to reniform; petiole terete, 14–35 cm long, 0.3–0.5 cm diameter, pubescent at distal end, trichomes conical; sheath 4.5–8 cm long. Inflorescence racemose, erect; peduncle terete, inflated at the distal end, 30–45 cm long, 0.5–0.7 cm diameter, pubescent at distal end, trichomes conical; rachis terete, inflated near the first whorls, 4–10 cm long, pubescent, 3–9 whorls, 2–3 flowers at the whorls, the lower whorls with carpellate flowers and staminate flowers at the upper whorls; staminate bracts elliptic, 10–15 mm long, 15–18 mm wide, 36–42 veined, chartaceous, glabrous, apex acute, base free; carpellate bracts widely elliptic, 10–15 mm long, 10–12 mm wide, the largest ones at the first whorl, 20–38 veined, chartaceous, glabrous, apex acute or rounded, base free. Staminate flowers with recurved pedicels; pedicels filiform, 23–35 mm long, ca. 1 mm diameter, glabrous; sepals obovate, adpressed, concave, 16–18 mm long, 12–16 mm wide, smooth, 30–32 veined; petals obovate, 10–15 mm long, 0.5–0.8 mm wide, clawed, colour not seem; stamina 10–16; filaments with enlarged base, ca. 4 mm long, pubescent; anthers linear, ca. 2 mm long, apex acute; whorl of sterile carpels present. Carpellate flowers with erect pedicels; pedicel terete, 10–12 mm long, 1–2 mm diameter in flower, expanded in fruit, 10–18 mm long, ca. 5 mm diameter, glabrous; sepals ovate, adpressed, concave, 1–1.5 mm long, 1.5–1.7 mm wide, 23–28 veined, smooth; petals widely elliptic, 10–18 mm long, 10–16 mm wide clawed, colour not seem; whorl of sterile stamina present. Achenecetum, 1.5–2 cm



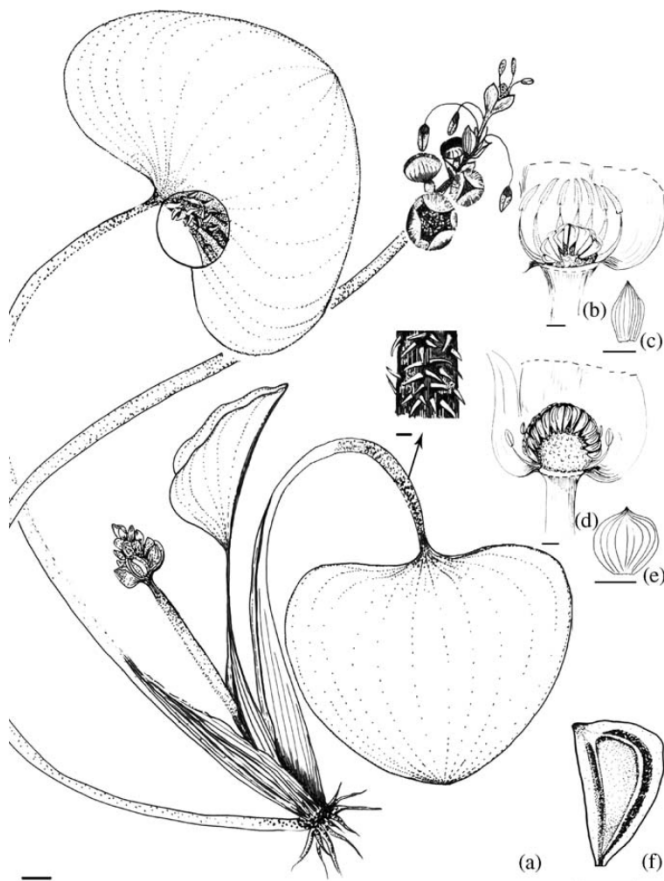


Fig. 4. *Sagittaria planitiana* Agostini: (a) habit and details of pubescent petiole and leaf, bars = 1 cm; (b) staminate flower, bars = 1 mm; (c) staminate bracts, bars = 1 mm; (d) carpellate flower, bars = 1 mm; (e) carpellate bracts, bars = 1 mm; (f) fruit, bars = 1 mm).

diameter; sepals persistent adpressed, erect. Achenes obovate, 3–3.5 mm long, 1–1.2 mm wide, surface 2 ribbed, 2 wings, keeled; beak erect lateral, 0.2–0.3 mm long, oil duct present between the rib and the dorsal wing. Seeds ca. 1.5 mm long, yellowish-brown.

#### 3.4.1. Well-established local names: golfe

The distribution of *Sagittaria planitiana* has been documented in Venezuela and Brazil (Haynes and Holm-Nielsen, 1994). This species occurs in the Brazilian states of Rondônia and Goiás. *S. planitiana* is rare in north-eastern Brazil (Bahia and Ceará) (Fig. 5).

A prevalence of plants with reniform leaves and pubescent surfaces on the foliar abaxial faces, petioles and scapes was observed in populations of *S. planitiana* occurring in north-eastern South America. Some native populations from Venezuela showed similar morphological characteristics [Aristeguieta 4361 (VEN), Delascio et Montes s.n. (VEN 64763)].

#### 3.4.2. Specimens examined

Brazil: Bahia—Barreiras, 24 Dec 1954, Black 54-17752 (IAN). Ceará: Sobral, Estrada para Taparuaba, 15 Jun 1995, Fernandes s.n. (EAC 22996).

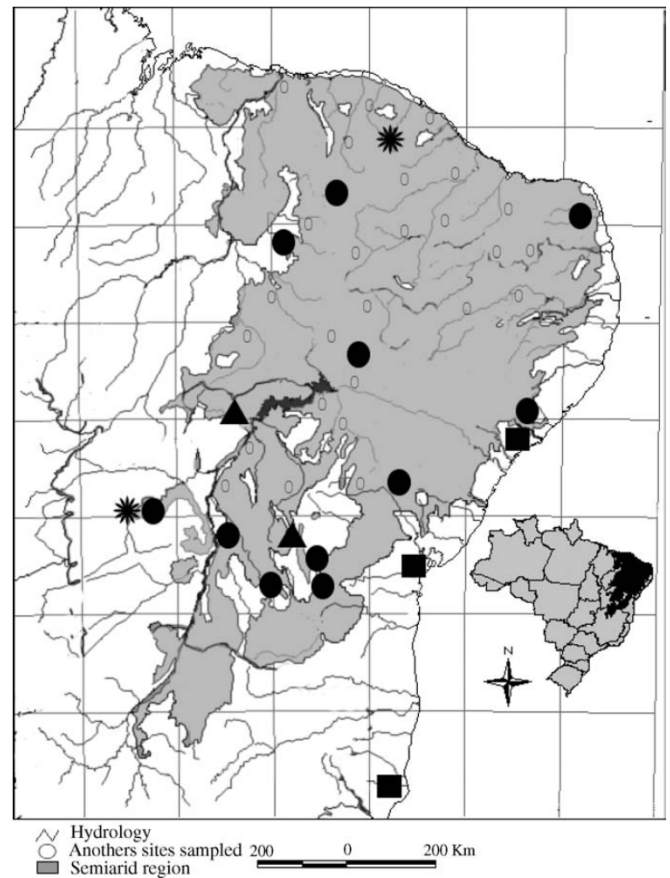


Fig. 5. Documented distribution of *Sagittaria* species from north-eastern Brazil: (●) *S. guayanensis guayanensis*; (■) *S. lancifolia lancifolia*; (▲) *S. rhombifolia*; (★) *S. plantiana*.

#### 3.4.3. Additional specimens

Venezuela: Guárico. Calabozo, Estación Experimental de Los Llanos, Jun 1966, Gilberoes s.n. (VEN 76352); Calabozo, Estación Experimental de Los Llanos, VIII-1960, Aristeguieta 4361 (VEN); San Fernando del Apure, calle hacia Calabozo, 10 Sep 1973, Davidse et Agostini 3965 (VEN); río Orituco, 2 Dec 1982, Ramirez 1987 (VEN); Miranda Palmar vía Cazorla, 8 km de la Estación Biológica de Los Llanos, Jul 1982, Delascio et Montes s.n. (VEN 64763). Anzoátegui: Laguna en vía Aragua de Barcelona-Anco, Oct 1970, Velasquez 1357 (VEN).

## 4. Discussion and conclusions

Despite the aridity that prevails in north-eastern Brazil, four out of eight species that occur in this country (Haynes and Holm-Nielsen, 1994) were confirmed for that region. This number is higher than that found by Pott and Pott (2000) in Brazilian wetlands, or reported by Henriques et al. (1988) and Bove et al. (2003) in south-eastern Brazil, or by Almeida Rego (1988) and Rataj (1970) in south-eastern South America. Only the Amazon region presents a higher number of species, including *S. sprucei* Prance, which is endemic, and *S. montevidensis* Chamisso et Schlectendal.



Northern South America, including Venezuela, Peru, Guyanas and Surinam, demonstrates the greatest species diversity of the genus *Sagittaria*, due to the superposition of areas of occurrence of species characteristic of both the northern and southern hemispheres. Species such as *S. latifolia* Willdenow, which predominates in North America, and *S. intermedia* Micheli and *S. lancifolia* Linneaus subsp. *media* (Micheli) Bogin, which are characteristic of Central America and northern South America (Haynes and Holm-Nielsen, 1994), are found in this region. The Amazon is the second region in terms of significant numbers of species of the genus *Sagittaria*, and the only region with a species with restricted distribution (*S. sprucei*).

*S. lancifolia* subsp. *lancifolia* was encountered in shoals and coastal lagoons in southern Bahia State, and in estuaries in Alagoas State. These populations are characteristic of either littoral lentic environments or lotic environments with low kinetic energy such as estuaries and deltas (Bogin, 1955). Thus, data on this species from north-eastern South America are in accordance with previously recorded patterns of distribution and occupation of habitats.

*S. guayanensis* subsp. *guayanensis* can occupy similar environments at different latitudes, and in north-eastern South America populations of this species occur in the central semiarid region as well as along its borders. However, these environments are composed of perennial shoreline wetlands, perennial shallow lakes or intermittent shallow lakes in regions with only a short period of drought. This indicates that populations need to be either submersed or in water-saturated soil during the dry periods. These environments are predominantly eutrophic (Maltchik et al., 1999).

This pattern of habitat occupation is similar to that seen in populations of *S. rhombifolia* (which occurs in perennial aquatic environments in semiarid regions) and *S. lancifolia* (which occurs in perennial shoreline environments). *S. planitiana* occurs in only two areas, where perennial lakes and rivers predominate.

A new occurrence of *S. planitiana* has been recorded in far western South America, in a region characterized by high mean temperatures (ca. 28 °C) and a dry season lasting from 7 to 8 months. This species also occurs in central South America where savannah vegetation predominates (Haynes and Holm-Nielsen, 1994) with mild temperatures and variable rainfall, and a dry season lasting from 5 to 6 months. This species also occurs in the Amazon and the Great Plains of Central Venezuela (Agostini, 1970), regions with a hot and humid tropical climate. Hence, the occurrence of this species in north-eastern Brazil in a different and distinct environment reveals plasticity and an ability to occupy quite different environments.

Haynes and Holm-Nielsen (1989) described seven categories of distribution patterns for Alismatidae species in the Neotropics. *S. platiniiana* is reported as a bicentric species with centres in northern South America and on the Brazilian shield. But the actual distribution of *S. platiniiana* shows similarities to the hypothetical migration route of *Hydrocleis* species that was suggested by the authors. Therefore, the authors point to the

possible centre of origin and routes of distribution of *Hydrocleis* species (Limnocharitaceae) as being from north-eastern South America to the southwest, and then north to Central America along the belt of seasonal forests on the east side of the Andes. This range coincides with the geographical distribution of *S. planitiana*.

With improved floristic diagnoses in poorly inventoried areas, it should be possible to obtain greater biological evidence that will aid our understanding of the adaptive strategies of aquatic plants to a wide range of habitats. In addition, this may provide a means of comparison between the distribution pattern of these different groups, elucidating evolutionary and biogeographical aspects of South America's natural history.

## Acknowledgements

Boticário Foundation, CAPES/PIDCT for research grants, as well as Dra. Rose Bortoluzzi and Dr. Luis Baptista for revision of the manuscript.

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