

Rediscovery of a Neotropical rheophyte (Podostemaceae) after 160 years: Implications for the location of conservation unit boundaries (Tocantins, Brazil)

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ABSTRACT: Podostemaceae (angiosperms) occur only in swift river currents. *Podostemum flagelliforme* is a member of this family that was originally described by materials collected from the Tocantins River in 1844. The species was known only from the type collection until 2013, when the authors rediscovered it in the Balsas River (Tocantins), Brazil. The latter river does not occur in any current conservation unit. It is recommended that the margins of a proposed ecological corridor (Corredor Ecológico da Região do Jalapão) be adjusted to encompass the only known population of *Podostemum flagelliforme*.

DOI: 10.15560/10.5.1170

Few angiosperms occur in the turbulent current of river-rapids and waterfalls, *i.e.*, are true rheophytes. Yet, members of two phylogenetically unrelated families, Hydrostachyaceae and Podostemaceae, are comprised of plants that occur exclusively in such habitats. The first (Hydrostachyaceae) is a relatively small family with one genus and about 22 species distributed in Africa and Madagascar (Heywood *et al.* 2007). The second, the pantropical Podostemaceae, is the largest angiosperm family comprised entirely of aquatics, with 50 genera and more than 250 species (Philbrick *et al.* 2010). The current contribution addresses the rediscovery of a species of neotropical Podostemaceae after more than 160 years.

Podostemum flagelliforme (Tul. & Wedd.) C.T. Philbrick & Novelo (Podostemaceae, Podostemoideae) was originally described in the monotypic genus *Devillea* Tul. & Wedd. (*D. flagelliformis* Tul. & Wedd., Tulasne 1849). Types are located in P (holotype), C and L (isotypes) (Philbrick and Novelo 2004). Baillon (1866) transferred the species to the genus *Oserya* Tul. & Wedd. In contrast, Royen (1954) reestablished the original position of this species in *Devillea*, due to the possession of character states not otherwise observed in *Oserya*: introrsely dehiscent anthers and capsules lacking ribs (Figure 1). Most recently, Philbrick and Novelo (2004) moved *D. flagelliforme* into *Podostemum* Mich., based on phylogenetic analyses of morphological features that placed it as monophyletic with other neotropical species of *Podostemum*. These authors noted, however, that *P. flagelliforme* lacked several features that otherwise characterize *Podostemum* (*e.g.*, two stamens, an andropodium, pollen united in dyads). Other distinctive characters observed for this species are the entire boat shape stipules, upright petiolate leaves that are simple or 1–6 times dicotomously divided, short blunt stigmas, and smooth capsule (lacking ribs).

Podostemum flagelliforme was originally collected by Hugh Algernon Weddell (1819–1877) in July, 1844

(Weddell 2367). According to information provided in Weddell's unpublished notebook that is housed in the Muséum National d'Histoire Naturelle (Paris) ["Catalogue

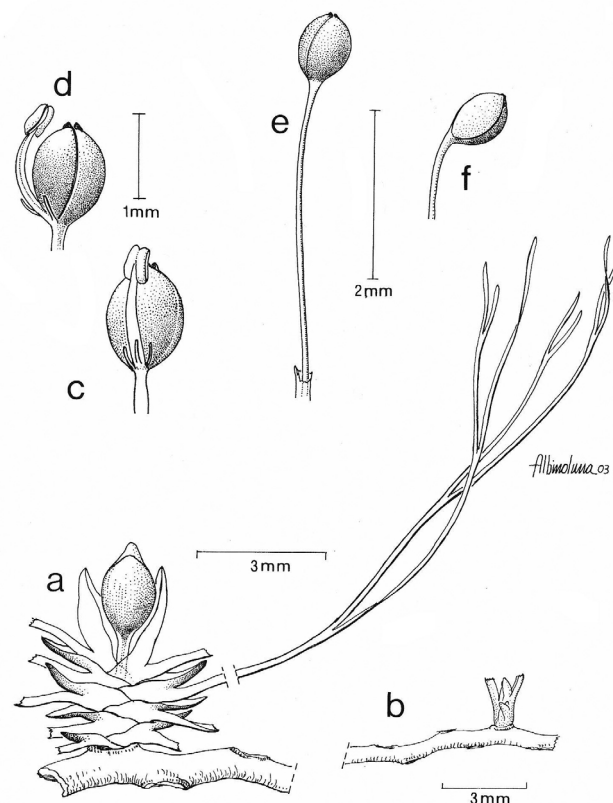


FIGURE 1. *Podostemum flagelliforme*. a: Prostrate root with upright stem, distichous leaves (only one complete leaf shown) with expanded, boat-shaped stipules, and apical flower bud. b: Prostrate root with short stem projecting upward. c: 'Back' side of flower showing apex of pedicel, three linear tepals, and one stamen. d: 'Side' view of flower showing apex of pedicel, two linear tepals (one arising from base of stamen filament), one stamen, and two apical blunt stigmas. e: Mature capsule. f: Mature capsule after one capsule valve has been shed (reproduced from Philbrick and Novelo 2004; figure used with permission from *Systematic Botany Monographs*).

a

Plantes recueillies sur le Tocantins
entre S. João das Duas Barras.
et Porto Imperial.

Prov. de Goyaz - Juillet - Août. 1844.

2316. Arbuste de 1 à 2 metres - Fleurs roses.
2317. Fleurs blanches - Berges sablonneuses.

b

2366. Fleurs rougeâtres - Rapides du Tocantins.
 (2367) - Sur les pierres limoneuses dans les points de la
rivière ou l'eau a peu de profondeur.
 2368. Roches abandonnées par le sang du Tocantins.
 2369 bis. Arbre de 3 metres - Bords du Tocantins.
 2370 - Eau stagnante sur les bords du Tocantins -
Stellaria gracilis var. *officinalis* A. Braun.
 2371 - 2369 bis = *Chara hydrophytes* var. *Chamaephytes* A. Braun.
 2372 Fleurs blanches - Bord des mares à la Capoeira
da Lageada - (Epigée).
 2373. Flottant dans les mares ou entièrement submergé.
 2374. - Submergé - Endroits peu profonds du Tocantins
et de l'Araguaia.
 2375. Arbuste de 2 à 4 metres - Fleurs blanches - Feuilles

Figure 2. Two elements of Weddell's unpublished notebook "Catalogue du plantes recueillies dans l'Amérique du Sud, 1843-47"; original in the Muséum National d'Histoire Naturelle (Paris). a: Part of the page with notes on the general region from which collections were made. b: Part of the page listing the location from which the collection of *Podostemum flagelliforme* (no. 2367; red ellipse) was made (running waters of Tocantins River and from confluence of the Tocantins and Araguaia Rivers). Note that information from no. 2366 indicates collections from rapids of the Tocantins River (underlined in red).

du plantes recueillies dans l'Amérique du Sud, 1843–47”), the type locality is the Tocantins River between São João das Duas Barras and Porto Imperiale, in the province of Goiás, Brazil (Figure 2). Weddell indicated (*cf.*, information provided with no. 2374; Figure 1b) that São João das Duas Barras was a small town in the Brazilian state of Pará located close to the confluence of the Araguaia and Tocantins Rivers. Presently, this town does not exist (Segurado 1982).

During the period when Weddell visited Brazil, the country was an empire recently turned independent from Portugal. In 1889 the Brazilian Republic was born, and as a consequence on 7 March 1890, Porto Imperial had its name changed to Porto Nacional. During this time Porto Imperial (Porto Nacional) was located within the state of Goiás. In 1988, however, the state of Goiás was subdivided. The northern portion, where the collection of *P. flagelliforme* was made, was renamed the state of Tocantins, while the southern portion remained as the state of Goiás.

It is notable that the region along the Tocantins River noted in Weddell's notebook spans >800 km. The only additional information provided as to the precise locality where the type of *P. flagelliforme* was collected is listed in his notebook accompanying his collection 2367 (Figure 1b): “...Sur les pierres limoneuses dans les points de la rivière où l'eau a peu de profondeur” (On the siltstones in the points of the river where the water is shallow). It is likely that the collection was made in the region of Porto Nacional, as extensive river-rapid habitat occurred in that region of the Tocantins River during the time of Weddell. For example, IBGE (1972) indicates that several waterfalls (*e.g.*, Cachoeira do Rebojo, Cachoeira Carreira Comprida, Cachoeira do Berbera) were located in the Tocantins River within 10 km of Porto Nacional. The majority of these locations are presently covered by a reservoir behind the Lajeado Hydroelectric dam, which was constructed on the Tocantins River from 1998–2002 (Philbrick and Bove 2011).

Podostemum flagelliforme is listed in the IUCN Red List as critically endangered B1ab (iii) or possibly extinct (Philbrick and Bove 2011, under the basionym *Devillea flagelliformis*). The evaluation is based on the paucity of collections of the species, the specialized habitat, the presence of a large reservoir in the region where it occurs, and the inability to find the species during field studies by the authors in 2005, 2006, and 2010.

Podostemum flagelliforme was rediscovered by the authors in July, 2013, *ca.* 120 km southeast of Porto Nacional in the Balsas River, a tributary of the Sono River, which subsequently flows into the Tocantins River. The location is between the cities of Ponte Alta do Tocantins and Pindorama do Tocantins (11.01808° S, 47.48596° W; 324 m altitude), in the domain of Cerrado (Figure 3). Voucher specimens (Bove, Philbrick and Katz 2368), with vegetative as well as reproductive structures (flowers and capsules), are deposited in R and WCSU (Thiers, continuously updated). At this location plants of the species are common along the south side of the Balsas River. They occur attached to scattered large granite rocks ranging from 1–3 m from the sandy shore. The plants that were found correspond completely with the description and illustration of *P. flagelliforme* in



FIGURE 3. Region of the Balsas River where *Podostemum flagelliforme* was collected. This location is located in the Cerrado Domain of the state of Tocantins.

Philbrick and Novelo (2004).

Rivers are one of the most heavily impacted of aquatic habitats in the tropics. Habitat destruction from factors such as siltation, water flow manipulation and large dam construction results in reduced river biodiversity (*e.g.*, Giller and Malmqvist 2002, and references cited in Philbrick *et al.* 2010). Plants of Podostemaceae only occur in rivers. Indeed, some are known from only a single river. These latter species are of particular conservation concern (Philbrick *et al.* 2010). *Podostemum flagelliforme* is one such species.

The general region where *Podostemum flagelliforme* was found includes several conservation units, *e.g.*, Northeast—Parque Estadual do Jalapão; Northwest—Parque Estadual do Lajeado; and Eastern—Estação Ecológica da Serra Geral do Tocantins. Efforts to find this species in these areas were not successful. Presently there is a project to create an ecological corridor called Corredor Ecológico da Região do Jalapão (ICMBio 2013), and the locality where *P. flagelliforme* occurs is within the limits of one of the municipalities involved. The authors have contacted the Chico Mendes Conservation Biodiversity Institution, the Brazilian governmental authority that is planning the implantation of the conservation unit to encourage the inclusion of *P. flagelliforme* as an additional species to support the establishment of Corredor Ecológico da Região do Jalapão. The inclusion of this rare aquatic species supports a southward extension of this corridor.

ACKNOWLEDGEMENTS: We are grateful to Axel Katz who helped in the field, Jean Pierre Ybert who transcribed the French text and Allan Crema (ICMBio) for provide details on the Corredor Ecológico da Região do Jalapão. This work was supported by Conselho Nacional de Desenvolvimento Científico e Tecnológico—Ministério de Ciência e Tecnologia (CNPq-MCT) to C.P.B. and by National Science Foundation Grant [DEB-0444589], PROTAX, REFLORA and Productive Grants, and Connecticut State University-AAUP research grants to C.T.P.

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RECEIVED: April 2014

ACCEPTED: June 2014

PUBLISHED ONLINE: October 2014

EDITORIAL RESPONSIBILITY: Angelo Gilberto Manzatto