



## Flora of the *cangas* of Serra dos Carajás, Pará, Brazil: Isoetaceae

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### Abstract

This study presents taxonomic treatment of the species of Isoetaceae from Serra dos Carajás, Pará, Brazil. Two species occur in this locality (*Isoetes cangae* and *I. serracarajensis*). We provide descriptions, illustrations, images of the mega- and microspores, comments, distribution data and a key for these species as a contribution to the knowledge of the flora of the *cangas* from this area.

**Key words:** aquatic plants, endemism, *Isoetes*, lycophytes, taxonomy.

### Resumo

Este estudo apresenta o tratamento taxonômico das espécies de Isoetaceae da Serra dos Carajás, Pará, Brasil. Nesta localidade ocorrem duas espécies (*Isoetes cangae* e *I. serracarajensis*). Aqui são apresentados descrições, ilustrações, imagens dos mega- e microsporos, comentários, dados da distribuição geográfica e uma chave para estas espécies como contribuição para o conhecimento da flora das *cangas* desta área.

**Palavras-chave:** plantas aquáticas, endemismo, *Isoetes*, licófitas, taxonomia.

### Isoetaceae

Plants aquatic, amphibious or terrestrial in wet soils. Corm subglobose or obovoid, 2 to 3-lobate, with sclerified phyllopodia present or absent. Roots conspicuous, dichotomously branched. Leaves acicular, linear or triangular, containing a central vascular strand surrounded with four transversely septate lacunae, straight or flexuous, recurved to erect, apex acute or attenuate, partially or completely alate; alae hyaline, light green or brown. Gemma at the base of the leaf present or absent. Subula olive green or light green, terete to trigonal in transection. Labium rudimentary or well-developed, persistent or caducous. Ligule lanceolate, ovate or cordate. Velum rudimentary to complete. Sporangium elliptic, obovate or orbicular, hyaline to dark brown. Megaspores subspheroidal, trilete, white to dark grey, lustrous or not lustrous. Microspore grey to dark brown, monolete, heteropolar. Monotypic family.

### 1. *Isoetes* L.

The genus is distributed worldwide and comprises approximately 250 species, with South America being its center of taxonomic diversity with 64 species (Troia *et al.* 2016). In Brazil, *Isoetes* is represented by 24 species, three of which occur in the state of Pará (Prado *et al.* 2015; Pereira *et al.* 2016). The genus is readily identified by its leaves with four air-chambers in transection, a single sunken sporangium at the base of the leaf, sporangial trabeculae and ligula with a basal glossopodium (Gifford & Foster 1987; Pigg 1992; Moran 2004). However, *Isoetes* is known by its morphological simplicity that provides few characters for the taxonomy (Taylor & Hickey 1992). Habitat, habit, color, size and ornamentation of the mega- and microspore, the proportion of the sporangium wall covered by the velum and the sporangial wall coloration are some of the most useful characters in the taxonomy of the genus.

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### Key to species of *Isoetes* from the canga of Serra dos Carajás

1. Plants growing in permanent lakes; leaves slightly flexuous, laxly ascending to recurved; gemmae absent; velum covering 1/5–1/4 of the sporangium surface, fenestra pyriform; mega- and microsporangium hyaline to light brown; tubercles or verrucae of the megaspore inconspicuous, laesurae taller than wide ..... 1.1. *Isoetes cangae*
- 1'. Plants growing in seasonal lakes and ponds, or terrestrial in wet soils; leaves straight, rigidly ascending or erect; gemmae present; velum absent to less than 1/5 of the sporangium surface, fenestra elliptic or ovate; megasporangium dark or red brown, and microsporangium grey or dark brown; verrucae of the megaspore conspicuous, laesurae wider than high or as wide as tall. .... 1.2. *Isoetes serracarajensis*

**1.1. *Isoetes cangae*** J.B.S.Pereira, Salino & Stützel, *Phytotaxa* 272(2): 145. 2016.

Figs. 1a-b; 2a-b

Plants aquatic submerged, growing in permanent lakes. Corm subglobose or obovoid, 0.8–1.3 cm large, 3-lobate, with sclerified phyllopodia absent or present. Leaves 0.65–1.2 mm wide at mid length, 15–25 cm long, 25–50 per individual, linear, slightly flexuous, laxly ascending to recurved, apex attenuate; alae 1.5–2.5 mm wide at the sporangium, 2.5–4 cm long, stretching 1/5–1/4 of the leaf, hyaline or light green. Gemmae absent. Subula olive green or light green, semi-terete. Labium 1.5–3.5 mm wide, 0.8–2.4 mm long, reniform or cordate. Ligule 4–5.5 mm wide, 3–6 mm long, hyaline, ovate-lanceolate or cordate. Velum covering 1/5–1/4 of the sporangium surface, fenestra pyriform. Sporangium 2.2–3 mm wide, 2–4.5 mm long, elliptic, mega- and microsporangium light brown or hyaline. Megaspores 490–600 µm diam., white, slightly lustrous; laesures taller than wide, with straight and inclined sides, apex acute to obtuse, slightly separated from the remaining macrosculptural elements; proximal and distal surface verrucate to tuberculate, tubercles or verrucae inconspicuous. Microspores 29–34 µm long, light brown; proximal surface echinate; distal surface echinate to tuberculate.

**Material selected:** Canaã dos Carajás, Serra Sul, S11D, 6°23'57"S, 50°22'13"W, 730 m, 22.I.2013, A.J. Arruda et al. 1329 (B, BHCB).

*Isoetes gardneriana* Kunze ex A. Braun is similar to *I. cangae* by its laxly ascending to recurved leaves (Fig. 1a) having tuberculate megaspores (Fig. 2a) and a reduced velum covering less than 1/4 of the adaxial sporangial surface (Fig. 1b). However, in *I. gardneriana* the megaspores are dark brown to grey (vs. white in *I. cangae*), the laesures are knife-like (vs. sharply triangular), and the distal surface

of the microspores is laevigate to papillate (vs. echinate; Fig. 2b).

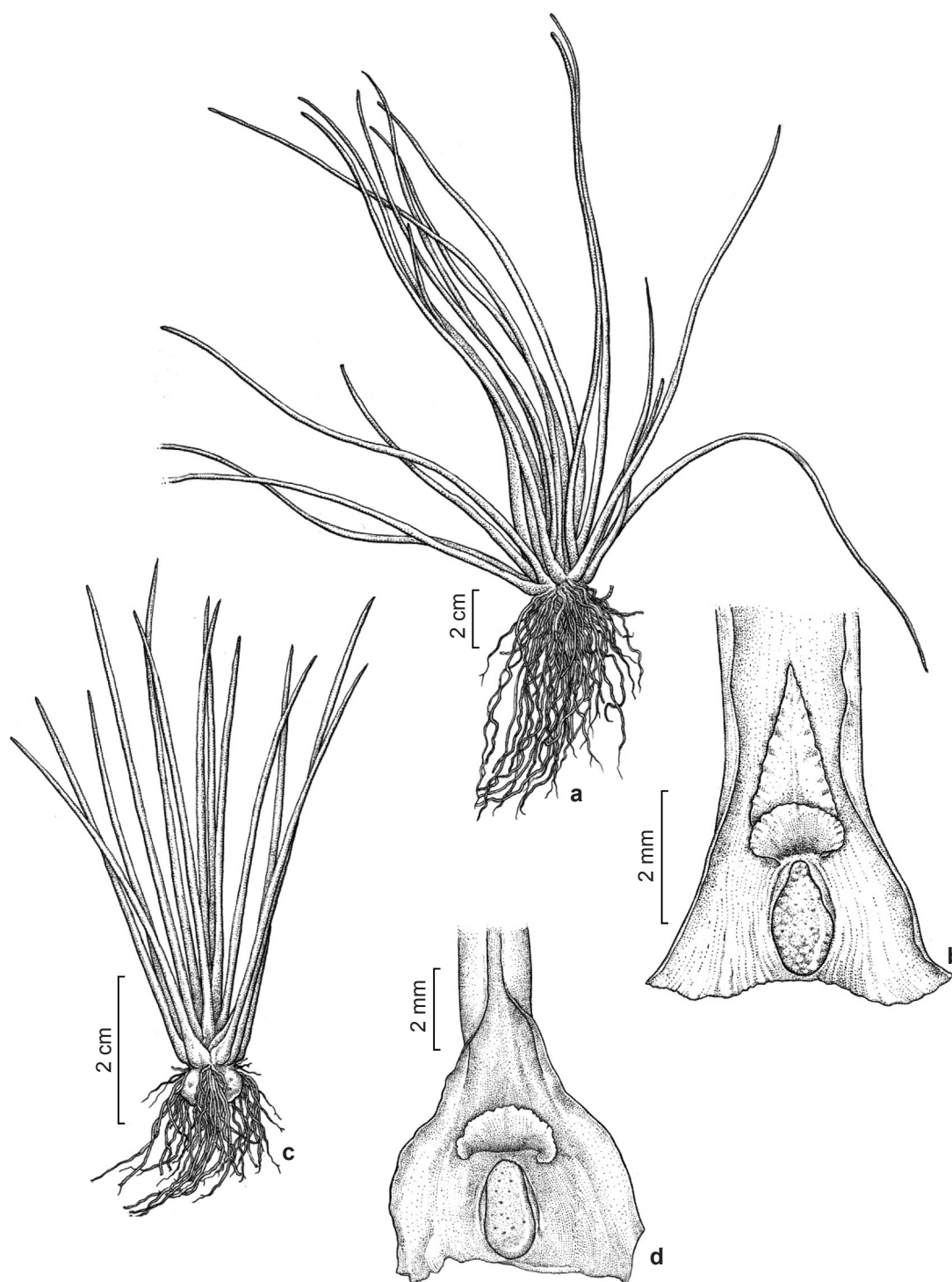
*Isoetes cangae* is known only from its type locality in Serra Sul: S11D, Canaã dos Carajás, in southern Pará, Brazil. It is found submerged in permanent lakes over ironstone in rupestrian field vegetation at 730 m.

**1.2. *Isoetes serracarajensis*** J.B.S.Pereira, Salino & Stützel, *Phytotaxa* 272(2): 142. 2016.

Figs. 1c-d; 2c-f

Plants aquatic submerged, growing in seasonal lakes and ponds, or terrestrial in wet soils. Corm subglobose or obovoid, 0.4–1.3 cm large, 3-lobate, with sclerified phyllopodia present. Leaves 0.5–1.5 mm wide at mid length, 2.5–25 cm long, 8–70 per individual, linear or triangular, straight, rigidly ascending or erect, apex acute or attenuate; alae 1.5–2 mm wide at the sporangium, 0.7–6 cm long, stretching 1/6–1/4 of the leaf, hyaline. Gemmae present. Subula olive green, semi-terete. Labium 0.5–3 mm wide, 0.8–1.5 mm long, reniform or cordate. Ligule 1.4–3 mm wide, 1.8–4.7 mm long, hyaline, ovate or cordate. Velum rudimentary, fenestra elliptic to ovate. Sporangium 1.3–3.3 mm wide, 2–5 mm long, elliptic or orbicular, megasporangium dark or red brown, microsporangium grey or dark brown. Megaspore 470–650 µm diam., white, not lustrous; laesures wider than tall or as wide as tall, with straight and parallel sides, apex rounded to truncate, slightly separated from the remaining macrosculptural elements; proximal and distal surface verrucate, verrucae conspicuous. Microspore 30–36 µm long, light brown to dark brown, proximal surface psilate (rarely echinate); distal surface echinate to tuberculate.

**Material selected:** Canaã dos Carajás, Serra da Bocaina, 6°19'45"S, 49°57'46"W, 713 m, 17.V.2016, B.F. Falcão et al. 460 (MG, HCJS); Serra Sul,

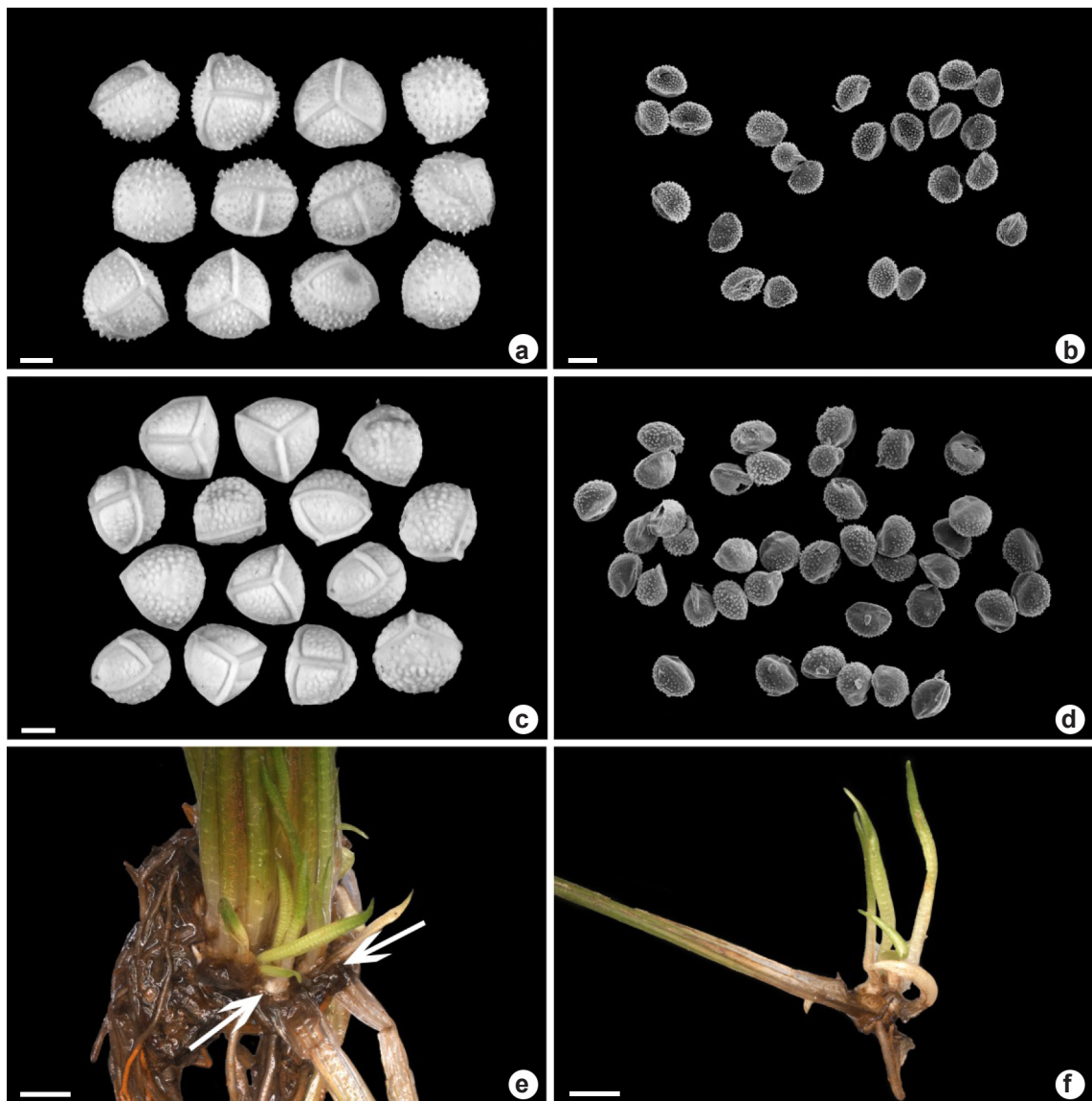


**Figure 1** – a-b. *Isoetes cangae* – a. habit; b. adaxial view of the base of the leaf with ligula ovate-lanceolate, labium reniform-cordate and fenestra of the velum pyriform. c-d. *Isoetes serracarajensis* – c. habit; d. adaxial view of the base of the leaf with labium reniform-cordate and fenestra of the velum elliptic-ovate (a,b. B.F. Falcão *et al.* 34, c,d. B.F. Falcão *et al.* 43). Illustration: João Silveira.

6°21'7"S, 50°23'44"W, 735 m, 23.I.2013, *A.J. Arruda et al. 1338* (B, BHCB); Serra Sul, Corpo B, 6°21'06"S, 50°23'43"W, 733 m, 14.II.2010, *T.E. Almeida et al. 2157* (BHCB, UPCB); Serra do Tarzan, 6°20'11"S, 50°09'49"W, 733 m, 29.III.2016, *B.F. Falcão et al. 262* (MG, HCJS, BHCB). Parauapebas, Serra Norte, corpo N3, 6°02'44"S, 50°12'38"W, 710 m, 24.III.2016, *B.F. Falcão et al. 201* (MG); Serra Norte, corpo N4, 6°06'08"S, 50°11'12"W, 708 m, 26.III.2016, *B.F. Falcão et al. 240* (MG, HCJS); Serra Norte, N6,

6°7'48"S, 50°10'32"W, 694 m, 26.I.2013, *A.J. Arruda et al. 1356* (B, BHCB); Serra Norte, N7, 6°09'13"S, 50°10'21"W, 692 m, 25.III.2012, *A.J. Arruda et al. 854* (B, BHCB).

*Isoetes amazonica* A.Braun is similar to *I. serracarajensis* by the size of its leaves, verrucate megaspores (Fig. 2c) and echinate microspores (Fig. 2d). However, in *I. amazonica* the gemma at the base of the leaf is absent (vs. present in *I.*



**Figure 2** – a-b. *Isoetes cangae* – a. megaspores; b. scanning electron microscopy image of microspores. c-f. *Isoetes serracarajensis* – c. megaspores; d. scanning electron microscopy image of microspores; e. buds at the base of the leaves (white arrows); f. detail of the bud at the base of the mature leaf. Scale bars: a,c = 0,2 mm; b,d = 20  $\mu$ m; e,f = 1 cm. (a-b. *B.F. Falcão et al. 34*; c-f. *B.F. Falcão et al. 43*). Photos: Jovani Pereira.

*serracarajensis*; Fig. 2e-f), the adaxial surface of the microsporangium is hyaline (*vs.* grey to dark brown), the laesures of the megaspore have convex sides and obtuse apices (*vs.* parallel sides and rounded to truncate apex), and the macrosclptural elements of the proximal surface are connected to laesures (*vs.* macrosclptural elements clearly separated from laesures).

*Isoetes serracarajensis* is widespread in Serra dos Carajás, being known from Serra Norte: N3, N4, N6, N7; Serra Sul: S11B, Serra da Bocaina, and Serra do Tarzan. *Isoetes serracarajensis* is found narrowly associated with ‘canga’ vegetation and submerged in seasonal lakes, ponds, or terrestrial on wet soil on top of the mountains at 650–822 m.

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### List of exsiccatae

Almeida TE 2157 (1.2). Arruda AJ 854 (1.2), 1329 (1.1), 1338 (1.2), 1356 (1.2). Falcão BF 34 (1.1), 43 (1.2), 201 (1.2), 240 (1.2), 262 (1.2), 293 (1.2), 318 (1.2), 241 (1.2), 242 (1.2), 243 (1.2), 319 (1.1), 458 (1.2), 459 (1.2), 460 (1.2), 477 (1.2), 478 (1.2), 479 (1.2), 480 (1.2), 518 (1.2), 532 (1.2). Giorni V (1.2).