ZooKeys 114: 1–14 (2011)
doi: 10.3897/zookeys.114.1490
www.zookeys.org

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

Two new cavernicolous genera of Julidae (Diplopoda, Julida), with notes on the tribe Brachyiulini and on julid subanal hooks and anchors

Nesrine Akkari[1,†], Pavel Stoev[2,‡], Henrik Enghoff[1,§]

1 *Natural History Museum of Denmark (Zoological Museum), University of Copenhagen, Universitetsparken 15, DK-2100 København Ø, Denmark* **2** *National Museum of Natural History, 1, Tsar Osvoboditel Blvd, 1000 Sofia and Pensoft Publishers, 13a, Geo Milev Str., 1111 Sofia, Bulgaria*

† *urn:lsid:zoobank.org:author:8DF67798-8E47-4286-8A79-C3A66B46A10F*
‡ *urn:lsid:zoobank.org:author:333ECF33-329C-4BC2-BD6A-8D98F6E340D4*
§ *urn:lsid:zoobank.org:author:9B9D901F-D6C8-4BCA-B11B-CF6EE85B16DC*

Corresponding author: *Nesrine Akkari* (nakkari@snm.ku.dk)

Academic editor: *Sergei Golovatch* | Received 7 May 2011 | Accepted 26 May 2011 | Published 30 June 2011

urn:lsid:zoobank.org:pub:C2194878-D0EE-4B4C-B090-C4ADE0F32E40

Citation: Akkari N, Stoev P, Enghoff H (2011) Two new cavernicolous genera of Julidae (Diplopoda, Julida), with notes on the tribe Brachyiulini and on julid subanal hooks and anchors. ZooKeys 114: 1–14. doi: 10.3897/zookeys.114.1490

Abstract

Two remarkable genera and species of the millipede family Julidae, *Titanophyllum spiliarum* **gen. n. sp. n.** and *Mammamia profuga* **gen. n. sp. n.**, are described from caves in Greece and Italy, respectively. The presence of a flagellum and the absence of a 'pro-mesomerital forceps' on the gonopods place them in the tribe Brachyiulini Verhoeff, 1909, an unnatural grouping based on plesiomorphic characters. Both are outstanding in being the only hitherto known blind julidans having such gonopodal features. A dichotomous key to the nine valid brachyiulinine genera based on peripheral and gonopodal characters is presented. Moreover, notes on subanal hooks and anchors in Julida are provided with hypotheses on their possible function.

Keywords

Greece, Italy, cave, millipedes, new genera, new species, *Titanophyllum*, *Mammamia*

Introduction

We describe here two new genera and species of Julidae, collected from caves in Italy and Greece, which we tentatively assign to the poorly characterised tribe Brachyiulini. In addition to the taxonomic description we discuss the status of the tribe and provide a dichotomous key to its nine currently valid genera. Notes on the presence of subanal hooks and anchors in Julida are also given with hypotheses on their possible function.

Material and methods

Specimens were collected in two caves in Italy and Greece and preserved in 70% ethanol. All measurements were made using a Leica Wild M10 microscope equipped with an ocular micrometer. Vertical body diameter was measured at midbody. Antennae, legs and gonopods were mounted in glycerin for temporary microscope preparations.

Microphotographs were obtained using a Leica digital camera M205A mounted on a stereomicroscope Leica DFC 420. Images were processed with a Leica Application Suite program and final stacking made with Helicon Focus 4.60.2 Pro software. SEM micrographs were obtained using a JEOL JSM-6335F scanning electron microscope. Drawings were made using a camera lucida mounted on a Leica DMRXE microscope. All pictures were later assembled for a final layout with Adobe Photoshop CS.

Results

Taxonomy

Order Julida Brandt, 1833
Family Julidae Leach, 1814
Tribe Brachyiulini Verhoeff, 1909

***Mammamia* gen. n.**
urn:lsid:zoobank.org:act:16F56F2A-E20D-43FA-815D-2C1E242401E1
http://species-id.net/wiki/Mammamia

Diagnosis. Differs from all other genera of Brachyiulini by lacking ocelli and by having a distally expanded promerite and a slightly shorter posterior gonopod, the latter with a basally broad and distally slender mesomerital process mostly lodged in an opisthomerital furrow.

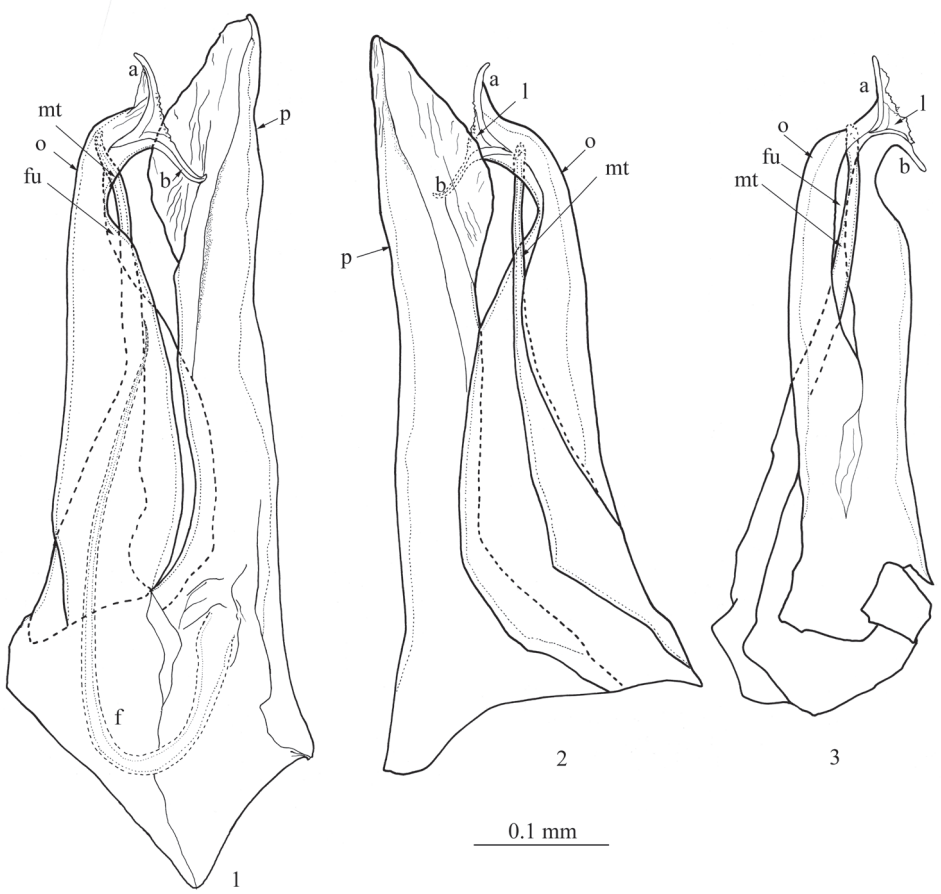
Etymology. The name derives from the Italian exclamation “Mamma mia” which came to our mind when we first saw this astonishing species. Gender feminine.

***Mammamia profuga* sp. n.**
urn:lsid:zoobank.org:act:C319EC4E-FB69-4756-B1CE-609ACDE9F347
http://species-id.net/wiki/Mammamia_profuga
Figs 1–8

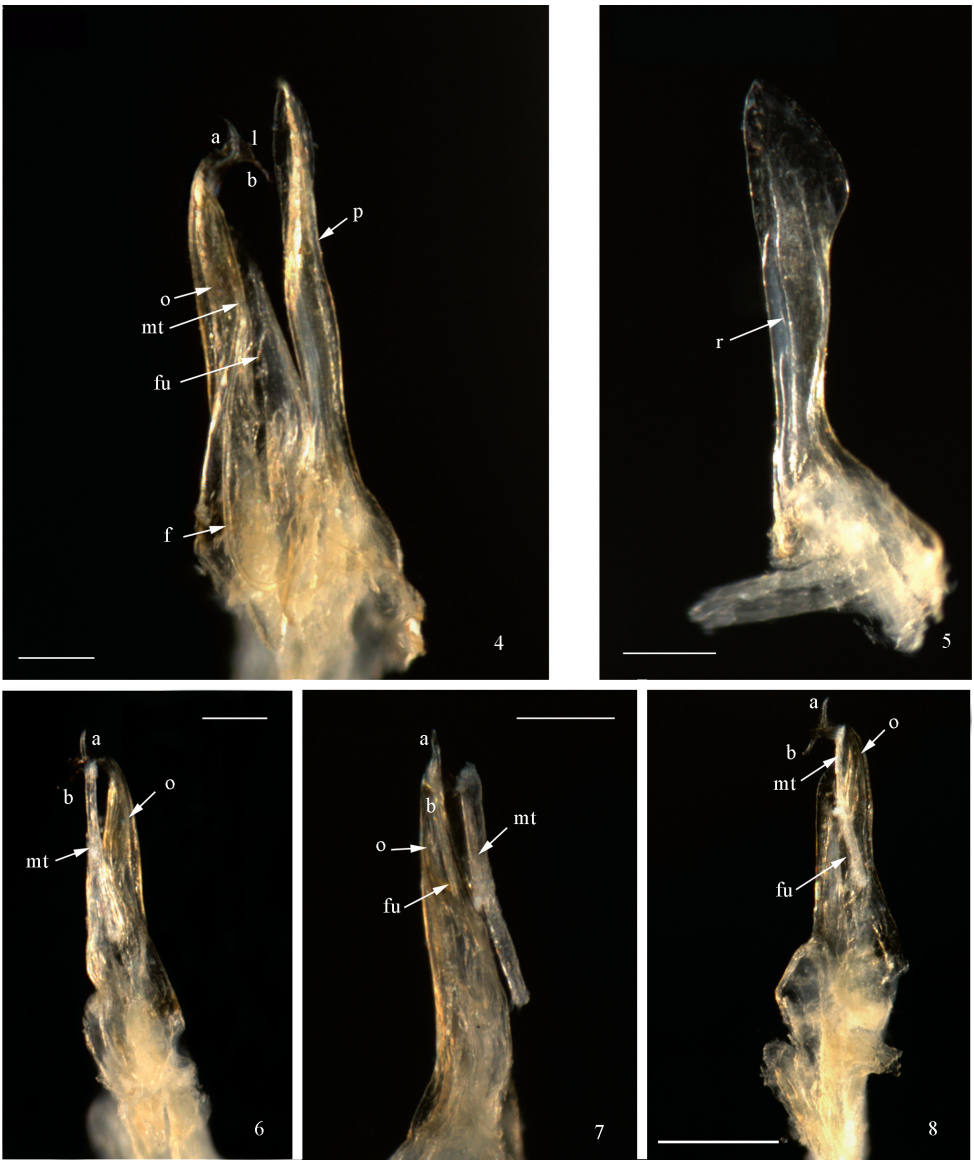
Material examined. Holotype: adult ♂ (broken into head and 6 body parts), Italy, Taranto, Grotta della Cava, iii.1964, P. Parenzan leg. (Natural History Museum of Denmark, Zoological Museum, University of Copenhagen – ZMUC).

Description of locality. The new species was collected in a cave in Taranto Province (south-eastern Italy). P. Parenzan (1984, in a letter to HE) wrote that the cave where the species have been collected was subsequently destroyed.

Etymology. 'profuga' in Latin means homeless; the name emphasizes the destroyed type locality of the species.



Figures 1–3. *Mammamia profuga* gen. n., sp. n., gonopods: **1** right gonopod, mesal view **2** right gonopod, lateral view **3** left posterior gonopod, anterior view. Abbreviations: *a*, *b*: opisthomerital processes *a* and *b*, *f*: flagellum, *fu*: furrow, *l*: lamella, *mt*: mesomerital process, *o*: opisthomerite, *p*: promerite.



Figures 4–8. *Mammamia profuga* gen. n., sp. n., gonopods: **4** right gonopod, mesal view **5** left promerite, posterior view **6** left posterior gonopod, lateral view **7** left posterior gonopod, postero-lateral view **8** left posterior gonopod, posterior view. Abbreviations: *a*, *b*: opisthomerital processes *a* and *b*, *f*: flagellum, *fu*: furrow, *l*: lamella, *mt*: mesomerital process, *o*: opisthomerite, *p*: promerite, *r*: ridge. Scale bar: 0.1 mm.

General description (all measurements in mm). Body uniformly pale yellowish, approximately 26 mm in length, vertical body diameter (height, H) 1.5, length/height ratio 17. Head: ocelli absent, frontal setae and setal sockets missing; gnathochilarium with 2 setae in apical parts of the stipites and with a seta on each lamella lingualis; 4 supralabral setae and a row of *ca* 12 labral setae; mandibular stipital lobes not expanded in males;

antennal length *ca* 1.5×H. Body with 51 podous + 2 apodous rings and telson; striation moderately dense; setae apparently missing, probably broken off; legs yellowish, their length *ca* 1.5×H. Male first leg-pair reduced and hook-shaped. Telson blunt, preanal ring without projection, with at least 5 long setae; subanal scale with 2 long setae; anal valves pilose.

Gonopods. Anterior gonopod (promerite, *p*) slightly longer than posterior gonopod (Figs 1, 2, 4); broad at base, abruptly narrowing at about 1/4 of its height, then gradually broadening distally to form a spatula-like process (Figs 1, 2, 5); apically blunt and mesally with a quite high ridge (*r*) (Fig. 5). Flagellum (*fl*) (Figs 1, 4) moderately long, falcate, emerging from the promerite's base, its tip reaching about 2/3 the height of the posterior gonopod. Posterior gonopod: Opisthomerite (*o*) (Figs 1–4, 6–8) broadest at base, gently tapering up to about 3/4 of its height, then abruptly narrowing and curving anterolaterad; mesally with a wide furrow (Figs 1, 2, *fu*) running along its length; apex resembling a fish-tail, with two processes (*a*, *b*) pointing in opposite directions (Figs 1–4, 6–8) connected by a thin, marginally serrated lamella (*l*) bearing several small spines on the surface (Figs 2–4). Mesomerital process (*mt*) (Figs 1–3, 4, 6–8) emerging from the anterior side of the opisthomerite, mostly lodged in the opisthomerital furrow, broad at base, narrowing at about midlength, thereafter becoming very slender and bent, apical margin gently serrated.

***Titanophyllum* gen. n.**
urn:lsid:zoobank.org:act:C09ADA27-45ED-49E0-A2CB-1457D0CDF629
http://species-id.net/wiki/Titanophyllum

Diagnosis. Differs from all other genera of Brachyiulini by lacking ocelli and by having a rather simple, apically incised promerite devoid of any filamentous processes or apical appendages, and a simple unipartite posterior gonopod with a proximal lobe laterally and a subbasal fold and a groove mesally, the latter ending in a subapical opening.

Etymology. The name combines the type locality, Titanospilia (the cave of Titans) and the suffix – *phyllum* – referring to the simple, leaf-shaped posterior gonopods. Gender neuter.

***Titanophyllum spiliarum* sp. n.**
urn:lsid:zoobank.org:act:C4B8738C-470F-4F54-A4F4-B69741C20EF4
http://species-id.net/wiki/Titanophyllum_spiliarum
Figs 9, 10–14

Material examined. Holotype: adult ♂, Greece, Magnesia, Othris Mts., village of Kofi, Titanospilia (Cave of Titans), 13.VII.2003, P. Beron leg. (National Museum of Natural History Sofia – NMNHS); Paratypes: 4 ♂♂, 5 ♀♀, same locality, date and collector (ZMUC); 12 adult ♂♂, 11 adult ♀♀, 2 subadult ♂♂, 2 subadult ♀♀, same locality, date and collector (NMNHS).

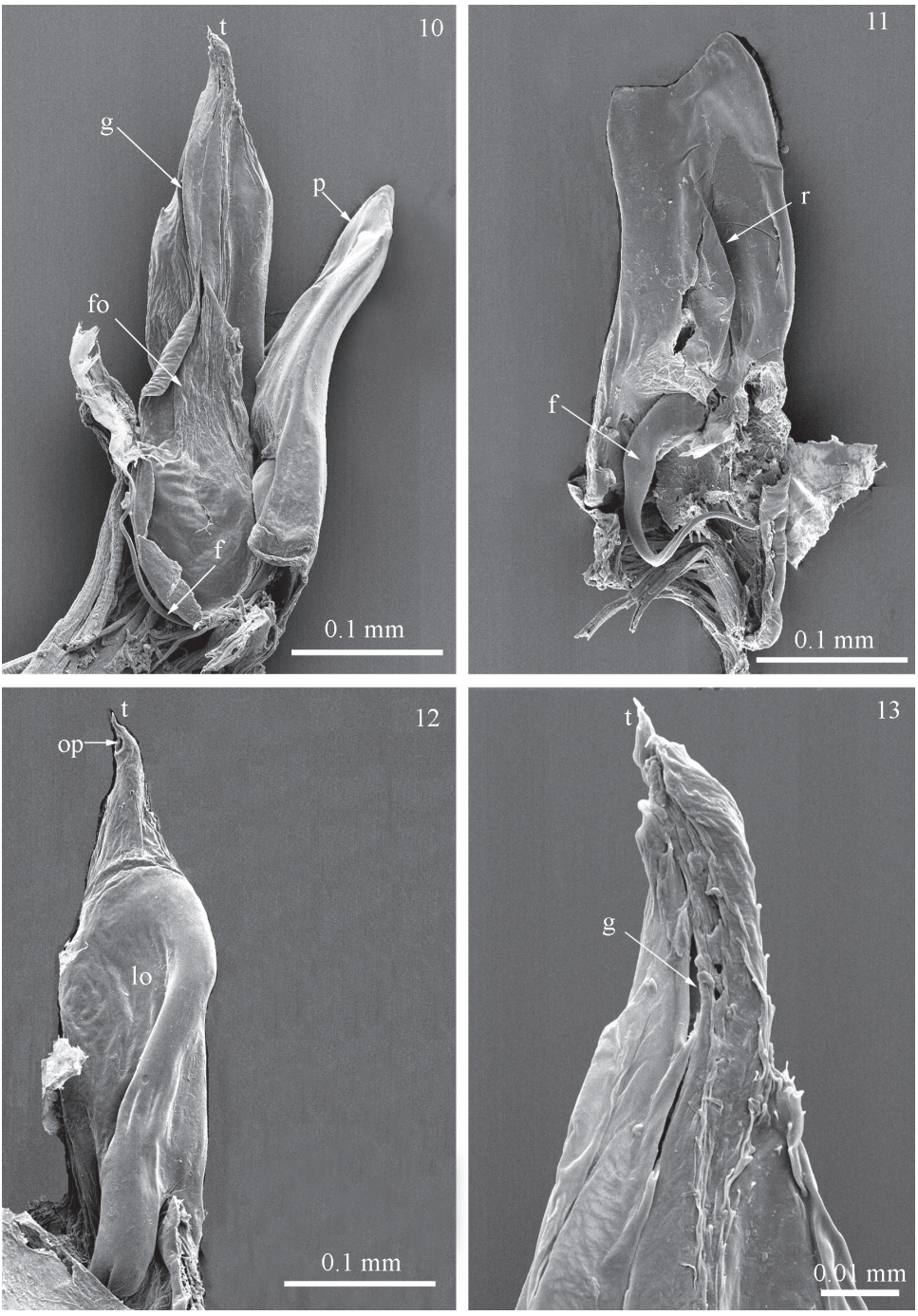
Figure 9. *Titanophyllum spiliarum* gen. n., sp. n., habitus. Scale bar: 2mm.

Description of locality. Titanospilia is an approximately 100 m long vertical cave composed of a single voluminous hall. All material was collected at the bottom of the shaft (P. Beron, pers. comm.).

Etymology. The names means "of caves" in Greek and emphasizes the troglomorphic character of the species.

General description (all measurements in mm). Body uniformly pale to yellowish, legs brownish, metazonites with a slightly darker posterior band; length: 17.3–33.5 mm, vertical body diameter (height, H) 1–1.2 (♂) and 1–1.4 (♀); length/height ratio 16 (♂). Head: ocelli absent (Fig. 9); frons with 2 setae; gnathochilarium with 3 setae in apical part of each stipites, and with a long seta on each lamella lingualis; 4 supralabral setae and a row of *ca* 8 labral setae; mandibular stipites not expanded; male first leg-pair reduced and hook-shaped; antennal length about 1.6×H. Body rings with more or less dense striation and a whorl of moderately dense long setae; 50–61 (♂) and 47–54 (♀) podous rings, 1–2 apodous rings + telson. Defense glands visible as dark spots opening on the suture. Length of legs *ca* 0.83×H. Preanal ring dorsally only slightly protruding beyond anal margin; subanal scale with a small hook pointing anteriad (Fig. 14); anal valves pilose, with long setae. Male 7th body ring with well developed ventral lobes.

Gonopods. Gonopods protruding from the 7th body ring. Anterior gonopod (promerite, *p*) much shorter than posterior gonopod (Figs 10, 11), uniformly broad along its length, slightly expanded at midlength; apex incised, with a lower angular



Figures 10–13. *Titanophyllum spiliarum* gen. n., sp. n., gonopods: **10** right gonopod, mesal view **11** left promerite, posterior view **12** right posterior gonopod, lateral view **13** close up of the tip of posterior gonopods, mesal view. Abbreviations: *f*: flagellum, *fo*: fold, *g*: groove, *lo*: lobe, *op*: opening, *p*: promerite, *r*: ridge, *t*: tip.

process mesally and a higher triangular one laterally (Fig. 11). Posterior side of promerite at middle with a quite high, semitriangular ridge (*r*) pointing postero-laterad (Fig. 11). Flagellum (*f*) (Figs 10, 11) moderately long, falcate, pointing ventrad, emerging from the base of ridge.

Posterior gonopod (Figs 12, 13) unipartite, long, broad at base and midlength, gradually tapering distally; with a proximal lobe (*lo*) laterally (Fig. 12) and a subbasal fold (*fo*) mesally (Fig. 10), the latter giving rise to a mesal groove (*g*) running proximal and distal (Figs 10, 13) and ending in a subapical opening (*op*) (Fig. 12). Gonopodal apex (*t*) with a pointed tip (Figs 12, 13).

Discussion

The tribe Brachyiulini Verhoeff, 1909, is a grouping of julid genera based exclusively on plesiomorphic gonopod characters: presence of a flagellum and absence of a 'pro-mesomerital forceps' (Verhoeff 1926–1932, Enghoff 1987, Read 1990). The gonopods of some brachyiulinines do, however, have a process on the posterior gonopod which has been called 'mesomerite', 'mesomerital process', or 'mesomere' (see e.g., Verhoeff 1910, Schubart 1934, Golovatch et al. 2004). This process, unlike a 'true' mesomerite, is posterior rather than anterior as in most of the other julid tribes (Attems 1927) and does not form a forceps together with the promerite. Attems (1927) homologized this process with the posterior coxal process of *Cylindroiulus* and the paracoxal process of *Ommatoiulus* (as *Archiulus*). Whatever its name, this process cannot be regarded as a homologue of the 'true' mesomerite as seen in 'higher julids' or of the mesomerital processes as seen in Oncoiulini and Leucogeorginii (Enghoff 1987, Read 1990).

Hoffman (1980) listed 25 valid genera of Brachyiulini but noted that due to the general confusion that has applied to this tribe, he had "listed all names uncritically without regard to status, except in a few cases of very obvious synonymy". Of the 25 genera, two (*Chromatoiulus* Verhoeff, 1894, and *Heteroiulus* Verhoeff, 1897) were moved to another tribe, Leucogeorgiini (Mauriès 1983, see also Enghoff 1987), and the status of *Campodes* Koch, 1847, is still unsettled (Hoffman 1999). Seven genera are currently considered as valid, viz., *Acropoditius* Strasser, 1980 – described as a subgenus of *Rhamphidoiulus*, elevated to full genus by Enghoff (2007); *Anaulaciulus* Pocock, 1895; *Balkanophoenix* Verhoeff, 1937; *Brachyiulus* Berlese, 1883; *Grusiniulus* Lohmander, 1936; *Megaphyllum* Verhoeff, 1894 and *Rhamphidoiulus* Attems, 1905. With about 17 subgenera (some of them considered synonyms) *Megaphyllum* is by far the largest but also the most problematical brachyiulinine genus. The last comprehensive study of this genus (as *Chromatoiulus*) was given by Attems (1927) and subsequently by Strasser (1974, 1976). Golovatch et al. (2004) reviewed the subgenus *Persebrachyiulus* Golovatch, 1983 and commented on subgenus *Cyphobrachyiulus* Verhoeff, 1900, and Lazányi and Korsós (2011) revised the type species of *Megaphyllum*.

The assignment of *Titanophyllum* gen. n. and *Mammamia* gen. n. to Brachyiulini is based on purely typological considerations. They have gonopodal flagella and no mesomerites and therefore fall into the brachyiulinine 'pigeonhole'. In the classical key to subfamilies/tribes of Julidae by Verhoeff (1926–32: 1647 ff), both genera easily run to couplet XI/XII (Heteroiulinae vs. Brachyiulinae) but because of their blindness do not make it all the way to Brachyiulinae.

Non-monophyly of Brachyiulini as currently defined is quite probable and is indeed suggested by recent molecular analyses of the phylogeny of the family Julidae (Enghoff et al. 2011). In the cladogram of these authors, based on partial sequences of the mitochondrial 16S rRNA (16S) and the nuclear 28S rRNA (28S) genes, and including 40 species and 22 genera of julids, two of the three included brachyiulinine genera, *Brachyiulus* and *Megaphyllum,* appear as sister genera but well apart from the third, *Anaulaciulus*. Contrastingly, the latter forms a clade with *Nepalmatoiulus* Mauriès, 1983, a morphologically distant genus having the characteristic pro-/mesomerital forceps. Both, however, share the trait of being the only julids occurring in South East Asia (Enghoff et al. 2011).

Even though all genera of Brachyiulini agree in the absence of a 'pro-mesomerital' forceps and the presence of a flagellum, the brachyiulinine gonopods exhibit great variation in the degree of complexity, size and position of the processes (see Table 1). The nine valid genera also vary in peripheral characters such as the presence/absence of ocelli, frontal setae and preanal hook, as well as the length of the preanal projection. The peripheral character that best characterises the new genera described here vis-a-vis the rest of the tribe is the lack of eyes.

Table 1. Characters matrix for the brachyiulinine genera. Ac – *Acropoditius*; An – *Anaulaciulus*; Ba – *Balkanophoenix*; Br – *Brachyiulus*; Gr – *Grusiniulus*; Me – *Megaphyllum*; Rh – *Rhamphidoiulus*; Tit – *Titanophyllum*; Mam – *Mammamia*

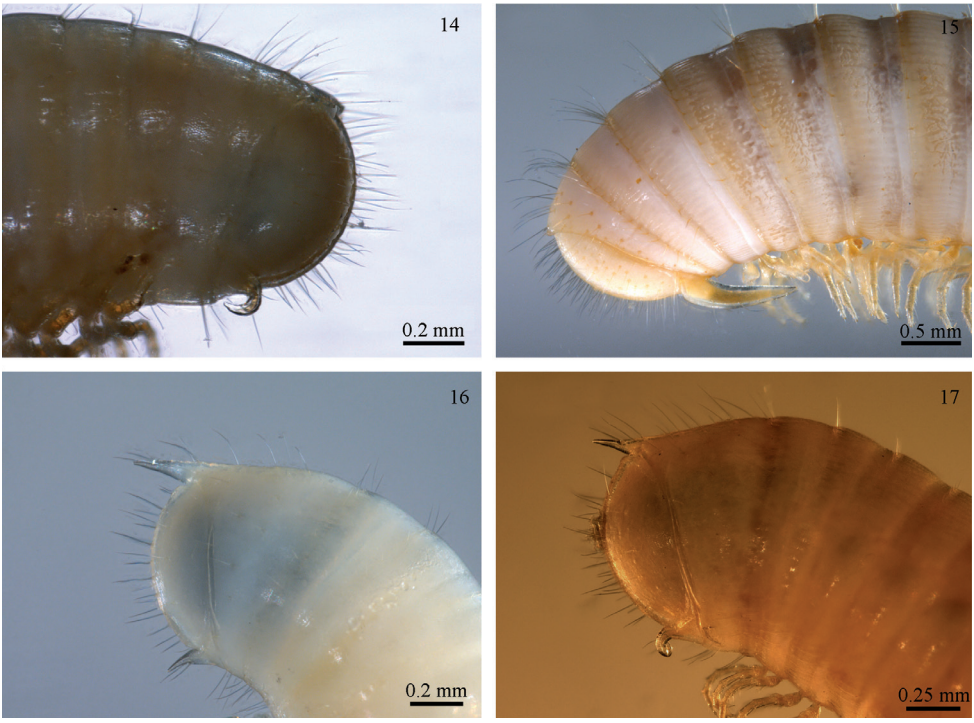
Character	**Ac**	**An**	**Ba**	**Br**	**Gr**	**Me**	**Rh**	**Tit**	**Mam**
Eyes	+	+	+	+	+	+	+	-	-
Frontal setae		+		+	+	+	+/-	+	-?
Subanal hook	-	-	-	-	-	-	-	+	-
Male mandibles with protruding lobe	+	-	-	+(all?)	+	+(all?)	+	-	-
Length of anterior gonopods compared to posterior gonopods	~as long	~half as long	~as long	~half as long	~half as long	~as long	~as long	¾ as long	longer
Anterior gonopods: flagelliferous lobe with very long, almost filamentous appendage	-	-	-	-	-	-	+	-	-
Anterior gonopods with a distal very long, almost filamentous appendage	+	-	-	-	-	-	-	-	-
Posterior gonopods simple, unipartite (S) vs. complex, bearing one or more processes distally (C)	S	C	C	C	C	C	S	S	C

Key to the genera of Brachyiulini based on gonopods and peripheral characters

1(4) Ocelli absent **2**
2(3) Subanal scale with a hook; promerite broad, incised apically, much shorter than posterior gonopods ..... ***Titanophyllum* gen. n.**
3(2) Subanal scale without a hook; promerite slenderer, distally expanded, slightly longer than posterior gonopods ..... ***Mammamia* gen. n.**
4(1) Ocelli present **5**
5(6) Promerite with a long, falcate appendage apically ..... ***Acropoditius***
6(5) Promerite without such an appendage **7**
7(8) Promerite with a long, straight filamentous process at midlength; posterior gonopods simple ..... ***Rhamphidoiulus***
8(7) Promerite a filamentous process; posterior gonopods complex **9**
9(15) Promerite half as long as posterior gonopod **10**
10(11) Male mandibular stipes with expanded lobes (Southeast Asia) ..... ***Anaulaciulus***
11(12) Male mandibular stipes without a lobe (Europe, Caucasus) **13**
13(14) Promerite simple; posterior gonopods with an anterior 'mesomerital' process ..... ***Brachyiulus***
14(13) Promerite complex, with a well developed ridge and a basal cavity mesally, apex subconcave; posterior gonopods without anterior 'mesomerital' process ..... ***Grusiniulus***
15(9) Promerite nearly as long as posterior gonopod **16**
16(17) Male mandibular stipes without a lobe; metazonital striation absent; mesomerital process lying well apart from the main stem of the posterior gonopods, separated by a deep, broad concavity ..... ***Balkanophoenix***
17(16) Male mandibular stipes with a lobe; metazonital striation present; mesomerital process usually lying in close proximity to the main stem of posterior gonopods ..... ***Megaphyllum***

Hooks and anchors in julid millipedes

Apart from the male gonopods, julid millipedes are relatively uniform in structure. There are some non-gonopodal characters in males that exhibit a certain degree of variability, as do the female cyphopods, but when it comes to non-sexual morphology, the diversity is modest and mostly concerns such details as size, colour, presence/absence of eyes, presence/absence of frontal and metazonital setae, length of preanal projection, etc. There are a few julid species, however, which stand out by having some remarkable apomorphies. The first such species to be described was *Unciger foetidus* (C.L. Koch, 1838). The generic name *Unciger* Brandt, 1841, refers to its peculiar character: a stout forward-pointing hook on the subanal scale (Fig. 15). The hook occurs in both sexes. Waga (1839) gave a detailed description of the early postembryonic development of *U. foetidus* (under the name *Iulus*



Figures 14–17. Hooks in julids: **14** *Titanophyllum spiliarum* **15** *Unciger transsilvanicus* (ZMUC) **16** *Syrioiulus* sp., Crete (ZMUC) **17** *Syrioiulus andreevi* (paratype, National Museum of Natural History, Sofia).

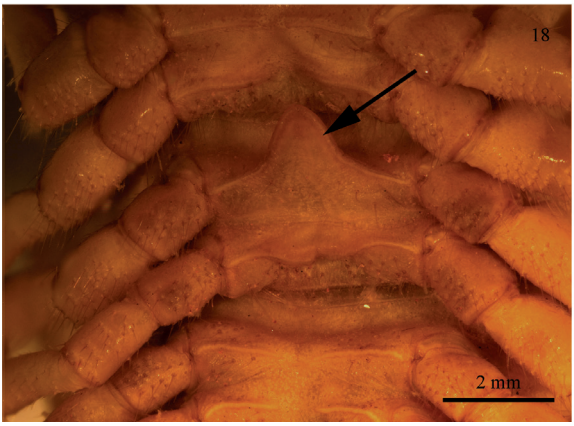
unciger Waga, 1839). He found that the subanal hook first makes its appearance in individuals with 15 pairs of legs, belonging to stadium III (cf. Enghoff et al. 1993). Two further species of the genus *Unciger* have been described, *U. transsilvanicus* (Verhoeff, 1899) (Fig. 15) and *U. kubanus* Lohmander, 1936, both having the characteristic subanal hook.

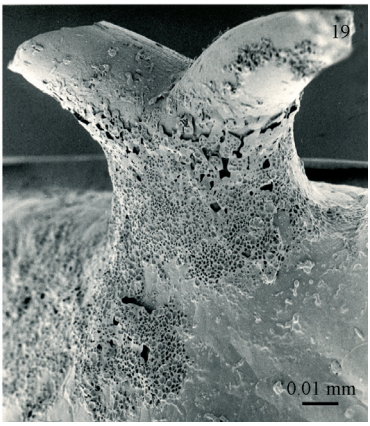
Strasser (1974) described another hook-bearing species: *Typhloiulus* (?) *uncinifer*, based on a juvenile collected on Cephalonia Island in Greece. As the question mark indicates, the assignment of this species to *Typhloiulus* is tentative – judged from the original description, the only indication in this direction is the lack of eyes. Ten years later, another julid with a hook on the subanal scale, *Syrioiulus andreevi* Mauriès, 1984 was described (Mauriès 1984), and now we add *Titanophyllum spiliarum* to the group possessing this peculiar character. We suspect that *Typhloiulus* (?) *uncinifer*, rather than belonging to the tribe Typhloiulini, may be related to *T. spiliarum*. Even if this is not true, we now have hook-bearing species belonging to at least three tribes: Oncoiulini (*Unciger*), Pachyiulini (*Syrioiulus*), and Brachyiulini (*Titanophyllum*). Although the monophyly of Brachyiulini is questionable, there is no doubt that subanal hooks have arisen independently three times. A further argument in support of this statement is that all other species of *Syrioiulus* have no hooks. However, an undescribed *Syrioiulus*

from Crete (Fig. 16) has a very prolonged subanal scale – perhaps a predecessor of the hook in *S. andreevi* (Fig. 17).

Occurring in adults (both sexes) as well as juveniles, this hook has probably no function in courtship or copulation. One possibility could be that the hook is a protective device: when a julid rolls up into a spiral, as many julids do when disturbed, the hook might be inserted under one metazonital hind margin, 'locking' the spiral and making it more difficult for a would-be predator to uncoil. The only structure remotely similar to the julid hook we have been able to identify in other millipedes is the paxillus in certain Gomphodesmidae, order Polydesmida (Hoffman 2005). The paxillus is a forward-directed triangular process on the sternal part of the 15th body ring (Fig. 18). The topographical position of the paxillus would make a function similar to that suggested for the julid hook possible (and gomphodesmids do spiral when disturbed, HE pers. obs.). On the other hand, the paxillus occurs only in male gomphodesmids, so its function may be of a sexual rather than a generally defensive nature.

The julid hook may be a spiral-locking device, but there would be a different way obtaining the same effect if a structure on the dorsal side of the body rings could anchor itself to the leg coxae on the spiralled millipede. In fact there is a single species with such a structure, namely *Chersoiulus sphinx* Strasser, 1940, from north-eastern Italy, Slovenia and Croatia. In this species, each body ring carries a tiny mid-dorsal 'anchor' on the posterior margin of the metazonites (Fig. 19). The function of the anchors, which are missing in the only known congener, *C. ciliatus* (Strasser, 1938), could very well be as suggested above for the subanal hooks. However, until somebody makes observations on behaviour of the hook- or anchor-bearing julids, the functional explanation given above remains entirely hypothetical.





Figures 18–19. Anchors and sternal processes in millipedes: **18** Sternal process (indicated by an arrow) in *Astrodesmus laxus* (Gerstäcker, 1873) (Gomphodesmidae) (ZMUC) **19** Anchor in *Chersoiulus sphinx* (ZMUC).

Acknowledgements

We want to express our gratitude to the late Professor Pietrio Parenzan, Taranto, and Dr. Petar Beron, Sofia, who made the specimens here described available to us. We are grateful to Peter Decker (Senckenberg Museum, Görlitz) for his kind assistance in taking some of the photographs. Many thanks are also due to two anonymous reviewers for their helpful comments. This project has partly been made possible with funding to PS from the EC FP6 Integrated Infrastructure Initiative Synthesys (DK-TAF).

References

Attems C (1927) Über palaearktische Diplopopden. Archiv für Naturgeschichte 92(1–2): 1–256.

Enghoff H (1987) Revision of *Nepalmatoiulus* Mauries 1983 – a southeast Asiatic genus of millipedes (Diplopoda: Julida: Julidae). Courier Forschungs-Institut Senckenberg 93: 241–331.

Enghoff H (2007) The millipedes of Turkey (Diplopoda). Steenstrupia 29: 175–198.

Enghoff H, Dohle W, Blower JG (1993) Anamorphosis in millipedes (Diplopoda) – the present state of knowledge with some developmental and phylogenetic considerations. Zoological Journal of the Linnean Society 109: 103–234. doi:10.1111/j.1096-3642.1993.tb00305.x

Enghoff H, Petersen G, Seberg O (2011) Phylogenetic relationships in the millipede family Julidae. Cladistics, published online 17 May 2011. doi:10.1111/j.1096-0031.2011.00360.x

Golovatch S, Spelda J, Wytwer J (2004) The millipede subgenus *Persebrachyiulus* Golovatch, 1983, genus *Megaphyllum* Verhoeff, 1894, with the description of a new species from Israel and Cyprus (Diplopoda: Julida: Julidae). Annales Zoologici 54 (4): 677–685.

Hoffman RL (1980) (for 1979) Classification of the Diplopoda. Muséum d'Histoire naturelle, Genève, 238 pp.

Hoffman RL (1999) Checklist of the millipedes of North and Middle America. Virginia Museum of Natural History, Special Publication 8, 584 pp.

Hoffman RL (2005) Monograph of the Gomphodesmidae, a family of African polydesmoid millipeds. Naturhistorisches Museum, Wien, 537 pp.

Lazányi E, Korsós Z (2011) Revision of the *Megaphyllum projectum* Verhoeff species complex (Myriapoda: Diplopoda: Julida: Julidae). Zootaxa 2864: 43–56.

Mauriès J-P (1982) *Dolichoiulus tongiorgii* (Strasser), diplopode halophile nouveau pour la faune de France. Remarques sur la classification des Pachyiulini (Myriapoda, Diplopoda, Iulida). Bulletin du Muséum national d'histoire naturelle, 4e série, Section A, Zoologie 4 (3–4): 433–444.

Mauriès J-P (1983) Myriapodes du Népal (Mission I. Löbl et A. Smetana 1981) I. Diplopodes Iuliformes (Iulida, Cambalida et Spirostreptida): *Nepalmatoiulus* nov. subgen. Revue suisse de Zoologie 90: 127–138.

Mauriès J-P (1984) Deux espèces nouvelles de Diplopodes cavernicoles des Cyclades: *Hyleoglomeris beroni* (Glomerida) et *Syrioiulus andreevi* (Iulida). Biologia gallo-hellenica 11: 37–49.

Read H (1990) The generic composition and relationships of the Cylindroiulini – a cladistic analysis (Diplopoda, Julida: Julidae). Entomologica Scandinavica 21: 97–112.

Schubart O (1934) Tausendfüßler oder Myriapoda. I: Diplopoda. Die Tierwelt Deutschlands und der angrenzenden Meeresteile 28: 1–318.

Strasser K (1974) Über Diplopoda-Chilognatha Griechenlands. Revue suisse de Zoologie 81(1): 219–300.

Strasser K (1976) Über Diplopoda-Chilognatha Griechenlands, II. Revue suisse de Zoologie 83(3): 579–645.

Verhoeff KW (1910) Über Diplopoden. 11.-15. (31.-35.) Aufsatz: Beiträge zur Kenntnis der Glomeriden, Juliden, Ascospermorpha und Lysiopetaliden, sowie zur Fauna Siziliens, Untersuchungen über Art- und Gruppensystematik; Morphologie, nachembryonale Entwicklung, Biologie und Geographie. Nova Acta der Kaiserlichen Leopoldinischen-Carolinischen Deutschen Akademie der Naturforscher 92(2): 139–448.

Verhoeff KW (1926–1932) Gliederfüssler: Arthropoda, Klasse Diplopoda. In HG Bronn: Bronn's Klassen und Ordnungen des Tier-Reichs, 5, II Abteilung, 2 Teil, 7–13 Lieferung, iii–vi: 1073–2084.

Waga AF (1839) Observations sur les Myriapodes. Revue zoologique par la Société Cuvierienne: 76–90, pl. I.

ZooKeys 114: 15–27 (2011)
doi: 10.3897/zookeys.114.1364
www.zookeys.org

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

Baeopterogyna mihalyii Matile (Diptera, Mycetophilidae): association of sexes using morphological and molecular approaches with the first description of females

Olavi Kurina[1], Erki Õunap[1,2,3], Gordon Ramel[4]

1 *Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences, Riia st 181, 51014 Tartu, Estonia* **2** *Institute of Ecology and Earth Sciences, University of Tartu, Vanemuise 46, EE-51014 Tartu, Estonia* **3** *Museum of Zoology, University of Tartu, Vanemuise 46, EE-51014 Tartu, Estonia* **4** *Ploy Plu Residency, 165/5 Moo 9, Pho Khum Rd., Rob Wiang Sub-District, Muang District, Chiang Rai. 57000, Thailand*

Corresponding author: *Olavi Kurina* (olavi.kurina@emu.ee)

Academic editor: *Vladimir Blagoderov* | Received 7 April 2011 | Accepted 27 May 2011 | Published 30 June 2011

Citation: Kurina O, Õunap E, Ramel G (2011) *Baeopterogyna mihalyii* Matile (Diptera, Mycetophilidae): association of sexes using morphological and molecular approaches with the first description of females. ZooKeys 114: 15–27. doi: 10.3897/zookeys.114.1364

Abstract

Both males and females of *Baeopterogyna mihalyii* Matile, 1975 are recorded from northern Greece. Females are described for the first time providing photographs of the general facies and terminalia. In contrast to the single congener with stenopterous females – *B. nudipes* Vockeroth, 1972 – *B. mihalyii* is shown to have normally developed wings in both sexes. Association of sexes is based on both morphological characters and sequence data from cytochrome oxidase subunit one (COI). DNA sequences are used for the first time for the association of sexes in Mycetophilidae.

New country record from Greece is provided for *Sciophila nigronitida* Landrock, 1925.

Keywords

Diptera, Mycetophilidae, *Baeopterogyna*, systematics, Europe, COI

Introduction

Baeopterogyna Vockeroth, 1972 is a small genus of Mycetophilidae including only two species: *B. nudipes* Vockeroth, 1972 from the Nearctic and *B. mihalyii* Matile, 1975 from the Palaearctic region, respectively. The genus belongs to the subfamily Sciophilinae and is most closely related to the *Neuratelia* Rondani (Vockeroth 1972,

Matile 1975a) distinguished from it by absence of distinct tibial bristles, setosity of the thorax and wing (Søli et al. 2000), and structure of the male terminalia. Both known species of *Baeopterogyna* have simple slender gonostyli compared to the complex convoluted gonostyli of *Neuratelia*. The type species – *B. nudipes* – was described by Vockeroth (1972) from North America (Yukon Territory and Alaska) but since then it has not been recorded. The European species – *B. mihalyii* – was described from Hungarian material (Matile 1975a) and subsequently it has been recorded in the Czech and Slovak Republics (Ševčík 1999, Chandler 2005). Females of *B. nudipes* are described as stenopterous (Vockeroth 1972) while females of *B. mihalyii* were so far unknown but, analogically to the congener, were also supposed to have reduced wings (e.g. Søli et al. 2000).

Since the introduction of the 'DNA barcoding' approach (Hebert et al. 2003), it has repeatedly been shown for different groups of organisms that the intraspecific genetic distances of the mitochondrial *COI* gene are in most cases at least a magnitude smaller than the interspecific genetic distances. Moreover, it has been demonstrated that sharing the same *COI* haplotype between different species is rare (Hebert et al. 2010, Raupach et al. 2010, Hausmann et al. 2011). Exceptions to these rules are not frequent and it has been shown that ambiguities have often been derived from taxonomically poorly known groups (Handfield and Handfield 2006; Ståhls and Savolainen 2008, Alexander et al. 2009). These findings have allowed the use of *COI* sequences in different approaches. In addition to being useful in identifying and delimiting species that are otherwise hard to distinguish (Janzen et al. 2005, Burns et al. 2008, Pauls et al. 2010), these so-called 'DNA barcodes' have been shown to be powerful tools in e.g. clarifying the status of morphologically different sexes or races of polymorphic species (Foottit et al. 2009, Janzen et al. 2009) and associating different life stages of insects (Zhou et al. 2007, Pauls et al. 2010). These two practices have repeatedly been implemented in earlier studies of Diptera (e.g. Carew et al. 2005, Ekrem et al. 2010, Stur and Ekrem 2011), but to the best of our knowledge, no attempts have been made to utilize them in research of Mycetophilidae. In this article, we implemented section from the 3' end of the *COI* gene, commonly used in the phylogenetic studies of the Mycetophilidae (Rindal et al. 2007, 2009). Despite this part of the *COI* does not overlap with the so-called ‚barcoding fragment' from near the 5' end of the gene, it still is influenced by the identical evolutionary processes as part of the same gene. Therefore, all predictions and conclusions regarding to the systematic utility of the ‚barcoding fragment' can be attributed to the 3' end of *COI*.

The current study was initiated by finding both sexes of *B. mihalyii* in Malaise trap samples from northern Greece. The aims of this article are to describe the so far unknown female of *B. mihalyii* and introduce a possibility of using *COI* sequence data for association of females and males of fungus gnat species.

Material and methods

Collection, illustration and morphological study

All *B. mihalyii* material was collected by GR from the Kerkini Lake area in Northern Greece south of the Bulgarian border. Despite an extensive Mycetophilidae material collected from the area during a survey of invertebrates from 2003 to 2009 (for details see Ramel et al. 2008 and http://www.ramel.org/lake-kerkini/project.html), only samples from one home-made Malaise trap yielded 11 specimens of *B. mihalyii*. The trap was situated over the bog from where the Sultanitsa stream springs and faced down hill into a beech (*Fagus sylvatica*) forest. All material was initially collected and preserved in 70% ethanol while the final preservation method of the studied specimens is indicated in Table 1. For detailed study of terminalia they were detached and cleared in solution of KOH, followed by neutralization in acetic acid and washing in distilled water (see also Kurina 2003). The remaining chitinous parts were either (1) inserted into glycerine for study and photography and thereafter preserved as glycerine preparations in polyethylene micro vials or (2) slide-mounted in Euparal following the method described by Kurina (2008). After detaching the terminalia, the remaining part of the abdomen was used for molecular study while the rest of body was slide-mounted. Some male specimens are preserved in alcohol or dry-mounted in accordance with the method dercribed by Vockeroth (1966). The habitus photos were taken in alcohol using a Canon EOS7D camera fitted with a Canon MP-E65 (F2.8 1–5 x) lens. Illustrations of male and female terminalia are combined using Helicon Focus 4.7 software, from several partly focused images taken with a Leica DFC295 camera attached to an Olympus CX31 compound microscope. Morphological terminology follows Søli (1997).

The material has been deposited in IZBE (Institute of Agricultural and Environmental Science, Estonian University of Life Sciences, former Institute of Zoology and Botany) and all specimen data have been inserted into the database of Estonian animal collections (Abarenkov et al. 2010, see also http://elurikkus.ut.ee/collections.php?lang=eng). All specimen information including photographs is available also on the Fungus Gnats Online website (www.sciaroidea.info/taxonomy/45717).

Molecular techniques

The genomic DNA was extracted using a High Pure PCR Template Preparation Kit (Roche Diagnostics GmbH, Mannheim, Germany). Anterior segments of the abdomen that had been stored after genitalia dissection were crushed and used for the extraction. This process was carried out following the manufacturer's instructions for extraction of genetic material from mammalian tissue.

Table 1. Details of specimens used for taxonomic study and molecular analysis

Voucher No	Species	Sex	Collecting site, collecting method and collector	Date	Method of preservation	GenBank acc. code for COI
IZBE0200002	*Allocotocera pulchella* (Curtis, 1837)	♂	Estonia, Palupõhja 58°25'54,68"N 26°14'28,90"E, Malaise trap, Soon, V. leg.	25.vii – 4. viii 2009	Abdomen used for DNA sequencing; terminalia in glycerin; rest of body dry mounted from ethanol	JN007851
IZBE0200003		♀			Abdomen used for DNA sequencing; terminalia in glycerin; rest of body dry mounted from ethanol	JN007851
IZBE0200004	*Baeopterogyna mihalyii* Matile, 1975	♂	Greece, Central Macedonia, Kerkini lakes area, village Neo Petritsi, Sultanitsa site, 41°19'02,1"N 023°12'05,0"E, 1485 m a.s.l., Malaise trap, Ramel G. leg.	12 – 18.v 2008	In ethanol	
IZBE0200005		♂			In ethanol	
IZBE0200006		♀			Abdomen used for DNA sequencing; terminalia in glycerin; rest of body in ethanol	JN007850
IZBE0200007		♂		19 – 25. v 2008	Abdomen used for DNA sequencing; rest of body and terminalia slide mounted	JN007850
IZBE0200008		♂			Abdomen used for DNA sequencing; terminalia in glycerin; rest of body in ethanol	JN007850
IZBE0200009		♂			Slide mounted under 5 different coverslips	
IZBE0200010		♂			In ethanol	
IZBE0200011		♂			In ethanol	
IZBE0200012		♂		25.v – 1. vi 2008	Abdomen used for DNA sequencing; rest of body and terminalia slide mounted	JN007850
IZBE0200013		♂			In ethanol	
IZBE0200014		♀			Abdomen used for DNA sequencing; terminalia in glycerin; rest of body slide mounted	JN007850
IZBE0200015	*Sciophila nigronitida* Landrock, 1925	♂	Greece, Central Macedonia, Kerkini lakes area, village Neo Petritsi, Farfara site, 41°19'30,5"N 023°15'00,1"E, 750 m a.s.l., Malaise trap, Ramel G. leg.	16 – 22. vi 2008	Abdomen used for DNA sequencing; terminalia in glycerin; rest of body dry mounted from ethanol	JN007853
IZBE0200016		♀			Abdomen used for DNA sequencing; terminalia in glycerin; rest of body dry mounted from ethanol	JN007852

A 762-bp fragment of cytochrome C oxidase subunit 1 (*COI*), corresponding to positions 2228–2989 of the mitochondrial genome of *Drosophila melanogaster* Meigen, 1830 (RefSeq NC_001709) was amplified and sequenced using primers C1-J-2195 (5'-TTGATTTTTTGGTCACCCTGAAGT-3') and TL2-N-3014 (5'-TCCAATG-CACTAATCTGCCATATTA-3') (Simon et al. 1994). PCR was performed in a total volume of 20 µl, with the reaction mixture containing 1X BD Advantage 2 PCR buffer, 1U BD Advantage 2 Polymerase mix (BD Biosciences, San Jose, USA), 0.2 mM dNTP (Fermentas, Vilnius, Lithuania), 4 pmol of primers and 20–80 ng of purified genomic DNA. PCR was carried out in a Biometra T1 Thermocycler (Biometra, Göttingen, Germany), its conditions were an initial denaturation at 94°C for 2 min, 35 cycles of 30 s at 94°C, 30 s at 50°C and 1 min at 68°C, followed by a final extension at 68°C for 7 min. PCR products were visualised on a 1.6% agarose gel, and 10 µl of the PCR solution was treated with fast alkaline phosphatase and exonuclease I (Fermentas). DNA cycle sequencing was performed in a total volume of 10 µl using the Big Dye Terminator v.3.1 Cycle Sequencing Kit (Applied Biosystems, Foster City, USA). Cycling conditions were: initial denaturation for 1 min at 96°C followed by 25 cycles of 10 s at 95°C, 15 s at 47°C and 4 min at 60°C. Both DNA strands were sequenced using 1.6 pmol of primers. The sequences were resolved on a 3730xl DNA Analyzer (Applied Biosystems).

Phylogenetic analysis

In total, 9 specimens including three species of fungus gnats from the subfamily Sciophilinae were analysed. In addition to 3 males and 2 females of *B. mihalyii*, both sexes of *Allocotocera pulchella* (Curtis 1837) and both sexes of *Sciophila nigronitida* Landrock, 1925, the latter as an outgroup, were included. For detailed information about specimens see Table 1.

Consensus sequences were created with the program Consed (Gordon et al. 1998) using sequence data from both DNA strands. Sequences were double-checked by eye and aligned with ClustalW (Thompson et al. 1994), using BioEdit (Hall 1999) as a sequence editor. Modeltest 3.06 (Posada and Crandall 1998) was used to search for the optimal model of DNA substitution. Bayesian phylogenetic inference, maximum likelihood (ML), maximum parsimony (MP) and neighbour-joining (NJ) approaches were all used to evaluate the robustness of the phylogenetic analysis. The GTR+I model, selected by Modeltest using Akaike Information Criterion, was implemented for NJ and ML analysis in PAUP*4.0b10 (Swofford 1998). Branch supports were assessed using 1000 bootstrap replicates. MP analysis with simple addition of taxa was also performed in PAUP and resulted in a single most parsimonious tree. Branch supports for this tree were assessed using 1000 bootstrap replicates, with 10 heuristic searches and simple addition of taxa used for each replicate. ML, NJ and MP trees were visualised in TreeView 1.6.6 (Page 1996).

Bayesian phylogenetic analysis implementing the GTR+I model was performed using MrBayes 3.1 (Ronquist and Huelsenbeck 2003). Four simultaneous Markov

chains (one cold and three heated) were run for 4 million generations, with trees sampled every 1000 generations. Likelihood values were inspected, and the first 1000 sampled trees were discarded as 'burn-in'. To estimate posterior probabilities of recovered branches, a 50% majority rule was applied. Phylograms were created as average-branch-length consensus trees and visualised in TreeView 1.6.6**.**

Results and discussion

For determination of male material of *B. mihalyii*, the key to mycetophilid genera by Søli et al. (2000) was used successfully. In addition, male specimens were compared with type material of *B. nudipes* (paratypes, 2♂♂, in MNHN; see also Vockeroth 1972) and they were found to be congeneric. Primary association of sexes of *B. mihalyii* was based on simultaneous finding of females and males that were morphologically similar, except characters in terminalia, in the same sample. However, these females have normally developed wings while those of *B. nudipes* are stenoperous (Matile 1975a, Søli et al. 2000). Moreover, they lack setae on the upper part of the anepisternum which are present in males, a character that is considered diagnostic of the genus by Søli et al. (2000). Therefore, additional support by COI sequence data was needed to associate the sexes of *B. mihaylii* unambiguously.

All specimens identified preliminarily as *B. mihalyii* according to their morphological characteristics carried identical COI haplotypes, and the same applied for both *A. pulchella* individuals, thus proving that morphology-based identification was correct. The *S. nigronitida* specimens, however, carried different COI haplotypes at one locus corresponding to position 2508 of the full mitochondrial genome of *D. melanogaster* (RefSeq NC_001709); the male had an adenine nucleotide, whereas the female had a guanine nucleotide. Since the genetic distance between these two specimens is only 0,13%, i. e. significantly below the average pairwise distance between individuals belonging to different species (Hebert et al. 2010, Raupach et al. 2010, Hausmann et al. 2011), we conclude that their conspecificity is not under question. Due to the non-existing or minimal genetic distance between the conspecific individuals, all three species formed clearly monophyletic well-supported lineages in the phylogenetic trees (Figure 1). Concerning the main question of the current article, we conclude that it has been proven that the hitherto unknown females of *B. mihalyii* have fully developed wings in contrast to the stenopterous females of its only known congener, *B. nudipes*.

Among the species used for phylogenetic analysis also *Sciophila nigronitida* is representing the first record from Greece (for collecting details see Table 1).

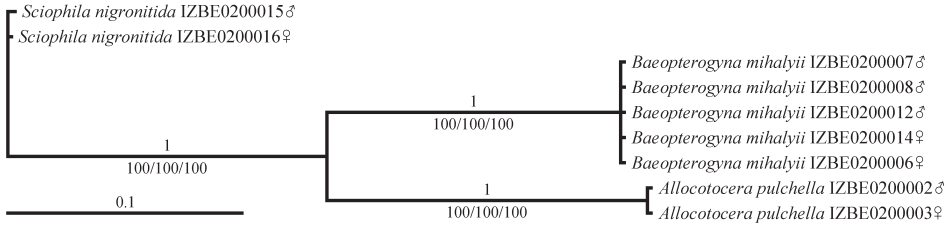


Figure 1. Bayesian phylogenetic tree (GTR+I model) of selected Mycetophilidae taxa, based on a 762 bp fragment of a *COI* gene. Bayesian posterior probabilities are given above the branches; bootstrap support for the ML/NJ/MP trees, which exhibited identical topology, are presented below the branches.

Taxonomy

***Baeopterogyna mihalyii* Matile, 1975**
http://species-id.net/wiki/Baeopterogyna_mihalyii
Figs 2, 3

Material studied: 9♂♂ 2♀♀, for collecting data see Table 1: voucher numbers from IZBE0200004 to IZBE0200014.

Female (Figs 2a, 2c – 2f, 3a – 3c).

Description. Length of body 4.65 – 4.94 mm (n=2).

Head brown with dark setae. Three equally sized ocelli in a triangular arrangement. Clypeus subrounded. Palpus with 5 light brown setose segments with ratios of 1: 1.17:1.58: 2.25:4.33. Mouthparts brownish. Antenna with 2+14 segments. Scape, pedicel and base of first flagellar segment light brown, rest of flagellomeres brown. Scape with sparse setae including dorsoapicals extending to middle of pedicel. Pedicel with sparse and all flagellomeres with dense setae. First flagellomere 3 times as long as wide, succeeding segments gradually shorter. Apical flagellomere cylindrical, about three times as long as wide.

Thorax brown. Scutum covered with pale setae including long lateral hairs. Lateral parts of thorax slightly paler than scutum. Antepronotum with numerous long pale hairs. Proepisternum with numerous shorter setae. Laterotergite and mediotergite with upward directed hairs. Anepimeron and metepisternum with short setae, anepisternum bare. Scutellum with setae not in distinct pairs.

Legs. Fore coxa light brown with hind margin and apical fourth yellow. Mid and hind coxae brown, apically slightly paler. All trochanters brown. All femora and tibiae yellow with apical brown markings. All tarsi dark brown. Tibiae with irregularly arranged setae but without distinct bristles. Fore tibia with a spur 0.18 of basitarsus length. Mid and hind tibiae both with two equal spurs, 0.19 and 0.21 of basitarsus length, respectively. Ratio of femur to tibia for fore, mid and hind legs: 1.00; 0.82; 0.81. Ratio of tibia to basitarsus for fore, mid and hind legs: 1.15; 1.57; 1.86.

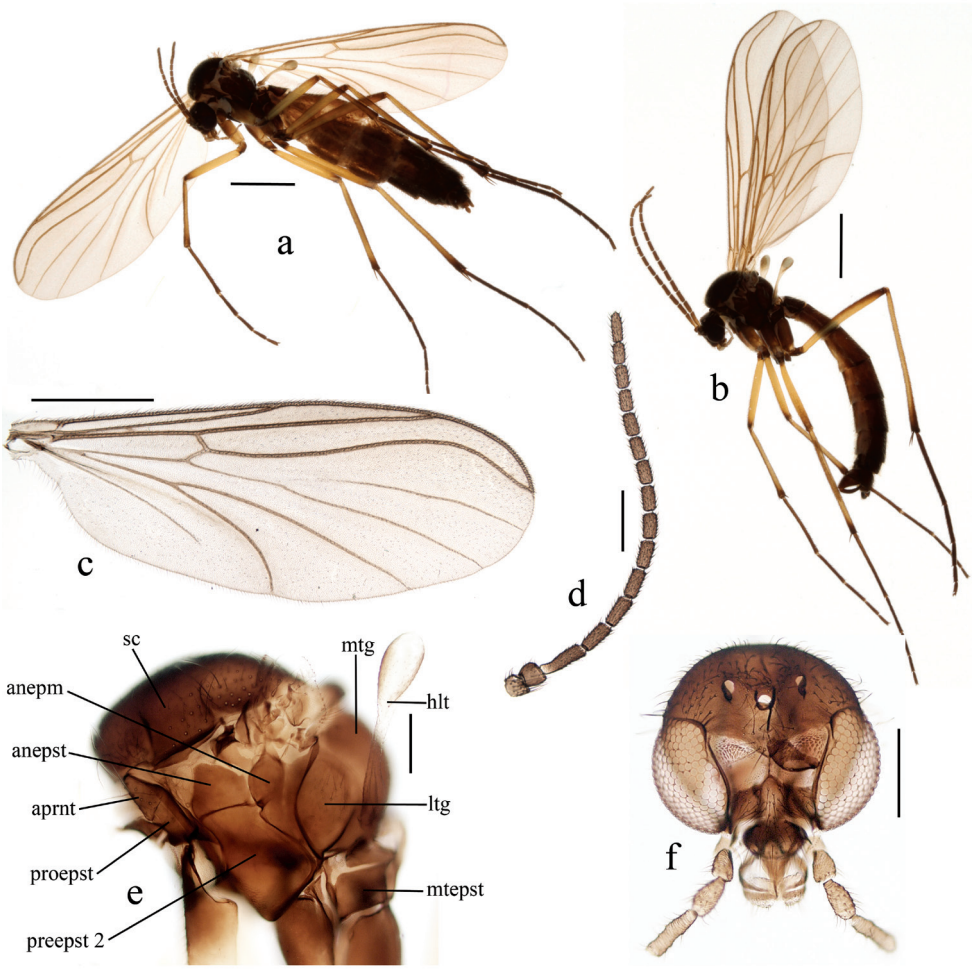


Figure 2. *Baeopterogyna mihalyii.* **a** female **b** male **c** female wing **d** female antenna **e** female thorax **f** female head (last palpal segments absent). Scale = 1 mm (a, b, c), 0.2 mm (d, e, f).
anepm = anepimeron; anepst = anepisternum; aprnt = antepronotum; htl = halter; ltg = laterotergite; mtepst = metepisternum; mtg = mediotergite; proepst = proepisternum; preepst = preepisternum; sc = scutum.

Wing hyaline. Length of wing 4.00 – 4.23 mm (n=2). Ratio of length to width 2.83. Veins light brown, setose on both surfaces. Wing membrane with dense irregularly arranged microtrichia and with few macrotrichia in anal area and close to wing tip below of R_1 and R_5. C not produced beyond apex of R_5, which is strongly sinuate. Sc ends in C at the level of beginning of medial fork. Sc_2 situated at the level of middle of bM-Cu. M_1 basally obsolete. Cubital fork begins slightly before the base of r-m. Haltere pale with brownish knob. Both, stem and knob with short setae.

Abdomen brown with segments I–IV lighter. Terminalia (Figs 3a, 3b, 3c) light brown. Cercus distinctly two-segmented, segments with subequal length, proximal segment more than twice as wide as distal. Tergite VIII subquadrate, as large as tergite IX and

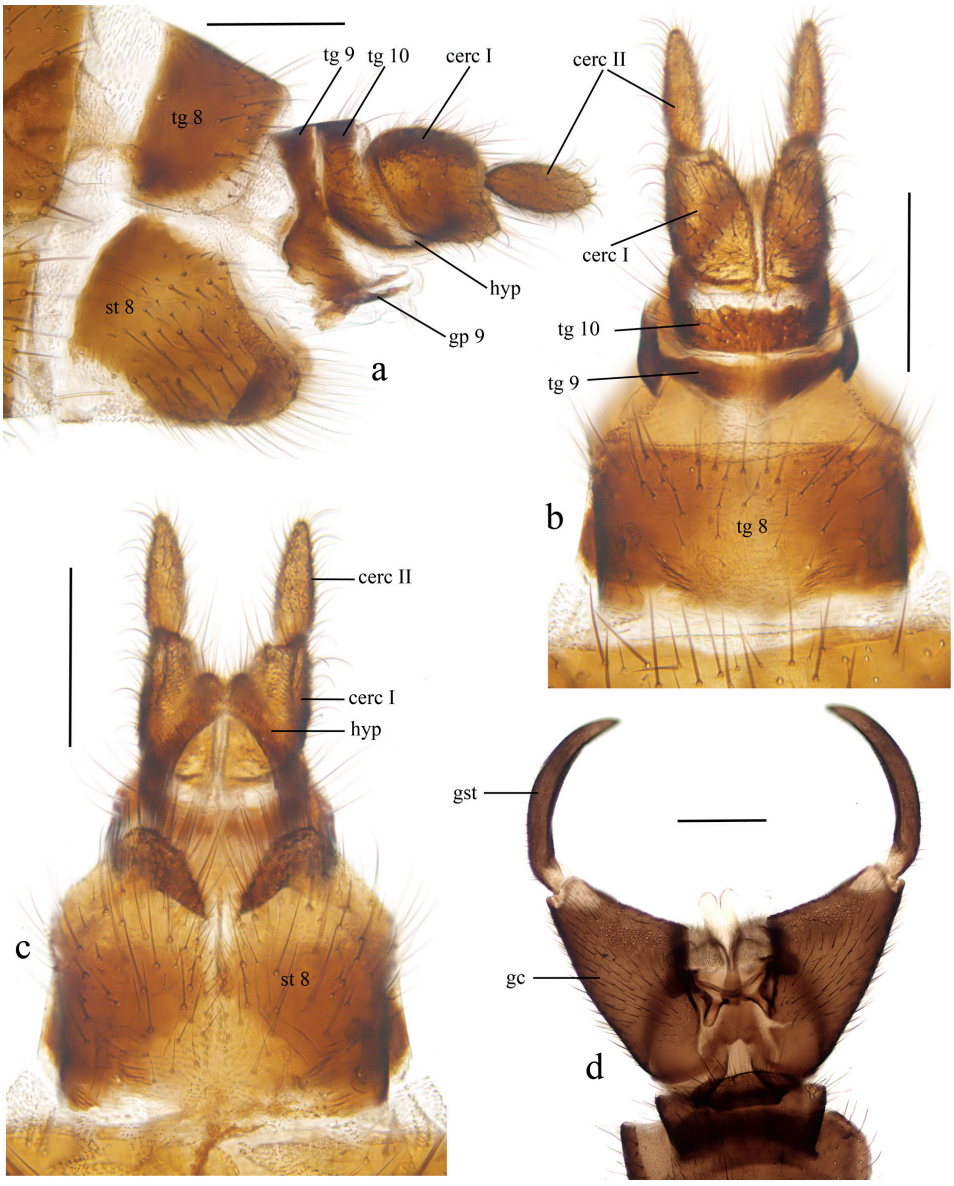


Figure 3. *Baeopterogyna mihalyii*. **a** female terminalia, lateral view **b** female terminalia, dorsal view **c** female terminalia, ventral view **d** male terminalia, ventral view. Scale = 0.2 mm.
cerc = cercus; gc = gonocoxite; gp = gonapophysis; gst = gonostylus; hyp = hypoproct; st = sternite; tg = tergite

tergite X together. Sternite VIII with deep ventral cleft. Gonapophysis IX well sclerotized and visible in lateral view. Hypoproct with apical incision, exposed in ventral view.

Male (Figs 2b, 3d).

Length of body 5.36 – 6.32, 5.65 mm (n=5). Length of wing 4.37 – 5.30, 4.76 mm (n=5), ratio of length to width 2.55 – 2.82, 2.64 (n=5). Coloration and other

non-terminal characters similar to female except anepisternum, which has short setae on upper part. Terminalia brown. Gonostylus simple, without any additional lobes or spines, slender, tapering, curved medially and covered with short setae.

Conclusive remarks

Vockeroth (1972) described *B. nudipes* in both sexes. In contrast to the normally developed wings in male specimens, the wings in females were greatly reduced: narrow and extending only to the apex of second abdominal tergite. Female halteres were also reduced, with a weak knob (cf. Vockeroth 1972: Figs 2, 5, 6). As the description of females based on two specimens from separate samples (although from the same locality: Herschel Island in Yukon Territory, Canada), this peculiarity cannot be argued as a possible aberration. Hackman (1964) summarized the knowledge of wing reduction in Diptera and discussed, among others, low temperature and wind-exposed habitats like oceanic islands as the causes. In addition to *B. nudipes* from an arctic habitat, only a few fungus gnats (Sciaroidea excl. Sciaridae) are described with reduced wings. *Macrocera crozetensis* Colless, 1970 with stenopterous females (cf. Matile 1975b: Figs 2, 3) has been described from the subantarctic Crozet Islands and *Mycetophila brachyptera* Duret, 1989 with two forms, one of them brachypterous (cf. Duret 1989: Figs 9 – 15), has been described from cold and wet forest of the Argentine-Chilean Patagonia. *Moriniola grilloti* Matile, 1976 with reduction of wing width in females (cf. Matile 1976: Fig. 1) has been described from the Afrotropics (Mayombe, Congo). In most cases, the reduction is obviously caused by the extreme habitat in which the species lives and is a characteristic only of females. This is an adaptive response to environmental pressure and can provide fitness advantages as shown in female flightlessness of some geometrid moths (e.g. Wahlberg et al. 2010). This type of reduction cannot be expected in congeners that inhabit more favourable habitats and finding *B. mihalyii* with normally developed wings of both sexes in central Europe is therefore not surprising.

Acknowledgments

The study was funded by Estonian Science Foundation grants 7558 and 8583, targeted financing projects SF0170160s08 and SF0180122s08, and by the European Union through the European Regional Development Fund (Center of Excellence FIBIR). OK is grateful to the European Commission's Research Infrastructure for funding the study visit to MNHN via the SYNTHESYS programme (FR-TAF-5005) and is much obliged to the curator Dr. Christophe Daugeron (MNHN) for the opportunity to work with the collections in Paris. We thank Tuuli Reisberg (Estonian Biocentre, Tartu, Estonia) for technical assistance with sequencing. Peter Chandler (Melkshamn, United Kingdom) and Peter Kerr (Sacramento, USA) are acknowledged for their comments and suggestions to the manuscript.

References

Abarenkov K, Tedersoo L, Nilsson RH, Vellak K, Saar I, Veldre V, Parmasto E, Prous M, Aan A, Ots M, Kurina O, Ostonen I, Jõgeva J, Halapuu S, Põldmaa K, Toots M, Truu J, Larsson, K-H, Kõljalg U (2010) PlutoF – a web based workbench for ecological and taxonomic research, with an online implementation for fungal ITS sequences. Evolutionary Bioinformatics 6: 189–196.

Alexander LC, Delion M, Hawthorne DJ, Lamp WO, Funk DH (2009) Mitochondrial lineages and DNA barcoding of closely related species in the mayfly genus *Ephemerella* (Ephemeroptera: Ephemerellidae). Journal of the North American Benthological Society 28: 584–595. doi:10.1899/08-150.1

Burns JM, Janzen DH, Hajibabaei M, Hallwachs W, Hebert PDN (2008) DNA barcodes and cryptic species of skipper butterflies in the genus *Perichares* in Area de Conservacio´ n Guanacaste, Costa Rica. Proceedings of the National Academy of Sciences of the United States of America 105: 6350–6355. doi:10.1073/pnas.0712181105

Carew ME, Pettigrove V, Hoffmann AA (2005) The utility of DNA markers in classical taxonomy: using cytochrome oxidase I markers to differentiate Australian *Cladopelma* (Diptera: Chironomidae) midges. Annals of the Entomological Society of America 98: 587–594. doi:10.1603/0013-8746(2005)098[0587:TUODMI]2.0.CO;2

Chandler PJ. (2005) Fauna Europaea: Mycetophilidae. – In: de Jong H (Ed) Fauna Europaea: Diptera, Nematocera. Fauna Europaea version 1. 2. Available from: http://www.faunaeur.org [accessed 15.02.2011]

Colless D (1970) A new species of *Macrocera* from the Crozet Islands (Diptera: Mycetophilidae). Proceedings of the Royal Entomological Society of London (B) 39: 27–28. doi:10.1111/j.1365-3113.1970.tb00249.x

Duret JP (1989) El genero *Mycetophila* Meigen, 1803, en la Patagonia (Diptera, Mycetophilidae). Parte 13. Descripcion de *Mycetophila brachyptera* sp. n. Boletin de la Sociedad de Biologia de Concepción 60: 111–122.

Ekrem T, Stur E & Hebert PDN (2010) Females do count: Documenting Chironomidae (Diptera) species diversity using DNA barcoding. Organisms Diversity & Evolution 10: 397–408. doi:10.1007/s13127-010-0034-y

Foottit RG, Maw HEL, Pike KS (2009) DNA barcodes to explore diversity in aphids (Hemiptera Aphididae and Adelgidae). Redia XCII: 87–91.

Gordon D, Abajian C, Green P. (1998) Consed: a graphical tool for sequence finishing. Genome Research 8: 195–202.

Hackman W (1964) On reduction and loss of wings in Diptera. Notulae Entomologicae 44: 73–93.

Hall TA (1999) BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. Nucleic Acids Symposium Series 41: 95–98.

Handfield D, Handfield L (2006) A new species of *Plusia* (Lepidoptera: Noctuidae) from North America. The Canadian Entomologist 138: 853–859. doi:10.4039/n06-041

Hausmann A, Haszprunar G, Hebert PDN (2011) DNA Barcoding the Geometrid Fauna of Bavaria (Lepidoptera): Successes, Surprises, and Questions. PLoS ONE 6(2): e17134. doi:10.1371/journal.pone.0017134

Hebert PDN, Cywinska A, Ball SL, deWaard JR (2003) Biological identification through DNA barcodes. Proceedings of the Royal Society B: Biological Sciences 270: 313–321. doi:10.1098/rspb.2002.2218

Hebert PDN, deWaard JR, Landry J (2010) DNA barcodes for 1/1000 of the animal kingdom. Biology Letters 6: 359–362. doi:10.1098/rsbl.2009.0848

Janzen DH, Hajibabaei M, Burns JM, Hallwachs W, Remigio E, Hebert PDN (2005) Wedding biodiversity inventory of a large and complex Lepidoptera fauna with DNA barcoding. Philosophical Transactions of the Royal Society B 360: 1835–1845. doi:10.1098/rstb.2005.1715

Janzen DH and 44 authors (2009) Integration of DNA barcoding into an ongoing inventory of complex tropical biodiversity. Molecular Ecology Resources 9 (s1): 1–26. doi:10.1111/j.1755-0998.2009.02628.x

Kurina O (2003) Notes on the Palaearctic species of the genus *Polylepta* Winnertz (Diptera : Mycetophilidae) with a new synonymization. Entomologica Fennica, 14(2): 91–97.

Kurina O (2008) *Cluzobra matilei* sp. n. from French Guyana, with notes on congeners (Diptera: Mycetophilidae). Zootaxa 1874: 63–68.

Matile L (1975a) Découverte du genre *Baeopterogyna* en Région paléarctique; description d'une espèce nouvelle de Hongrie (Diptera, Mycetophilidae). Cahiers des naturalistes, Bull. N. P., n. s. 29 (1973): 87–88.

Matile L (1975b) Un nouveau cas de brachyptérisme chez les Diptères Mycetophilidae: la femelle de *Macrocera crozetensis* Colless. Bulletin de la Société entomologique de France 80: 2–6.

Matile L (1976) Un genre nouveau de Mycomyini à nervation alaire reduite; diagnose préliminaire (Dipt., Mycetophilidae Sciophilinae). Bulletin de la Société entomologique de France 81: 139–140.

Page RD (1996) TreeView: an application to display phylogenetic trees on personal computers. Computer Applications in the Biosciences 12: 357–358.

Pauls SU, Blahnik RJ, Zhou X, Wardwell CT, Holzenthal RW (2010) DNA barcode data confirm new species and reveal cryptic diversity in Chilean Smicridea (Smicridea) (Trichoptera: Hydropsychidae). Journal of the North American Benthological Society 29: 1058–1074. doi:10.1899/09-108.1

Posada D, Crandall KA (1998) MODELTEST: testing the model of DNA substitution. Bioinformatics 14: 817–818. doi:10.1093/bioinformatics/14.9.817

Ramel G, Baquero E, Jordana R (2008) Biodiversity of the Collembola Fauna of Wetland Kerkini (N. Greece), with description of the sexual dimorphism of *Entomobrya atrocincta* Schött 1896 (Collembola: Entomobryomorpha). Annales de la Société Entomologique de France *(N.S.)*, 44 (1): 113–128.

Raupach MJ, Astrin JJ, Hannig K, Peters MK, Stoeckle MY, Wägele J (2010) Molecular species identification of Central European ground beetles (Coleoptera: Carabidae) using nuclear rDNA expansion segments and DNA barcodes. Frontiers in Zoology 7: 26. doi:10.1186/1742-9994-7-26

Rindal E, Søli GEE, Kjærandsen J, Bachmann L (2007) Molecular phylogeny of the fungus gnat tribe Exechiini (Mycetophilidae, Diptera). Zoologica Scripta 36: 327–335. doi:10.1111/j.1463-6409.2007.00285.x

Rindal E, Søli GEE, Bachmann L (2009) On the systematics of the fungus gnat subfamily Mycetophilinae (Diptera): a combined morphological and molecular approach. Journal of Zoological Systematics and Evolutionary Research 47: 227–233. doi:10.1111/j.1439-0469.2008.00498.x

Ronquist F, Huelsenbeck JP (2003) MrBayes 3: Bayesian phylogenetic inference under mixed models. Bioinformatics 19: 1572–1574. doi:10.1093/bioinformatics/btg180

Simon C, Frati F, Beckenbach A, Crespi B, Liu H, Flook P (1994) Evolution, weighing, and phylogenetic utility of mitochondrial gene sequences and a compilation of conserved polymerase chain reaction primers. Annals of the Entomological Society of America 87: 651–707.

Søli GEE (1997) On the morphology and phylogeny of Mycetophilidae, with a revision of *Coelosia* Winnertz (Diptera, Sciaroidea). Entomologica Scandinavica Supplement 50: 1–139.

Søli GEE, Vockeroth RJ, Matile L (2000) A. 4. Families of Sciaroidea. In: Papp L, Darvas B (Eds) Contribution to a Manual of Palaearctic Diptera. Appendix. Science Herald, Budapest, 49–92.

Ståhls G, Savolainen E (2008) MtDNA COI barcodes reveal cryptic diversity in the *Baetis vernus* group (Ephemeroptera, Baetidae). Molecular Phylogenetics and Evolution 46: 82–87. doi:10.1016/j.ympev.2007.09.009

Stur E, Ekrem T (2011) Exploring unknown life stages of Arctic Tanytarsini (Diptera: Chironomidae) with DNA barcoding. Zootaxa 2743: 27–39.

Swofford DL (1998) PAUP*: Phylogenetic Analysis Using Parsimony (*And Other Methods), Version 4.0b10. Sinauer Associates, Massachusetts.

Ševčík J (1999) Fifty species of fungus gnats (Diptera: Mycetophilidae) new for the Czech Republic and/or Slovakia, including a new species of *Allodia* Winnertz. Časopis Slezského zemského muzea, Opava (A) 48: 97–105.

Thompson JD, Higgins DG, Gibson TJ (1994) ClustalW: improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position specific gap penalties and weight matrix choice. Nucleic Acids Research 22: 4673–4680. doi:10.1093/nar/22.22.4673

Vockeroth JR (1966) A method of mounting insects from alcohol. The Canadian Entomologist 98: 69–70. doi:10.4039/Ent9869-1

Vockeroth JR (1972) A new Nearctic genus of Mycetophilidae (Diptera) with a stenopterous female. The Canadian Entomologist 104: 1529–1533. doi:10.4039/Ent1041529-10

Wahlberg N, Snäll N, Viidalepp J, Ruohomäki K, Tammaru T (2010) The evolution of female flightlessness among Ennominae of the Holarctic forest zone (Lepidoptera, Geometridae). Molecular Phylogenetics and Evolution 55(3): 929–938. doi:10.1016/j.ympev.2010.01.025

Zhou X, Kjer KM, Morse JC (2007). Associating larvae and adults of Chinese Hydropsychidae caddisflies (Insecta:Trichoptera) using DNA sequences. Journal of the North American Benthological Society 26: 719–742. doi:10.1899/06-089.1

ZooKeys 114: 29–40 (2011)
doi: 10.3897/zookeys.114.1310
www.zookeys.org

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

New species of the genus *Cyamops* Melander from New Zealand (Diptera, Periscelididae, Stenomicrinae)

Wayne N. Mathis[1,†], Masahiro Sueyoshi[2,‡]

1 *Department of Entomology, PO Box 37012, MRC 169; Smithsonian Institution, Washington, D.C. 20013-7012, USA* **2** *Forest Zoology Group, Kyushu Research Center, Forestry and Forest Products Research Institute, 4-11-16 Kurokami, Kumamoto, 860-0862 Japan*

† *urn:lsid:zoobank.org:author:343B52CC-CFFB-4DC1-AE3A-EC76D0C4B94A*
‡ *urn:lsid:zoobank.org:author:B69E84BD-3895-4E5C-890B-ED14DF1A749F*

Corresponding author: *Wayne N. Mathis* (mathisw@si.edu)

Academic editor: *Torsten Dikow* | Received 28 March 2011 | Accepted 3 June 2011 | Published 30 June 2011

urn:lsid:zoobank.org:pub:C03FC644-0ED2-4695-8527-B1BAD631CDC0

Citation: Mathis WN, Sueyoshi M (2011) New species of the genus *Cyamops* Melander from New Zealand (Diptera, Periscelididae, Stenomicrinae). ZooKeys 114: 29–40. doi: 10.3897/zookeys.114.1310

Abstract

Two new species of the genus *Cyamops* (Diptera: Periscelididae), the first from New Zealand, are described. The two newly described species are: *Cyamops alessandrae* and *C. crosbyi*. A key to the genera of the subfamily Stenomicrinae and to the species of *Cyamops* from the Australasian/Oceanian Region and detailed illustrations of structures of the male terminalia are provided.

Keywords

Diptera, Periscelididae (Stenomicrinae), new species, New Zealand

Introduction

The genus *Cyamops* Melander 1913 includes 30 valid species: two from the Afrotropical Region; 12 from the Australasian/Oceanian Region; three from the Nearctic Region, seven from the Neotropical Region, five from the Oriental Region, and one from

the Palearctic Region (Mathis and Rung 2011). Previously none was known from New Zealand. The purpose of this paper is to describe two new species from New Zealand that were recently discovered. These discoveries were made while conducting general research on acalypterates of this island nation.

To facilitate identification of these species, we have included a key to the genera of the subfamily Stenomicrinae and to the species of *Cyamops* from the Australasian/Oceanian Region (modified from the key produced by Baptista and Mathis 2000). We have also produced detailed illustrations of structures of the male terminalia of the new species.

Methods and materials

The descriptive terminology, with the exceptions noted in Baptista and Mathis (1994, 2000), is that published in the Manual of Nearctic Diptera (McAlpine 1981). The format for the species' description adheres to Baptista and Mathis (1994, 2000). Because specimens are small, less than 3.00 mm in length, study and illustration of the male terminalia requires use of a compound microscope. For most of the structures of the male terminalia, we follow the terminology adopted by other workers in Periscelididae (Baptista and Mathis 1994, 2000, Sueyoshi and Mathis 2004). The species' descriptions are composite and not based solely on holotypes.

Three venational ratios used in the descriptions of new species are based on the largest, smallest, and one other specimen and is defined as: (1) Wing ratio: straight line distance between wing base and apex/greatest straight line distance from anterior margin to posterior margin. (2) 1st costal ratio: the straight line distance between the apices of R_1 and R_{2+3} (costal section II)/distance between the apices of R_{2+3} and R_{4+5} (costal section III). (3) 2nd costal ratio: straight line distance between the apices of R_{2+3} and R_{4+5} (costal section IV)/distance between the apices of R_{4+5} and M (costal section III).

Most specimens examined as part of this study are deposited in the New Zealand Arthropod Collection (NZAC, Auckland, New Zealand). A few specimens have been deposited in the Smithsonian Institution (USNM) and California Department of Food and Agriculture (CDFA).

Dissections of male and female genitalia and descriptions were performed using the method of Clausen and Cook (1971) and Grimaldi (1987). Microforceps were used to remove abdomens, which were macerated in a hot sodium hydroxide solution. Cleared terminalia were rinsed in distilled water and 70% ethanol and then transferred to glycerin for observation. For long-term storage, abdomens were placed in an attached plastic microvial filled with glycerin and attached to the pin supporting the remainder of the insect from which it was removed.

Systematics

Key to genera of the subfamily Stenomicrinae

1 Frons with 1 pair of interfrontal setae; eyes bare. Katepisternum with 2 subequal setae. Hindfemur bearing anterodorsal, preapical seta..... .....***Planinasus*** **Cresson 1914**

– Frons lacking interfrontal setae; eyes microsetulose, sometimes sparsely. Katepisternum bearing 1 prominent seta. Hindfemur lacking anterodorsal, preapical seta.....**2**

2 Fronto-orbital setae reclinate or occasionally mesoclinate, lacking a proclinate seta; medial vertical seta present but with proclinate orientation; face in profile angulate, dorsal surface flattened. Supra-alar seta lacking; lateral scutellar setae 1 pair, apical. Crossvein bm-cu absent, making cells bm and dm confluent; vein CuA_2 weak or lacking; cell cu*p* lacking .*Stenomicra* Coquillett 1900

– Fronto-orbital setae comprising 1 proclinate and 1 reclinate setae; medial vertical seta absent; face in profile shallowly and vertically arched, lacking a flattened, dorsal area. Supra-alar seta present, well developed; lateral scutellar setae variable but usually 2. Crossvein bm-cu well developed, cell bm distinct from dm; vein CuA_2 present, well developed; cell cu*p* present..... ***Cyamops***

Genus *Cyamops* Melander 1913

http://species-id.net/wiki/Cyamops

Cyamops Melander 1913: 291. Type species: *C. nebulosus* Melander, by original designation. Sturtevant 1954: 557–559 [revision]. Hennig 1958: 633 [generic characters, relationships], 1969: 610–613 [discussion]. Sabrosky 1958: 169–171 [revision], 1965: 820 [Nearctic catalog]. Khoo 1985: 527–536 [revision, Australian species]. Khoo and Sabrosky 1989: 551 [Australasian/Oceanian catalog]. Baptista and Mathis 1994: 1–25 [revision, New World species], 2000: 481–506 [review]. Grimaldi 2009: 23–27 [revision, Fiji].

Description. Adult: Small flies, body length 1.65–3.30 mm, with slender habitus.

Head: Typically dark brown in ground color; fronto-orbits below the insertion of fronto-orbital setae, parafacial and genal region usually with silvery white microtomentum; occipital region shiny, sparsely microtomentose; lower face usually strongly microtomentose below genal region; median plate of clypeus shiny brown; head usually broader than thorax; postcranium strongly concave; eye bearing interfacetal setulae, shape of eye in profile more or less diagonal, lower anterior facets enlarged and encroaching on facial region more in males than in females (males and females of two species from Oceanic Region have the face with almost the same width); eyes closer together at lower edge of frons than at top of head; frons slightly longer than wide; ocel-

lar tubercle small, situated near vertex; mesofrons somewhat depressed, concave; antennal form as for other Periscelididae; arista 3-segmented (see D.K. McAlpine 1983), branched, in some species with basal bifurcate rays; face in profile nearly straight to distinctly angulate, ventral portion (below narrowest gap between eyes) more broadly developed, sometimes shallowly carinate medially, carina narrow to broad, but always broader in females; lower epistomal margin of midface extended around oral opening to form a narrow peristomal area; clypeus a large inverted U, somewhat retracted in males but easily visible in females; palpus short, compressed, with silver luster when viewed under certain angles. Chaetotaxy: Lateral vertical seta slightly to strongly divergent, curved outward; medial vertical and postocellar setae lacking; 2 pairs of fronto-orbital setae, inner pair reclinate, sometimes oriented outward, outer pair proclinate, in most cases pointed inward; inner fronto-orbital seta usually about 3/4 length of outer, rarely shorter; fronto-orbits typically bearing small setulae below setae; true vibrissa apparently absent, but uppermost pair of facial setae developed as porrect, anaclinate "pseudovibrissae," followed by a row of peristomal setulae and setae at margin of gena; pseudovibrissae sometimes placed externally to row of peristomal setae.

Thorax: Shiny, brown to dark brown, sparsely whitish microtomentose, microtomentum more dense at lower portion of katepisternum; calypter brown; postscutellum developed; greater ampulla convex; prosternum bare. Chaetotaxy: Acrostichal setulae in 2 more or less regular rows, slightly diverging behind, being strongly reduced in some species; dorsocentral setae 0+1 or 0+2, 1st seta, when present smaller, 1 row of dorsocentral setulae in front of setae; some setulae also present between acrostichal and dorsocentral rows in some species; supra-alar seta 1, preceded by small setulae, which can be sometimes strongly reduced; scutellum typically with 1 or 2 pairs of setae, basal pair, when present, smaller, notopleural setae 1+1, 1st seta usually longer; katepisternal seta 1, located dorsally (sometimes a 2nd, smaller and weaker seta is present); anepisternum bare or with 1 seta and few setulae along posterior margin. Wing: Costal vein without true costal breaks, but with a weakness before end of vein R_1; costal vein extended to vein M; crossvein bm-cu either present, delimiting discal cell from cell bm (species in Afrotropical, Australian, Nearctic, Neotropical, Oriental, and Palearctic Regions), or absent (some Oceanian species); anal vein sometimes strongly reduced in length; anal cell present, well delimited. Legs: Posteroventral setulae of forefemur sometimes differentiated as a row of distal small, spine-like setulae; mid tibia bearing an apicoventral spine.

Abdomen of Male: Sparsely microtomentose, brown to dark brown; 6th tergite somewhat narrowed, asymmetrical, extended more on right side near 6th sternite; 7th tergite narrow, asymmetrical, fused to 6th and 7th sternites on left side; 7th right spiracle, sometimes also the left, in 7th tergite; surstyli articulated with epandrium, asymmetrical (left usually longer), connected with hypandrium posteriorly by a weak membrane; cerci small, weakly sclerotized to completely membranous, bearing some setae on posterior half; hypandrium asymmetrical, expanded posteriorly on each side into convex, bowl-shaped structures, sometimes bearing a ventral projection on left side, visible near base of 6th sternite ("hypandrial projection"); parameres apparently

absent (a single, setulose postgonite in *C. nebulosus*); gonopods present; aedeagal apodeme long, free or joined posteriorly with hypandrium; aedeagus completely sclerotized; ejaculatory apodeme developed, variously shaped.

Abdomen of Female: Syntergosternite 6 a complete ring (tergite and sternite fused), with spiracle within sclerotization; tergite and sternite 7 either fused (Nearctic, Neotropical, Oceanian species), forming a syntergosternal ring enclosing spiracle, or separate (Australian), with spiracle in sternite; segment 8 with tergite and sternite separate, sternite either free (Nearctic and Neotropical species) or partially fused with 7th (Australian species); 2–4 spherical to oblong spermathecae (2 in Australasian/Oceanian species, 3 in Nearctic species, and 4 in Neotropical species).

Discussion. The Australasian/Oceanian fauna demonstrates variation in characters that are constant in American and Afrotropical species, i.e., sexual dimorphism in the shape of the face (absent in *C. micronesicus* and an undescribed species from Ponape) and presence of crossvein bm-cu. All species, however, have a single pair of dorsocentral setae, and the anepisternum lacks setae along the posterior margin.

Key to Australasian/Oceanian Species of *Cyamops*

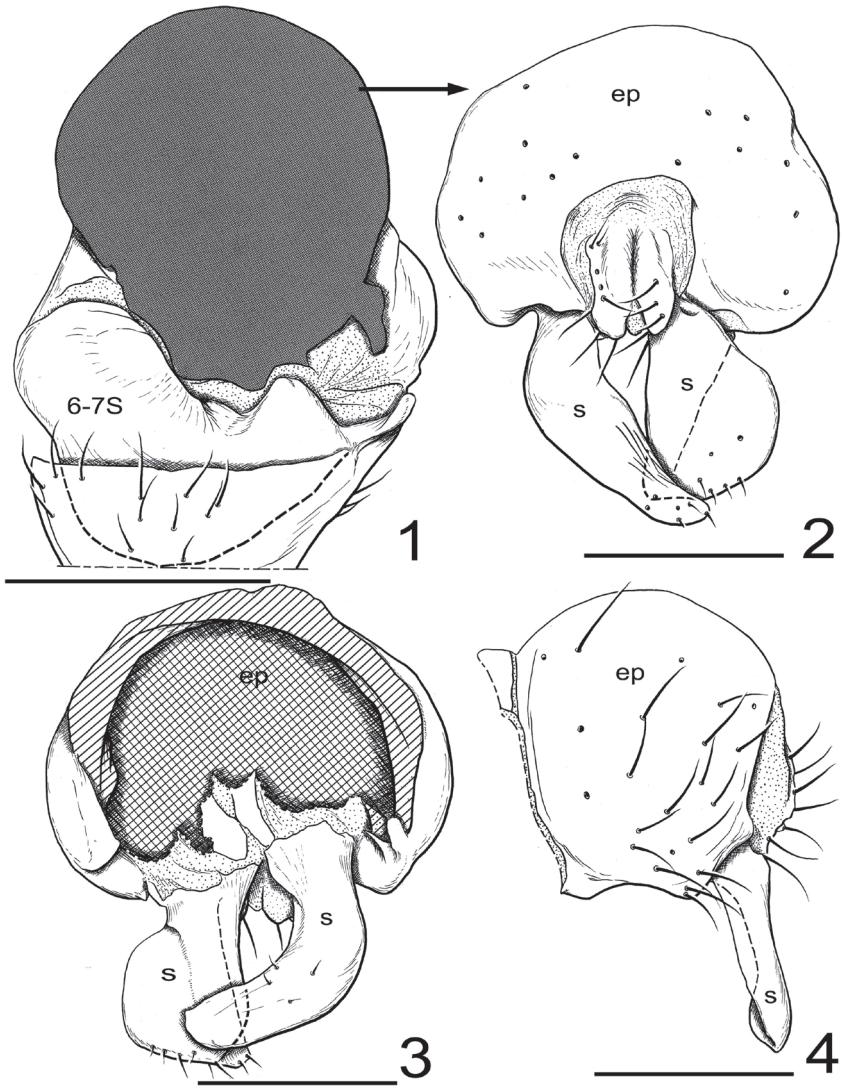
1 Basal aristal rays bifurcate **8**
– Basal aristal rays not bifurcate **2**
2 Midface flat throughout; face of male wide, not constricted medially..... **6**
– Midface bearing a vertical carina (male) or a wide elevated portion (female); face of male narrow, constricted medially..... **3**
3 Femora brown; male with left surstylus broadly curved (Fiji) ..... ***C. femobrunneus* Grimaldi 2009**
– Femora yellow or apically brown, male left surstylus virtually straight..... **4**
4 Ventral facial triangle yellow medially and laterally (New Zealand) ..... ***C. alessandrae*, sp. n.**
– Ventral facial triangle white laterally and whitish yellow medially **5**
5 Pedicel and basal flagellomere yellow (Fiji).. *C. fiji* Baptista and Mathis 2000
– Pedicel and basal flagellomere bicolored, black dorsally, yellow ventrally (New Zealand) ..... ***C. crosbyi*, sp. n.**
6 Pseudovibrissa placed externally to the row of peristomal setae; basal scutellar seta about 3/4 or more length of apical seta (Micronesia)..... **"Ponape" species complex**
– Pseudovibrissa aligned with other peristomal setae; basal scutellar seta about 1/2 length of apical seta **7**
7 Mesofacial plate without setae; foretibia and tarsus mostly brown to dark-brown; ocellar tubercle shiny; vertex shiny (Yap)..... ***C. micronesicus* Baptista & Mathis**
– Mesofacial plate setose between upper peristomal setae; foretibia and tarsus mostly yellow; ocellar tubercle dull microtomentose; vertex dull microtomentose (Ponape) ..... ***C.* "species 3"**
8 1st costal ratio 2.3 or more **13**

–	1st costal ratio 1.0–1.8 ..... **9**
9	Comb present on ventral margin of midcoxa (Australia) .... ***C. pectinatus*** **Khoo 1985**
–	Comb lacking on ventral margin of midcoxa **10**
10	Peristomal setae on mesofacial plate (Australia) ... ***C. claudiensis*** **Khoo 1985**
–	Peristomal setae on genal suture **11**
11	Basal scutellar seta at most 1/3 length of apical seta; tibia and tarsus of foreleg mostly brown to dark-brown (New Guinea) .... ***C. papuensis*** **Baptista and Mathis**
–	Basal scutellar seta about 3/4 or more length of apical seta; tibia and tarsus of foreleg mostly yellow to yellowish brown **12**
12	Wing hyaline (Australia) ..... ***C. truncatus*** **Khoo 1985**
–	Wing with a conspicuous brown pattern (Australia)..... ***C. dayi*** **Khoo 1985**
13	Forefemora with a ctenidium (Fiji) ..... ***C. femoctenidius*** **Grimaldi 2009**
–	Forefemora lacking a ctenidium **14**
14	5th sternite of male abdomen divided medially (American Samoa) .... ***C. samoensis*** **Baptista and Mathis 2000**
–	5th sternite of male abdomen entire **15**
15	Legs mostly yellowish; midfemur yellow; wing hyaline (Australia) .... ***C. australicus*** **Hennig 1969**
–	Legs mostly yellowish brown to black; midfemur brown apically; wing with a conspicuous brown pattern (Australia) ..... ***C. delta*** **Khoo 1985**

Cyamops alessandrae **Mathis and Sueyoshi, sp. n.**
urn:lsid:zoobank.org:act:8AA31D3E-BFD0-4D99-8827-683E5036FD3C
http://species-id.net/wiki/Cyamops_alessandrae
Figs 1–4

Description. Adult body length 1.90–2.60 mm; wing length 2.10–3.00 mm; wing width 0.70–1.10 mm.

Head: Ocellar tubercle polished; shiny spot on vertex large and distinct, extended from ocellus 2/3 distance to eye margin; depressed region of frons deep, velvet. Pedicel brownish on dorsal half, otherwise yellow; basal aristal rays minutely bifurcate apically; basal flagellomere yellow, infuscate dorsally. Face constricted medially by the anteroventral margin of the eyes, expanded into a ventral triangular region below level of pseudovibrissae and bearing a vertical, midfacial, yellow carina, facial triangle microtomentose, yellow to whitish yellow, bordered dorsolaterally with yellow stripe, facial setulae in yellow stripe, some specimens with blackish yellow on ventrolateral margin; gena when viewed anteriorly conspicuously silvery white microtomentose, in lateral view more yellowish tan; labellum and palpus pale yellow; face produced, very shallowly angulate. Chaetotaxy: Inner fronto-orbital setae slightly divergent, slightly



Figures 1–4. *Cyamops alessandrae* (New Zealand. North Island. WO: Whangamarino Peat Bog). **1** 6th and 7th abdominal segments and postabdomen in ventral view **2** epandrium, proctiger, and surstyli, posterior view **3** same, anterior view **4** same, left lateral view. Epandrium, surstyli, aedeagus, and hypandrium are masked by black tone in Fig. 1. All setae on the epandrium are abbreviated in Fig. 2 and 3. Abbreviations: ep, epandrium; s, surstylus; 6–7S: 6th and 7th abdominal sternites. Scale bar: 1 = 0.20 mm, 2–4 = 0.12 mm.

smaller than lateral vertical seta; arista bearing 6–7 dorsal, 3 ventral rays; pseudovibrissae oriented dorsally; peristomal setae 6–7.

Thorax: Halter brown yellow to yellow; scutellum triangular, posteroapical angle rounded, orientation of scutellum moderately more elevated than scutum, disk a little

convex; postpronotum sparsely microtomentose, subshiny to dull. Chaetotaxy: Dorsocentral setae 0+2, length of anterior seta subequal to posterior seta; mesonotal setulae moderately well-developed; scutellar setae 2, basal seta 1/2 length of apical seta. Wing: Hyaline, slightly fuscous; cells bm and dm separated by crossvein bm-cu; 1st costal ratio 2.6–2.9; 2nd costal ratio 2.2–2.7; wing ratio 0.35–0.36; crossvein bm-cu present. Legs mostly yellow; femora mostly yellow, gradually becoming blackish on apical 1/3; tibiae yellowish, blackish basally and especially apically; apical and subapical tarsomere of each leg blackish brown, 3rd tarsomere brown, basal 2 yellowish.

Male abdomen (Figs 1–4): 6th tergite about same width as dorsal portion of 7th tergite, both sclerites almost without setae; 4th and 5th sternites with well-developed lateral setae and a row of setae along posterior margin; 5th sternite twice as wide as long; 6th and7th sternite asymmetrically bilobed, left lobe much larger than medial lobe. Male terminalia (Figs 2–4): right surstylus in posterior view paddle-like with extended portion angulate ventromedially, lateral margin irregularly rounded, bearing setulae ventrally, basal stem narrowed, broadly stem-like; left surstylus elongate, somewhat digitiform, narrower than right surstylus, basal portion vertical, thereafter oriented ventromedially, apex moderately pointed, in lateral view elongate, almost parallel sided, pointed apically.

Female: Head: Ventral midfacial triangle black with silvery white microtomentum; gena densely microtomentose, silver except on facial carina where microtomentum is thin; basal flagellomere infuscate dorsally.

Thorax: Legs with femora and tibiae mostly brown.

Abdomen: 7th tergite and sternite separate; 7th tergite about 3/4 length of 6th tergite; 2 subequal, spherical spermathecae; sclerotized portion of spermathecal duct about 1/5 length of spermatheca.

Type material. The holotype male is labeled "NEW ZEALAND [North Island:] WO Whangamarino Peat Bog [37°20.9'S, 175°06.8'E], malaise [sic] trap[,] 22 Nov-20 Dec 2006[,] C. H. Watts/Site 2: Manuka/Baumea/Empodisma/N.Z. Arthropod Collection, NZAC Private Bag 92170 AUCKLAND New Zealand [yellow]/HOLOTYPE ♂ *Cyamops alessandrae* Mathis and Sueyoshi NZAC [red]." The holotype is double mounted (glued to a paper point), is in fair condition (head partially collapsed), and is deposited in the NZAC. Twelve paratypes (8♂, 4♀; NZAC, USNM) bear the same locality label data as the holotype. Other paratypes are as follows:

NEW ZEALAND. North Island. WO: Kawhia, Taharoa (38°09'S, 174°44'E; Malaise trap), 22 Nov-20 Dec 2006, C. H. Watts (1♀; NZAC); Kopuatai Peat Bog (37°24.1'S, 175°34.1'E; Site 1: Sporodanthus & Site 2: Sporodanthus-Empodisma; Malaise trap), 22 Nov-20 Dec 2006, C. H. Watts (5♂, 4♀; NZAC).

Etymology. The species epithet, *alessandrae,* is a genitive Latin patronym to honor and recognize the numerous contributions of Dr. Alessandra Rung to the study of Periscelididae and to the genus *Cyamops* specifically.

***Cyamops crosbyi* Mathis and Sueyoshi, sp. n.**
urn:lsid:zoobank.org:act:B8FE6378-7DB8-4359-82FD-5704324BB908
http://species-id.net/wiki/Cyamops_crosbyi
Figs 5–12

Description. Adult body length 2.20–2.55 mm; wing length 2.30–2.75 mm; wing width 0.85–1.00 mm.

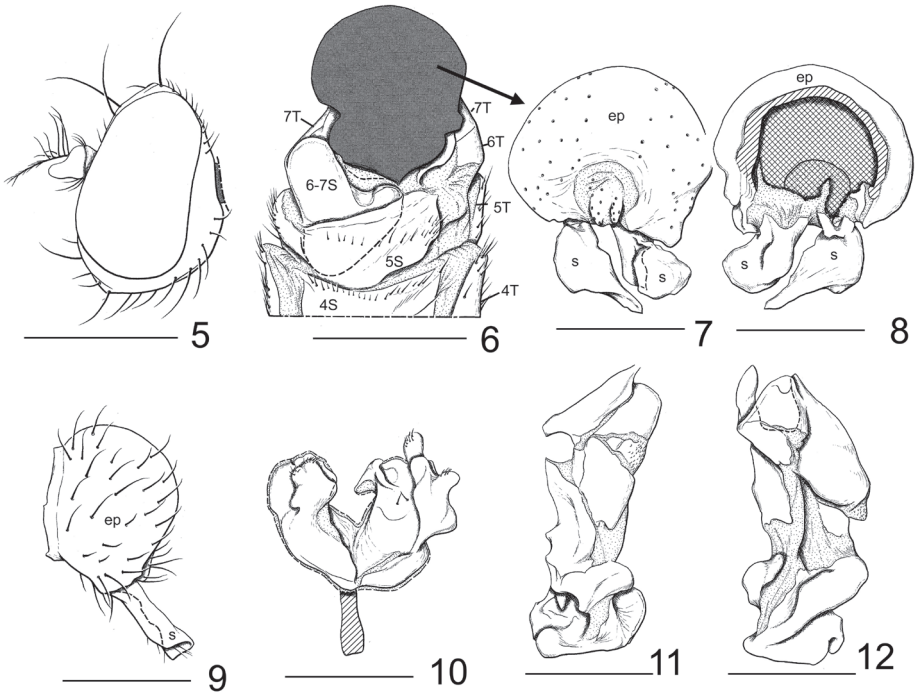
Head (Fig. 5): Ocellar tubercle sparsely microtomentose, subshiny; shiny spot immediately anterior of lateral vertical seta small, about the size of an ocellus; depressed region of frons densely microtomentose, appearing velvety black; fronto-orbits microtomentose, silvery white. Antenna bicolored, dorsal portion brownish black to black, ventral portion yellow; basal aristal rays minutely bifurcate apically; basal flagellomere yellow, infuscate dorsally. Face constricted medially by the anteroventral margin of the eyes, expanding into a triangular region ventrally below the level of the pseudovibrissae and bearing a verticomedial ridge facial region, face yellow in ground color, strongly microtomentose; labellum and palpus pale yellow; face produced and slightly angulate. Chaetotaxy: Inner fronto-orbital setae slightly divergent, slightly smaller than outer vertical seta; arista bearing 9 dorsal, 3 ventral rays, 6 basal rays bifurcate; pseudovibrissae oriented dorsally; peristomal setae 7.

Thorax: Halter brown; scutellum trapezoidal, orientation of scutellum moderately more elevated than scutum, disk a little convex; postpronotum polished. Chaetotaxy: Dorsocentral setae 0+2, anterior seta greatly reduced in length, at most 1/8 length of posterior seta; mesonotal setulae moderately well-developed; scutellar setae 2, basal seta 1/3 length of apical seta. Wing: Hyaline, slightly fuscous; cells bm and dm separated; 1st costal ratio 2.7–3.0; 2nd costal ratio 2.1–2.4; wing ratio 0.35–0.37; crossvein bm-cu present. Legs mostly yellow; femora mostly yellow, gradually becoming blackish on apical 1/3; tibiae yellowish, blackish basally and especially apically; apical and subapical tarsomere of each leg blackish brown, 3rd tarsomere brown, basal 2 yellowish.

Male abdomen (Figs 6–12): 6th tergite about same width as dorsal portion of 7th tergite, both sclerites almost without setae; 4th and 5th sternites with well-developed lateral setae and a row of setae along posterior margin; 5th sternite twice as wide as long; 6th and 7th sternite asymmetrically bilobed, left lobe much larger than medial lobe. Male terminalia (Figs 7–12): right surstylus with extended portion irregularly angulate, in posterior view (Fig. 7) subtriangular, with obtuse angles, basal stem parallel sided basally; left surstylus (Figs 7–9) moderately broad basally, apical half narrow, ventromedial extension, somewhat digitiform, apex pointed, in lateral view elongate (Fig. 9), almost parallel sided, truncate apically; hypandrium and gonites in ventral as in Fig. 10; aedeagus complex, as in Figs 11–12.

Female: Head: Ventral midfacial triangle black with sparse silvery white microtomentum; gena densely microtomentose, silver except on facial carina where microtomentum is thin; basal flagellomere infuscate dorsally.

Thorax: Legs with femora and tibiae mostly brown.



Figures 5–12. *Cyamops crosbyi* (New Zealand. North Island. AK: Cascade). **5** head, left lateral view **6** male 4–7th abdominal segments and postabdomen, ventral view **7** epandrium, proctiger, and surstyli, posterior view. 8, same, anterior view **9** same, left lateral view **10** hypandrim and gonites in ventral view **11** phallus, left lateral view **12** same, posterior view. Epandrium, surstyli, aedeagus, and hypandrium are masked by black tone in Fig. 6. All setae are abbreviated in Fig. 7. Abbreviations: ep, epandrium; s, surstylus; 4–7S, 4–7T:, 4–7th abdominal sternites and tergites. Scale bar: 5 = 0.50 mm, 6 = 0.40 mm, 7–10 = 0.25 mm, 11–12 = 0.05 mm.

Abdomen: 7th tergite and sternite separate; 7th tergite about 3/4 length of 6th tergite; 2 subequal, spherical spermathecae; sclerotized portion of spermathecal duct about 1/5 length of spermatheca.

Type material. The holotype male is labeled "NEW ZEALAND.N.Isl. AK: Cascade (36°53.2'S, 174°31.2'E; 60 m), 2 Jan 2994[,] Wayne N. Mathis/HOLOTYPE ♂ *Cyamops crosbyi* Mathis & Sueyoshi NZAC [red]." The holotype is double mounted (minuten in a block of plastic), is in excellent condition, and is deposited in the NZAC. Twenty-four paratypes (23♂, 1♀; NZAC, USNM) bear the same locality label data as the holotype.

Other material examined. NEW ZEALAND. AK: Henderson Valley, Scenic Reserve (36°53.8'S, 174°35.7'E; Candia Road entrance. On plants by stream), 14 Jan 2007, S. E. Thorpe (1♀; NZAC).

Etymology. The species epithet, *crosbyi,* is a genitive Latin patronym to honor and recognize the numerous contributions of Dr. Trevor K. Crosby to the study of Diptera from New Zealand, the family Simuliidae in particular.

Acknowledgments

We gratefully acknowledge the assistance and cooperation of many organizations and individuals who contributed to the field work and production of this paper. To Trevor K. Crosby (NZAC, New Zealand Arthropod Collection, Landcare Research, Entomology Division, Auckland, New Zealand) and his institution, who loaned specimens, we express our sincere thanks. We also thank Irina Brake and Alessandra C. Rung for reviewing a draft of this paper and the late Hollis B. Williams for generally facilitating the research for this paper.

Field work on New Zealand was facilitated through a grant from the Mr. Helmut Hollmann, benefactor for research on shore flies. We gratefully acknowledge his generous assistance. British Airways largely provided travel to and from New Zealand. We are very grateful to them for generously supporting this research, especially the fieldwork on New Zealand.

References

Clausen PJ, Cook EF (1971) A revision of the Nearctic species of the tribe Parydrini (Diptera: Ephydridae). Memoirs of the American Entomological Society 27: 1–150.

Baptista ARP, Mathis WN (1994) A revision of New World *Cyamops* Melander (Diptera: Periscelididae). Smithsonian Contributions to Zoology 563: 1–25.

Baptista ARP, Mathis WN (2000) Notes on the genus *Cyamops* Melander (Diptera: Periscelididae), including description of ten new species. Proceedings of the Entomological Society of Washington 102: 481–506.

Grimaldi DA (1987) Phylogenetics and taxonomy of *Zygothrica*. Bulletin of the American Museum of Natural History 186: 103–268.

Grimaldi DA (2009)The Asteioinea of Fiji (Insecta: Diptera: Periscelididae, Asteiidae, Xenasteiidae). American Museum Novitates 3671: 1–59.

Hennig W (1958) Die Familien der Diptera Schizophora und ihre phylogenetischen Verwandtschaftsbeziehungen. Beiträge zur Entomologie 8(5/6): 505–688.

Hennig W (1969) Neue Gattungen und Arten der Acalyptratae. Canadian Entomologist 101: 589–633.

Khoo KC (1985) The Australian species of *Cyamops* Melander (Diptera: Periscelididae). Australian Journal of Zoology 32: 527–536.

Khoo KC, Sabrosky CW (1989) 75. Family Stenomicridae. In: Evenhuis, NL (Ed) Catalog of the Diptera of the Australasian and Oceanian Regions. B. P. Bishop Museum special publication 86 and E. J. Brill, 1155 pp. Honolulu and Leiden, 551.

Mathis WN, Rung A (2011) World catalog and conspectus on the family Periscelididae (Diptera: Schizophora). Myia 12: in press.

McAlpine DK (1983) A new subfamily of Aulacigastridae (Diptera: Schizophora), with a discussion of aulacigastrid classification. Australian Journal of Zoology 31: 55–78.

McAlpine JF (1981) Morphology and terminology-adults. In: McAlpine JF, et al. (Eds) Manual of Nearctic Diptera. Volume 1. Research Branch Agriculture Canada, Monograph no. 27, Ottawa, 9–63.

Melander AL (1913) A synopsis of the dipterous groups Agromyzinae, Milichiinae, Ochthiphilinae and Geomyzinae. Journal of the New York Entomological Society 21: 283–300.

Sabrosky CW (1958) New species and notes on North American acalyptrate Diptera. Entomological News 69: 169–176.

Sabrosky CW (1965). Family Anthomyzidae. In Stone A et al. (Eds) A catalog of the Diptera of America north of Mexico. USDA handbook 276, Washington, D.C., 810–820.

Sturtevant AH (1954) Nearctic flies of the family Periscelidae (Diptera) and certain Anthomyzidae referred to the family. Proceedings of the United States National Museum 103(3332): 551–561.

Sueyoshi M, Mathis WN (2004) A new species of *Cyamops* Melander, 1913 (Diptera: Periscelididae) from Japan and a review of the Japanese Periscelididae. Proceedings of the Entomological Society of Washington 106: 74–84.

ZooKeys 114: 41–100 (2011)
doi: 10.3897/zookeys.114.1405
www.zookeys.org

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

Revision of the Neotropical caddisfly genus *Itauara* Müller, 1888 (Trichoptera, Glossosomatidae)

Desiree R. Robertson[1,2,†], Ralph W. Holzenthal[1,‡]

1 *University of Minnesota, Department of Entomology, 1980 Folwell Ave., Room 219, St. Paul, Minnesota 55108, U.S.A.* **2** *Frostburg State University, Biology Department, 101 Braddock Rd., Frostburg, Maryland 21532, U.S.A.*

† *urn:lsid:zoobank.org:author:EA7A21FC-EA6A-4497-B88C-9ABBC4E044A6*
‡ *urn:lsid:zoobank.org:author:C27A1C49-F372-4232-A49C-B8B5F753CC70*

Corresponding author: *Desiree R. Robertson* (drrobertson@frostburg.edu)

Academic editor: *Christy Geraci* | Received 18 April 2011 | Accepted 12 May 2011 | Published 30 June 2011

urn:lsid:zoobank.org:pub:96B9DFD8-CC6C-4449-9D43-A9DE11ACB478

Citation: Robertson DR, Holzenthal RW (2011) Revision of the Neotropical caddisfly genus *Itauara* Müller, 1888 (Trichoptera, Glossosomatidae). ZooKeys 114: 41–100. doi: 10.3897/zookeys.114.1405

Abstract

Systematics of the genus *Itauara* Müller, 1888 are reviewed. A generic diagnosis, illustrations, and descriptions are provided for males. The genus can be identified by several features of the male genitalia including an extremely reduced phallobase and a phallic apparatus that consists of a sclerotized dorsal sheath covering a very membranous ventral portion. A total 18 species are described as new: *Itauara alexanderi*, **sp. n.** (Brazil), *I. bidentata*, **sp. n.** (Guyana), *I. blahniki*, **sp. n.** (Brazil), *I. charlotta*, **sp. n.** (Brazil), *I. emilia*, **sp. n.** (Brazil), *I. flinti*, **sp. n.** (Brazil), *I. guyanensis*, **sp. n.** (Guyana), *I. jamesii*, **sp. n.** (Brazil), *I. julia*, **sp. n.** (Brazil), *I. lucinda*, **sp. n.** (Brazil), *I. ovis*, **sp. n.** (Guyana, Venezuela), *I. peruensis*, **sp. n.** (Peru), *I. rodmani*, **sp. n.** (Brazil), *I. simplex*, **sp. n.** (Brazil), *I. spiralis*, **sp. n.** (Guyana), *I. stella*, **sp. n.** (Brazil), *I. tusci*, **sp. n.** (Brazil), and *I. unidentata*, **sp. n.** (Guyana). These additions bring the total fauna of *Itauara* to 22 species.

Keywords

Trichoptera, Glossosomatidae, Protoptilinae, systematics, taxonomy, *Itauara*, new species, Neotropical, male genitalia

Table of contents

Introduction

The genus *Itauara* Müller, 1888, belongs to the saddle-, or tortoise-case making caddisfly family Glossosomatidae. The name *Itauara* comes from the Tupi-Guarani language and roughly translates to "born from rock," likely referring to glossosomatid larval cases, often found conspicuously on the surface of submerged rocks. *Itauara* larvae construct rather loose, easily deformable cases of large and small grains of sand that are vaulted dorsally, and almost flat ventrally (Angrisano 1993). In southeastern Brazil and surrounding regions in Argentina and Uruguay, larvae are known to occur in sandy bottom streams with scarce vegetation where they attach their cases to Characeae algae (Angrisano 1993).

Like other members of Protoptilinae, *Itauara* adults are minute, usually less than 3 mm in size. Their wings are brownish and may have a conspicuous white spot at the arculus or transverse line along the anastomosis (Fig. 1). *Itauara* are rather rare in occurrence; indeed, several of the new species described here are known from only a single specimen. The 4 known species of *Itauara* occur only in South America, with 3 of these [*I. brasiliana* (Mosely, 1939), *I. guarani* (Angrisano, 1993), and *I. plaumanni* (Flint, 1974)] endemic to southeastern Brazil and surrounding regions of Argentina and Uruguay. A fourth species, *I. amazonica* (Flint, 1971), is known from Amazonas state, Brazil.

A recent survey of the Trichoptera of southeastern Brazil by researchers at the University of Minnesota yielded numerous new species of *Itauara* and impetus for this study. Dr. Oliver S. Flint, National Museum of Natural History, Smithsonian Institution, generously provided several additional undescribed species from various locales in South America for inclusion in this study. In this paper, we determine the homologies and establish standardized terminology of the male genitalic structures among species. Additionally, we re-describe and illustrate the 4 known *Itauara* species and describe 18 new species from southeastern Brazil, Peru, Guyana, and Venezuela, bringing the total number of species to 22. These species are here assigned to 2 species groups and listed in Table 1. Finally, we provide a key to the males of *Itauara*.

Figure 1. Adult, lateral view, *Itauara julia* sp. n.

Table 1. *Itauara* species groups (Trichoptera: Glossosomatidae: Protoptilinae).

***amazonica* species group**
Itauara alexanderi, **sp. n.**
Itauara amazonica (Flint, 1971)
Itauara bidentata, **sp. n.**
Itauara emilia, **sp. n.**
Itauara guyanensis, **sp. n.**
Itauara jamesii, **sp. n.**
Itauara lucinda, **sp. n.**
Itauara ovis, **sp. n.**
Itauara peruensis, **sp. n.**
Itauara spiralis, **sp. n.**
Itauara stella, **sp. n.**
Itauara unidentata, **sp. n.**
***brasiliana* species group**
Itauara blahniki, **sp. n.**
Itauara brasiliana (Mosely, 1954)
Itauara charlotta, **sp. n.**
Itauara flinti, **sp. n.**
Itauara guarani (Angrisano, 1993)
Itauara julia, **sp. n.**
Itauara plaumanni (Flint, 1974)
Itauara rodmani, **sp. n.**
Itauara simplex, **sp. n.**
Itauara tusci, **sp. n.**

Material and methods

Specimen preparation and observation

To observe certain structural features of the male genitalia, soft tissues were cleared using a lactic acid method outlined in detail by Holzenthal and Anderson (2004) and Blahnik et al. (2007). For some specimens, the entire individual was cleared (after removing the wings) to more easily observe external structures obscured by setae, such as thoracic warts. Specimens that were over-cleared or lightly sclerotized were stained. Such specimens were immersed in a small watch-glass containing Chlorazole Black E (Sigma Chemical Co.) dissolved in glycerin for 15 minutes to several hours, depending on the size and condition of the specimen. Stained specimens were then rinsed in distilled water to remove any excess stain. Specimens were examined in a small watch-glass containing glycerin using an Olympus SZX12 dissecting microscope or Olympus BX41 compound microscope. To observe wing venation, wing mounts of each species were prepared following the protocols of Blahnik and Holzenthal (2004).

Illustrations, descriptions, and identification key

Pencil sketches of the male genitalia were completed using either an optical grid on a dissecting microscope, or *camera lucida* (drawing tube) mounted on a compound microscope. Pencil sketches were scanned digitally, and then placed as a template layer in Adobe Illustrator® for final rendering. Wing preparations were digitally photographed using a Leica EC3 digital camera mounted on an Olympus SZX12 dissecting microscope. Digital images were then placed as a template layer in Adobe Illustrator® for final rendering. Descriptions of species and generation of the identification key were facilitated by using the software package DELTA (DEscriptive Language for Taxonomy) (Dallwitz 1980; Dallwitz et al. 1993 onwards; 1999 onwards).

Females, with similar size and coloration as males that were collected at the same time and locality, are listed as paratypes under the material examined for some species. Previous experience has shown that having presumptively associated female specimens may be useful for future associative studies. However, since there is some uncertainty of association, we have deferred descriptions of females.

Morphological terminology

Morphological terminology for male genitalia was adapted from Blahnik and Holzenthal (2006; 2008), Holzenthal (2004), Holzenthal and Blahnik (2006), and Morse (1988). Terminology for specific structures of male genitalia, as homologized in this study, is indicated in Figures 4–25. Wing venation terminology follows the Comstock-Needham system as interpreted by Ross (1956) and Schmid (1998).

Depositories

Types and additional material examined for this study are deposited at the British Museum of Natural History, London, UK (BMNH); the National Museum of Natural History, Washington, DC, USA (NMNH), the Museo Argentino de Ciencias Naturales Bernardino Rivadavia, Buenas Aires, Argentina (MACN), the Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil (MZUSP), and the University of Minnesota Insect Collection, Saint Paul, USA (UMSP). All specimens or lot of alcohol specimens examined in this study were affixed with a barcode label with a unique 9 digit alphanumeric code starting with the prefix UMSP. This prefix indicates that the specimen has been databased at UMSP, but it is not meant to imply possession by UMSP. Specimen-level taxonomic, locality, and other information, are stored in the University of Minnesota Insect Collection Biota Trichoptera Database using the software program Biota (Colwell 2003), and can be accessed at http://www.entomology.umn.edu/museum/databases/BIOTAdatabase.html.

Systematics

Until recently, the generic status of *Itauara* was uncertain. Müller (1888) first used the name *Itauara* in a discussion of larval morphology, but he did not include any species or illustrations. In a later, posthumous work (Müller 1921), he provided sketches of the female forewing venation and some larval structures. Ulmer (1957) thought that Müller's illustrations resembled those of other genera in Protoptilinae of South American origin, and suggested that the larvae be split into different species and perhaps even different genera. He also noted that Müller's forewing illustration completely matched that of *Antoptila brasiliana* Mosely, 1939 (Ulmer 1957). In his studies of Trichoptera collected from the Amazon, Marlíer (1964) later described some Protoptilinae larvae and female pupae and attributed them to *Itauara.* However, since the pupae were all females and the wings were not in a condition to adequately observe wing venation, Marlíer (1964) declined to provide a species name. Later, Flint (1971, 1974) described 2 new *Antoptila* species from the Amazon and southeastern Brazil. Angrisano (1993) described the female, larvae and pupae of *A. brasiliana* Mosely, 1939 and males and females of *A. plaumanni* Flint, 1974 and another new species *A. guarani* Angrisano, 1993. Subsequently, based on similarities in wing venation and of cases and larval morphology, Flint et al. (1999) synonymized *Itauara* with *Antoptila* Mosely 1939, designated *A. brasiliana* as the type species, and transferred the 3 other known species of *Antoptila* to *Itauara*.

In a recent phylogenetic analysis of the entire protoptiline subfamily, *Itauara* was recovered as a monophyletic group with strong support (Robertson 2010). The presence of a dorsal sheath-like phallicata was identified as a unique synapomorphy of *Itauara* (Robertson 2010). Although members of this genus have superficially similar male genitalia, certain structures are not homologous. For example, the type species *I. brasiliana* (Mosely, 1939) has 2 pairs of curious elongate, seta-like processes on sternum IX. The 3 additional species placed in the genus have similarly looking elongate ventral processes, yet they are not the same as in the type species; these processes are parameres, and arise directly from the phallobase or endotheca, rather than sternum IX.

Genus *Itauara* Müller, 1888

http://species-id.net/wiki/Itauara

Itauara Müller, 1888: 275 [Type species: *Antoptila brasiliana* Mosely, 1939, subsequent selection by Flint, Holzenthal, and Harris 1999].

Antoptila Mosely, 1939: 219 [Type species: *Antoptila brasiliana* Mosely, 1939, original designation] Flint, Holzenthal, and Harris 1999, to synonymy.

The genus *Itauara* can be identified by features of the male genitalia. The phallic apparatus consists of a sclerotized dorsal sheath covering a very membranous ventral portion, an apparent posterior extension of the phallobase or phallicata. Rarely, the

phallicata is tubular or separated from the phallobase by a membranous portion. In some species, this sclerotized dorsal sheath seems to detach from the ventral membrane apically to reveal a single dorsomesal process or spine (e.g., *I. amazonica*). *Mortoniella* has a similar dorsomesal process or spine, but in *Mortoniella* it arises internally from the phallobase, whereas in *Itauara* it arises dorsobasally, as an extension of the phallicata. In several species the sheath produces a dorsolateral flange-like process, although this character is not diagnostic for the genus. Another genitalic feature characteristic of *Itauara* is an extremely reduced phallobase. In most species, the phallobase is barely visible, consisting of a small, very lightly sclerotized or an entirely membranous structure. The genera *Mastigoptila* and *Canoptila* display similar reductions or absences of the phallobase, but can easily be separated from *Itauara* by other genitalic characters: *Mastigoptila* has an elongate, whip-like process arising from the membranes of the phallocrypt; *Canoptila* has highly membranous digitate parameres. When present (they have been lost in many species), the inferior appendages are rather distinct for *Itauara*, consisting of a single or apically bifid process produced mesally and fused to the phallobase ventrobasally. This inferior appendage process articulates with the base of the phallobase and in doing so, is capable of pivoting downward (Fig. 13A and inset). All species, except in *I. brasiliana,* have rather elongate, sclerotized, rod-like parameres, whose shape varies greatly among species. In many species these parameres arise ventrobasally from the phallobase, with which they appear to articulate. As the inferior appendage process is absent in those species, it is possible that the parameres have taken on a clasper-like function.

The forewing venation of *Itauara* is most similar to that of *Cariboptila* and *Canoptila*, with apical forks I–III and a lack of 3A (Fig. 2A, B). A single species also possesses apical fork IV (Fig. 2C). *Canoptila* can be differentiated from *Itauara* by having stout setae occurring below Cu2 whereas in *Itauara* the setae occur along the vein. *Cariboptila* can be differentiated from *Itauara* by the presence of a short discoidal cell, that of *Itauara* being long. The lengths of the apical forks vary among species. The hind wing venation of *Itauara* is variable, with either apical forks II, III, and V (Fig. 3C); II and V (Fig. 3A); III only, or II only (Fig. 3B).

Adult. Body, wings, and appendages pale or tawny brown, often intermingled with rufous or golden hairs, tibia and tarsi yellowish brown (Fig. 1). Wings often with partial white transverse line along anastomosis not reaching costal margin, or often with conspicuous white spot at the arculus (Fig. 1). Head broader than long, vertex rounded, with pair of small anteromesal setal warts or with large anteromesal setal wart, either 1 distinct pair or 1 divided pair of suboval anterior setal warts, small or large suboval posterior warts, suboval or triangular and bulging posterolateral setal warts. Ocelli present. Antennal scape less than or equal to 2 times the length of pedicel. Maxillary palps 5 segmented, 1st and 2nd segments short; 2nd segment bulbous; last 3 segments each nearly same length as 1st and 2nd segments combined. Prothorax with 2 large subtriangular or suboval pronotal setal warts. Mesothorax wider than long, without apparent tegular glands; mesoscutum with pair of suboval anteromesal setal warts, suboval posterolateral warts; mesoscutellum sparsely setose, without

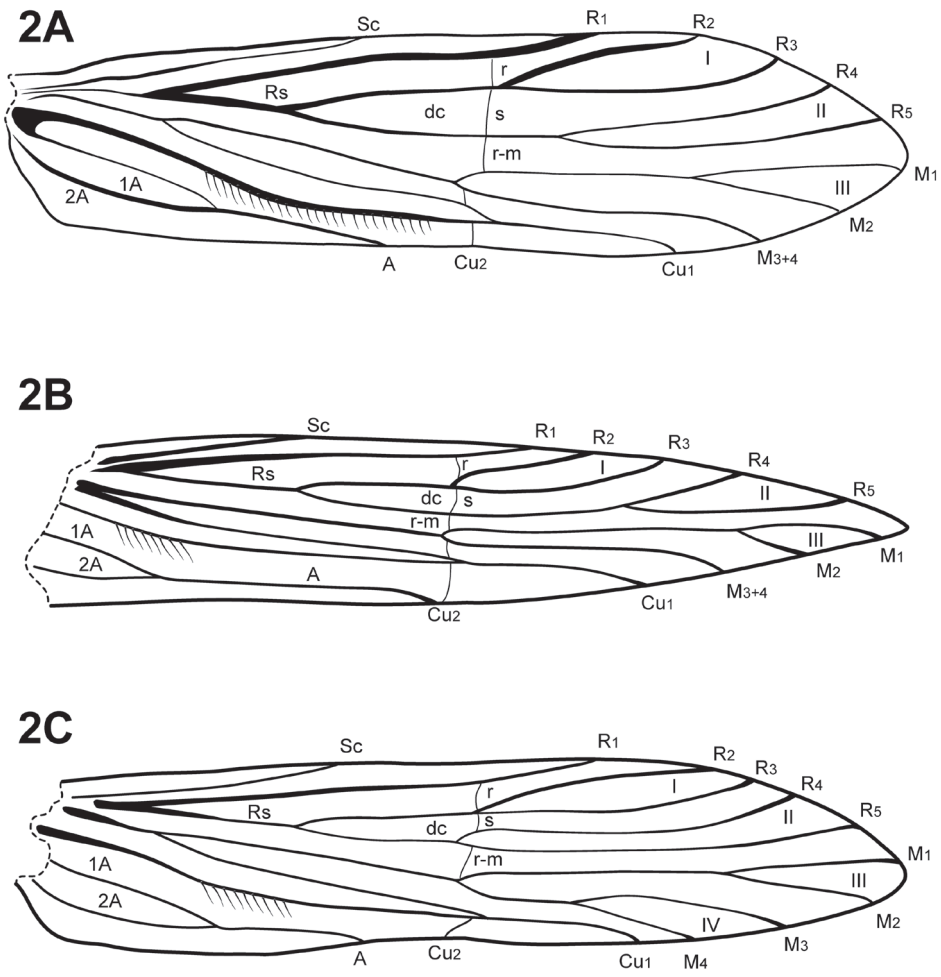


Figure 2. Forewings **A** *Itauara brasiliana* (Mosely) **B** *Itauara guyanensis*, sp. n. **C** *Itauara unidentata*, sp. n. Wings between taxa not to scale.

distinct setal warts. Forewing (Fig. 2) usually relatively narrow, with margins nearly parallel, occasionally narrowed past anastomosis or much reduced, apex acute, subacute, or rounded. Male occasionally with callosity present in apical costal region of forewing. Forewing venation incomplete, with apical forks I, II, and III present, or rarely I–IV present; Sc and R1 distinct along their entire lengths; fork I sessile or only slightly petiolate with extremely short stem; fork II petiolate or sessile, when petiolate, stem length variable; fork III petiolate, stem variable in length; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing (Fig. 3) margins nearly parallel,

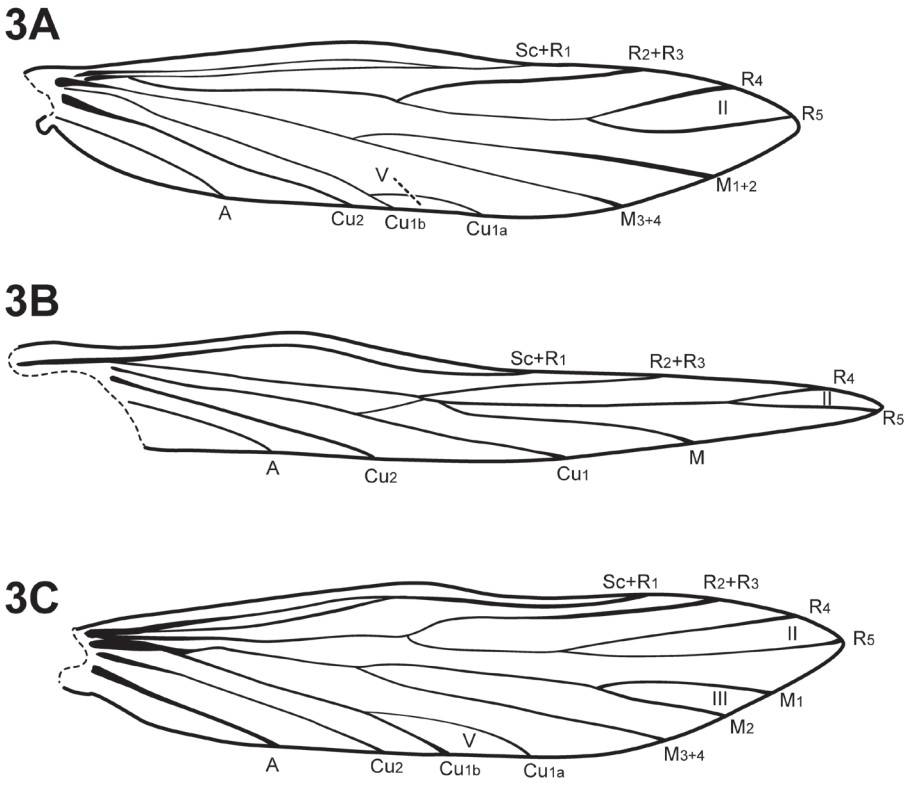


Figure 3. Hind wings **A** *Itauara brasiliana* (Mosely) **B** *Itauara guyanensis*, sp. n. **C** *Itauara julia*, sp. n. Wings between taxa not to scale.

tapering only slightly past anastomosis, or narrowed, scalloped past anastomosis, or much reduced; venation variable, either with apical forks II, III, and V present, II and V present, III present, or II present; Sc and R1 fused basally or converging near wing margin; A2 absent. Tibial spurs 1,4,4, rarely 1,3,4, foretibial spur extremely reduced and hairlike. Sixth sternal process present, short and digitate or thumb-like and prominent, apex rounded or attenuate and pointed, usually associated with oblique apodeme posteriorly.

Male genitalia. Segment IX usually rather broad, anterior margin rounded, posterolateral margin without lateral process or lobes in lateral view; tergum IX usually not well developed, simple, and without processes; sternum IX without modification, except in *I. brasiliana*, which bears 2 pairs of elongate, seta-like processes. Tergum X incompletely fused to tergum IX ventrolaterally or rarely (*I. amazonica*) completely fused and indistinct from tergum IX, shape extremely variable; dorsomesal margin may be simple without processes, bifid apicomesally, with a single broad, plate-like process, or irregular with several small processes; dorsolateral margin either a simple structure without processes, or more commonly with small paired lobes, elongate, down-turned,

finger-like process, or irregular setose processes; ventrolateral margin with paired elongate or broad flange-like processes directed ventrally and sometimes anteriorly, or with one or more irregular, paired, setose, digitate lobes directed posteriorly. Inferior appendages either present or absent; when present, consisting of single or apically bifid process produced mesally, broadest at base and fused to phallobase ventrobasally. Parameres present except in *I. brasiliana,* arising either ventrobasally from phallobase or laterally from endotheca, sclerotized, shape variable. Phallobase extremely reduced and difficult to discern. Phallicata a sclerotized dorsal sheath covering membranous ventral portion, sometimes receding to a single dorsomesal process arising dorsobasally from phallobase, phallicata occasionally with dorsolateral flange, or occasionally with dorsomesal spine arising posteriorly to phallobase. Endophallus highly membranous, enlarged and convoluted when evaginated, occasionally bearing apical spine-like sclerites and processes.

Female genitalia. (Females unknown for many species.) Truncate posteriorly, not extensible. Abdominal segment VIII short, synscleritous, posterolateral margin slightly incised. Segments IX and X closely associated, with pair of small digitate cerci dorsolaterally.

Species relationships

The 22 species of *Itauara* fall into 2 broad species groups (Table 1). Members of the *amazonica* species group are recognized by the presence of a fused inferior appendage process. The group is also characterized by the position of the parameres, arising laterally from the endotheca in this group. Species included in the *brasiliana* species group have completely lost the inferior appendages. When parameres are present (they are vestigial in *I. brasiliana*) they arise ventrobasally from the phallobase, to which they are often fused. Several members of the *brasiliana* group also have lateral flange-like processes on the phallicata.

Species descriptions

Itauara alexanderi **Robertson & Holzenthal, sp. n.**
urn:lsid:zoobank.org:act:55610B1E-3E37-4B64-9380-5C2A86CD3EA1
http://species-id.net/wiki/Itauara_alexanderi
Fig. 4A–C

Description. This species is similar to *Itauara emilia* sp. n., *I. lucinda* sp. n., and *I. stella* sp. n., as discussed under each of those species. Each of these species possesses an inferior appendage process, a dorsomesal process on tergum X, and rather sinuous parameres. Of these species, *I. alexanderi* is most similar to *I. stella*. Both of these species have similarly shaped dorsomesal and ventrolateral processes of tergum X and both have apically bifid inferior appendage processes. *Itauara alexanderi* can be distinguished from *I. stella* by the length of the parameres, those of *I. alexanderi* being much shorter. Additionally,

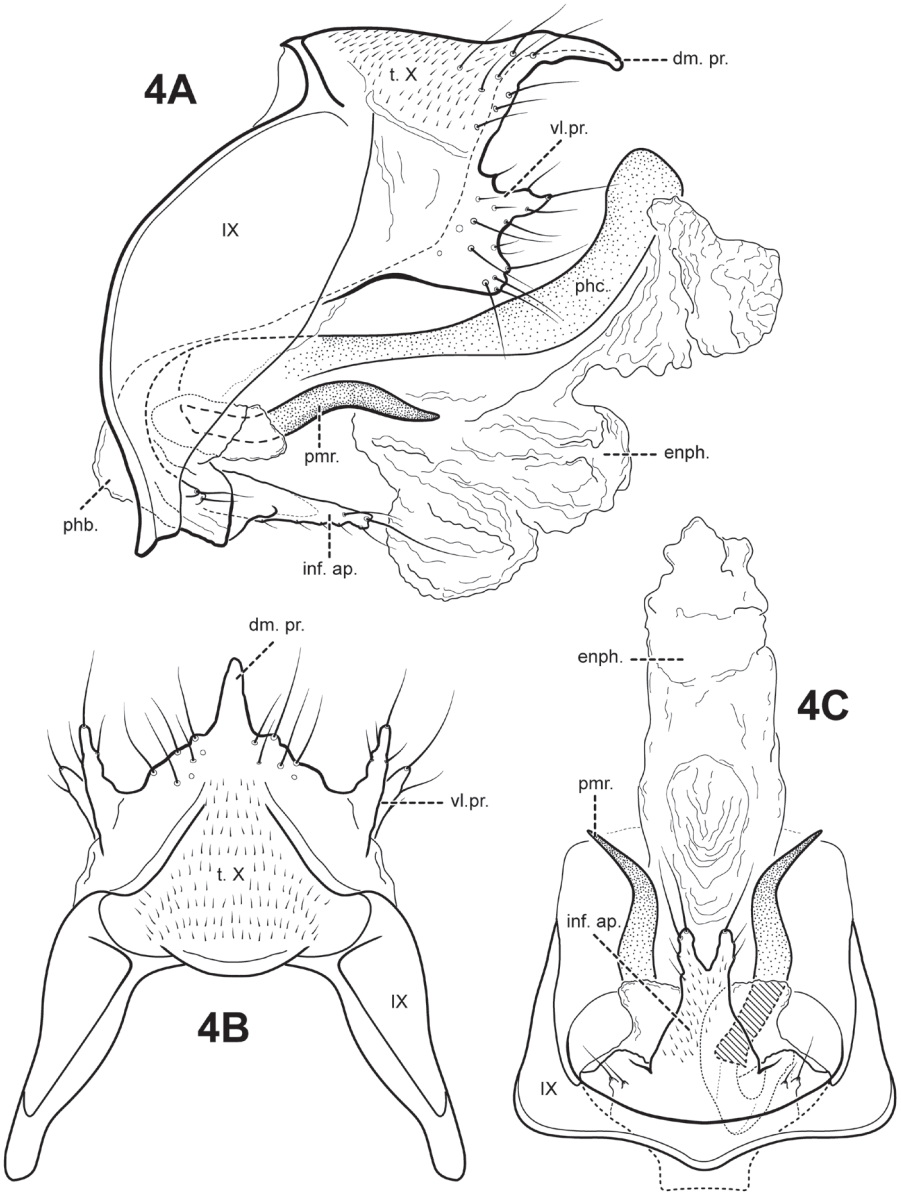


Figure 4. *Itauara alexanderi*, sp. n. (composite of UMSP000114626 & UMSP000052590). Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: dm. pr. = dorsomesal process; enph. = endophallus; inf. ap. = inferior appendage process; phb = phallobase; phc. = phallicata; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

the inferior appendage process of *I. alexanderi* is broader than that of *I. stella*. *Itauara lucinda* differs from *I. alexanderi* in having a forked paramere and an inferior appendage process that is not bifid. *Itauara alexanderi* can be distinguished from *I. emilia* based on differences in the shape of the dorsomesal process of tergum X.

Adult. Body, wings, and appendages fuscous, intermingled with rufous or golden hairs, tibia and tarsi tawny brown. Wings with white transverse line along anastomosis. Forewing slightly broader past anastomosis, but with margins nearly parallel, apex rounded. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I sessile; fork II petiolate, stem about the same length as fork; fork III petiolate, stem longer than fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing margins nearly parallel, tapering only slightly past anastomosis; apical forks II and V present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process thumb-like, apex rounded, associated with oblique apodeme posteriorly.

Male genitalia. Preanal appendages absent. Segment IX ventrally narrow, broad medially; anterior margin rounded; posterolateral margin membranous or very lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin with single, downturned, elongate process; dorsolateral margin without processes; ventrolateral margin with paired, broad flange-like setose process consisting of upper subtriangular lobe and lower subquadrate lobe. Inferior appendages present as apically bifid, setose process produced mesally, broadest at base and fused to phallobase ventrobasally, with 2 pairs of small digitate lobes ventrolaterally, each bearing a seta. Parameres present, paired, inserted in membranous lobe, arising laterally from endotheca, sclerotized and rod-like, relatively short, sinuous, directed ventrolaterally, apex pointed. Phallobase reduced, lightly sclerotized. Phallicata forming a long sclerotized dorsal sheath extending from phallobase, narrow and straight mesally, distal portion broad, curving dorsally. Endophallus membranous, enlarged and convoluted when invaginated, with 1 upper and 1 lower lobe.

Material examined. Holotype male: BRAZIL: Nova Friburgo, 22°16'00"S, 042°31'59"W, 950 m, 20.iv.1977 (C. & O. Flint) (UMSP000052592) (NMNH)

Paratypes: BRAZIL: Rio de Janeiro, Teresopolis, 18 km S, Km 17 (road), 1180 m, 18–19.iv.1977 (C. & O. Flint) — 2 males (NMNH).

Etymology. We are delighted to name this species for the senior author's husband, Alexander Bishop Thompson, in gratitude of his patience, support, and encouragement as she worked to finish her dissertation.

***Itauara amazonica* (Flint, 1971)**
http://species-id.net/wiki/Itauara_amazonica
Fig. 5A–D

amazonica (Flint), 1971:13 [Type locality: Brazil [Edo. Amazonas], Rio Marauiá, Endstation langer Cachoeira, Fluß tritt hier aus dem Gebirge mit starkem Gefälle; NMNH; in *Antoptila*]. –Flint, Holzenthal, and Harris, 1999:74 [to *Itauara*].

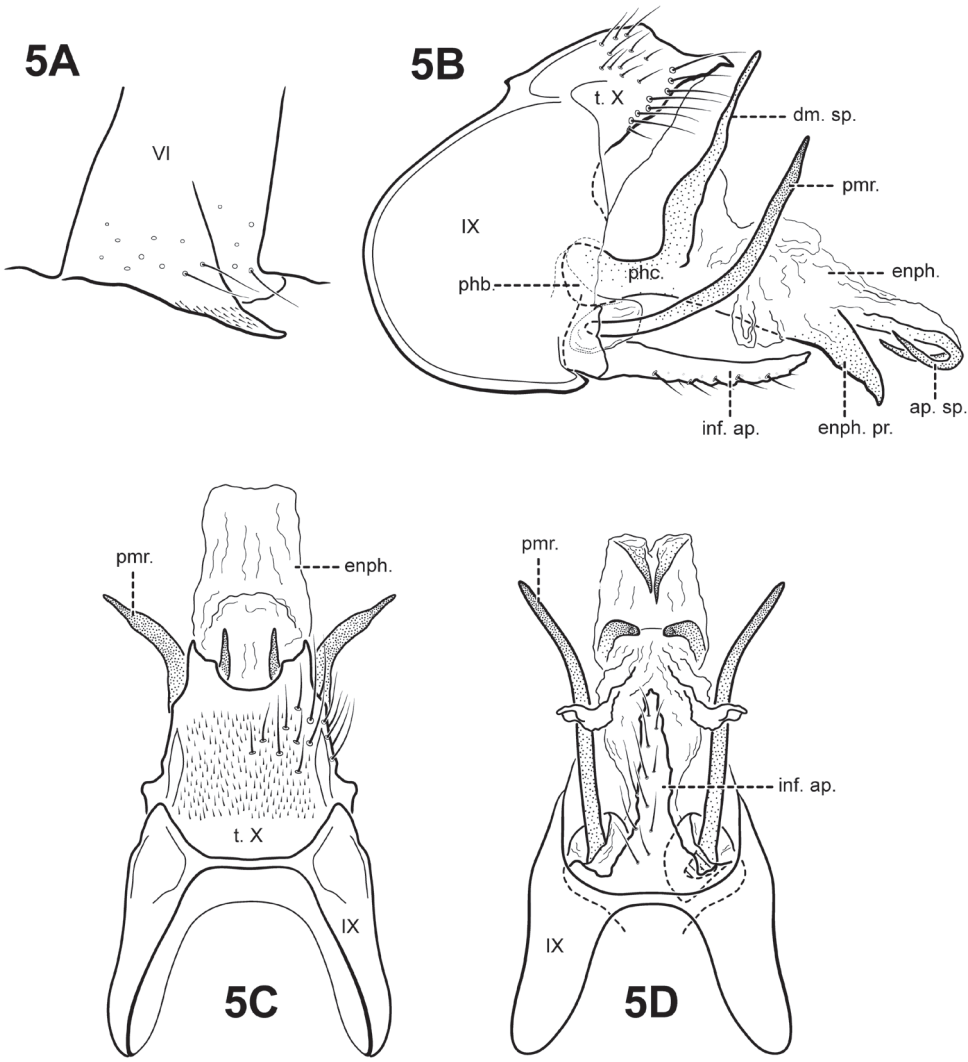


Figure 5. *Itauara amazonica* (Flint, 1971) (UMSP000027156) **A** Process of sternum VI. Male genitalia **B** lateral **C** dorsal **D** ventral. Abbreviations: ap. sp. = apical spine; dm. sp. = dorsomesal spine; enph. = endophallus; enph. pr. = endophallic process; inf. ap. = inferior appendage process; phb = phallobase; phc. = phallicata; pmr . = paramere; t. X = tergum X.

Description. This species is distinct in having a very elongate inferior appendage process, a rather simple tergum X, and sharply bent apical spines in the endophallus. *Itauara amazonica* is most similar to 3 species from Guyana, *I. bidentata* sp. n., *I. spiralis* sp. n., and *I. unidentata* sp. n. These species, including *I. amazonica*, all have a dorsomesal spine arising from the phallicata. However, in *I. amazonica*, this spine appears as a short, posterior extension of the phallicata, whereas in the other species, the spine arises basally, as a separate spine. *I. amazonica* can further be distinguished from these species based on differences in the shape of tergum X and parameres.

Adult. Body, wings, and appendages pale or tawny brown in alcohol. Forewing relatively narrow, with margins nearly parallel, apex subacute. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I sessile; fork II petiolate, stem shorter than fork; fork III petiolate, stem longer than fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing narrow and slightly scalloped past anastomosis; apical fork III present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process short and digitate, apex attenuate and pointed, associated with weak oblique apodeme posteriorly.

Male genitalia. Preanal appendages absent. Segment IX relatively broad; anterior margin rounded; posterolateral margin membranous or very lightly sclerotized; sternum IX without modification. Tergum X completely fused to tergum IX, divided or bifid apicomesally, each half terminating in pointed process directed posteriorly; dorsolateral margin without processes; ventrolateral margin without processes. Inferior appendages present as single, elongate setose process produced mesally, broadest at base and fused to phallobase ventrobasally. Parameres present, paired, inserted in membranous lobe, arising laterally from endotheca, sclerotized and rod-like, slender and elongate, upturned, directed dorsally, apex pointed. Phallobase reduced, lightly sclerotized. Phallicata forming a long sclerotized dorsal sheath extending from phallobase, bent sharply upward at middle, divided apicomesally, terminating in 2 pointed processes. Endophallus membranous, enlarged and convoluted when invaginated, receding anterior to apex of phallicata, ventrally bearing a pair of broad, tooth-like downturned processes, apically with pair of sharply bent sclerotized spines, pointing anteriorly.

Material examined. Holotype male: BRAZIL: Amazonas: Rio Marauia, Endstation langer Cachoeira, Fluß tritt hier aus dem Gebirge mit starkem Gefälle, 00°23'00"N, 065°13'00"W, 28.i.1963 (E.J. Fittkau) (UMSP000027159) (NMNH).

Paratypes: BRAZIL: Amazonas: same data as holotype — 3 males, 2 females (NMNH).

***Itauara bidentata* Robertson & Holzenthal, sp. n.**
urn:lsid:zoobank.org:act:76A03637-7788-4644-975B-4AC7F58E37EA
http://species-id.net/wiki/Itauara_bidentata
Fig. 6A–C

Description. *Itauara bidentata* can be diagnosed by its large, bifid paramere process, and spade-like shaped inferior appendage. It is most similar to *I. unidentata* sp. n., which has a similarly shaped tergum X, dorsomesal spine, and apical sclerites. The 2 species can be separated by their paramere processes; in *I. unidentata* the paramere consists of a single large tooth-like spine, whereas in *I. bidentata*, the paramere process is bifid. *Itauara spiralis*, sp. n., has a similarly shaped tergum X, but is easily distinguished from *I. bidentata* by differences in the shape of the inferior appendage process, parameres, and phallicata.

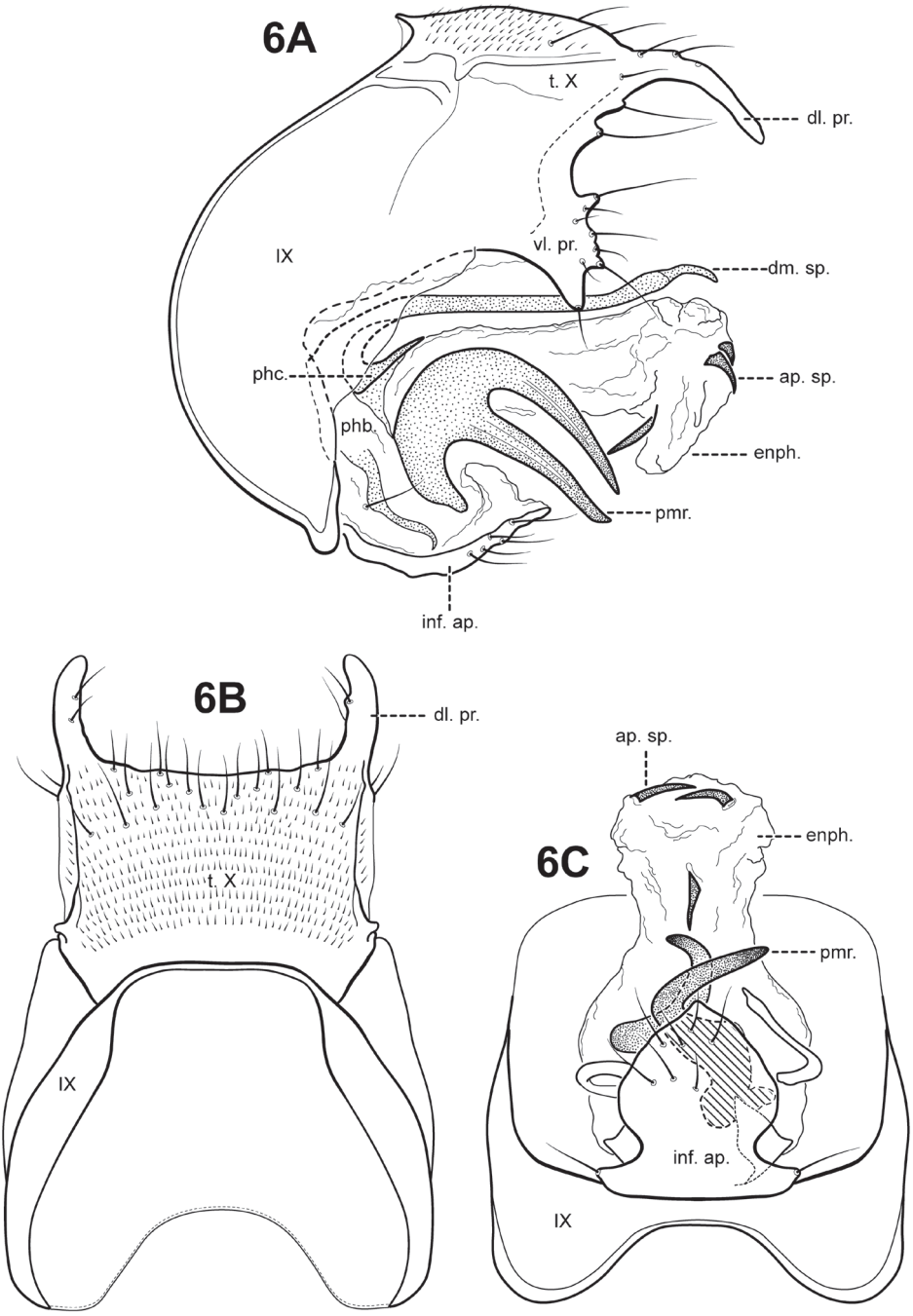


Figure 6. *Itauara bidentata*, sp. n. (UMSP000210958). Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: ap. sp. = apical spine; dl. pr. = dorsolateral process; dm. sp. = dorsomesal spine; enph. = endophallus; inf. ap. = inferior appendage process; phb. = phallobase; phc. = phallicata; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

Adult. Body, wings, and appendages pale or tawny brown in alcohol. Forewing relatively narrow, with margins nearly parallel, apex subacute. Forewing venation incomplete, with apical forks I, II, and III present; fork I sessile; fork II petiolate, stem about the same length as fork; fork III petiolate, stem longer than fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing narrow and slightly scalloped past anastomosis; apical fork II present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process short and digitate, apex attenuate and pointed, associated with strong oblique apodeme posteriorly.

Male genitalia. Preanal appendages absent. Segment IX ventrally narrow, broad medially; anterior margin rounded; posterolateral margin membranous or very lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin straight, without processes; dorsolateral margin with paired elongate, downturned, finger-like process; ventrolateral margin with paired, broad flange-like setose process consisting of several small irregular lobes. Inferior appendages present as single, broad, irregular setose process, broadest basally, fused to phallobase ventrobasally, bearing a single pair of small digitate lobes ventrolaterally, each bearing a seta. Parameres present, paired, arising laterally from endotheca, strongly sclerotized, large bifid tooth-like process, curving ventrally and outward, apices pointed. Phallobase reduced, lightly sclerotized dorsally, laterally membranous, with 2 irregular and elongate sclerites arising basolaterally. Phallicata forming a short slerotized dorsal sheath with an elongate dorsomesal spine arising posteriorly to phallobase. Endophallus membranous, enlarged and convoluted when invaginated, apically bearing 3 small sclerotized spines.

Material examined. Holotype male: GUYANA: KUMU: 25 km. SE Lethem, 03°15'54"N, 059°43'36"W, 4–5.iv.1994 (O.S. Flint) (UMSP000127385) (NMNH)

Paratypes: GUYANA: KUMU: same data as holotype — 1 male, 3 females.

Etymology. The name *bidentata* comes from the bidentate form of the paramere process.

Itauara blahniki Robertson & Holzenthal, sp. n.

urn:lsid:zoobank.org:act:2ED84A59-BC4E-4140-843D-DC11FFE4B8E6
http://species-id.net/wiki/Itauara_blahniki
Fig. 7A–C

Description. *Itauara blahniki* can be recognized by the shape of the phallicata, which has a pair of very short spines dorsobasally, and a sclerotized lobe ventrobasally. The ventrolateral process of tergum X is also distinct, consisting of a an outwardly projecting flange-like setose process, and an inner, small digitate setose process. *Itauara blahniki* has elongate, tusk-like parameres. *Itauara rodmani* sp. n., and *I. tusci* sp. n., also

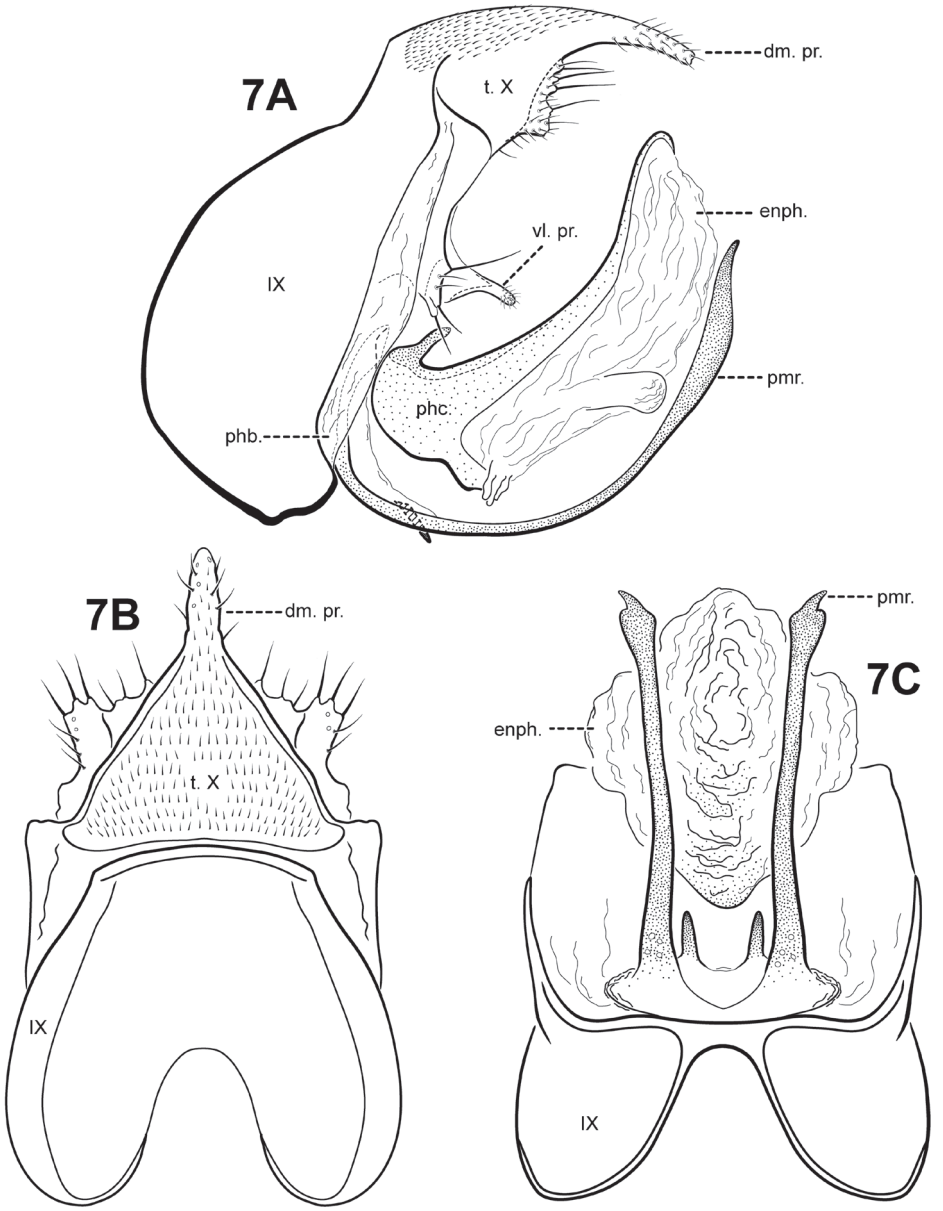


Figure 7. *Itauara blahniki*, sp. n. (UMSP000087057) Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: dm. pr. = dorsomesal process; enph. = endophallus; phb = phallobase; phc. = phallicata; pmr. = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

have tusk-like parameres, but unlike *I. blahniki*, these species have flange-like lateral processes on the phallicata. The species also have differently shaped terga X.

Adult. Body, wings, and appendages pale or tawny brown, often intermingled with rufous or golden hairs, tibia and tarsi tawny brown. Wings with conspicuous white

spot at the arculus. Forewing slightly broader past anastomosis, but with margins nearly parallel, apex rounded. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I sessile; fork II sessile; fork III petiolate, stem about the same length as fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing margins nearly parallel, tapering only slightly past anastomosis; apical forks II, III, and V present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process thumb-like, apex rounded, associated with oblique apodeme posteriorly.

Male genitalia. Preanal and inferior appendages absent. Segment IX dorsally and ventrally narrow, broad medially; anterior margin rounded; posterolateral margin membranous or very lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin with single, downturned, elongate process; dorsolateral margin irregular and setose; ventrolateral margin with paired, outwardly projecting flange-like setose process, and medially with paired digitate setose process. Parameres present, paired, arising ventrobasally from fused endotheca and phallobase, sclerotized and rod-like, slender and elongate, upturned, with distal portion slightly broader, directed dorsally, apex pointed, ventrobasally with small patch of setae. Phallobase reduced, mostly membranous, ventromesally bearing pair of small sclerotized spines. Phallicata forming a long sclerotized dorsal sheath, curving upward, dorsobasally with pair of short processes, ventrally, with lightly sclerotized lobe. Endophallus membranous, enlarged and convoluted when invaginated, with lightly sclerotized lobe ventrally.

Material examined. Holotype male: BRAZIL: Sao Paulo: Estação Biológica Boraceia, Rio Guaratuba, 23°40'02"S, 045°53'46"W, 775 m, 17.ix.2002 (Blahnik, Prather, Melo, Froehlich, Silva) (UMSP000087057) (MZUSP).

Paratypes: BRAZIL: Sao Paulo: same data as holotype except 17.iv.1998 (Holzenthal, Melo, Froehlich) — 1 male (UMSP); same data as holotype — 1 female (UMSP).

Etymology. We are delighted to name this species for Dr. Roger Blahnik, in honor of his many contributions to the systematics of Protoptilinae.

Itauara brasiliana (Mosely 1939)

http://species-id.net/wiki/Itauara_brasiliana
Fig. 2A, 3A, 8A–C

brasiliana (Mosely), 1939: 220 [Type locality: Brazil, Santa Catarina, Nova Teutonia; BMNH] in *Antoptila*]. –Angrisano, 1993: 59 [larva, pupa, case, distribution] 1997:58 [distribution] – Flint, Holzenthal, and Harris, 1999:74 [to *Itauara*].

Description. This species is easily diagnosed by the presence of 2 pairs of extremely elongate, seta-like processes on sternum IX. *Itauara brasiliana* is also distinct in having

vestigial parameres, consisting only of very small, setose lobes. Another distinguishing characteristic is the shape of segment IX, which is rather narrow, and receded ventrally. The rather elongate profile of tergum X, as well as the shape of the dorsomesal

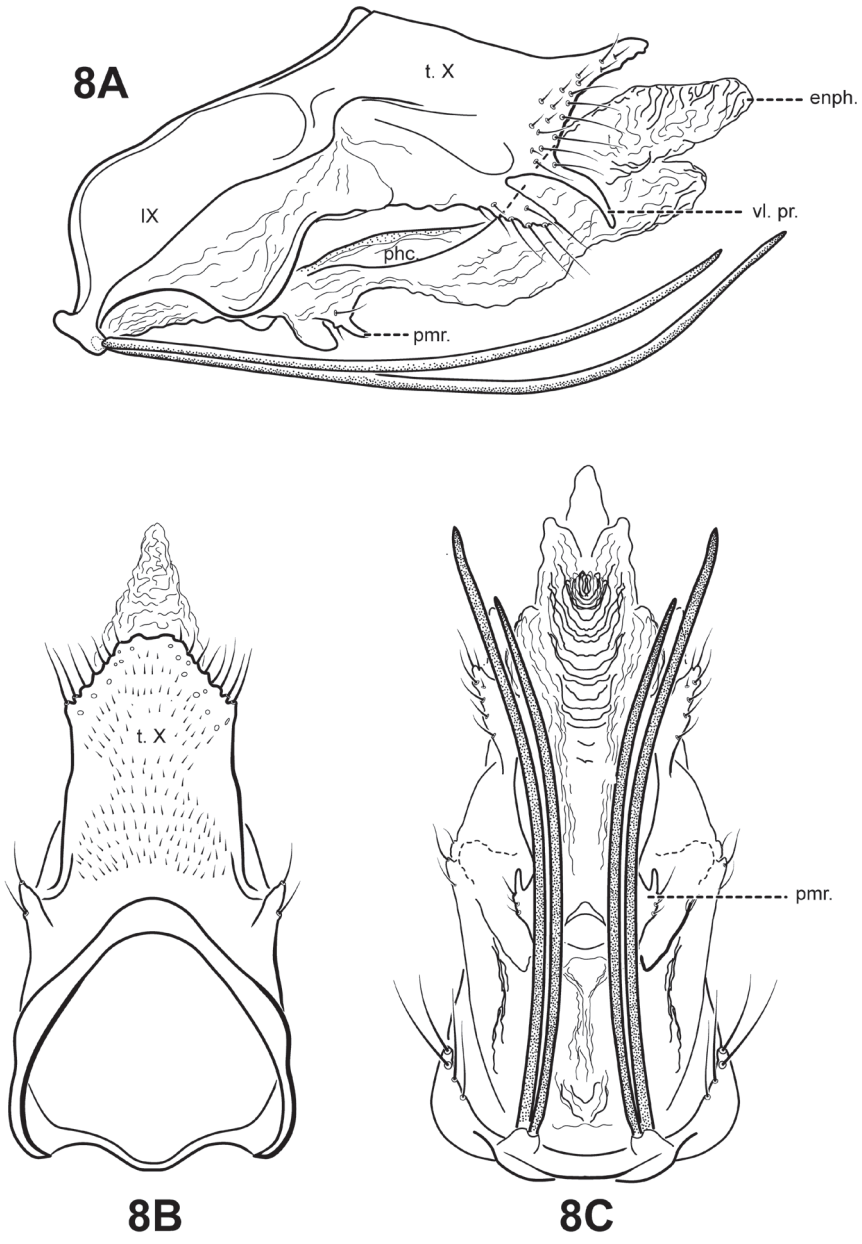


Figure 8. *Itauara brasiliana* (Mosely, 1939). Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: enph. = endophallus; phc. = phallicata; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

and lateral margins of tergum X, slightly resembles that of *I. plaumanni* (Flint 1974). However, *I. plaumanni* has much more pronounced, elongate parameres, and lacks the seta-like processes on sternum IX.

Adult. Body, wings, and appendages pale or tawny brown in alcohol. Forewing slightly broader past anastomosis, but with margins nearly parallel, apex rounded. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I sessile; fork II petiolate, stem shorter than fork; fork III petiolate, stem about the same length as fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing margins nearly parallel, tapering only slightly past anastomosis; apical forks II and V present; Sc and R1 converging near wing margin; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process thumb-like, apex rounded, associated with oblique apodeme posteriorly.

Male genitalia. Preanal and inferior appendages absent. Segment IX ventrally narrow, broad medially; anterior margin relatively straight from dorsum to medial area, ventral portion rounded; posterolateral margin highly membranous, receding ventrally; sternum IX bearing 2 pairs of extremely elongate, seta-like processes. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin subtriangular, slightly upturned; dorsolateral margin slightly irregular, without processes; ventrolateral margin with 2 pairs of processes, the upper an elongate finger-like process slightly downturned, the lower a smaller lobe-like setose process. Parameres vestigial, consisting of a pair of small, digitate setose lobes arising ventrolaterally from endotheca. Phallobase apparently absent or entirely membranous. Phallicata forming a long, lightly sclerotized dorsal sheath, sinuous, broadest medially, narrowed distally. Endophallus membranous, enlarged and convoluted when invaginated.

Material examined. Holotype male: BRAZIL: Santa Catarina: Nova Teutonia, ii. 1937 (F. Plaumann) (BMNH)

Additional material examined: ARGENTINA: Misiones: Arroyo Piray Mini, W., Dos Hermanas, 23.11.1973 (O.S. Flint) — 5 males, 14 females (NMNH); **BRAZIL: Santa Catarina:** Seara (Nova Teutônia), 27°11'00"S, 052°23'00"W, 300–500 m, 10.1964 (F. Plaumann) — 1 male (NMNH).

Itauara charlotta Robertson & Holzenthal, sp. n.

urn:lsid:zoobank.org:act:EE8E2255-6A12-407B-9D1F-921D251401B7
http://species-id.net/wiki/Itauara_charlotta
Fig. 9A–C

Description. This species is only known from the male holotype. *Itauara charlotta* is diagnosed by the unique combination of several male genitalic characters. The dorsomesal margin of tergum X has several small, irregular, setose processes. *Itauara tusci* sp. n., has a similarly shaped dorsomesal margin, but differs in the shape of the parameres and phallica-

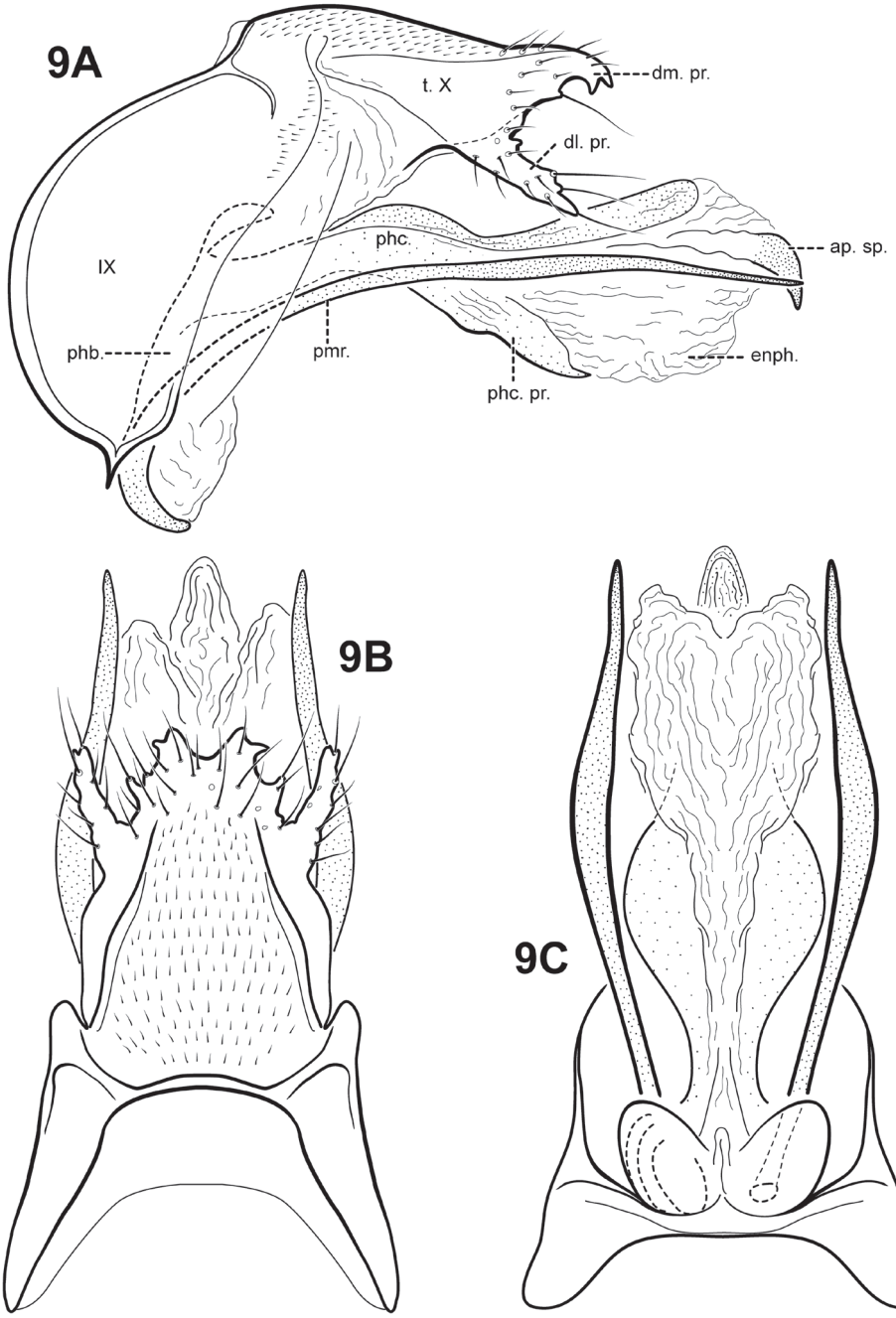


Figure 9. *Itauara charlotta*, sp. n. (UMSP000086390). Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: ap. sp. = apical spine; dl. pr. = dorsolateral process; dm. pr. = dorsomesal process; enph. = endophallus; phb = phallobase; phc. = phallicata; phc. pr. = phallicata process; pmr . = paramere; t. X = tergum X.

ta. The parameres of *I. charlotta* are similar to those of *I. flinti* sp. n.; both arise ventrobasally from the phallobase, and are curved and downturned. *Itauara flinti* is easily separated from *I. charlotta* based on differences in the shape of tergum X and phallicata processes.

Adult. Body, wings, and appendages pale or tawny brown in alcohol. Wings with conspicuous white spot at the arculus and faint transverse line along anastomosis. Forewing slightly broader past anastomosis, but with margins nearly parallel, apex rounded. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I sessile; fork II petiolate, stem shorter than fork; fork III petiolate, stem longer than fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing margins nearly parallel, tapering only slightly past anastomosis; apical forks II, III, and V present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process thumb-like, apex rounded, often associated with weak oblique apodeme posteriorly.

Male genitalia. Preanal and inferior appendages absent. Segment IX ventrally narrow, broad medially; anterior margin rounded; posterolateral margin membranous or very lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin slightly produced with several small irregular setose processes; dorsolateral margin with pair of large irregular, setose process and several smaller processes; ventrolateral margin without processes. Parameres present, paired, arising ventrobasally from fused endotheca and phallobase, sclerotized and rod-like, slender and elongate, slightly downturned, curved basally, straight medially and distally, directed posteriorly, apex pointed. Phallobase reduced, lightly sclerotized. Phallicata forming a long, lightly sclerotized dorsal sheath, slightly sinuous, medially with pair of slender lateral flanges projecting posteroventrally, apices pointed. Endophallus membranous, enlarged and convoluted when evaginated, with pointed apical sclerite.

Material examined. Holotype male: BRAZIL: Minas Gerais: Serra do Cipó, Cardeal Mota, Cachoeira Veu da Noiva, 19°18'55"S, 043°36'16"W, 800 m, 12.11.2001 (Holzenthal, Amar., Blahnik, Paprocki) (UMSP000086390) (MZUSP).

Etymology. We are delighted to name this species for the senior author's mother, Charlotte Ruth Robertson.

***Itauara emilia* Robertson & Holzenthal, sp. n.**
urn:lsid:zoobank.org:act:EDA5DA9E-6661-4F15-96A2-B6166861CA49
http://species-id.net/wiki/Itauara_emilia
Fig. 10A–C

Description. This species is known only from the male holotype. *Itauara emilia* can be recognized by the distinct, rather blunt shape of the dorsomesal process of tergum X. The species is similar to *I. alexanderi* sp. n., *I. lucinda* sp. n., and *I. stella* sp. n., as

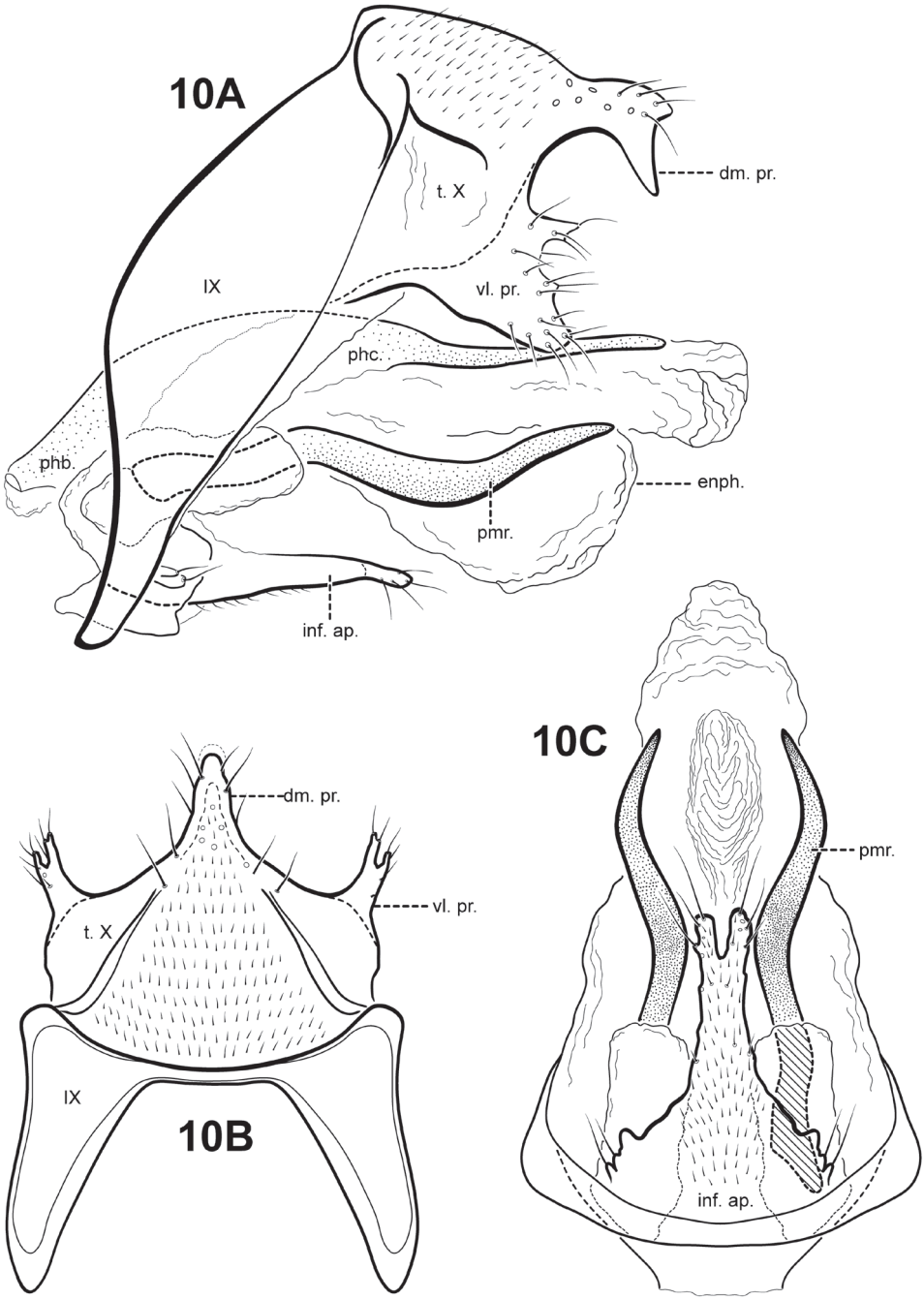


Figure 10. *Itauara emilia* (UMSP000029788). Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: dm. pr. = dorsomesal process; enph. = endophallus; inf. ap. = inferior appendage process; phb. = phallobase; phc. = phallicata; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

discussed under each of those species. Each of these species possess an inferior appendage process, a dorsomesal process on tergum X, and rather sinuous parameres. *Itauara emilia* is most similar to *I. alexanderi* and *I. stella* in having similarly shaped parameres and an apically bifid inferior appendage process. *Itauara emilia* differs from these 2 species in having a much more elongate inferior appendage process and a blunt dorsomesal process on tergum X.

Adult. Body, wings, and appendages tawny brown (specimen missing hairs). Forewing slightly broader past anastomosis, but with margins nearly parallel, apex rounded. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I sessile; fork II petiolate, stem about the same length as fork; fork III petiolate, stem longer than fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing margins nearly parallel, tapering only slightly past anastomosis; apical forks II and V present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process thumb-like, apex rounded, associated with oblique apodeme posteriorly.

Male genitalia. Preanal appendages absent. Segment IX ventrally narrow, broad medially; anterior margin rounded; posterolateral margin membranous or very lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin with large, blunt, dorsomesal process, in dorsal view, elongate, in lateral view, subtriangular; dorsolateral margin without processes; ventrolateral margin with paired, broad flange-like setose process consisting of small upper lobe and larger subtriangular lower lobe. Inferior appendages present as apically bifid, setose process produced mesally, broadest at base and fused to phallobase ventrobasally, with 2 pairs of small digitate lobes ventrolaterally, each bearing a seta. Parameres present, paired, inserted in membranous lobe, arising laterally from endotheca, sclerotized and rod-like, long, sinuous, directed inward and posteriorly, apex pointed. Phallobase reduced, lightly sclerotized. Phallicata forming a long sclerotized dorsal sheath extending from phallobase, straight, broadest basally, distal portion narrow. Endophallus membranous, enlarged and convoluted when invaginated, with 1 upper and 1 lower lobe.

Material examined. Holotype male: BRAZIL: Sao Paulo: Estação Biológica Boraceia, Rio Coruja, 23°40'06"S, 045°53'57"W, 850 m, 18.iv.1998 (Holzenthal, Melo, Froehlich) (UMSP000029788) (MZUSP).

Etymology. This species is named in loving memory of the senior author's paternal grandmother, Grace Emily Gardner Robertson.

***Itauara flinti* Robertson & Holzenthal, sp. n.**
urn:lsid:zoobank.org:act:08207511-83D1-46A4-8168-BAE2935AAC0A
http://species-id.net/wiki/Itauara_flinti
Fig. 11A–C

Description. This species is known only from the male holotype. It is diagnosed by a unique combination of male genitalic characters and can be recognized by the shape of the phallicata process. *Itauara flinti* is most similar to *I. charlotta* sp. n., by having similarly shaped parameres, but these species are easily separated based on differences in the shape of tergum X and the phallicata process. The elongate and downturned dorsomesal process of tergum X is similar to that of *I. guarani* (Angrisano 1993), but the 2 species differ in the shape of the parameres and phallicata processes. The ventrolateral process of tergum X is similar to that of *I. tusci* sp. n. These species differ in the shape of the parameres, dorsomesal margins of tergum X, and phallicata processes.

Adult. Body, wings, and appendages pale or tawny brown in alcohol. Forewing relatively narrow, with margins nearly parallel, apex subacute. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I petiolate, but with extremely short stem; fork II petiolate, stem about the same length as fork; fork III petiolate, stem longer than fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing narrow and slightly scalloped past anastomosis; apical forks II and V present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process thumb-like, apex rounded, associated with weak oblique apodeme posteriorly.

Male genitalia. Preanal and inferior appendages absent. Segment IX dorsally narrow, broad ventrally; anterior margin rounded; posterolateral margin lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin with single, downturned, elongate process; dorsolateral margin irregular and setose; ventrolateral margin with 2 pairs of processes, the upper a small lobe-like setose process, the lower an elongate finger-like process bearing a few elongate setae. Parameres present, paired, arising ventrobasally from fused endotheca and phallobase, sclerotized and rod-like, slender and elongate, downturned, curved basally, straight medially and distally, directed ventrally and inward, apex pointed. Phallobase reduced, lightly sclerotized. Phallicata forming a long, lightly sclerotized dorsal sheath, slightly sinuous, medially with pair of lightly sclerotized rounded lateral flanges projecting posteroventrally, ventrally with several sclerotized points, thorn-like apices directed inward. Endophallus membranous, enlarged and convoluted when invaginated, with 1 large upper lobe and 1 smaller lower lobe.

Material examined. Holotype male: BRAZIL: Sao Paulo: Parque Estadual de Campos do Jordão, Rio Galharada, 22°41'40"S, 045°27'47"W, 1530 m, 13–15. ix.2002 (Blahnik, Prather, Melo, Huamantinco) (UMSP000086388) (MZUSP).

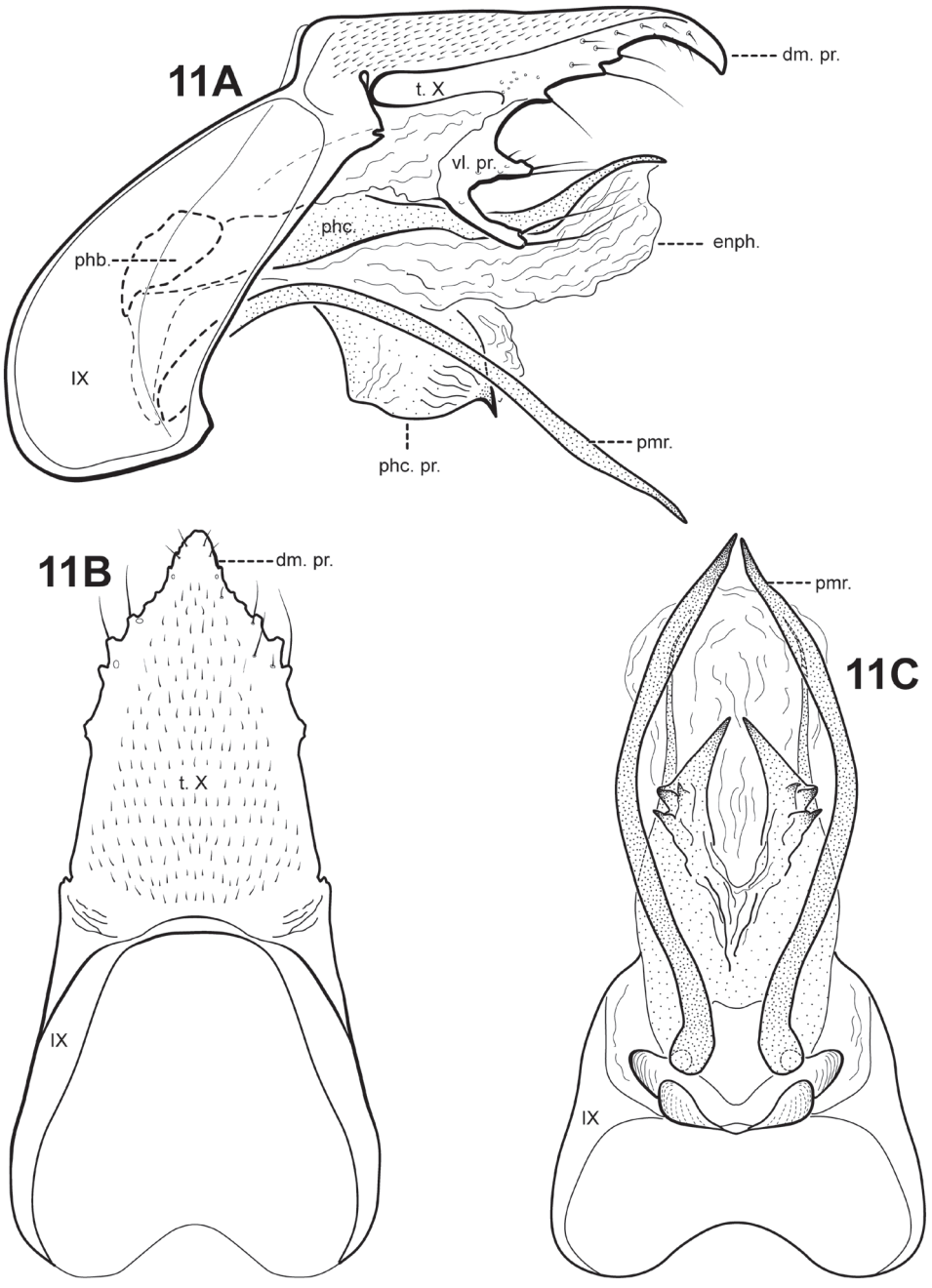


Figure 11. *Itauara flinti*, sp. n. (UMSP000086388) Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: dm. pr. = dorsomesal process; enph. = endophallus; phb = phallobase; phc. = phallicata; phc. pr. = phallicata process; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

Etymology. We are delighted to name this species for Dr. Oliver Flint, Jr. in honor of his numerous important contributions to Neotropical caddisfly taxonomy.

***Itauara guarani* (Angrisano, 1993)**
http://species-id.net/wiki/Itauara_guarani
Fig. 12A–D

guarani (Angrisano), 1993: 57 [Type locality: Argentina, Misiones, Dpt. Belgrano, Río Urugua-í; MACN; in *Antoptila*] – Flint, Holzenthal, and Harris, 1999:74 [to *Itauara*].

Description. This species can be recognized by the very broad, lateral flanges on the phallicata. The phallicata of *I. guarani* is slightly sinuous, with a lightly sclerotized basal portion and a rugous or almost membranous distal portion. *Itauara simplex* sp. n., also has a very lightly sclerotized phallicata, but the 2 species differ in the shape of the parameres and *I. simplex* lacks the processes of phallicata. The parameres of *I. guarani* arise ventrobasally from the phallobase and are sinuous, like those in *I. plaumanni*. However, the phallicata in *I. plaumanni* is much more sclerotized and the 2 species also differ in the shape of tergum X and the phallicata processes.

Adult. Body, wings, and appendages pale or tawny brown in alcohol. Forewing slightly broader past anastomosis, but with margins nearly parallel, apex rounded. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I petiolate, but with extremely short stem; fork II petiolate, stem shorter than fork; fork III petiolate, stem longer than fork; Cu1 incomplete, not reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing margins nearly parallel, tapering only slightly past anastomosis; apical forks II and III present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process short and digitate, apex rounded, associated with weak oblique apodeme posteriorly.

Male genitalia. Preanal and inferior appendages absent. Segment IX dorsally narrow, broad ventrally; anterior margin rounded; posterolateral margin membranous or very lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin with single, downturned, elongate process; dorsolateral margin irregular and setose; ventrolateral margin with paired subtriangular setose process directed posteriorly. Parameres present, paired, arising ventrobasally and fused to phallobase, sclerotized and rod-like, slender and elongate, sinuous, strongly downturned basally, distal portion slightly upturned and broader, directed posteriorly, apex pointed. Phallobase reduced, lightly sclerotized. Phallicata sinuous, with lightly sclerotized base, distal portion membranous, with pair of broad, sclerotized wing-like lateral flanges.

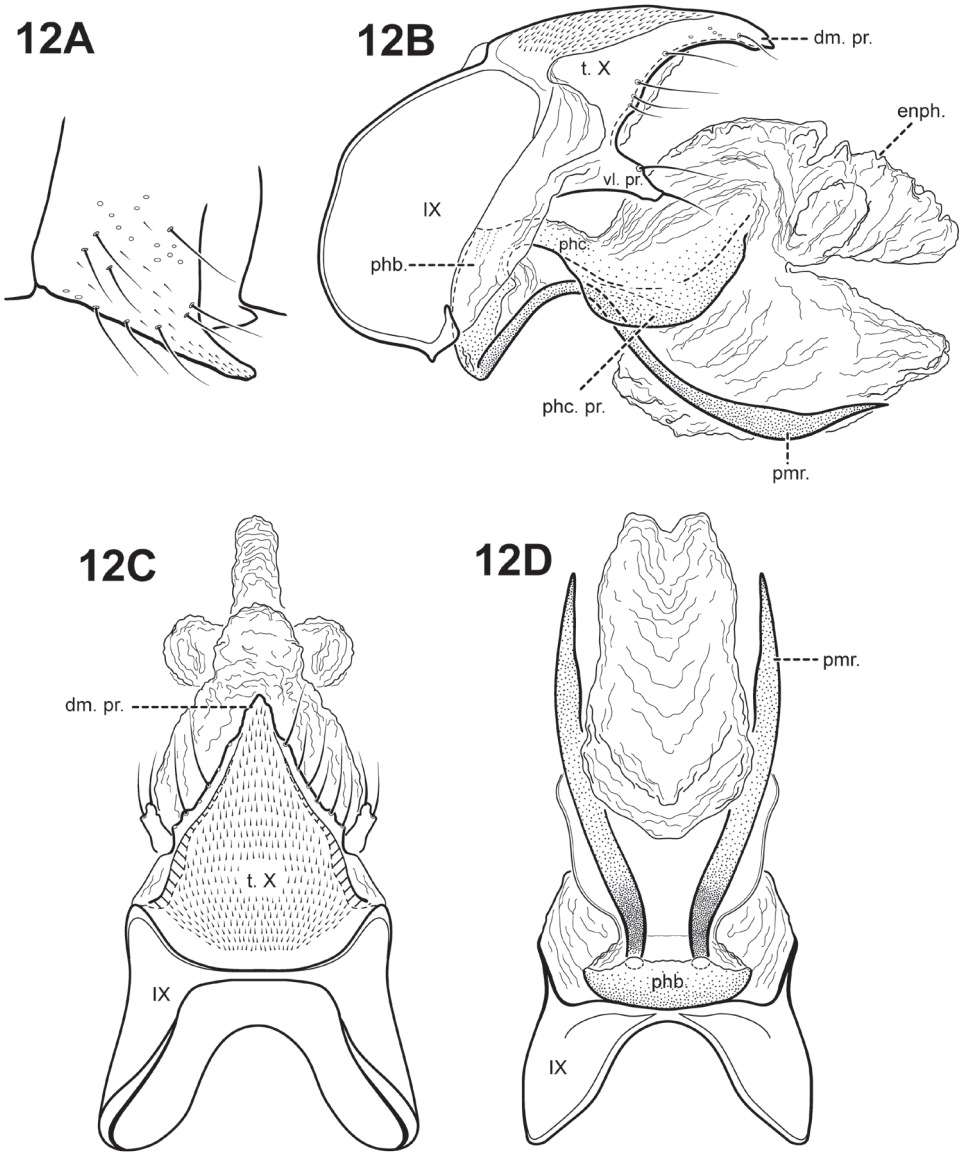


Figure 12. *Itauara guarani* (Angrisano, 1993) (UMSP000086361). Male genitalia **A** Sternum VI process; ttt **B** lateral **C** dorsal **D** ventral. Abbreviations: dm. pr. = dorsomesal process; enph. = endophallus; phb = phallobase; phc. = phallicata; phc. pr. = phallicata process; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

Endophallus membranous, enlarged and convoluted when invaginated, with 3 upper lobes and 1 large lower lobe.

Material examined. Holotype male: ARGENTINA: Misiones: Departmento Belgrano, Rio Urugua-í (Releveamiento Faunístico Urugua-í [segundo campaña]) (UMSP000211316) (MACN).

Allotype female: ARGENTINA: Misiones: same data as holotype (MACN).

Paratypes: ARGENTINA: Misiones: same data as holotype – 3 males, 2 females (MACN).

The genitalia of the holotype and allotype were reported missing (E. Angrisano, *personal communication*).

***Itauara guyanensis* Robertson & Holzenthal, sp. n.**
urn:lsid:zoobank.org:act:3CD78294-B5E5-4191-A04E-23082102925F
http://species-id.net/wiki/Itauara_guyanensis
Fig. 2B, 3B, 13A–C

Description. *Itauara guyanensis* has distinct extremely sinuous, almost corkscrew-shaped, parameres. The phallicata is short, sclerotized, and upturned apically and with 2 pointed lateral processes. The species can also be recognized by the thumb-like shape of the inferior appendage process and the presence of a bifid apical process in the endophallus. *I. guyanensis* is somewhat similar to *I. jamesii* sp. n., and resembles that species in the shape of the inferior appendage process and sinuous parameres. The 2 species can be easily separated by differences in the shape of tergum X and the phallicata. The species *I. alexanderi* sp. n., *I. emilia* sp. n., and *I. stella* sp. n., also have rather sinuous parameres, but differ in the shape of the phallicata, tergum X, and several other characters.

Adult. Body, wings, and appendages pale or tawny brown in alcohol. Forewing narrow past anastomosis, apex acute. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I sessile; fork II petiolate, stem about the same length as fork; fork III petiolate, stem longer than fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing narrow and slightly scalloped past anastomosis; apical fork II present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,3,4, foretibial spur extremely reduced and hairlike. Sixth sternal process short and digitate, apex attenuate and pointed, associated with strong oblique apodeme posteriorly.

Male genitalia. Preanal appendages absent. Segment IX dorsally narrow, broad medially and ventrally; anterior margin rounded; posterolateral margin membranous or very lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin with single, downturned, elongate process; dorsolateral margin with

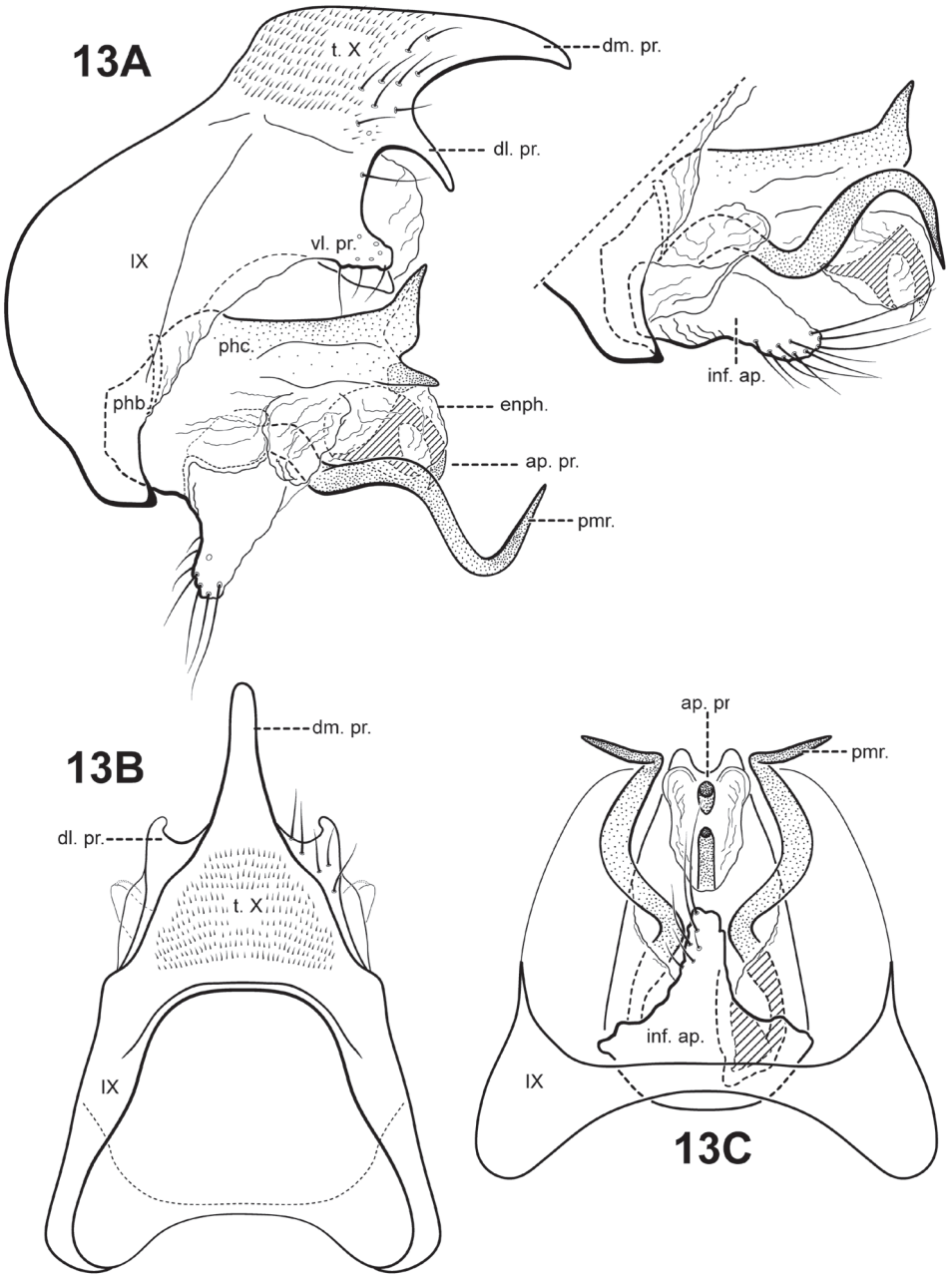


Figure 13. *Itauara guyanensis*, sp n. Male genitalia, everted (UMSP000210959) and non-everted (UMSP000210962) **A** lateral: left, everted; inset, non-everted **B** dorsal **C** ventral. Abbreviations: ap. pr. = apical process; dl. pr. = dorsolateral process; dm. pr. = dorsomesal process; enph. = endophallus; inf. ap. = inferior appendage process; phb. = phallobase; phc. = phallicata; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

paired small, down-turned, finger-like process; ventrolateral margin with an outer pair of subquadrate setose processes directed posteriorly, and an inner pair of subtriangular processes directed posteroventrally. Inferior appendages present as single thumb-like setose process, broadest at base and fused to phallobase ventrobasally. Parameres present, paired, inserted in membranous lobe, arising laterally from endotheca, sclerotized and rod-like, extremely sinuous, corkscrew-shaped, apex pointed. Phallobase reduced, lightly sclerotized with phallic shield. Phallicata forming a rather short sclerotized dorsal sheath extending from phallobase, straight basally and medially, bent sharply upward, medially with pair of lightly slerotized lateral flanges with pointed apices projecting posteriorly. Endophallus membranous, apically with sclerotized bifid process.

Material examined. Holotype male: GUYANA: Dubulay Ranch: Warniabo Cr., 05°39'48"N, 057°53'24"E, 14–19.iv.1995 (O.S. Flint) (UMSP000210959) (NMNH).

Paratypes: GUYANA: Dubulay Ranch: Aramatani Cr., 05°39'24"N, 057°55'30"W, 15–18.iv.1995 (O.S. Flint) — 2 males, 2 females (NMNH).

Etymology. This species is named for the country of Guyana, where the specimens were collected.

***Itauara jamesii* Robertson & Holzenthal, sp. n.**
urn:lsid:zoobank.org:act:9EAE24A5-16C2-4B9F-8BDD-42976CE0E569
http://species-id.net/wiki/Itauara_jamesii
Fig. 14A–C

Description. *Itauara jamesii* is known only from the male holotype, and its relationship to other species in not immediately evident. The parameres have a rather asymmetrical aspect, but it is possible that this particular specimen is distorted. The species has an inferior appendage process like several other species, but has a distinct subtriangular shape. The dorsomesal margin of tergum X is bifid, each half a small setose protuberance. *Itauara peruensis* sp. n., also has a bifid dorsomesal margin, but in that species, it appears as a prominent process with pointed apices.

Adult. Body, wings, and appendages pale or tawny brown, often intermingled with rufous or golden hairs, tibia and tarsi tawny brown. Wings with conspicuous white spot at the arculus and faint transverse line along anastomosis. Forewing slightly broader past anastomosis, but with margins nearly parallel, apex subacute. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I sessile; fork II petiolate, stem shorter than fork; fork III petiolate, stem longer than fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing margins nearly parallel, tapering only slightly past anastomosis; apical forks II and V present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process thumb-like, apex rounded, associated with weak oblique apodeme posteriorly.

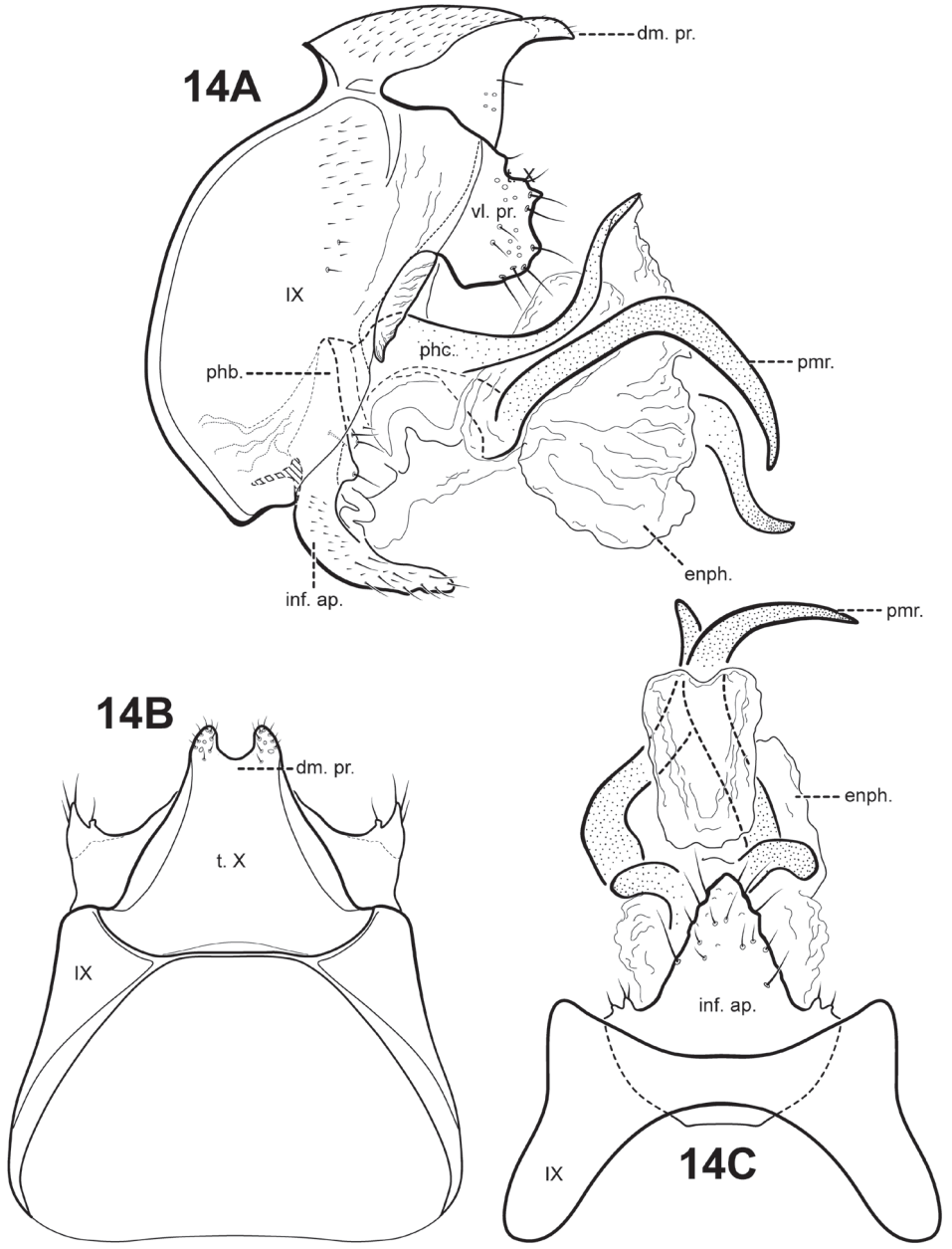


Figure 14. *Itauara jamesii*, sp. n. (UMSP000087916). Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: dm. pr. = dorsomesal process; enph. = endophallus; enph. pr. = endophallic process; inf. ap. = inferior appendage process; phb. = phallobase; phc. = phallicata; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

Male genitalia. Preanal and inferior appendages absent. Segment IX dorsally and ventrally narrow, broad medially; anterior margin rounded; posterolateral margin membranous or very lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin bifid and slightly produced, each half small, setose, with a rounded apex; dorsolateral margin without processes; ventrolateral margin with paired, broad, semi-circular setose flange-like process. Inferior appendages present as single, broad, subtriangular setose process, fused to phallobase ventrobasally, bearing small digitate lobes ventrolaterally, each bearing a seta. Parameres present, paired, inserted in membranous lobe, arising laterally from endotheca, sclerotized and rod-like, extremely sinuous, seemingly asymmetrical, apex pointed. Phallobase reduced, lightly sclerotized with phallic shield. Phallicata forming a long sclerotized dorsal sheath extending from phallobase, broadest basally, bent upward at middle, with paired sclerotized concave discs arising basodorsally and forming a connection with posterior margin of segment IX. Endophallus membranous, enlarged and convoluted when invaginated.

Material examined. Holotype male: BRAZIL: Minas Gerais: trib. to Rio do Salto, Ibitipoca, Fazenda Engenho, 21°44'06"S, 043°53'56"W, 875, 11–14.iii.2002 (Holzenthal, Blahnik, Paprocki, Prather) (UMSP000087916) (MZUSP).

Etymology. We are delighted to name this species for the senior author's father, James Gardner Robertson.

***Itauara julia* Robertson & Holzenthal, sp. n.**
urn:lsid:zoobank.org:act:5DE975A9-37FA-4BB0-9A52-662621648658
http://species-id.net/wiki/Itauara_julia
Fig. 1, 3C,15A–C

Description. This species is distinct in having a curved, spatulate ventral process in the endophallus and having a phallicata that is not continuous with the phallobase. The parameres of *I. julia* are strongly bent dorsally at the base, and terminate in a sharp, downturned point. The parameres curve upward, are fused to and continuous with the phallobase, and arise ventrobasally. The parameres of *I. blahniki* sp. n., *I. rodmani* sp. n., and *I. tusci* sp. n., are similarly structured. However, in these species, the parameres are not as abruptly bent.

Adult. Body, wings, and appendages pale or tawny brown, often intermingled with rufous or golden hairs, tibia and tarsi tawny brown. Wings with conspicuous white spot at the arculus. Forewing slightly broader past anastomosis, but with margins nearly parallel, apex rounded. With apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I sessile; fork II sessile; fork III petiolate, stem shorter than fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing margins nearly parallel, tapering only slightly past anastomosis; apical forks II, III, and V pre-

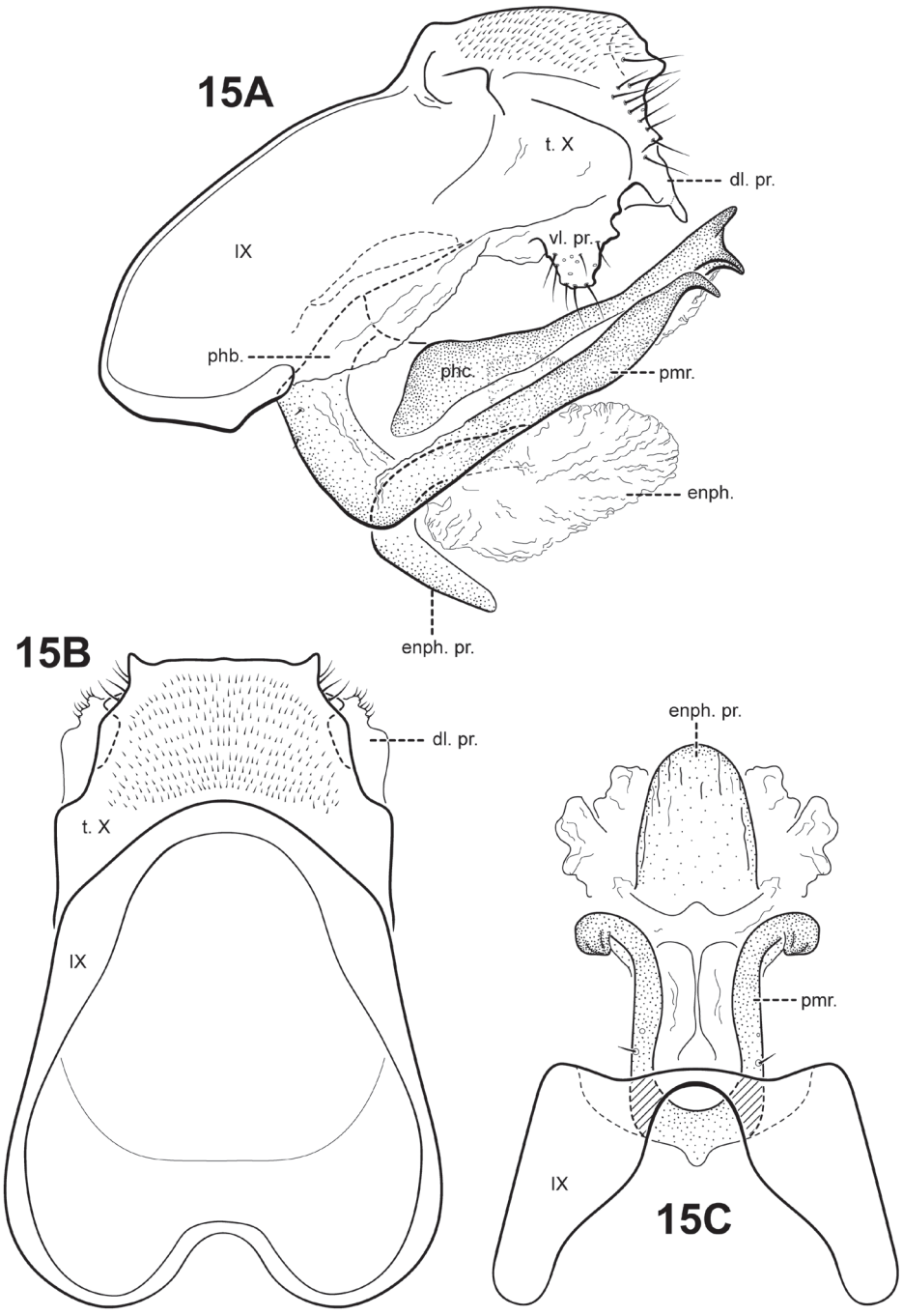


Figure 15. *Itauara julia*, sp. n. Male genitalia: Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: dl. pr. = dorsolateral process; enph. = endophallus; enph. pr. = endophallic process; phb. = phallobase; phc. = phallicata; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

sent; Sc and R1 converging near wing margin; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process thumb-like, apex attenuate and pointed, associated with weak oblique apodeme posteriorly.

Male genitalia. Preanal and inferior appendages absent. Segment IX dorsally narrow, broad ventrally; anterior margin relatively straight from dorsum to medial area, ventral portion blunt; posterolateral margin membranous or very lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin straight, without processes; dorsolateral margin with several small irregular setose processes; ventrolateral margin with paired subquadrate setose process projecting ventrally. Parameres present, paired, arising ventrobasally and fused to phallobase, sclerotized and rod-like, slender and elongate, strongly bent upward basally, apex pointed and downturned, ventrobasally with a small patch of setae. Phallobase reduced, lightly sclerotized. Phallicata forming a long sclerotized dorsal sheath, mostly straight, broadest basally, apex with apicomesal point and 2 lateral downturned points. Endophallus membranous, enlarged and convoluted when invaginated, ventrally with a curved spatulate process.

Material examined. Holotype male: BRAZIL: Rio de Janeiro: Parque Nacional do Itatiaia, Rio Campo Belo, trail to Veu da Noiva, 22°25'42"S, 044°37'10"W, 1310 m, 5.iii.2002 (Holzenthal, Blahnik, Paprocki, Prather) (UMSP000069560) (MZUSP).

Paratypes: BRAZIL: Rio de Janeiro: Parque Nacional do Itatiaia, same data as holotype — 9 males, 5 females (UMSP); same, 24.ix.2001 (Holzenthal, Blahnik, Neto, Paprocki) — 17 males, 8 females (UMSP); Rio Taquaral, 22°27'15"S, 044°36'34"W, 1300 m, 22–23.ix.2001 (Holzenthal & Blahnik) — 20 males; Rio Campo Belo, 22°27'02"S, 044°36'49"W, 1300 m, 23.ix.2001 (Holzenthal, Blahnik, Neto, Paprocki) — 28 males, 17 females (NMNH, UMSP); 7.iii.2002 (Holzenthal, Blahnik, Paprocki, Prather) —24 males, 46 females (MZUSP, UMSP).

Etymology. We are delighted to name this species for Julie Martinez, who rendered the beautiful color plate of this species.

Itauara lucinda Robertson & Holzenthal, sp. n.

urn:lsid:zoobank.org:act:F8FA9F0B-D595-4FDC-92D8-7F64F183E91D
http://species-id.net/wiki/Itauara_lucinda
Fig. 16A–C

Description. This species is similar to *Itauara alexanderi* sp. n., *I. emilia* sp. n., and *I. stella*, sp. n., as discussed under each of those species. Each of these species possess an inferior appendage process, a dorsomesal process on tergum X, and rather sinuous parameres. Among these species, *I. lucinda* is distinct in having forked parameres and a non-bifid inferior appendage process.

Adult. Body, wings, and appendages fuscous, intermingled with rufous or golden hairs, tibia and tarsi tawny brown. Wings with white transverse line along anastomo-

sis. Forewing slightly broader past anastomosis, but with margins nearly parallel, apex subacute. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I sessile; fork II petiolate, stem about the same length as fork; fork III petiolate, stem longer than fork; Cu1 complete, reaching

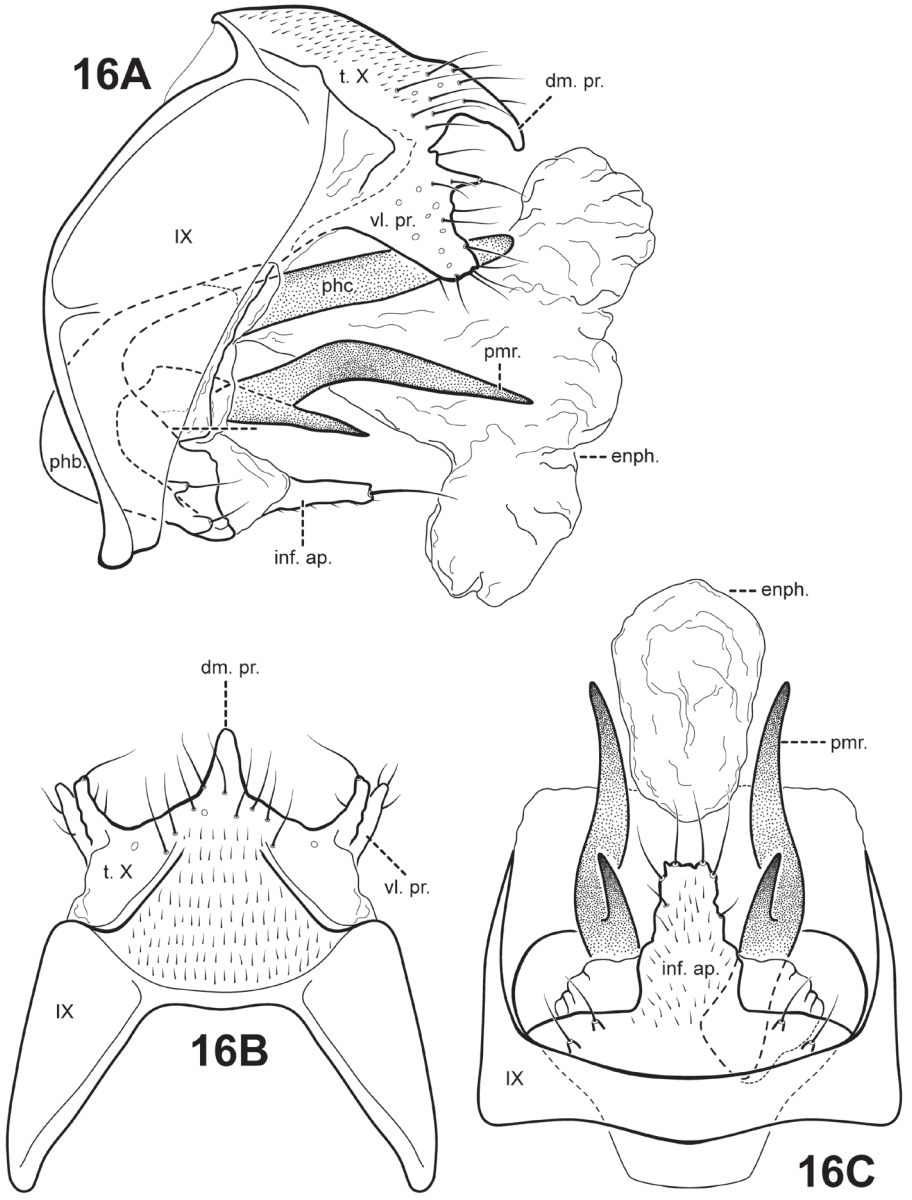


Figure 16. *Itauara lucinda*, sp. n. (UMSP000052593). Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: dm. pr. = dorsomesal process; enph. = endophallus; inf. ap. = inferior appendage process; phb. = phallobase; phc. = phallicata; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; discoidal cell longer than Rs vein. Hind wing margins nearly parallel, tapering only slightly past anastomosis; apical forks II and V present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process thumb-like, apex attenuate and pointed, associated with oblique apodeme posteriorly.

Male genitalia. Preanal appendages absent. Segment IX dorsally narrow, broad medially and ventrally; anterior margin rounded; posterolateral margin membranous or very lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin with single, downturned, elongate process; dorsolateral margin without processes; ventrolateral margin with paired, broad flange-like setose process with small upper lobe and larger subquadrate lower lobe. Inferior appendages present as single, broad, subquadrate setose process, broadest basally, fused to phallobase ventrobasally, with 2 pairs of small digitate lobes ventrolaterally, each bearing a seta. Parameres present, paired, inserted in membranous lobe, arising laterally from endotheca, sclerotized and rod-like, bifid, with short lower process and longer, slightly medially bent upper process, directed posteriorly, apices pointed. Phallobase reduced, lightly sclerotized. Phallicata forming a long, straight sclerotized dorsal sheath extending from phallobase. Endophallus membranous, enlarged and convoluted when invaginated, with 1 upper and 1 lower lobe.

Material examined. Holotype male: BRAZIL: Minas Gerais: Parque Nacional do Caparaó, small trib. to Rio Caparaó, Vale Verde, 20°25'02"S, 041°50'46"W, 1350, 12–14.iii.2002 (R.W. Holzenthal) (UMSP000052593) (MZUSP).

Paratype: BRAZIL: Minas Gerais: same data as holotype — 1 female (UMSP).

Etymology. We are delighted to name this species for the senior author's daughter, Lucinda Grace Thompson.

***Itauara ovis* Robertson & Holzenthal, sp. n.**
urn:lsid:zoobank.org:act:B534B28B-C523-4B04-9F33-FDE480C6D2BE
http://species-id.net/wiki/Itauara_ovis
Fig. 17A–C

Description. Perhaps the most notable feature of this species is the extremely curved, ram-like shaped parameres. *Itauara spiralis* sp. n., also has highly curved, spiral shaped parameres, but in *I. spiralis*, the paramere is curved along the entire length of the paramere, whereas in *I. ovis*, the paramere is curved basally, but straight distally. The 2 species differ in other respects, including the shape of the inferior appendage process. In *I. ovis,* the inferior appendage process is elongate, and rather inflated apically; in *I. spiralis*, the inferior appendage process is bifid. The 2 species also differ in the shape of tergum X. In *I. ovis,* tergum X is slightly notched apicomesally and has 2 pairs of rather small, subtriangular ventrolateral processes. In *I. spiralis*, tergum X is not notched, but

has a pair of very long, finger-like dorsomesal processes and a pair of very broad, irregular ventrolateral processes. The phallicata of *I. ovis* is also quite distinct, being rather broad, and saddle-shaped, with a dorsobasal hump and upturned apex.

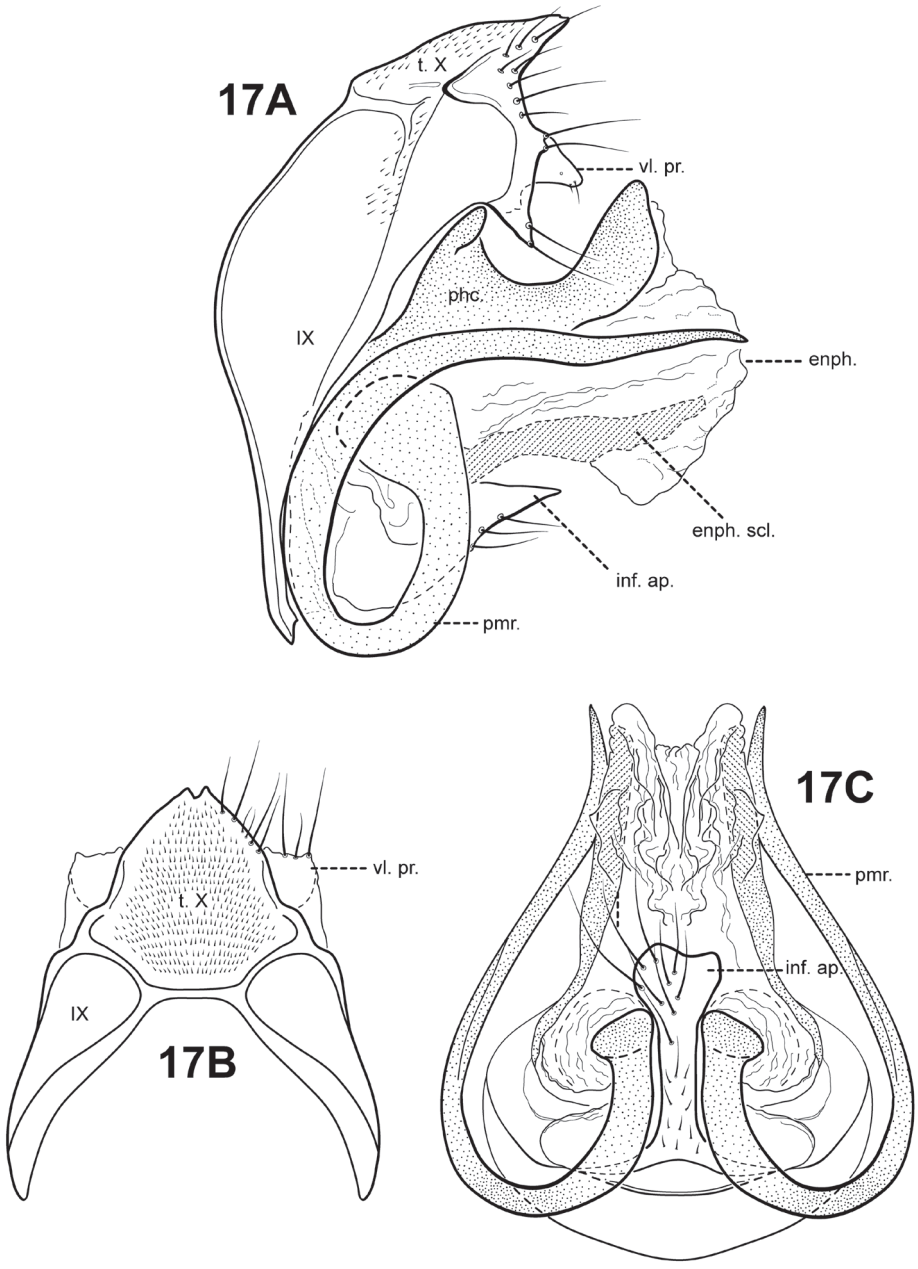


Figure 17. *Itauara ovis*, sp. n. (UMSP000118534) Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: enph. = endophallus; enph. scl. = endophallic sclerite; inf. ap. = inferior appendage process; phc. = phallicata; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

Adult. Body, wings, and appendages fuscous, intermingled with rufous or golden hairs, tibia and tarsi tawny brown. Wings often with a few pale cream-colored or white hairs at arculus. Forewing relatively narrow, with margins nearly parallel, apex subacute. Forewing venation incomplete, with apical forks I, II, and III present; fork I sessile; fork II petiolate, stem about the same length as fork; fork III petiolate, stem longer than fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing narrow and slightly scalloped past anastomosis; apical forks II and V present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process short and digitate, apex attenuate and pointed, associated with strong oblique apodeme posteriorly.

Male genitalia. Preanal appendages absent. Segment IX ventrally narrow, broad medially; anterior margin rounded; posterolateral margin lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin subtriangular, slightly produced with small cleft; dorsolateral margin without processes; ventrolateral margin with an outer pair of subtriangular setose processes directed ventrally, and an inner pair of subtriangular processes directed posteroventrally. Inferior appendages present as single, rather elongate setose process produced mesally, apex broad and slightly irregular, fused to phallobase ventrobasally. Parameres present, paired, inserted in membranous lobe, arising laterally from endotheca, sclerotized and rod-like, ram-like, curving 360 degrees at base, distal portion straight, directed posteriorly, apex pointed. Phallobase extremely reduced and difficult to discern. Phallicata forming a saddle-shaped sclerotized dorsal sheath, with dorsal hump basally, distal portion curving upward. Endophallus membranous, enlarged and convoluted when evaginated, with pair of elongate lateral sclerites ventrally.

Material examined. Holotype male: GUYANA: Kanuku Mountains: Kumu River & Falls, 03°15'54"N, 059°43'30"W, 28–30.iv.1995 (O.S. Flint) (UMSP000118534) (NMNH)

Paratypes: VENEZUELA: Bolivar: La Escalera, 108 km. S Rio Cuyuni, 11–12. ii.1976 (C. & O. Flint) — 5 males (NMNH).

Etymology. The name *ovis*, comes from the Latin for sheep, and is suggested by the shape of the parameres, which are reminiscent of a ram's horn.

***Itauara peruensis* Robertson & Holzenthal, sp. n.**
urn:lsid:zoobank.org:act:0F3E4131-B78D-470A-9DA5-83228D16BEC6
http://species-id.net/wiki/Itauara_peruensis
Fig. 18A–C

Description. This species is distinct in having a lightly sclerotized endophallus. Ventrally, the endophallus is membranous, but in lateral view, it has the appearance of being entirely sclerotized. Another unique feature is the prominent bifid dorsomesal

process of tergum X. *Itauara peruensis* has a rather elongate inferior appendage process like *I. ovis*, but it is not inflated apically like that species. The species also differ in the shape of the parameres; those of *I. peruensis* are nearly straight, while those of *I. ovis* are spiral-shaped.

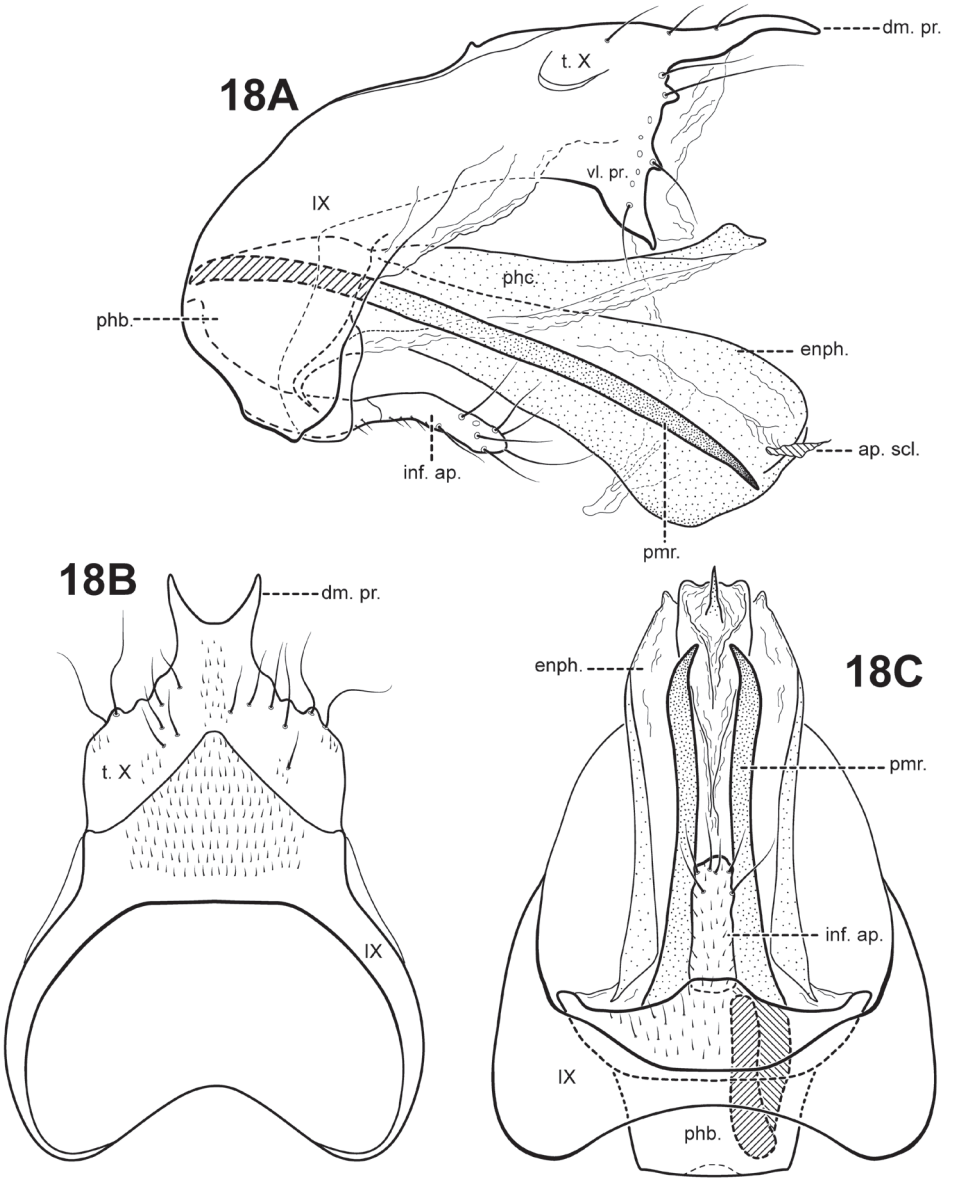


Figure 18. *Itauara peruensis*, sp. n. (UMSP000210957). Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: ap. scl. = apical sclerite; dm. pr. = dorsomesal process; enph. = endophallus; inf. ap. = inferior appendage process; phb. = phallobase; phc. = phallicata; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

Adult. Body, wings, and appendages pale or tawny brown in alcohol. Forewing narrow past anastomosis, apex acute. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I sessile; fork II petiolate, stem about the same length as fork; fork III petiolate, stem longer than fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing narrow and slightly scalloped past anastomosis; apical fork II present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process short and digitate, apex attenuate and pointed, associated with strong oblique apodeme posteriorly.

Male genitalia. Preanal appendages absent. Segment IX ventrally narrow, broad medially; anterior margin rounded; posterolateral margin membranous or very lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin with bifid process, each half with a pointed apex; dorsolateral margin slightly irregular, without processes; ventrolateral margin with paired subtriangular setose process directed ventrally. Inferior appendages present as single, narrow, rather short setose process produced mesally, fused to phallobase ventrobasally. Parameres present, paired, arising laterally from anterior portion of phallobase, sclerotized and rod-like, slender and elongate, straight, very slightly downturned, apex pointed. Phallobase reduced, lightly sclerotized. Phallicata forming a long sclerotized dorsal sheath, mostly straight, broadest basally, distal portion very slightly upturned. Endophallus lightly sclerotized tubular structure, ventrally with membranous folds, apically with small phallotremal sclerite.

Material examined. Holotype male: PERU: Madre de Dios: Manu Biosphere Reserve, Pakitza Biological Station, Trail 2, 1st stream, 12°07'00"S, 070°58'00"W, 250 m, 14–23.ix.1988 (Flint & Adams) (UMSP000210957) (NMNH)

Paratypes: PERU: Madre de Dios: same data as holotype — 7 males, 21 females; same, 17–20.ix.1988 (Flint & Adams) — 1 female (NMNH).

Etymology. This species is named for the country of Peru, where the specimens were collected.

***Itauara plaumanni* (Flint 1974)**
http://species-id.net/wiki/Itauara_plaumanni
Fig. 19A–D

plaumanni (Flint), 1974: 7 [Type locality: Brazil, Santa Catarina, Nova Teutonia; NMNH; in *Antoptila*]. – Angrisano, 1993: 59 [distribution] – Flint, Holzenthal, and Harris, 1999:74 [to *Itauara*].

Description. *Itauara plaumanni* can be recognized by the irregular lobe-like shape of the lateral flanges on the phallicata. Additionally, this species has a rather elongate

segment IX and tergum X. The profile of tergum X resembles that of *I. brasiliana*, but *I. plaumanni* has fewer lateral processes than that species. *Itauara plaumanni* has parameres similar in shape to those of *I. guarani*, yet these species are easily separated by differences in the shape of the lateral flanges of the phallicata, and tergum X.

Adult. Body, wings, and appendages pale or tawny brown in alcohol. Forewing slightly broader past anastomosis, but with margins nearly parallel, apex rounded. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I sessile; fork II petiolate, stem shorter than fork; fork III petiolate, stem about the same length as fork; Cu1 complete, reaching

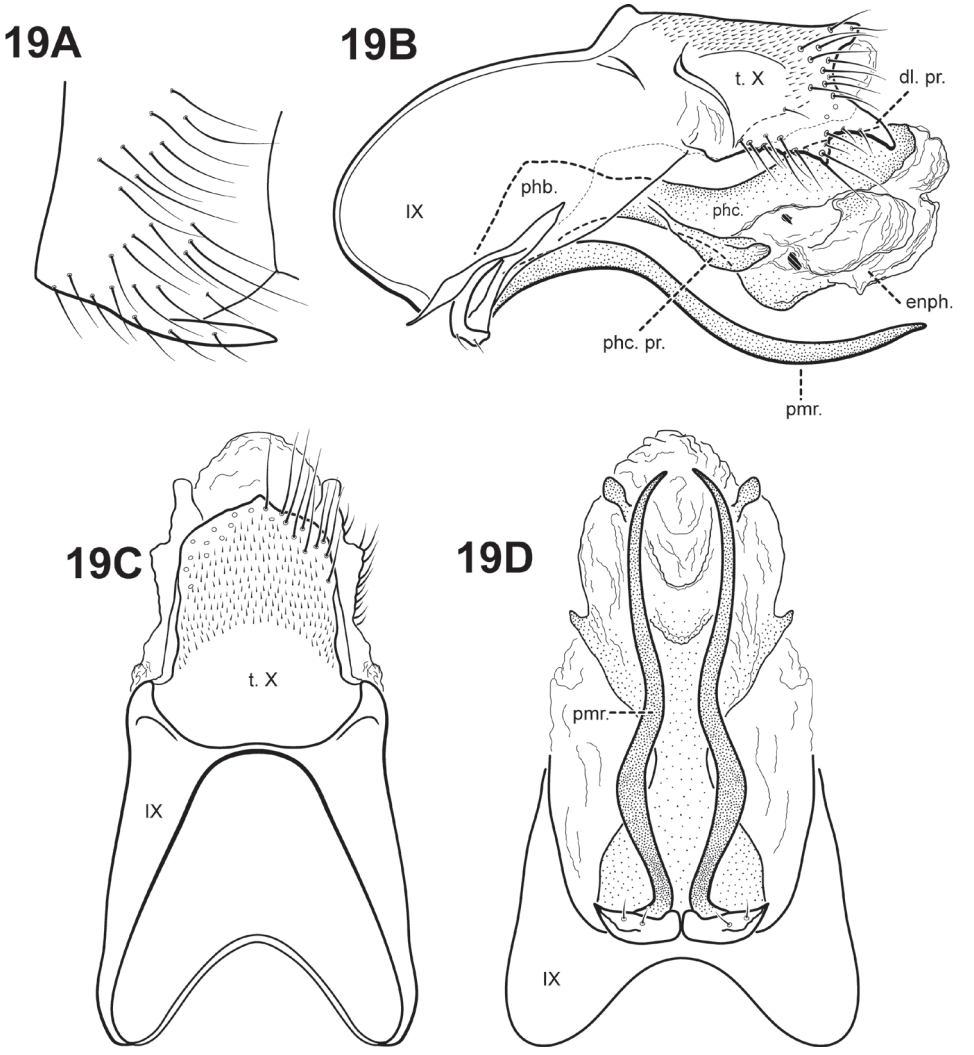


Figure 19. *Itauara plaumanni* (Flint, 1974) (UMSP000086359). Male genitalia **A** Sternum VI process; ttt **B** lateral **C** dorsal **D** ventral. Abbreviations: dl. pr. = dorsolateral process; enph. = endophallus; phb = phallobase; phc. = phallicata; phc. pr. = phallicata process; pmr . = paramere; t. X = tergum X.

wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing margins nearly parallel, tapering only slightly past anastomosis; apical forks II, III, and V present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process short and digitate, apex attenuate and pointed.

Male genitalia. Preanal and inferior appendages absent. Segment IX relatively broad; anterior margin rounded; posterolateral margin membranous or very lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin slightly produced as small irregular point; dorsolateral margin with 2 pairs of processes, the upper an elongate subtriangular process slightly downturned, the lower a small lobe-like setose process; ventrolateral margin without processes. Parameres present, paired, arising ventrobasally and fused to phallobase, sclerotized and rod-like, slender and elongate, sinuous, downturned basally, distal portion slightly upturned, directed posteriorly and inward, apex pointed, ventrobasally with small patch of setae. Phallobase reduced, lightly sclerotized. Phallicata forming a long sclerotized dorsal sheath, slightly bent upward medially, with pair of irregular lobe-like lateral flanges projecting posteroventrally. Endophallus membranous, enlarged and convoluted when invaginated, with lightly sclerotized lobe ventrally and laterally, containing 2 small sclerites.

Material examined. Holotype male: BRAZIL: Santa Catarina: Nova Teutonia, 27°03'00"S, 052°24'00"W, 1.ii.1964 (F. Plaumann) (UMSP000027160) (NMNH).

Paratypes: BRAZIL: Santa Catarina: same data as holotype, 1.ix.1963 (F. Plaumann) — 1 male (NMNH), same, 1.xi.1963 (F. Plaumann) — 7 males (NMNH); same, Nova Teutonia, 27°11'00"S, 052°23'00"W, 300–500 m, 1.i.1963 (F. Plaumann) — 1 male, (NMNH), same, 1.i.1964 (F. Plaumann) — 7 males (NMNH).

Additional material examined: **ARGENTINA: Misiones:** Cataratas del Iguazú, 14.x.1985 — 2 males (MACN); **Salto:** Salto Grande, cascada, 10.xi.1955 (C.S. Carbonell) — 46 males (MACN); **URUGUAY: Artigas:** San Gregorio, 30°33'00"S, 057°52'00"W (Carbonell, Mesa, & San Martin) — 1 male (MACN); Orillas Rio Uruguay (Carbonell, AM, PSM) — 1 male, 3 females (MACN); **Paysandu:** Sta. Rita, Orilla Rio Uruguay, 32°07'00"S, 058°09'00"W, 8.xii.1955 (C.S. Carbonell) — 10 males (MACN); 1.xii.1959 (C.S. Carbonell) — 1 male (MACN).

Itauara rodmani Robertson & Holzenthal, sp. n.

urn:lsid:zoobank.org:act:B5D07A37-7980-4300-B3E1-C856A34EA331
http://species-id.net/wiki/Itauara_rodmani
Fig. 20A–D

Description. This species is very similar to *I. tusci* sp. n., which also has very long, upturned, tusk-like parameres and a strongly upturned phallicata. The 2 species can be

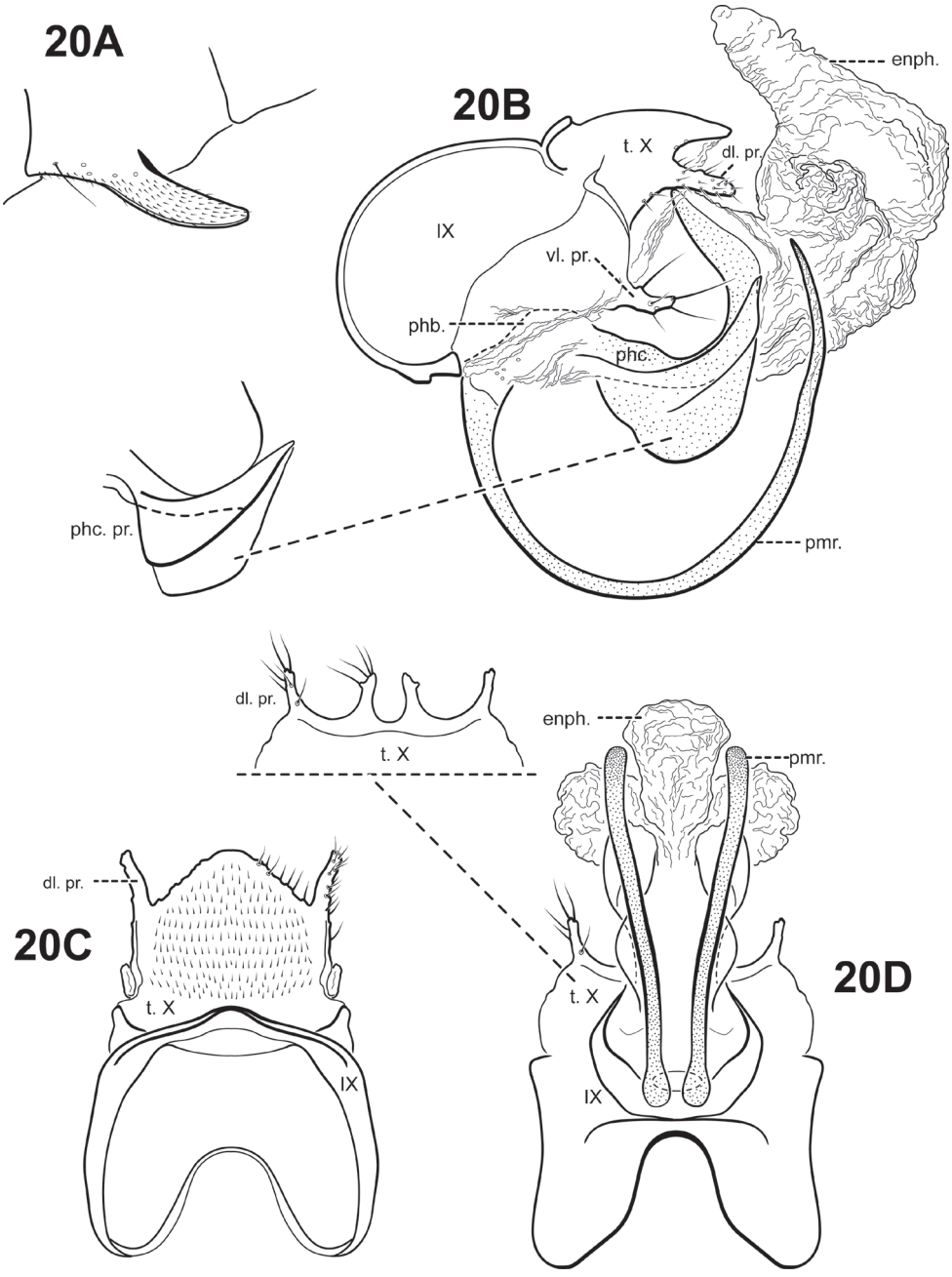


Figure 20. *Itauara rodmani*, sp. n. (UMSP000081856). Male genitalia **A** sternum VI process **B** lateral; inset, variant **C** dorsal **D** ventral; inset, tergum X. Abbreviations: dl. pr. = dorsolateral process; enph. = endophallus; phb = phallobase; phc. = phallicata; phc. pr. = phallicata process; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

separated based on the shape of the phallicata process, which is pointed and blade-like in *I. tusci* and rounded or blunt in *I. rodmani*. The phallicata is also more sclerotized in *I. rodmani*. Additionally, the dorsomesal margin of tergum X is irregular, with several small setose processes in *I. tusci*, whereas in *I. rodmani*, the dorsomesal margin is rather smooth and triangular. The ventrolateral processes of the 2 species also differ: *I. tusci* has a small upper and more elongate lower process; *I. rodmani* has a single, short, digitate process. *I. blahniki* also has upturned, tusk-like parameres, but is easily distinguished from *I. rodmani* based on differences in tergum X and the phallicata. *Itauara blahniki* and *I. blahniki*, sp. n., also has tusk-like parameres, but they are not as long and curved as *I. rodmani*.

Adult. Body, wings, and appendages pale or tawny brown in alcohol. Wings with conspicuous white spot at the arculus. Forewing slightly broader past anastomosis, but with margins nearly parallel, apex subacute. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I sessile; fork II petiolate, stem shorter than fork; fork III petiolate, stem about the same length as fork; Cu1 incomplete, not reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing margins nearly parallel, tapering only slightly past anastomosis; apical forks II, III, and V present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process thumb-like, apex rounded, associated with weak oblique apodeme posteriorly.

Male genitalia. Preanal and inferior appendages absent. Segment IX relatively broad; anterior margin rounded; posterolateral margin membranous or very lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin subtriangular, very slightly downturned; dorsolateral margin with paired small, slightly down-turned, setose process; ventrolateral margin with an outer and inner pair of small setose processes directed posteriorly. Parameres present, paired, arising ventrobasally from fused endotheca and phallobase, sclerotized and rod-like, tusk-like, strongly curving upward, apex pointed. Phallobase reduced, lightly sclerotized with phallic shield. Phallicata forming a long sclerotized dorsal sheath extending from phallobase, strongly curving upward with apex directed dorsally, with pair of broad, sclerotized wing-like lateral flanges with rounded or subquadrate ventral margins. Endophallus membranous, enlarged and convoluted when invaginated, with 1 tubular upper lobe and 3 smaller lower lobes.

Material examined. Holotype male: BRAZIL: Minas Gerais: Corrego das Aguas Pretas & tribs., ca. 15 km S Aiuruoca, 22°03'42"S, 044°38'14"W, 1386 m, 21.xi.2001 (Holzenthal, Blahnik, Neto, Paprocki) (UMSP000081857) (MZUSP).

Paratypes: BRAZIL: Minas Gerais: same data as holotype — 6 females, 3 males (UMSP).

Etymology. We are delighted to name this species for Dr. James Rodman, the NSF program director who initiated the Partnership for Enhancing Expertise in Taxonomy

(PEET) program. The PEET program provides funding for the training of taxonomists of little known organisms. The senior author is grateful for the wonderful experience she had while participating in the PEET program as a doctoral student and the opportunity to study Trichoptera taxonomy.

Itauara simplex Robertson & Holzenthal, sp. n.

urn:lsid:zoobank.org:act:E7688425-1DE8-4A29-8902-DCDCFC75B036
http://species-id.net/wiki/Itauara_simplex
Fig. 21A–C

Description. This species can be recognized by its rather simple genitalic capsule. Tergum X is produced dorsomesally into a broad, elongate plate and has just one small ventrolateral process. The parameres are relatively short, straight basally, but slightly bent downward distally. The phallicata is short and very lightly sclerotized, and the endophallus is large and membranous, with 2 lateral patches or elongate setae apically. *Itauara guarani* also has a very lightly sclerotized phallicata, but the 2 species differ in the shape of the parameres and *I. guarani* has lateral flange-like processes on the phallicata.

Adult. Body, wings, and appendages fuscous, intermingled with rufous or golden hairs. Wings with conspicuous white spot at the arculus. Forewing slightly broader past anastomosis, but with margins nearly parallel, apex subacute. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I petiolate, but with extremely short stem; fork II petiolate, stem about the same length as fork; fork III petiolate; stem longer than fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing margins nearly parallel, tapering only slightly past anastomosis; apical fork II present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hair-like. Sixth sternal process thumb-like, apex rounded, associated with weak oblique apodeme posteriorly.

Male genitalia. Preanal and inferior appendages absent. Segment IX dorsally narrow, broad medially and ventrally; anterior margin rounded; posterolateral margin lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin produced into a single broad, plate-like process; dorsolateral margin slightly irregular, without processes; ventrolateral margin with small, irregular, paired setose process. Parameres present, paired, arising ventrobasally from fused endotheca and phallobase, sclerotized and rod-like, slender and elongate, straight medially and basally, curving downward distally, directed posteroventrally, apex pointed. Phallobase reduced, lightly sclerotized with phallic shield. Phallicata short, with lightly sclerotized base, rugous medially, becoming membranous distally. Endophallus membranous, en-

larged and convoluted when invaginated, with1 upper lobe and 2 lower lobes, with paired patch of elongate setae laterally.

Material examined. Holotype male: BRAZIL: São Paulo: Parque Nacional da Serra da Bocaina, Cachoeira dos Posses, 22°46'26"S, 044°36'15"W, 1250, 3.iii.2002 (Holzenthal, Blahnik, Paprocki, Prather) (UMSP000069700) (MZUSP).

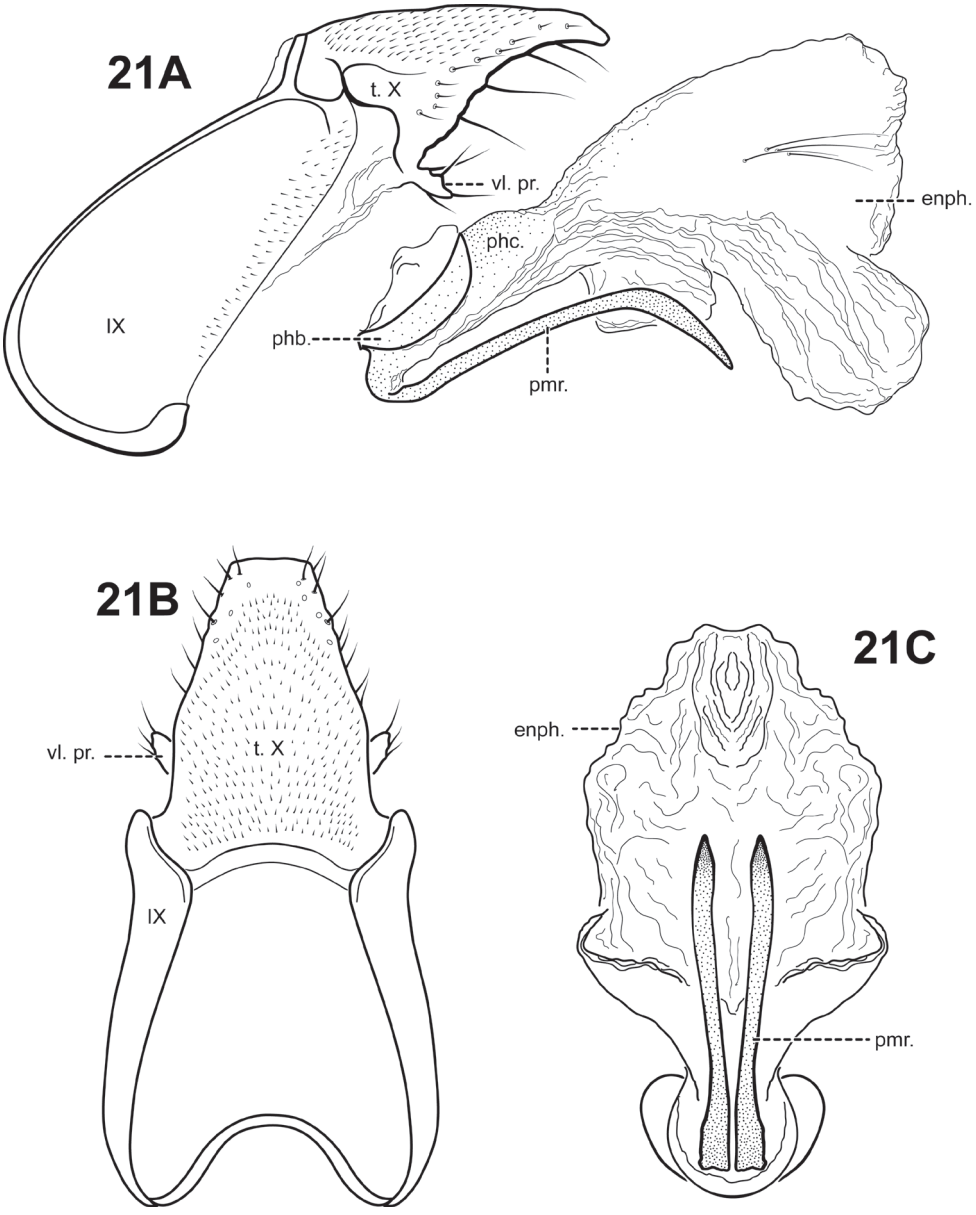


Figure 21. *Itauara simplex*, sp. n. (UMSP000069700). Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: enph. = endophallus; phb = phallobase; phc. = phallicata; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

Paratype: BRAZIL: São Paulo: same data as holotype — 1 female (UMSP).

Etymology. This species is so named for the rather simple structure of the phallic apparatus and genital capsule.

***Itauara spiralis* Robertson & Holzenthal, sp. n.**
urn:lsid:zoobank.org:act:0568AD89-DD46-4FCB-87F4-0F9D884AEC04
http://species-id.net/wiki/Itauara_spiralis
Fig. 22A–C

Description. This species is distinct in having a sclerotized, tubular phallicata, and an elongate, laterally compressed, dorsomesal spine. The phallicata in other species are less tubular, appearing as a dorsal sheath. This dorsal sheath was identified as a synapomorphy for the genus in a previous phylogenetic study of Protoptilinae (see Chapter 1, this work). *Itauara spiralis* was not included in that study, however, *I. spiralis* is placed in *Itauara* since it shares many other characteristics common to the genus such as an inferior appendage process, and a tergum X that is nearly identical to *I. bidentata* sp. n. and *I. unidentata* sp. n.

Itauara spiralis can be recognized by the extremely curved, spiral-shaped parameres. *I. ovis*, sp. n., also has highly curved, spiral shaped parameres, but in *I. spiralis*, the paramere is curved along the entire length of the paramere, whereas in *I. ovis*, the paramere is curved basally, but straight distally. The 2 species differ in other respects, including the shape of the inferior appendage process, which is bifid in *I. spiralis* and inflated apically in *I. ovis*. The 2 species also differ in the shape of tergum X and the phallicata. Tergum X is very similar to those of *I. bidentata* and *I. unidentata*; all have elongate, finger-like dorsolateral processes and broad, irregular, setose ventrolateral processes. *Itauara spiralis* is distinguished from these other 2 species by having a bifid inferior appendage process, spiral-shaped parameres, and laterally compressed dorsomesal spine.

Adult. The only specimen of this species is in very poor condition. Therefore, head, thoracic, and wing characters could not be observed. However, the genitalia are intact.

Male genitalia. Preanal appendages absent. Segment IX ventrally narrow, broad medially; anterior margin rounded; posterolateral margin membranous or very lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin straight, shallowly excavate; dorsolateral margin with paired elongate, down-turned, finger-like process; ventrolateral margin with paired, very broad flange-like setose process consisting of several small irregular lobes. Inferior appendages present as apically bifid, setose process produced mesally, broadest at base and fused to phallobase ventrobasally. Parameres present, paired, arising laterally from endotheca, spiral-shaped, curving 360 degrees at base with curve continuing to apex, directed posteroventrally, apex pointed. Phallobase reduced, lightly sclerotized. Phallicata forming a short slerotized dorsal tube extending from phallobase, with a long, broad dorsomesal spine arising posteriorly to phallobase. Endophallus membranous, rather small, apically sharply bent downward, pointing anteroventrally.

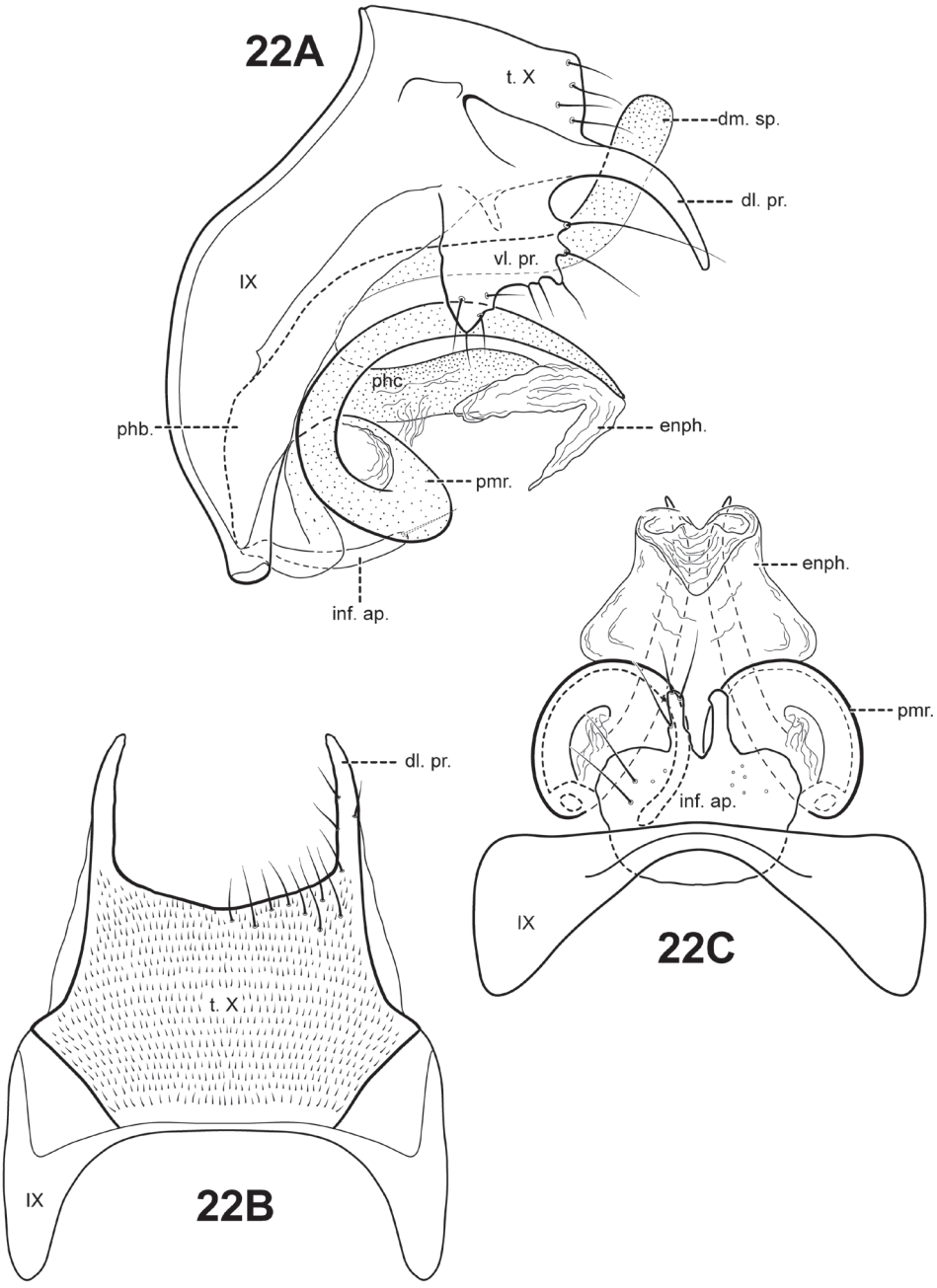


Figure 22. *Itauara spiralis*, sp. n. (UMSP000210960). Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: dl. pr. = dorsolateral process; dm. sp. = dorsomesal spine; enph. = endophallus; inf. ap. = inferior appendage process; phb. = phallobase; phc. = phallicata; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

Material examined. Holotype male: GUYANA: Paramakatoi: 04°42'00"N, 059°42'48"W, 24–25.viii.1997 (W.N. Mathis) (UMSP0000210960) (NMNH).

Etymology. The name *spiralis* refers to the spiral form of the parameres.

***Itauara stella* Robertson & Holzenthal, sp. n.**

urn:lsid:zoobank.org:act:D8B2481D-60A2-42D3-A6A7-3D904B397203
http://species-id.net/wiki/Itauara_stella
Fig. 23A–C

Description. This species is associated with *Itauara alexanderi* sp. n., *I. emilia* sp. n., and *I. lucinda* sp. n., as discussed under each of those species. Each of these species possess an inferior appendage process, a dorsomesal process on tergum X, and rather sinuous parameres. Of these species, *I. stella* is most similar to *I. alexanderi*. Both of these species have similarly shaped elongate dorsomesal processes and broad ventrolateral processes of tergum X. Both also have apically bifid inferior appendage processes. *Itauara stella* can be distinguished from by the length of the parameres; those of *I. stella* are longer and more strongly directed laterally than those of *I. alexanderi*. Additionally, the inferior appendage process of *I. alexanderi* is broader than that of *I. stella*. *Itauara stella* can be differentiated from *I. emilia* by the shape of the dorsomesal process and from *I. lucinda* by the shape of the parameres and inferior appendage process.

Adult. Body, wings, and appendages pale or tawny brown in alcohol. Wings with white transverse line along anastomosis. Forewing slightly broader past anastomosis, but with margins nearly parallel, apex rounded. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I sessile; stem about the same length as fork; fork III petiolate, stem about the same length as fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord. Hind wing margins nearly parallel, tapering only slightly past anastomosis; apical forks II and V present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process thumb-like, apex attenuate and pointed, associated with weak oblique apodeme posteriorly.

Male genitalia. Preanal appendages absent. Segment IX ventrally narrow, broad medially; anterior margin rounded; posterolateral margin lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin with single, downturned, elongate process; dorsolateral margin irregular and setose; ventrolateral margin with paired, broad flange-like setose process consisting of small upper lobe and larger subtriangular lower lobe. Inferior appendages present as apically bifid, setose process produced mesally, broadest at base and fused to phallobase ventrobasally, with 2 pairs of small digitate lobes ventrolaterally, each bearing a seta. Parameres present, paired, inserted in membranous lobe, arising laterally from endotheca, sclerotized and rod-like, long, sinuous, directed outward and posteriorly, apex pointed. Phallobase

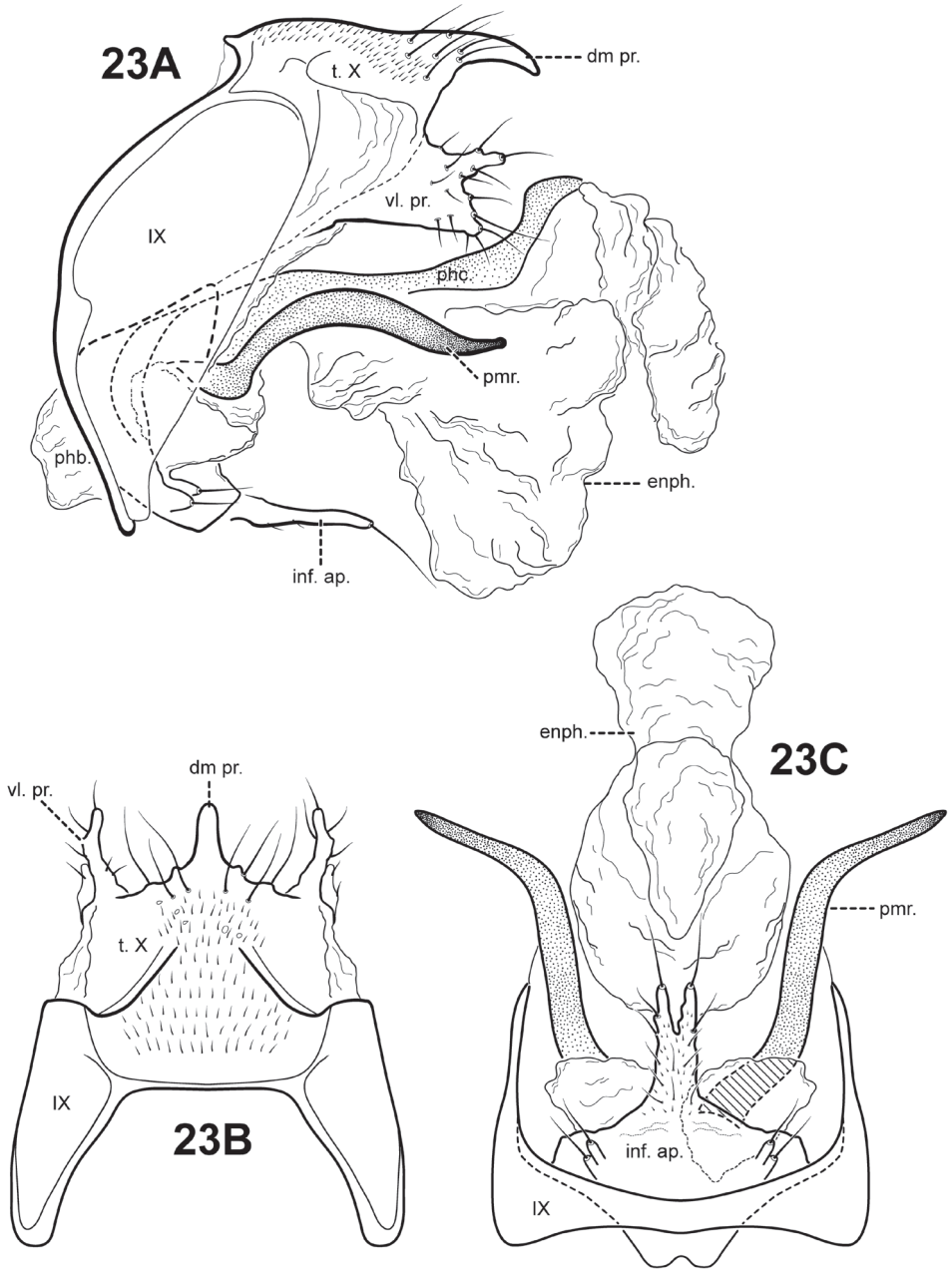


Figure 23. *Itauara stella*, sp. n. (UMSP000052589). Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: dm. pr. = dorsomesal process; enph. = endophallus; inf. ap. = inferior appendage process; phb. = phallobase; phc. = phallicata; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

reduced, lightly sclerotized. Phallicata forming a long sclerotized dorsal sheath extending from phallobase, broadest basally, narrowed slightly, distal portion curving dorsally. Endophallus membranous, enlarged and convoluted when invaginated, with 1 tubular upper lobe and 1 smaller lower lobe.

Material examined. Holotype male: BRAZIL: Sao Paulo: Estação Biológica Boraceia: Rio Venerando & tribs, 23°39'11"S, 045°53'25"W, 850 m, 18–21.ix.2002 (Blahnik, Prather, Melo, Froehlich, Silva) (UMSP000052589) (MZUSP)

Paratypes: BRAZIL: Sao Paulo: same data as holotype — 9 males, 9 females (UMSP).

Etymology. We are delighted to name this species for the senior author's daughter, Stella Claire Thompson.

Itauara tusci Robertson & Holzenthal, sp. n.

urn:lsid:zoobank.org:act:8080F8F1-4471-4A27-A919-65C247501BDD
http://species-id.net/wiki/Itauara_tusci
Fig. 24A–C

Description. This species is very similar to *I. rodmani* sp. n., which also has very long, upturned, tusk-like parameres and a strongly upturned phallicata. The 2 species are separated based on the shape of the phallicata process, which is pointed and blade-like in *I. tusci* and rounded or blunt in *I. rodmani*. The phallicata of *I. tusci* is more lightly sclerotized than *I. rodmani*, especially at the distal portion. Additionally, in *I. tusci*, the dorsomesal margin of tergum X is irregular, with several small setose processes, whereas in *I. rodmani*, the dorsomesal margin is rather smooth and triangular. The ventrolateral processes of the 2 species also differ: *I. tusci* has a small upper and more elongate lower process; *I. rodmani* has a single, short, digitate process. *Itauara blahniki* also has upturned, tusk-like parameres, but is easily distinguished from *I. tusci* based on differences in tergum X and the phallicata.

Adult. Body, wings, and appendages pale or tawny brown, often intermingled with rufous or golden hairs, tibia and tarsi tawny brown. Wings with conspicuous white spot at the arculus. Forewing slightly broader past anastomosis, but with margins nearly parallel, apex rounded. Forewing venation incomplete, with apical forks I, II, and III present; Sc and R1 distinct along their entire lengths; fork I sessile; fork II petiolate, stem shorter than fork; fork III petiolate, stem about the same length as fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord; discoidal cell longer than Rs vein. Hind wing margins nearly parallel, tapering only slightly past anastomosis; apical forks II, III, and V present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process thumb-like, apex attenuate and pointed, associated with weak oblique apodeme posteriorly.

Male genitalia. Preanal and inferior appendages absent. Segment IX dorsally narrow, broad medially and ventrally; anterior margin rounded; posterolateral margin

membranous or very lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin slightly produced with several small irregular setose

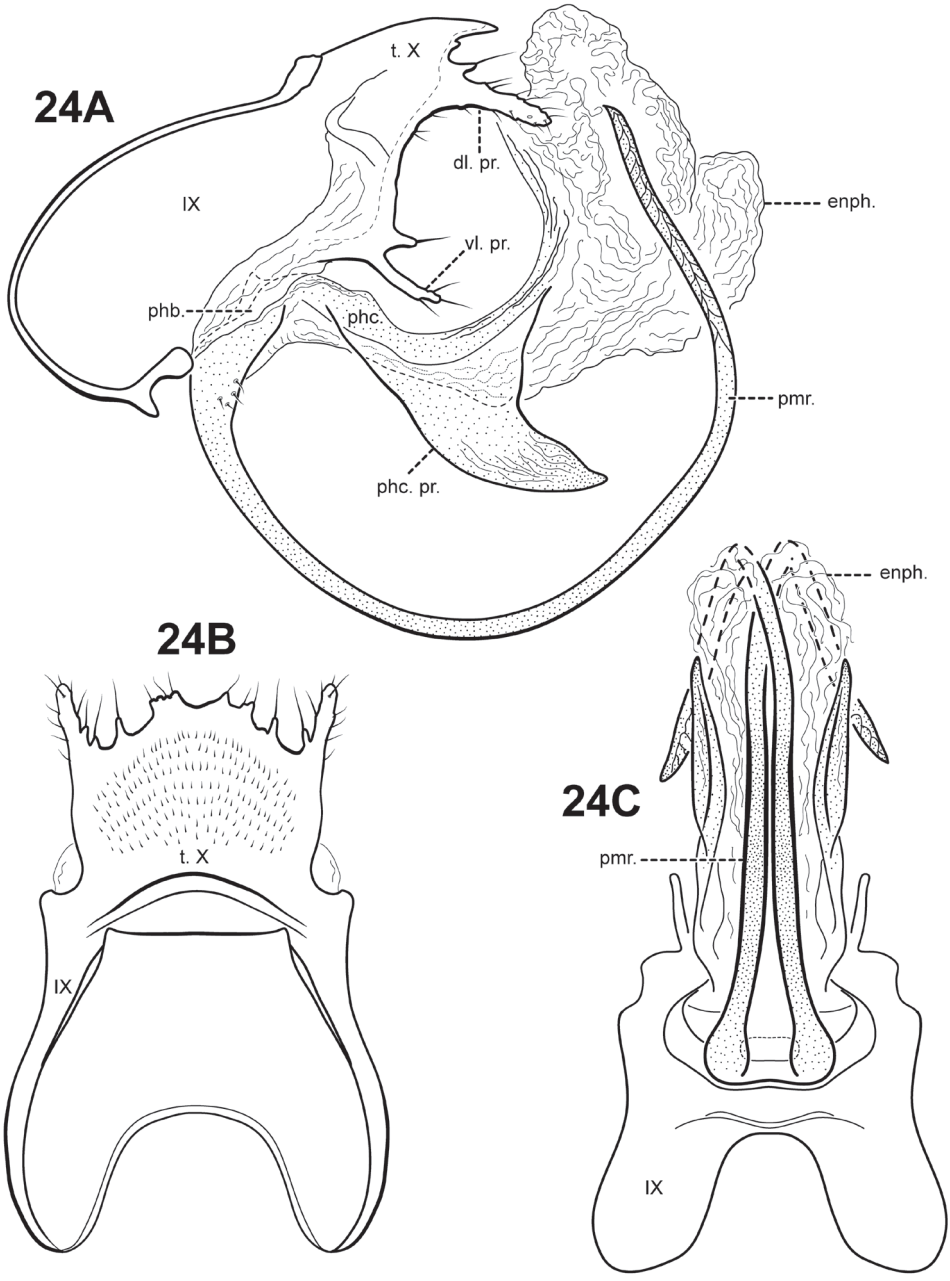


Figure 24. *Itauara tusci*, sp. n. (UMSP000070932). Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: dl. pr. = dorsolatera; process; enph. = endophallus; phb = phallobase; phc. = phallicata; phc. pr. phallicata process; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

processes; dorsolateral margin with paired small, slightly down-turned, setose process; ventrolateral margin with 2 pairs of processes, the upper a small lobe-like process, the lower an elongate finger-like process bearing a few setae. Parameres present, paired, arising ventrobasally from fused endotheca and phallobase, sclerotized and rod-like, tusk-like, strongly curving upward, apex pointed. Phallobase reduced, lightly sclerotized with phallic shield. Phallicata forming a long lightly sclerotized dorsal sheath extending from phallobase, rugous distally, strongly curving upward with apex directed anterodorsally, with pair of broad, sclerotized blade-like lateral flanges, apex pointed and directed posteriorly. Endophallus membranous, enlarged and convoluted when invaginated, with 1 upper and 1 lower lobe.

Material examined. Holotype male: BRAZIL: Rio de Janeiro: Rio das Flores, Macaé de Cima, 10 km SE Mury, 1000 m, 9.iii.2002 (Holzenthal, Blahnik, Paprocki, Prather) (UMSP000070932) (MZUSP).

Paratypes: BRAZIL: Rio de Janeiro: same data as holotype — 4 males, 26 females (UMSP); Rio Macaé, Macaé de Cima, 22°23'41"S, 042°30'08"W, 1000 m, 8.iii.2002 (Holzenthal, Blahnik, Paprocki, Prather) — 2 males, 10 females (UMSP); Encontro dos Rios (Macaé/Bonito), 6 km S Lumiar, 22°23'29"S, 042°18'42"W, 600 m, 10.iii.2002 (Holzenthal, Blahnik, Paprocki, Prather) — 64 males, 145 females (MZUSP, UMSP).

Etymology. The name *tusci* is derived from the Old English word for tusk, and refers to the extremely long parameres of this species.

Itauara unidentata Robertson & Holzenthal, sp. n.

urn:lsid:zoobank.org:act:63403AB7-370C-4DA2-8628-C630D0C9C1E6
http://species-id.net/wiki/Itauara_unidentata
Fig. 2C, 25A–C

Description. This species can be diagnosed by its large, tooth-like paramere process, and broad inferior appendage process. It is most similar to *I. bidentata* sp. n., which has a similarly shaped tergum X, dorsomesal spine, and apical sclerites. The 2 species can be separated by their paramere processes; in *I. unidentata* the paramere consists of a single large tooth-like process, whereas in *I. bidentata*, the paramere process is bifid. *Itauara amazonica* also has a dorsomesal spine, but can be distinguished from *I. unidentata* by the simple shape of tergum X and parameres. Itauara *spiralis*, sp. n., has a similarly shaped tergum X, but is easily distinguished from *I. unidentata* by differences in the shape of the inferior appendage process, parameres, and phallicata.

Adult. Body, wings, and appendages pale or tawny brown in alcohol. Forewing slightly broader past anastomosis, but with margins nearly parallel, apex subacute. Forewing venation incomplete, with apical forks I, II, III, and IV present; Sc and R1 distinct along their entire lengths; fork I sessile; fork II sessile; fork III petiolate, stem longer than fork; fork IV petiolate, stem slightly shorter than fork; Cu1 complete, reaching wing margin; Cu1 and Cu2 intersecting near anastomosis; row of erect setae present along Cu2; A3 absent; crossveins forming a relatively linear transverse cord;

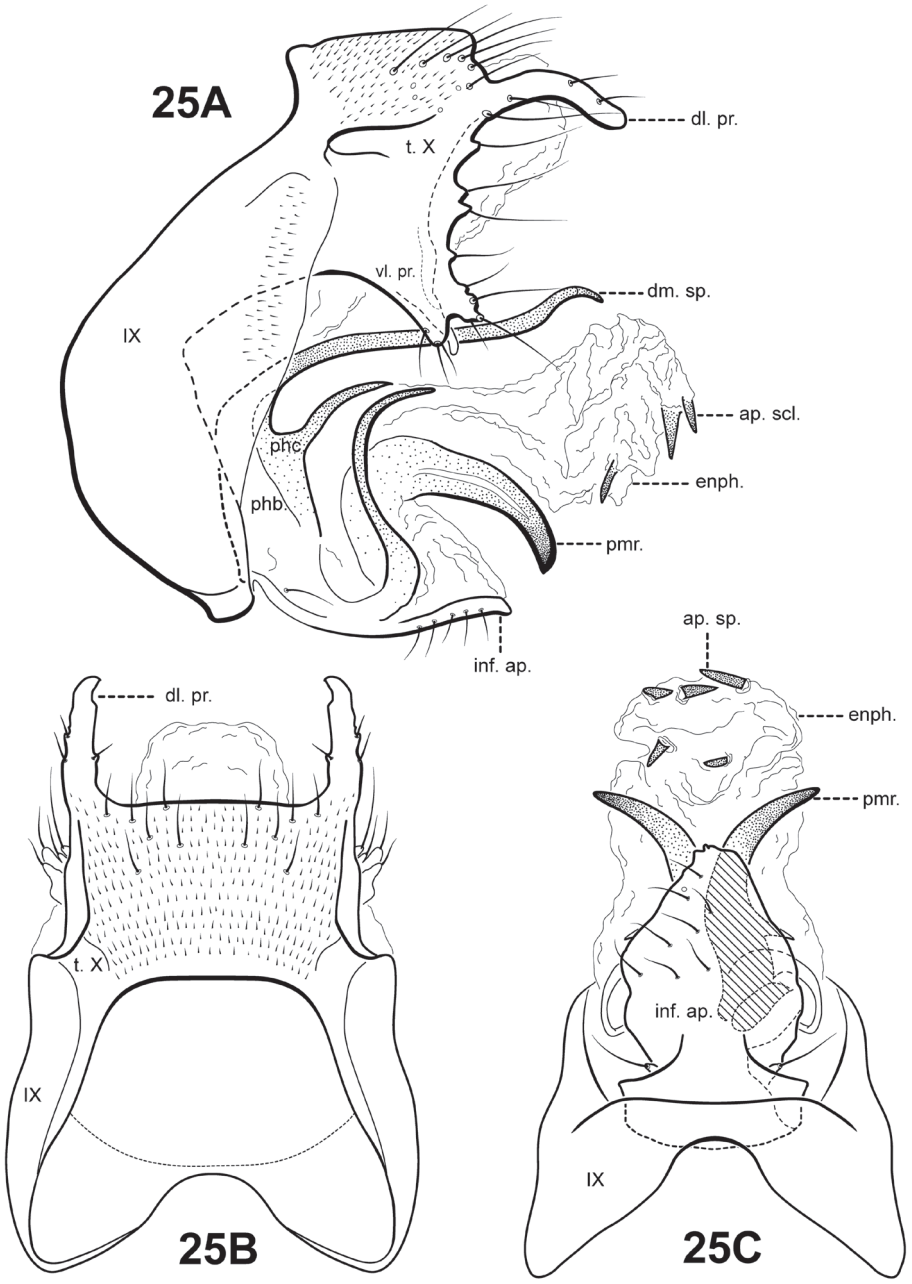


Figure 25. *Itauara unidentata*, sp. n. (UMSP000118535). Male genitalia **A** lateral **B** dorsal **C** ventral. Abbreviations: ap. sp. = apical spine; dl. pr. = dorsolateral process; dm. sp. = dorsomesal spine; enph. = endophallus; inf. ap. = inferior appendage process; phb. = phallobase; phc. = phallicata; pmr . = paramere; t. X = tergum X; vl. pr. = ventrolateral process.

discoidal cell longer than Rs vein. Hind wing narrow and slightly scalloped past anastomosis; apical forks II and V present; Sc and R1 fused basally; A2 absent. Tibial spurs 1,4,4, foretibial spur extremely reduced and hairlike. Sixth sternal process short and digitate, apex attenuate and pointed, associated with strong oblique apodeme posteriorly.

Male genitalia. Preanal appendages absent. Segment IX dorsally and ventrally narrow, broad medially; anterior margin rounded; posterolateral margin membranous or very lightly sclerotized; sternum IX without modification. Tergum X incompletely fused to tergum IX with membrane or lightly sclerotized region ventrolaterally; dorsomesal margin straight, without processes; dorsolateral margin with paired elongate, down-turned, finger-like process; ventrolateral margin with paired, broad flange-like setose process consisting of several small irregular lobes. Inferior appendages present as single, broad, irregular setose process, broadest basally, fused to phallobase ventrobasally, bearing a single pair of small digitate lobes ventrolaterally, each bearing a seta. Parameres present, paired, arising laterally from endotheca, strongly sclerotized, large tooth-like process, curving ventrally and outward, apex pointed. Phallobase reduced, lightly sclerotized dorsally, laterally membranous, with 2 irregular and elongate sclerites arising basolaterally. Phallicata forming a short slerotized dorsal sheath with an elongate dorsomesal spine arising posteriorly to phallobase.

Material examined. Holotype male: GUYANA: Kanuku Mountains: Kumu River & Falls, 03°15'54"N, 059°43'30"W, 28–30.iv.1995 (W.N. Mathis) (UMSP000118535) (NMNH).

Paratypes: GUYANA: Kanuku Mountains: same data as holotype, (W.N. Mathis) — 1 female (NMNH); same, (O.S. Flint) — 1 male (NMNH).

Etymology. The name *unidentata* is suggested by the single tooth-like paramere process.

Key to males of *Itauara*

In most cases, it should be possible to identify most species by simple comparisons to illustrations and reference to the species diagnoses and descriptions. The following key is meant to help the user focus on male genitalic features most useful in identifying species and should be used in conjunction with the provided illustrations and descriptions.

1	Inferior appendages present as single, sometimes apically bifid, setose process, fused to phallobase ventrobasally (Figs 4–6, 10, 13, 14, 16–18, 22, 23, 25...**2**
–	Inferior appendages absent (Figs 7–9, 11, 12, 15, 19–21, 24 .....**13**
2(1)	Inferior appendage process relatively short and broad (Figs 4C, 6C, 13C, 14C, 16C, 22C, 25C.....**3**
–	Inferior appendage process relatively narrow and elongate (Figs 5D, 10C, 17C, 18C, 23C) **9**

3(2) Tergum X dorsolateral margin with paired, very long, finger-like processes; phallicata with elongate dorsomesal spine (Figs 6, 22, 25) **4**

– Tergum X dorsolateral margin without paired long, finger-like processes; phallicata without dorsomesal spine (Fig. 4, 13, 14, 16) **6**

4(3) Inferior appendage process bifid apically; endophallus without apical sclerites; parameres rather elongate, spiral-shaped, curving nearly 360 degrees (Fig. 22)..... ***Itauara spiralis* sp. n.**

– Inferior appendage process not bifid; endophallus with apical sclerites; parameres rather broad and tooth-like, not spiral-shaped (Figs 6, 25)..... **5**

5(4) Parameres bifid (Fig. 6)..... ***Itauara bidentata* sp. n.**

– Parameres not bifid (Fig. 25)..... ***Itauara unidentata* sp. n.**

6(3) Tergum X with elongate, attenuate, downturned dorsomesal process (Figs 4A–B, 13A–B, 16A–B)..... **7**

– Tergum X dorsomesal margin bifid (Fig. 14)..... ***Itauara jamesii* sp. n.**

7(6) Inferior appendage process bifid apically (Fig. 4C)..... ***Itauara alexanderi* sp. n.**

– Inferior appendage process not bifid (Figs 13C, 16C)..... **8**

8(7) Parameres extremely sinuous, not forked; endophallus with large, bifid apical processes; tergum X ventrolateral margin with small, subtriangular setose process (Fig. 13) ..... ***Itauara guyanensis* sp. n.**

– Parameres forked, not sinuous; endophallus entirely membranous without apical processes or sclerites; tergum X ventrolateral margin with broad, irregular, flange-like setose process (Fig. 16) ..... ***Itauara lucinda* sp. n.**

9(2) Tergum X dorsomesal margin divided apicomesally, slightly notched, or with large, prominent bifid process; inferior appendage process not bifid (Figs 5, 17, 18)..... **10**

– Tergum X dorsomesal margin not divided apicomesally, bifid, slightly notched, or with large, prominent bifid process; inferior appendage process bifid apically (Figs 10, 23)..... **12**

10(9) Parameres curving upward or tusk-like; phallicata with elongate, apically bifid, dorsomesal spine (Fig. 5) ..... ***Itauara amazonica* (Flint 1971)**

– Parameres not curving upward or tusk-like; phallicata without dorsomesal spine (Figs 17, 18) **11**

11(10) Parameres spiral-shaped or ram-like, curving nearly 360 degrees; endophallus largely membranous, without apical sclerite (Fig. 17)..... ***Itauara ovis* sp. n.**

– Parameres nearly straight; endophallus lightly sclerotized, with small apical sclerite (Fig. 18)..... ***Itauara peruensis* sp. n.**

12(9) Tergum X with elongate, attenuate, downturned dorsomesal process (Fig. 23)..... ***Itauara stella* sp. n.**

– Tergum X with large, blunt, dorsomesal process, elongate in dorsal view, subtriangular in lateral view (Fig. 10) ..... ***Itauara emilia* sp. n.**

13(1) Phallicata with paired lateral flanges or processes (Figs 9A, 11A, 12B, 19B, 20B, 24A)..... **14**

– Phallicata without paired lateral flanges or processes (Figs 7A, 8A, 15A, 21A) **19**

14(13) Tergum X dorsomesal margin irregular, with several small setose processes (Figs 9B, 24B) **15**

– Tergum X dorsomesal margin not irregular (Figs 11A–B, 12B–C) **16**

15(14) Parameres curving upward, tusk-like; endophallus without apical processes or sclerites (Fig. 24) ..... ***Itauara tusci* sp. n.**

– Parameres arcuate, curving downward; endophallus with tooth-like apical sclerite (Fig. 9) ..... ***Itauara charlotta* sp. n.**

16(14) Tergum X with elongate, attenuate, downturned dorsomesal process (Figs 11A–B, 12B–C) **17**

– Tergum X without elongate dorsomesal processes (Figs 19B–C, 20B–C) .. **18**

17(16) Parameres sinuous; phallicata very lightly sclerotized basally, rugous or membranous distally (Fig. 12) ..... ***Itauara guarani* (Angrisano 1993)**

– Parameres arcuate, curving downward; phallicata entirely sclerotized (Fig. 11) ..... ***Itauara flinti* sp. n.**

18(16) Parameres curving upward, tusk-like; phallicata strongly curved medially, directed anterodorsally (Fig. 20) ..... ***Itauara rodmani* sp. n.**

– Parameres sinuous; phallicata nearly straight, distal portion slightly upturned (Fig. 19) ..... ***Itauara plaumanni* (Flint 1974)**

19(13) Sternum IX bearing 2 pairs of extremely elongate, seta-like processes; parameres vestigial, consisting only of a pair of small, digitate setose lobes arising ventrolaterally from endotheca (Fig. 8) .. ***Itauara brasiliana* (Mosely 1939)**

– Sternum IX without modification; parameres prominently present (Figs 7, 15, 21) **20**

20(19) Tergum X with elongate, attenuate, slightly downturned dorsomesal process; parameres curving upward, tusk-like (Fig. 7) ..... ***Itauara blahniki* sp. n.**

– Tergum X without elongate dorsomesal processes; parameres not curving upward or tusk-like (Figs 15, 21) **21**

21(20) Tergum X dorsomesal margin blunt; parameres bent basally at nearly 90 degree angle, directed dorsally; phallicata sclerotized, not continuous from phallobase (Fig. 15) ..... ***Itauara julia* sp. n.**

– Tergum X dorsomesal margin roof-like, strongly produced; parameres arcuate, curving downward; phallicata very lightly sclerotized basally, more membranous and rugous distally, continuous from phallobase (Fig. 21) ..... ***Itauara simplex*, sp. n.**

Acknowledgments

We are thankful to Len Ferrington, George Weiblen, and Susan Weller (University of Minnesota) for helpful comments and suggestions on earlier drafts of this manuscript. We thank Roger Blahnik (U. of MN) for his valuable insight regarding protoptiline

morphology, systematics, and evolution. We express our appreciation to Ivalio Stoyanov, *Zookeys* Editorial Secretary, C.J. Geraci, *Zookeys* Guest Editor, and 2 anonymous reviewers for their helpful comments. We also thank Jolanda Huisman, John Luhman, Steffen Pauls, and Claire Serieyssol for translating various taxonomic works. Julie Martinez rendered the beautiful full habitus illustration. DRR thanks the following individuals for assistance throughout this project: Roger Blahnik, Phil Clausen, Lourdes Chamorro, John Luhman, Patina Mendez, Henrique Paprocki, Steffen Pauls, Greg Setliff, Robin Thomson, Anne Wasmund, and Jen Zaspel. DRR is grateful to her parents, Jim & Charlotte Robertson, for the financial assistance they provided which allowed her to complete this work. She also extends her deepest gratitude and affection to her husband, Alex Thompson, and their daughters, Stella & Lucinda.

We are grateful to the many curators, colleagues, and staff at several natural history collections around the world who loaned material: Elisa Angrisano (MACN), David Goodger (BMNH), and Oliver Flint (NMNH). We are particularly grateful for the assistance provided by Oliver Flint, National Museum of Natural History, Smithsonian Institution. Many of the new species described here were collected by Dr. Flint and other researchers at the NMNH.

DRR is grateful for the following funding sources received as a graduate student: Alexander and Lydia P. Anderson Fellowship (University of Minnesota, Graduate School), Doctoral Dissertation Fellowship (U. of MN, Graduate School), Dayton & Wilkie Natural History Fund (U. of MN, Bell Museum), Boesel-Sanderson Natural History Award (North American Benthological Society), Student Conservation Award (North American Benthological Society), NSF GK-12 Fellowship (U. of MN, Bell Museum), Morris & Elaine Soffer Rockstein Fellowship (Dept. of Entomology, U. of MN), MN Futures grant (to D. Andow), Walter Judd International Fellowship (U. of MN, Graduate School), and U. of MN, Graduate School Block travel grants. This material is based upon work supported by the National Science Foundation under Grant Nos. DEB 0117772 and 9971885 (to RWH).

References

Angrisano EB (1993) Contribucíon al conocimiento del genero *Antoptila* Mosely (Trichoptera: Glossosomatidae). Revista de la Sociedad Entomológica Argentina 52: 57–62.

Blahnik RJ, Holzenthal RW (2004) Collection and curation of Trichoptera, with an emphasis on pinned material. Nectopsyche, Neotropical Trichoptera Newsletter 1: 8–20.

Blahnik RJ, Holzenthal RW (2006) Revision of the genus *Culoptila* (Trichoptera: Glossosomatidae). Zootaxa 1233: 1–52.

Blahnik RJ, Holzenthal RW (2008) Revision of the Mexican and Central American species of *Mortoniella* (Trichoptera: Glossosomatidae: Protoptilinae). Zootaxa 1711: 1–72.

Blahnik RJ, Holzenthal RW, Prather AL (2007) The lactic acid method for clearing Trichoptera genitalia. In: Bueno-Soria J, Barba-Alvarez R, Armitage BJ (Eds) Proceedings of the 12th International Symposium on Trichoptera. The Caddis Press, Columbus, Ohio, 9–14.

Colwell RK (2003) Biota 2: The Biodiversity Database Manager, + CD-ROM. Sunderland, Massachusetts, Sinauer Associates.

Dallwitz MJ (1980) A general system for coding taxonomic descriptions. Taxon 29: 41–46.

Dallwitz MJ, Paine TA, Zurcher EJ (1993 onwards) User's guide to the DELTA System: a general system for processing taxonomic descriptions. 4th edition. http://delta-intkey.com [accessed 24 March 2011].

Dallwitz MJ, Paine TA, Zurcher EJ (1999 onwards) User's guide to the DELTA Editor. http://delta-intkey.com [accessed 24 March 2011].

Flint OS, Jr. (1971) Studies of Neotropical caddisflies, XII: Rhyacophilidae, Glossosomatidae, Philopotamidae, and Psychomyiidae from the Amazon Basin (Trichoptera). Amazoniana 3: 1–67.

Flint OS, Jr. (1974) Studies of Neotropical caddisflies, XVIII: new species of Rhyacophilidae and Glossosomatidae (Trichoptera). Smithsonian Contributions to Zoology 169: 1–30.

Flint OS, Jr., Holzenthal RW, Harris SC (1999) Nomenclatural and systematic changes in the Neotropical caddisflies. Insecta Mundi 13: 73–84.

Holzenthal RW (2004) Three new species of Chilean caddisflies (Insecta: Trichoptera). Proceedings of the Entomological Society of Washington 106: 110–117.

Holzenthal RW, Andersen T (2004) The caddisfly genus *Triaenodes* in the Neotropics (Trichoptera: Leptoceridae). Zootaxa 511: 1–80.

Holzenthal RW, Blahnik RJ (2006) The caddisfly genus *Protoptila* in Costa Rica (Trichoptera: Glossosomatidae). Zootaxa 1197: 1–37.

Marlier G (1964) Trichoptères de l'Amazonie recueillis par le Professeur H. Sioli. Memoires l'Institut Royal des Sciences Naturelles de Belgique series 2: 1–167.

Morse JC (1988) *Protoptila morettii* (Trichoptera: Glossosomatidae), a new caddisfly species from the southeastern United States. Rivista di Idrobiologia 27: 299–308.

Mosely ME (1939) The Brazilian Hydroptilidae (Trichoptera). Novitates Zoologicae 41: 217–239.

Müller F (1888) Larven von Mücken und Haarflüglern mit zweierlei abwechselnd thätigen Athemwerkzeugen. Entomologische Nachrichten 14: 273–277.

Müller F (1921) Briefe un noch nicht veröffentliche Abhandlungen aus dem nachlass 1854–1897. In: Möller A (Ed) Fritz Müller: Werke, Briefe und Leben, 2. G. Fischer, Jena, 383–642.

Robertson DR (2010) Systematic studies of the caddisfly subfamily Protoptilinae (Trichoptera: Glossosomatidae). PhD thesis, Saint Paul, Minnesota, USA: University of Minnesota.

Ross HH (1956) Evolution and Classification of the Mountain Caddisflies. University of Illinois Press, Urbana, 213 pp.

Schmid F (1998) The insects and arachnids of Canada, Part 7. Genera of the Trichoptera of Canada and adjoining or adjacent United States. NRC Research Press, Ottawa, 319 pp.

Ulmer G (1957) Köcherfliegen (Trichopteren) von den Sunda-Inseln. Teil III. Larven und Puppen der Annulipalpia. Archiv für Hydrobiologie, Supplement 23: 109–470.