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A new species of *Lophogyne s.l.* (Podostemaceae) from the Amazonian savanna of Amapá, Brazil

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Abstract

A new species of *Lophogyne* from a Brazilian Amazon savanna is described and illustrated. It is morphologically similar to the former *Jenmaniella* species, due to the presence of stems that arise from prostrate roots attached to the substratum, a gynophore at anthesis, and three prominent non-suture ribs per valve in the fruit, currently merged in *Lophogyne s.l.*. *Lophogyne wilsonii* can be distinguished from all others species of *Lophogyne s.l.* by the apical region of the roots unattached from the substratum. The conservation status is discussed and an identification key is presented.

Kewwords: aquatic plants, Guiana shield, rheophyte

Resumo

Uma nova espécie de *Lophogyne* de uma Savana Amazônica brasileira é descrita e ilustrada. É morfologicamente similar às espécies do antigo gênero *Jenmaniella* devido à presença de caule surgindo de raízes prostradas aderidas ao substrato, ginóforo na antese e três costas (não incluindo as linhas de sutura) em cada valva do fruto, atualmente inserido em *Lophogyne s.l. Lophogyne wilsonii* se distingue das demais espécies do gênero pela região apical da raiz não aderida ao substrato. É discutido o estado de conservação da espécie e apresentada uma chave de identificação.

Palavras-chave: Escudo das Guianas, plantas aquáticas, reófitas

Introduction

Lophogyne s.s. was established with two species, *L. arculifera* Tul. & Wedd. (Tulasne 1849: 100) and *L. helicandra* Tul. (1849: 99), and was distinguished by the flattened, comb-like form of the stigmas. These two nominal species were placed in synonymy under *L. lacunosa* (Gardner: 1847: 169) C.P.Bove & C.T.Philbrick (Bove *et al.* 2011: 158) since *L. helicandra* was illegitimate because there was a homotypic synonym based on the same type specimen as the earlier published *Marathrum lacunosum* Gardner, rendering the genus monotypic. Philbrick & Bove (2019) recognized a broadened concept of the genus *Lophogyne*, as *Lophogyne* s.l. In doing so, they merged species from four genera into *Lophogyne s.l.*: all species of *Jenmaniella* and *Monostylis*, as well as single species each from *Apinagia* and *Marathrum*. Their changes result in *Lophogyne* s.l. being monophyletic, i.e., corresponding to Clade J as reported in Tippery *et al.* (2011).

The Cerrado of Amapá is a tropical savanna comprising about 140,012 km^2, the second largest Cerrado island in the Amazon Domain (Prance 1996, Costa-Neto 2014, Mustin *et al.* 2017). They are open lands that have slow current rivers, floodplains and seasonal waterlogged areas. Cerrado in Amapá consists of a natural mosaic of savanna vegetation types (grass, shrub and savanna woodland) settled between transitional gallery forests and coastal Amazon vegetation (Figure 1).

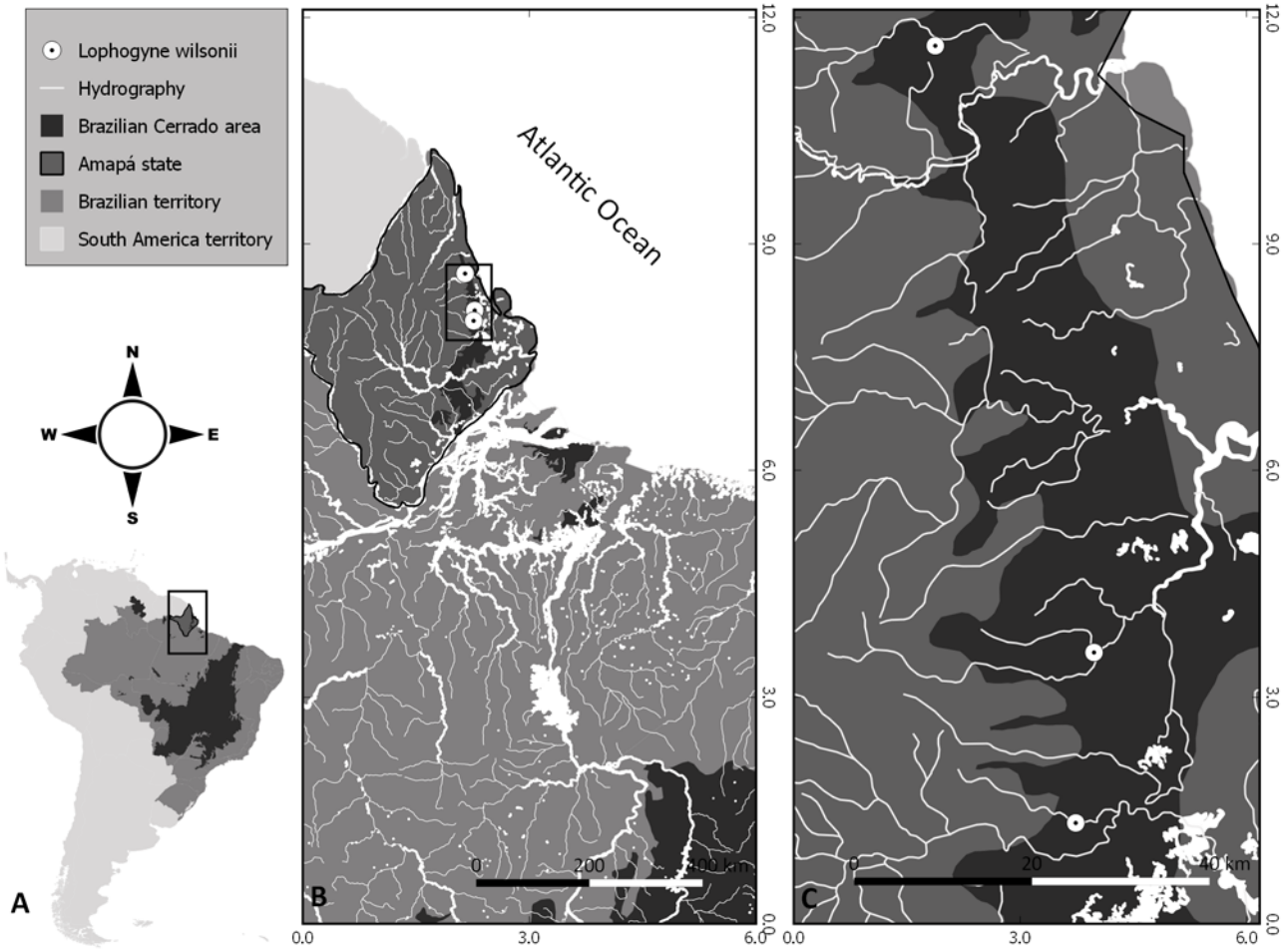

FIGURE 1. Distribution of *Lophogyne wilsonii* in the state of Amapá, Brazil; showing its occurrence restricted in rivers surrounded by Amazonian savanna vegetation.

During field work in Amapá (Brazil) specimens were collected that did not correspond to any known species of Podostemaceae (c.f., Philbrick *et al.* 2018). The presence of an incomplete whorl of stamens, a vertically oriented ovary at anthesis, flowers that project from the ruptured spathella, and the absence of silica bodies (Costa unpublished data) in leaves aligns the new species with *Lophogyne s.l.* (cf., Philbrick & Bove 2019). It is morphologically most similar to species previously placed in the genus *Jenmaniella*: *Lophogyne ceratophylla* (Engl. 1927: 7–8) C.T. Philbrick & C.P. Bove (2019: 83), *L. fimbriata* (P. Royen 1951: 122–123, 137) C.T. Philbrick & C.P. Bove (2019: 84), *L. fimbrifolia* (P. Royen 1951: 62-63, 130) C.T. Philbrick & C.P. Bove (2019: 84), *L. isoetifolia* (P. Royen 1951: 124, 137) C.T. Philbrick & C.P. Bove (2019: 84), *L. tridactylitifolia* (Engl. 1927: 8) C.T. Philbrick & C.P. Bove (2019: 84), *L. varians* (Engl. 1927: 7) C.T. Philbrick & C.P. Bove (2019: 84). Each of these species, as well as the new species proposed herein, have stems that arise from prostrate, attached roots, a prominent gynophore at anthesis, and three prominent non-suture ribs per valve in the fruit.

The orientation of the cylindrical linear roots, however, distinguishes the new species from all others in *Lophogyne s.l.* The apical regions of the green elongate roots are unattached to the substratum; these are up to 40 cm long. Consequently, the roots are pendulous in the water column and appear stem-like. Stems, upon which flowers arise, develop along the pendulous roots. Pendulous roots are not common in Podostemaceae, but occur in the neotropical *Castelnavia noveloi* C.T.Philbrick & C.P.Bove (2008: 94-97; *cf*., Jäger-Zürn *et al.* 2016) and in the endemic to Sri Lanka, *Polypleurum elongatum* (Gardner) J.B. Hall (1971: 131; *cf*., Kato 2013), species that do not occur in *Lophogyne s.l.*

Lophogyne wilsonii C.P. Bove & C.T. Philbrick, *sp. nov*. Type:—BRAZIL. Amapá: Calçoene, Cachoeira da Asa Aberta, Rio Calçoene, 02.51897° N, -51.01494° W, 20 m, 22 Sept 2014, fl, fr, *Bove & Philbrick 2467* (Holotype: R !; Isotypes: MO !, WCSU !). Pracuúba, 15 km ao Norte da cidade de Pracuúba na BR-156, riacho sem nome. 1.931046°

N, -50.86094° W, 27 m, 22 Sept 2014, fl, fr, *Bove & Philbrick 2472*; 5 km ao Norte da cidade de Pracuúba na BR-156, Igarapé do Henrique. 1.76569° N, -50.878685° W; 27 m, 22 Sept 2014, fl, fr, *Bove & Philbrick 2474* (Paratypes: R !; Isoparatypes: MO !, WCSU !). Figures 1–3.

Aquatic herb, perennial (?). *Roots* green, presumed photosynthetic, linear, prostrate and attached to rocks or unattached (pendulous), branched or unbranched, oval to flattened in cross section; attached roots 0.8–2 mm wide, branched or not; unattached roots appearing stem-like, 0.4–2.2 mm wide, multiple times branched, 2–40 cm long, 1.5–9 mm wide mid-way between branches. *Stems* arising laterally from attached or unattached roots, branched or unbranched, distinct or indistinct, often obscured by leaf bases; stems arising from prostrate attached roots 0.5–4 x 0.3–0.6 mm, base often flattened and attached to the substratum, hapteron-like; stems arising from pendulous root 0.5–5 x 0.3–0.7 mm, hapteron-like base absent. *Leaves* 1-5 per stem; distichous, circinate, petiolate, 3–11 times pinnately divided, mature leaf 1.7–10 cm long; petiole sheathing stem, petiole of mature leaf 2–40 mm long, 0.2–0.7 mm wide at base (above sheathing leaf base), 0.3–0.7 mm wide at midpoint, 0.3–1.6 mm wide at base of first pinna; pinnae linear, 0.4–1.2 mm wide, ultimate division 0.6–23 x 0.05–0.2 mm; flattened to hair-like, blunt or acute. *Flowers* arising individually from between sheathing leaf bases, 1–4 per stem, bisexual, zygomorphic, pedicellate, covered by apically rounded sac-like spathella, spathella rupturing apically into 2–8 irregular tooth-like segments; pedicel elongating at anthesis, projecting from ruptured spathella, 10–20 x 0.1–0.15 mm at midpoint, oval in cross section; tepals 2–5, arising adjacent to or slightly below stamen filaments, in incomplete whorl around ovary, linear, rarely triangular or two-lobed, flattened, acute, tan to white, 0.2–0.6 x 0.05 mm at base, persisting in fruit or not; stamens 2–5; on one side of ovary, at anthesis filaments 1.5–2.2 x 0.05–0.1 mm at midpoint, narrowing apically, dorsifixed, apex becoming darkened, becoming spiral shaped post anthesis or not, persisting in fruit or not, not indurate; anthers 2 lobed apically, 1–2 x 0.2–0.6 mm; basal lobes divergent; pollen shed as radially symmetrical and isopolar monads, small in size (20–25 x 13.1–17.9 μm), prolate in shape (P/E = 1.41), tricolpate, longicolpate, small polar area (ca. 5 μm), microechinate exine (spinules < 1.0 μm), sexine as thick as nexine (ca. 0.5 μm); ovary 2 carpellate, somewhat flattened perpendicular to the suture margins, oriented vertically on pedicel or at angle, isolobous, 1.5–2.2 x 0.5–0.9 mm (suture side), 0.5–0.7 mm wide (non-suture side); with 3 prominent longitudinal non-suture lines per valve, suture lines also prominent; gynophore 0.3–0.9 mm long; ovules numerous, placentation axile, placenta thick; stigmas 2, apical, free, linear, 1–2.2 x 0.01 mm, papillose. *Capsules* pedicellate, pedicel 10–22.0 x 0.1–0.15 mm at midpoint, oriented vertically on pedicel or at an angle; oval in cross section, somewhat flattened, 1.8–2.6 x 0.9–1.3 mm (suture side), 0.8–1.1 mm wide (non-suture side), dehiscing by two-valves, each valve with 3 longitudinal non-suture ribs, suture margins also raised and rib-like, valves persisting; seeds orange-brown, obovate, 0.23–0.3 x 0.15–0.2 mm; outer integument expanding and becoming mucilaginous and sticky when wetted, 25–123 per capsule.

Geographic distribution and ecology:—*Lophogyne wilsonii* is known from three localities in the eastern region of Amapá, Brazil (Guiana Shield; Figure 1). The species occurs in medium to small rivers and in full sunlight at 20-27m elevation; inside a narrow strip of Cerrado in the Amazon region. Where it occurs it is abundant.

Conservation status:—The authors have conducted field studies throughout much of the state of Amapá, as well as along the border regions of the neighboring state of Pará. *Lophogyne wilsonii*, however, has been documented from only three localities in an area spanning about 70km. Extensive plantations of *Eucalyptus* sp. and *Pinus* sp. occur in the region where *L. wilsonii* is documented. These plantations along with human induced fire are known to have a negative impact on water quality (Melém Júnior *et al.* 2003, Mustin *et al.* 2017). Another aggravating factor is hydroelectric power generation which has been shown to have negative impacts on river ecology (e.g. Silva *et al.* 2015). The extent of occurrence (Tartarugalzinho and Calçoene Districts) is part of the Araguari Basin, where the potential hydroelectric power of the state is concentrated (ANEEL 2000, Corrêa & Porto 2017, Corrêa 2018). These factors directly and indirectly affect populations of *L. wilsonii*. About 72% of Amapá state is comprised of protected areas (Dias *et al.* 2016); however, only 9.25% of the Amapá's Cerrado is inside these areas (IEPA 2016) and *L. wilsonii* is not documented from any protected areas (UNEP-WCMC & IUCN 2019). According the IUCN Criteria (IUCN 2019) the extent of occurrence (EOO) is 165.963 Km² and the area of occupancy (AOO) is 12.000 Km². Based on AOO, *L. wilsonii* is classified as Endangered (EN). The human induced negative impacts summarized above, however, are predicted to have a negative impact on AOO. Consequently, the species is designated here as Critically Endangered (CR B2abiii, IUCN 2019).

Etymology:—The specific epithet of *Lophogyne wilsonii* is a tribute to the ichthyologist Wilson J.E. Moreira da Costa (the first author's husband), for introducing her to the "wonderful world of aquatic ecosystems" and for being a guiding influence on her development as a scientist. Most importantly, for all his love, support and encouragement.

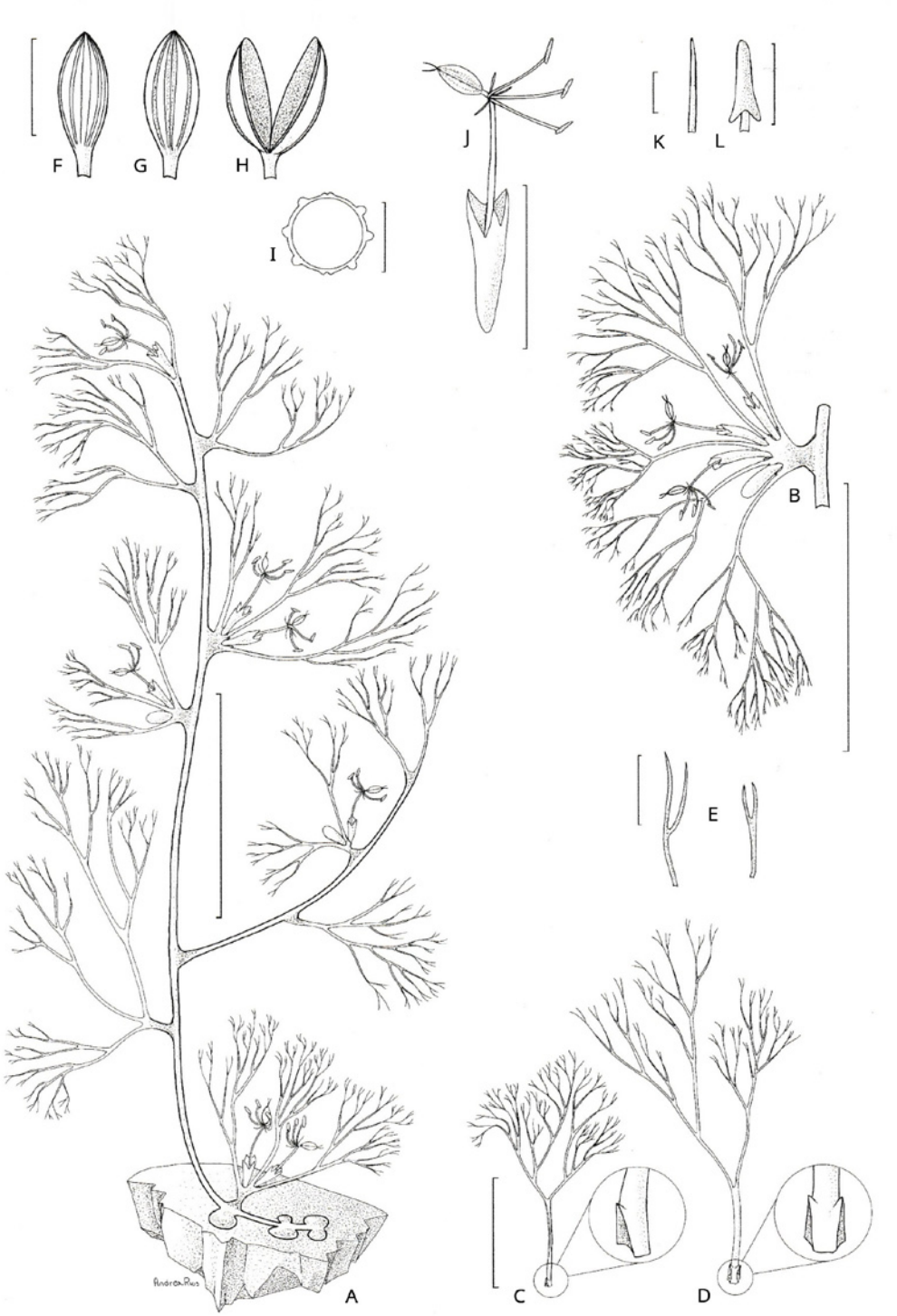

FIGURE 2. *Lophogyne wilsonii.* A. General habit of plant with attached and unattached regions of a branched root. One stem is shown arising from the prostrate attached root. Nine stems are shown arising from the unattached branched root. B. Detail of one stem arising from an unattached root. The stem includes five leaves, three flowers at anthesis and one unopened flower bud enclosed in the spathella. C-D. Two details of mature pinnately compound leaves. Insets show monothecous (C) and bithecous (D) petioles. E. Two details of branched leaf apices. F-I. Mature capsules. F. Intact capsule viewed from non-suture side showing pedicel apex and three non-suture ribs. G. Intact capsule viewed from suture side showing suture rib (combined suture margins) and two non-suture ribs. H. Dehisced capsule. I. Cross section of mature capsule with placenta and seeds removed showing three non-suture ribs per valve (left and right sides) and suture ribs (top and bottom). J. Flower at anthesis showing apex of ruptured spathella with three lobes, pedicel, three stamens, three tepals, and ovary at an angle. K. One tepal. L. Anther prior to dehiscence.
Bars: A = 4 cm; B = 6 cm; C-D = 2 cm; E = 1 mm; F-H = 2 mm; I = 1 mm; J = 1 cm; K = 1 mm; L = 2 mm.

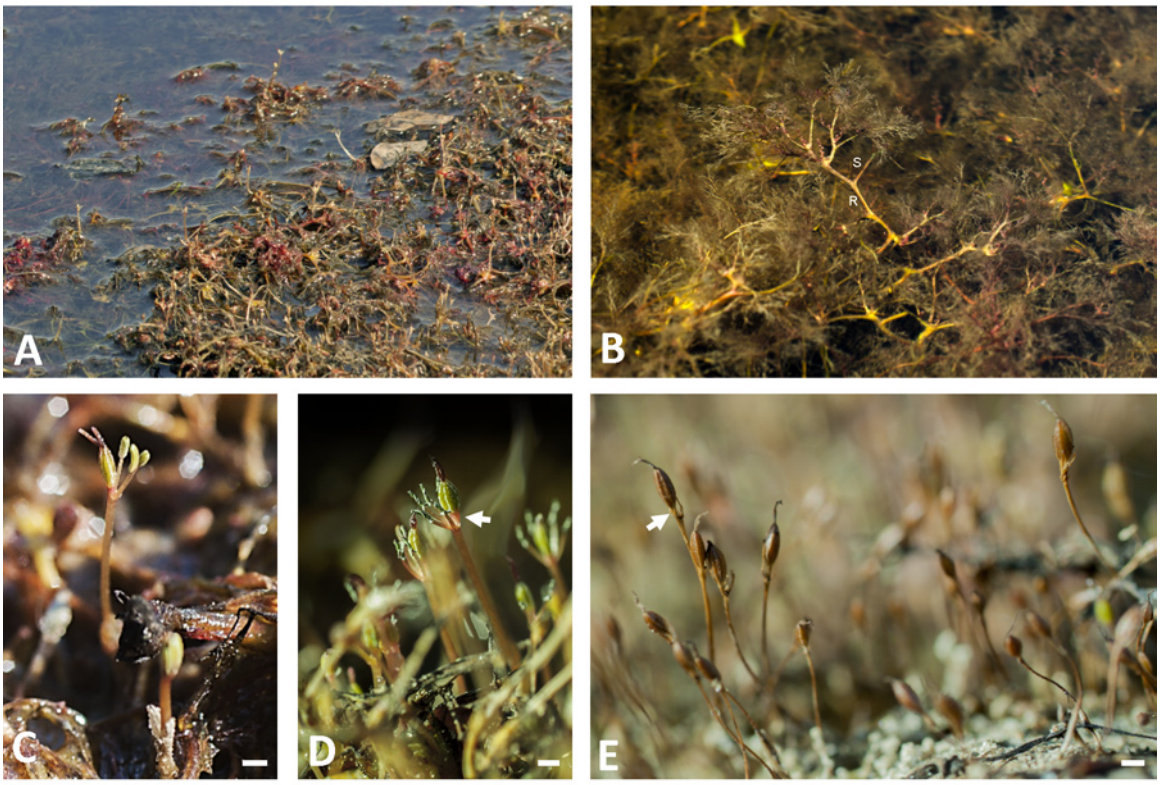

FIGURE 3. *Lophogyne wilsonii.* A. Habitat in the Calçoene River. B. Vegetative shoot showing non attached roots (R) with stems (S) and leaves. C. Flower in anthesis showing three closed anthers and ovary with two stigmas. D. Flower in post anthesis showing three dehisced (spiral) anthers and gynophores (arrow). E. Capsules and gynophore (arrow). Bars = 1mm.

Identification key to the species of *Lopogyne s.l.*

1.	Flower with dentate stigma	*L.lacunosa*
-	Flower with decurrent stigma	2
2.	Flower without gynophore	3
-	Flower with gynophore	4
3.	Nerved leaf	*L.aeroginosa*
-	Nerveless leaf	*L.fimbrifolia*
4.	Ovary and fruit with 6-10 non-suture ribs per valve	5
-	Ovary and fruit with 3 non-suture ribs per valve	8
5.	Erect stem	6
-	Prostate stem	7
6.	Ovary and fruit with 6 non suture ribs per valve	*L. goeldiana*
-	Ovary and fruit with 8 non suture ribs per valve	*L.aripuanensis*
7.	Petiolate leaf, flower with 1 stamen, fruit with 7 non suture ribs per valve	*L. royenella*
-	Leaf without petiole, flower with 2 stamens, fruit with 8-10 non suture ribs per valve	*L. paraensis*
8.	Petiole widened at the base	9
-	Petiole narrow thoroughly	12
9.	Leaf with ultimate division nerved	10
-	Leaf with ultimate division nerveless	11
10.	Flower with 2 tepals, 1 stamen	*L. ceratophylla*
-	Flower with 5-6 tepals, 2-4 stamens	*L. tridactylitifolia*
11.	Petiole terete in cross section	*L. isoetifolia/L.varians*
-	Petiole rhombiform in cross section	*L. fimbriata*
13.	Root-stem attached to the substratum thoroughly	*L. divertens*
-	Apical root and stem unattached from the substratum	*L. wilsonii*

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