Podostemaceae in Southern Brazil

Podostemaceae na Região Sul do Brasil

Anderson Santos de Mello¹,³, Aldaléa Sprada Tavares² & Rafael Trevisan²

Abstract

This study provides a taxonomic treatment of the Podostemaceae family in southern Brazil. Podostemaceae is the largest family of strictly aquatic angiosperms. The center of family richness is the equatorial region of South America. Taxonomic studies are still scarce in Brazil. For southern Brazil there are six genera and 10 species recognized. Dichotomous key and illustrations are presented for species identification.

Key words: taxonomy, Malpighiales, aquatic macrophytes, river-weeds.

Resumo


Palavras-chave: taxonomia, Malpighiales, macrófitas aquáticas, plantas de rio.

Introduction

Podostemaceae is distributed in rivers in tropical regions of the world and some temperate zones of North America and Asia (Tavares 1997), being the largest family of exclusively aquatic Angiosperms, with 50 genera and approximately 270 species (Philbrick & Novelo 2004). The plants of this family are aquatic herbs, that vary in size, and have unusual morphology for flowering plants. They have simple anatomical features, and generally are very distinct when compared to other groups of aquatic Angiosperms (Ameka ̇ et al. 2002). The representatives of this family grow on rocky substrates, in rivers with strong currents. Exceptionally they may occur in lentic ecosystems (Irgang ̇ et al. 2003). The life cycle is very singular when compared to other families of Angiosperms, especially because of the need to flower and fruit in synchrony with water-level fluctuations (Tavares et al. 2006). In periods when the rivers have low water levels, some of the plants or even the entire population begins the reproductive process, up to fruit maturity and seed dispersal (Imaichi ̇ et al. 2004; Tavares et al. 2006).

Due to their form, sometimes like lichens or bryophytes, the position of Podostemaceae has always been controversial (Tavares 1997) and the phylogenetic relationship discussed (Kita & Kato 2001). Different classification systems always had difficulty in relating the family to other taxonomic groups. When recognized as a family, it was initially placed among the monocots (Richard 1816; Martius & Zuccarini 1822). Lindley (1830) was the first to recognize Podostemaceae as a dicotyledonous family. Warming (1888) considered Podostemaceae related to Saxifragaceae. Cronquist (1981) included the family in the monotypical order Podostemales, subclass Rosidae. Cusset & Cusset (1988), studying the African Podostemaceae, established for the family the exclusive class Podostemopsida. Recently, the classification system APG III (2009) included the family in the order Malpighiales, having as a sister group Hypericaceae and affinities with Clusiaceae and Callophyllaceae. The species with neotropical distribution were recently investigated in a phylogenetical study (Tippery et al. 2011) and the clade clusioid, from the order Malpighiales in which Podostemaceae is included, presented for the first time well resolved phylogeny (Ruhfel et al. 2011).

²Universidade Federal de Santa Catarina, Centro de Ciências Biológicas, Depto. Botânica, Campus Reitor João David Ferreira Lima, 88040-970, Florianópolis, SC, Brazil.
³Autor para correspondência: japabio@yahoo.com.br
Despite the wide distribution and richness of the species, taxonomic studies of Podostemaceae in Brazil are still scarce, although there have been some important recent contributions (Philbrick & Bove 2008; Bove et al. 2011). Tulasne (1863) in the *Flora brasiliensis*, recognized 15 genera and 30 species. Van Royen (1951, 1953, 1954) did taxonomic treatments for the Americas. The taxonomic decisions of Van Royen represented higher levels of richness and grade of endemism for the South American taxa than those recognized by Philbrick & Bove (2010). Tavares (1997) studied Podostemaceae from some rivers in the Amazon, associating taxonomy with ecological concepts. Aona & Amaral (2006) studied the taxonomy of the family for the state of São Paulo. For the state of Santa Catarina Van Royen & Reitz (1971) indicated the occurrence of five genera and 13 species. Furthermore, the studies of Pontirolli (1955) and Tur (1975, 1988, 1997, 1999) for Argentina and Paraguay are references for taxonomic studies in southern Brazil, especially because of shared species in the watersheds. New genera and species have been recently described, mainly for Brazil and Argentina (Tur 2003, Philbrick & Novelo 2003, Philbrick et al. 2005, Philbrick & Bove 2008). Bove (2010) listed 17 genera and 87 species for Brazil. The scarcity of collections, few field studies, and unrepresentative and poorly preserved exsicatae in the collections favor controversial opinions on the taxonomy of the family (Philbrick & Novelo 1995). However, some herbaria from southern Brazil have good collections of Podostemaceae, comprising the most of the states of Paraná, Santa Catarina, and Rio Grande do Sul.

This study aims to present a taxonomic treatment of the species of Podostemaceae occurring in southern Brazil.

**Material and Methods**

For the taxonomic treatment we followed classical methodology, including a review of the specialized literature, herbarium material, and field expeditions from 2008 to 2010, in which the main rivers of the all important watersheds in southern Brazil were visited. We collected 60 specimens which were included in the collection of the herbarium of Universidade Federal de Santa Catarina, FLOR.

About 300 exsicatae were examined from different herbaria: FLOR, FURB, HAS, HBR, HURG, ICN, LP, MBM, PACA, UPCB, HUCS, from southern Brazil and CTES and LP, from Argentina (siglas according to Thiers 2010). Part of the type material was not analyzed, because it is deposited in European herbaria; however, images of type material available at the sites of the main herbaria were consulted. The morphological characterization of the vegetative and reproductive structures is according to the terminology used for the family. We accepted the synonymization of Van Royen (1951, 1953, 1954), Tur (1997, 1999), Tavares (1997) and Philbrick & Novelo 2004.

**Results and Discussion**

**Taxonomic treatment**


Aquatic herbs, submerged, fixed to the substrate by haptera, forming or not cenobia. Leaves with variable size and shape, sessile or petiolate, generally with sheath, linear, lanceolate, palmate, reniform, cordate, obovate, reduced to capillary filaments, or thalloid, margin entire or dichotomically subdivided; uninerved, penninerved or palminerved, surface smooth, papillose or spinulose, phyllotaxy opposite, spiraled, distichous, tristichous, rosulate or fasciculate. Inflorescence a spiciform monochasium, flowers fasciculate or solitary, axillary, basal, terminal, or extra-axillary, conspicuous or tiny, bisexual, zygomorphic or actinomorphic, 1 to many, generally enveloped by capillary filaments, or thallic, margin entire or dichotomically subdivided; uninerved, penninerved or palminerved, surface smooth, papillose or spinulose, phyllotaxy opposite, spiraled, distichous, tristichous, rosulate or fasciculate. Inflorescence a spiciform monochasium, flowers fasciculate or solitary, axillary, basal, terminal, or extra-axillary, conspicuous or tiny, bisexual, zygomorphic or actinomorphic, 1 to many, generally enveloped by a membranous spathe, rare coriaceous, opening irreguarly or wrapped by leaves. Perigone (1)3–5(many) tepals, sometimes reduced, free, partial or totally fused, triangular, linear, filiform or cordiform. Stamens 1-many, usually alternating with floral segments, free, partial or totally adelphic, forming androecium or not, filament entire, differently branched, 1 or 2 whorls complete or incomplete, sometimes on one side of the flower, persistent or not; anthers sagittate or rounded, apex emarginate or entire, dehiscence longitudinal, basifixate or dorsifixate. Ovary superior, gamocarpelar, 1–3 locules, sessile or forming gynophore, ribbed or smooth, pluriovulate, anatropous ovule; stylus 1–3, free to slightly fused; stigma entire, retuse or branched. Capsule 1–2 locules, septifragal or septicidal, valves equal or unequal, smooth or ornamented. Seeds 1 to many, ovoid to ellipsoid, exalbuminate; embryo straight.
Key to the genera of Podostemaceae occurring in southern Brazil

1. Plants with tristichous phyllotaxy, flowers never surrounded by spathellae; 3 tepals forming a well-developed perigone ................................................................. 5. Tristicha

1’. Plants with varied phyllotaxy, never tristichous; flowers always surrounded by spathellae before anthesis; tepals 2 to many, rudimentary, forming whorls complete or not.

2. Flowers arranged in spiciform monochasium; leaves rough due to the presence of papillae on the adaxial surface ........................................................................................................ 3. Mourera

2’. Flowers solitary or in fascicules, never in spiciform monochasium, leaves without papillae.

3. Flowers always solitary, stamens 2 supported by an andropodium .......... 4. Podostemum

3’. Flowers solitary or fasciculate, stamens 1-many, never forming andropodium.

4. Plants acaulescent, phyllotaxy rosulate, nerves conspicuous .................. 2. Marathrum

4’. Plants with developed stem, phyllotaxy alternate, nerves inconspicuous.

5. Leaves pinnate; flowers basal, fasciculate ................................................. 6. Wettsteiniola

5’. Leaves flabellate or pinnatilobed; flowers axillary or terminal, solitary .......... ................................................................. 1. Apinagia


The literature indicates the occurrence of Apinagia yguazuensis, A. guairaeensis (Tur, 1999), A. fucoides and A. riedelli (Van Royen 1954, Bove 2010) in southern Brazil. Van Royen & Reitz (1971) cited A. fucoides for the state of Santa Catarina and suggested the occurrence of A. riedelli. However, in the present study only A. yguazuensis was confirmed for southern Brazil.


Figs. 1a-e, 2a-c

Herbs 2–10 cm tall; roots simple, adhered to the substrate forming a basal disk. Stems erect, 1–10 cm long. Leaves 1.2–7 cm long, membranous, decurrent, cuneiform, somewhat flabellate or pinnatifoliated, lobes irregular, ending with dichotomous divisions, filiform, inconspicuous, without sheaths. Flowers solitary, axillary or terminal; tepals 3, rudimentary, subulate, not forming a whorl; stamens 2, inserts on the same side, filaments linear; ovary oblong, slightly asymmetrical, ribs indistinct. Fruit pedunculate, 10 mm long, bivalve, similar to the ovary, 3 ribs per valve, inconspicuous in young fruit, two lateral sutures.


Apinagia yguazuensis was treated by Van Royen & Reitz (1971) as A. fucoides in Santa Catarina. However, analysis of specimens from Paraguay and Argentina, associated with new collections from the state, confirmed A. yguazuensis as the taxon occurring in southern Brazil.

The species shows high phenotypic plasticity, varying in size and shape of leaves. Observations on populations occurring in the states of Santa Catarina and Rio Grande do Sul showed that A. yguazuensis lives in streams of low to medium depth and has narrow stems, smaller leaves with yellow to light green coloration. The collection L. Smith & R. Reitz 13927 (HBR) has wider stems and leaves, terminations dichotomous, filiform and tiny. This morphological variability was also observed by Fontana (2008) within a population.

Apinagia yguazuensis can be considered a rare species in southern Brazil, being proposed as vulnerable (VU) by Philbrick & Bove (2010), according to IUCN criteria. This species is distributed in the basins of the Paraná, Iguacu and Uruguay rivers, in the states of Paraná, Santa
Catarina and Rio Grande do Sul. It also occurs in Paraguay, Paraná River, and in Argentina, in the basins of the Uruguay and Paraná rivers.


The genus was previously recognized as restricted to Central America and the Amazon region (Van Royen 1954) and, recently, had its occurrence registered for austral South America with the description of Marathrum azarensis by Tur (2003).

2.1 Marathrum azarensis Tur, Hickenia 3(38): 153 (151-156; figs. 1-3). 2003. Fig. 2d-e

Herbs acaulescent, up to 2 cm tall. Roots thalloid, 1 mm wide. Leaves opposite or subopposite, rosulate, finely flat, membranous, with conspicuous nerves, cuneate, y pro 2 cm long, forming laciniae, last leaf divisions 1–2 mm long. Flowers solitary, axillary; spathella when closed forming prominences on the surface before anthesis, broken spathella funnel–shaped, 3 mm long; tepals 3, c. 1.5 mm long, free, apex spatulate; stamens 2, anthers introrse, c. 0.7 mm long, base emarginate, filaments 1.5–2 mm long. Ovary ellipsoid, c. 2 mm long, styli 2, c. 0.5 mm long. Capsule 2 mm long, 2 valves equal, persistent, each valve with 3 ribs and 2 longitudinal sutures, pedicels 4 mm long.

Selected material: SANTA CATARINA: Abelardo Luz, Rio Chapecó, 4 km ao norte do núcleo urbano, 3.IX.2010, A.S. Mello & A. Nuernberg 584 (FLOR).

Figure 2 – a-c. Apinagia yguazuensis – a. flowering plants in habitat; b-c. plant with mature fruits. d-e. Marathrum azarensis – d. habit; e. plant in habitat.
Marathrum azarensis is a new record for Brazil and it is certainly the rarest species of Podostemaceae in southern Brazil. It is considered to be vulnerable (VU) according to IUCN criteria by Philbrick & Bove (2010).

This species was cited by Bove (2010) for the state of Paraná, although the material referred to by the author had been collected in the Paraná River, in Paraguay, far from the border with Brazil (Fontana 2007). The collection A.S. Mello & A. Nuernberg 584 (FLOR) in the municipality of Abelardo Luz, Santa Catarina, is in effect the first and only record of the species in Brazil. Marathrum azarensis is hardly recognizable in the field because of its small size and lack of stem. The leaves are flattened, dorsiventral, rostrate, with thick petiole, endings filiform, coloration generally light green and reddish margin.


For the genus *Mourera* we registered the occurrence of *M. aspera* Tul., restricted to the state of Paraná. *Mourera weddeliana* Tul. was cited for Santa Catarina (Van Royen & Reitz 1971), however it was not confirmed, and the only reference is an undated collection by Müller s.n., which can not be analyzed.

3.1 **Mourera aspera** (Bong.) Tul. Ann.Sci. Nat. Bot. ser.3, 11: 93. 1849. Fig. 3 a-d

Herbs, variable size. Leaves 5.5–35 cm × 3–15 cm, adaxial surface rough, nerves prominent on the adaxial face, with remarkable papillae, abaxial face glabrous. Monochasmium scipiform, simple or branched, 4–23 cm long; rachis 5.5–17.5 cm long; bracts c. 5 mm × 2 mm, in the inflorescence branches. Flowers numerous; spathella 5–8 mm; pedicel 1–2 cm long; tepals 5–10, 5–9 mm long; anthers extrorse, obtuse or emarginate, basifixed, 2–3 mm. Capsule 3.5–4.5 mm long, 8–10 ribbed; pedicel up to 3.5 cm long in ripe fruit.


**Additional examined material:** ARGENTINA, CORRIENTES: Dep. del Ytuizaingó, 30.VIII.1994, S.


*Moureraaspera* was collected in southern Brazil in only a few areas in northwestern Paraná. This species has a very restricted area of distribution, so far, only in the basins of the Paraná and Iguaçu rivers. Although Van Royen & Reitz (1971) presented a taxonomic treatment and indicated its possible occurrence in the state of Santa Catarina, there are no herbarium records or field observations that confirm the occurrence of the species in that state. *Mourera aspera* has the largest leaves and flowers of the southern Podostemaceae. The most striking morphological features are the size and shape of leaves, inflorescence a spiciform monoachium, pink flowers, and the rough papillae that cover the adaxial surface of leaves, composed of a set of siliceous cells.

In southern Brazil, the species was collected in rivers of the watershed of the Paraná River, in the western portion of the state. In addition to Paraná, this species occurs in the states of Bahia, Espírito Santo, Goiás, Mato Grosso, Minas Gerais, São Paulo, and Rio de Janeiro. It is also found in Argentina and Paraguay.


*Podostemum* is the genus with the most species in southern Brazil, including five species. The most striking feature of the genus is the presence of an andropodium, a structure that bears the base of two stamens with anthers. Despite all available literature and the species of the genus being the most common and well reprepresented in collections in austral South America, the taxonomy is still controversial. The monograph on *Podostemum* (Philbrick & Novelo 2004) used phylogenetic analysis based only on morphological characters and presented a new proposal for the treatments of Van Royen (1954), Van Royen & Reitz (1971) and Tur (1988, 1997, 1999). According to Van Royen (1954), the genus has 12 species in south Brazil and Van Royen & Reitz (1971) cited the occurrence of seven species in Santa Catarina. In contrast, Philbrick & Novelo (2004) justified that the species recognized by Van Royen (1954) are, in fact, local forms of species with greater distribution. Those authors recognized only four species (*Podostemum comatum* Hicken, *P. distichum* (Cham.) Wedd., *P. muelleri* Warm. and *P. rutifolium* Warm.) and added *P. irgangii* Philbrick & Novelo.
This study was innovative, but it led to a discussion concerning their taxonomic conclusions, requiring intensification of taxonomic studies. The genus Crenias Spreng, treated by Van Royen & Reitz (1971) as Mniopsis Mart, had no confirmed occurrence for southern Brazil. In addition, the species of Crenias were transferred to Podostemum by Philbrik & Novelo (2004), a situation with which we do not agree.

**Key to the species of Podostemum occuring in southern Brazil**

1. Leaves usually entire, base of the leaves broad, asymmetrical, with extensions filiform simple or dichotomous; stipules entire, with a basal triangular tooth, visible only on one face of the leaves .......................................................................................................................... 4. *P. muelleri*

1’. Leaves compound, base of the leaves narrow, symmetric, often dichotomized or composed by leaflets in spiral arrangement; stipules consisting of two or more teeth, with variable morphology, visible on both faces of the leaves.

2. Plants with dimorphic stems; vegetative up to 115 cm long, fertile 0.1–2 cm long ..... 1. *P. comatum*

2’ Plants with monomorphic stems, not differentiating the vegetative from the reproductive.

3. Stipules of two kinds, the first composed of two ear lobes, symmetrical, arising one on each side of the stem, the second composed of a set of 3–9 teeth subequal, inserted above the petiole ........................................................................................................................................ 3. *P. irgangii*

3’. Stipule of only one kind, with 2–7 teeth, the lateral asymmetric.

4. Divisions of the leaves in the same plane, endings of the leaves spatulate or rarely acute; stipules always with two equal teeth ............................................................................................... 5. *P. rutifolium*

4’. Divisions of the leaves tridimensional, endings of the leaves varied; stipules with 2–7 teeth of different sizes and shapes ............................................................................................................. 2. *P. distichum*

---


Herbs of variable size. Roots 0.8–2 mm wide. Stem dimorphic, twisted, little branched, 2–115 cm long when vegetative and 1.5–2 cm long when reproductive. Leaves 2–20 cm long, dichotomously divided, divisions appearing in two dimensions; apex of endings elongate, rounded to acute; petiole flattened; stipules amplexicaulis, with 2(–3) triangular teeth, 0.2–1.5 mm long. Flowers growing on short stalks arising from the roots; pedicel 0.5–1.5 cm; tepals 3, linear to filiform, andropodium 1–3 mm long; ovary ellipsoidal, 1–2.7 mm long; stigmas entire, filiform, 1–1.5 mm. Capsule 2 mm long, 2 valves unequal, 3(–5) ribs on each valve.


*Podostemum comatum* is rare in southern Brazil, despite its wide dispersion area in the three states. The herbarium collections are limited and usually incomplete, especially the dimorphic stems, often collected separately and treated as distinct species. During field work it was not possible to collect this species in Santa Catarina, requiring intensified new sampling. In the municipality of Telêmaco Borba, Paraná, a population was found with stems over one meter in length, a fact never reported before in the literature.

*Podostemum comatum* is distributed in the states of Paraná, Santa Catarina and Rio Grande do Sul. It also occurs in the state of São Paulo and in Argentina, Paraguay and Uruguay.
2. **Podostemum distichum** (Cham.) Wedd.

**Prodromus.** 17: 73. 1873. Figs. 5b-d, 6a-c

Herbs. Roots prostrate, flattened, 0.6–2.9 mm wide. Monomorphic stems, older rigid, dark and twisted, 0.4–600 mm long. Leaves peciolate, compound, inserted perpendicularly on the stem axis, distichous, variable forms, when verticillate, 2 or 3 axes from which arise leaflets; when dichotomous, 2–8 dichotomic divisions emerging in three dimensions, last divisions of leaves in V or U shape, apex acute, 0.2–15 cm long; stipules emerging as an extension of the sheath navicular-shaped, persistent, hard and darkened in older stems, 0.2–1.4 mm long, 2–7 teeth of different sizes, triangular, lateral larger than the central, 0.05–0.3 mm long. Flowers 1–5 per stem; tepals 3, 2 lateral and 1 at the bifurcation of the andropodium; andropodium 0.3–5.2 mm long; ovary reddish, 6–8 ribs, stigmas entire. Capsule bivalvar, 3–4 ribs per valve.

Figure 4 – a–d. Podostemum comatum – a. terminal portion of the stem; b. roots with fertile stems; c. flower; d. roots with vegetative stems. (a A.S. Mello & M. Beretta 553 (FLOR); b–d Silva et al. 6036, 6038 (MBM)). Illustrations: a–c Fatima Zagonel; d Maria Virgilia.


Podostemum distichum is the most common species, with the greatest dispersion area in southern Brazil, occurring preferentially in waterways on the South Brazilian Plateau, forming dense communities with P. comatum, P. muelleri, P. rutifolium and Tristicha trifaria. In field works we realized that it is common at higher altitudes. P. distichum has the highest morphological variability within the genus, with little- or much-divided leaves, verticillate or not and stems short or long. It differs from other species by the leaf divisions arising in three dimensions.

Philbrick & Novelo (2004) synonymized P. atrichum, P. arguirense, P. glaziovianum, P. schenckii and P. warmingii under P. distichum. However, the phylogenetic approach of Moline et al. (2006), including morphological and molecular characters, indicated that the proposed complex should be carefully studied. The analysis of collections and field work were crucial to note this complexity. Although we are accepting the proposal made by Moline et al. (2006), it is necessary to intensify work and it will probably be given new taxonomic positions.

In Brazil, Podostemum distichum is widely distributed over the three southern states, as well as São Paulo and Minas Gerais. It also occurs in Argentina, in the basins of the Uruguay River and Paraná rivers, in Paraguay and Uruguay.

Figure 5 – a. Podostemum comatum – population with stems up to 115 cm long. b-d. Podostemum distichum – b. stems with short leaves; c. flower with recently split spathe; d. leaves with verticillate leaflets.
3. *Podostemum irgangii* C. T. Philbrick & A. Novelo, Novon 11: 92. 2001. Figs. 6d-g, 7a-b
Herbs. Roots prostrate, rounded, 0.2–2.1 mm wide. Monomorphic stems, prostrate or erect, 1–42 mm long. Leaves distichous, divided, divisions of the leaves verticillate, 1–5 cm long; whorls uniformly arranged, 5–14 whorls per leaf, 6–11 leaflets per whorl, 3.1–7.2 mm long, apex acute. Petioles 0.2–0.4 mm long; base symmetric, perpendicular to the axis of the stem, hard; stipules in two forms, hard, symmetric, persistent, dark in older stems; first type located at the base of the leaf insertion on the stem, with two lobes, 0.7–1.1 mm long, subamplexicaulis, protruding 0.4–0.6 mm from the stem; second type appearing above the insertion of the petiole; teeth 4–9, 0.2–0.5 mm long. Flowers 1–7 per stem, solitary; tepals 3, linear, sometimes curved, 2 lateral, 0.6–2 mm long and 1 at the bifurcation of the andropodium, 0.4–1.5 mm long; andropodium 0.3–1.7 mm × c. 4.5 mm. Ovary 0.8–2.1 mm × 0.8–1.6 mm; stigmas 2, entire, 0.4–1.6 mm. Capsule 1.2–2.2 × 0.9–1.7 mm; peduncle 1–6 mm long.


**Figure 6** – a-c. *Podostemum distichum* – a. roots with stems and leaves; b. stipule detail; c. stems with leaves and verticillate leaflets. d-g. *Podostemum irgangii* – d. flower; e. fruit; f. leaf; g. roots with stems, leaves and flowers. (a-c A.S. Mello & A. Nuernberg 581 (FLOR); d-g A.S. Mello & A. Nuernberg 587 (FLOR)). Illustrations: Fatima Zagonel
Figure 7 – a-b. *Podostemum irgangii* – a. population in the habit; b. two kinds of stipules, left arrow line corresponds to leaf stipule, right arrow line corresponds to stem stipule. c-e *Podostemum muelleri* – c. stem with leaves; d. leaves with characteristics broad-base; e. flower. f. *Podostemum rutifolium* – roots, stems and leaves.
Podostemum irgangii is the unique species of the genus with two kinds of stipules. Another striking feature is the even distribution of the leaflets and its leaves are usually evenly verticillate. Moreover, in communities where both stipules and its leaves are usually evenly divided, the leaves flattened, persistent and hardened in older stems. Flowers 1–10 per stem; tepals 3, 2 latera 0.5–1.9 mm long and 1 at the bifurcation of the andropodium 0.1–1.3 mm long; andropodium 0.1–3 mm long; ovary 0.8–2.3 × 0.6–1.8 mm; 6–8 ribs; stigmas entire. Capsule 1–2.7 mm × 0.9–1.9 mm; 6–8 ribs, 3–4 per valve.


Podostemum müelleri is recognized by the enlarged base of the leaves and the stipules consisting of a tooth and only visible on one side. Podostemum müelleri presents wide distribution in the southern states of Brazil, as well as São Paulo and Goiás. It also occurs in Argentina, Paraguay and Uruguay.

Herbs. Roots prostrate, flattened, 0.2–3.4 mm wide. Monomorphic stems, small, 0.1–94 mm long. Leaves distichous, entire to 5 times dichotomized or lobed, 1.5–20 mm long, spatulate; apex rounded, obtuse or acute, 0.9–2.1 mm long; base of the leaves symmetric; stipules 0.01–0.4 mm long, persistent, hardened and darkened in older stems, 2 teeth triangular and flattened, 0.05 mm long. Flowers 1–5 per stem; tepals 3, apex acute, 2 lateral 0.6–1.7 mm long and 1 at the bifurcation of the andropodium 0.2–1.2 long; ovary reddish pink, 8–10 ribs, 0.4–2.1 × 0.4–1.5 mm; stigmas entire. Capsule 1.2–2.3 mm × 0.8–1.6 mm; 8–10 ribs, 4–5 per valve.

**Figure 8** – a-d. *Podostemum rutifolium* – a. leaf with stipules; b. fruit; c. leaf; d. roots with stems, leaves and closed spathellae. e-f. *Tristicha trifaria* - e. stem with flowers; f. terminal portion of the stem with flowers. (a-d A.S. Mello 4, (FLOR); T.B. Guimarães 345 (FLOR)).

Podostemum rutifolium is common in southern Brazil, mainly in rivers in the states of Rio Grande do Sul and Santa Catarina. It also occurs in Argentina, Paraguay, and Uruguay.

5. Tristicha

The genus belongs to the subfamily Tristichoideae, recognized by Engler (1930) and considered by many authors as a different family, because it is characterized by the absence of spathella before anthesis and by having whorls that involve all floral parts. Recent works on the biogeography of Tristicha (Kita & Kato 2004) suggested that this genus had originated in Africa and dispersed to other continents, following a reverse path of the other species of the family.

5.1 Tristicha trifaria (Bory ex Willd.) Spreng., Syst. Veg., ed. 16: 1-22. 1824.

Herbs with branching roots, adhered to the substrate. Branches prostrate, attached or floating, 0.2–15 cm long. Leaves with phyllotaxy tristichous, laxly or densely arranged along the stem, membranous, sessile, entire, rarely lobed. Flowers axillary or terminal, solitary or not, surrounded by membranous leaves; tepals 3, connate at the base; stamen 1; anthers oblong, base obtuse, apex truncate, dehiscence intorse; ovary sessile, ovoid to ellipsoid, tricarpelar, trilocular; stigmas 3. Capsule similar to the ovary, trivalvar dehiscient; seeds minute, numerous.


Tristicha trifaria has received little attention from collectors, possibly due the dimunite size and the appearance that resembles a bryophyte. Herbarium collections are very often mixed mainly with...
Figure 9 – a-d. *Wettsteiniola pinnata* – a. flowers emerging in fascicle; b. flower; c. leaf; d. habit. (a-d Hatschbach 42236, 15871 (MBM)). Illustration: Fatima Zagonel.
specimens of *Podostemum*. This species is easily recognized in the fertile condition by large pedicels and three tepals involving the ovary. The tristichous phyllotaxy also assists in the identification.

*Tristicha trifaria* is widely distributed in southern Brazil, occurring mainly in communities with species of *Podostemum*. The species is the only one in the family that has a Pantropical distribution, occurring also in Africa. However, biogeographic analyses (Kita & Kato 2004) indicate that there are possibly two different species, one confined to the African continent and the other to the Americas.


The genus is endemic to the basin of the Paraná River and composed by *W. apipensis*, *W. accorsii* and *W. pinnata*, the first two are known only from the type locality. *Wettsteiniola apipensis* occurs only in the Salto Apipe, Corrientes province, Argentina. *Wettsteiniola accorsii* occurred in the former Salto de Piracicaba, in the municipality of Piracicaba, state of São Paulo. In southern Brazil, only *W. pinnata*, occurs in the state of Paraná. The genus presents affinities with species of the section *Hymenolacys* of the genus *Apinagia*, especially by arranging clusters of flowers at the thalloid base, forming fascicles.

Fig. 9a-d

Base or root thalloid, irregular, peltate, 5–10 mm diam. Leaves bipinnate, 8–10 cm long, petiole 4–5 cm long, 3–5 mm diam., rachis flattened.; first division of the sheet up to 1.5 cm long, secondary divisions repeatedly furcated, last divisions numerous, filiform, 2–4 cm long, stipules up to 3 mm wide. Flowers in fascicles, arising from the thalloid base; pedicels up to 3.5 cm long; tepals 3–5, membranous, apex acute, up to 0.5 mm long; stamens 1–4, up to 3 mm long, anthers up to 1 mm long. Ovary c. 3 mm long, 2 mm diam.; stylly acute. Capsule, bivalvar, c. 2 mm long, with 12 to 14 ribs, 6 to 7 per valve.


*Wettsteiniola pinnata* has the type indicated for the Paranapanema River, Salto Grande, São Paulo, Brazil. In addition to the type, we found specimens from the extinct “Sete-quetas” of the Paraná River, municipality of Guaira and the collections Silva et al. 6034 and 6037 (MBM) from Salto Cavalcanti, Rio das Cinzas, municipality of Tomazina, northwestern Paraná. Unfortunately, the field work in Salto Cavalcanti took place during periods of heavy rainfall, so the expedition was unsuccessful. The Salto Cavalcanti is a large waterfall with high flow, which drains into the basin of the Paraná River. The only collections for the genus *Wettsteiniola* were conducted in rivers with large waterfalls, located in the Paraná River basin.

*Wettsteiniola pinnata* has a very restricted distribution, occurring in southern Brazil only in the state of Paraná. The type of the species is indicated for the state of São Paulo, in Rio Paranapanema, however this river is located on the border with the state of Paraná and new collections of the species were not done in São Paulo. In addition, a revision of the genus may include *W. pinnata* and *W. accorsii* as synonyms.

**Acknowledgements**

The authors thank the herbaria curators for the loan the exsicatae; the Programa de Pós-Graduação em Biologia Vegetal of UFSC; Fátima Zagonel and Maria Virgília for the illustrations; Anelise Nuernberg and Mariane Beretta for photographs and CAPES for the scholarship granted to the first author.

**References**


