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Taxonomy and Systematics

New records, descriptions, and redescriptions of male horse flies (Diptera: Tabanidae) in Brazil

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Abstract. Females of Tabanidae Latreille are hematophagous and act as mechanical and biological vectors of several pathogens, and therefore they have been widely studied in both ecology and public health, as well as in taxonomy works. Males are nectarivorous and rarely captured, so for most species they remain unknown. Thus, we aimed to describe/redescribe the males of five species: *Esenbeckia osornoi* Fairchild, 1942, *Acanthocera marginalis* Walker, 1854, *Dicladocera mutata* Fairchild, 1958, *Stypommisa aripuana* Fairchild & Wilkerson, 1986, and *Tabanus mucronatus* Fairchild, 1961. Three males are described for the first time and two others are redescribed, we also provide a complete description of the species, including photographs of habitus, head and genitalia.

Keywords: Entomological collections; light traps; pollination; taxonomy; terminalia.

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Females of Tabanidae Latreille are mostly hematophagous and act as mechanical and biological vectors of various pathogens and, therefore, they are very important in medical-veterinary and economic aspects (Baldacchino *et al.* 2014), with many studies having been conducted in ecology, public health and taxonomy regarding them. Sexual dimorphism is quite evident in most species, the females have eyes separated by the frons while males have contiguous eyes; in cases where the males are also dichoptic, they differ from females in the shape of the palpi and the size of the body setulae (Chainey 2017).

Males are not hematophagous, but, like females, they visit flowers and play an important role in the pollination (Johnson 2000; Johnson & Morita 2006; Karolyi *et al.* 2014). Unlike females, knowledge about males is still scarce, so that Tabanidae taxonomy is largely based on females (Gorayeb *et al.* 1982; Coscarón 1999; Krolow *et al.* 2012). Male Tabanidae are rarely collected in flight traps and never in equine bait, which are the main collecting methods for the family. Better results to collect males have been obtained with the use of light traps (Frost 1953; Anthony 1960; Corbet 1964). More recently, Krolow *et al.* (2010) demonstrated that the use of artificial light hung over a white large sheet in the forest canopy was very efficient; the authors sampled 216 females and 135 males of 29 species, of these, three males were described for the first time. This can be explained due to the swarming behavior of some species, in which males gather in the treetops waiting for females to mating (Bailey 1948; Wilkerson *et al.* 1985; Rosa 2006; Mullens 2019).

Thus, males are rarely found in entomological collections. For example, there are 11,150 deposited specimens in the Tabanidae collection of the Instituto Nacional de Pesquisas da Amazônia (INPA), of which only 270 are males (Henriques 1997). A similar scenario is observed in the Coleção de Entomologia da Universidade Federal do Tocantins (CEUFT), in which the collection has 2,623 specimens of Tabanidae, with only 82 male specimens. In view of the above, this article aims to describe never-before-seen males of three species of Tabanidae (*Dicladocera mutata* Fairchid, 1958, *Stypommisa aripuana* Fairchild & Wilkerson, 1986 and *Tabanus mucronatus* Fairchild, 1961) and to redescribe the males of *Esenbeckia osornoi* Fairchild, 1942 and *Acanthocera marginalis* Walker, 1854, mentioned by Wilkerson (1979) and Henriques & Rafael (1995) respectively, but poorly described. Encouraging so the development of a taxonomy of males, which will be helpful in providing new data for the systematics of the family.

MATERIAL AND METHODS

The specimens studied are deposited in the Coleção de Entomologia da Universidade Federal do Tocantins (CEUFT), located on the campus of Porto Nacional, Tocantins, Brazil. The dissection of the terminalia was performed according to the protocol proposed by Cumming (1992).

Photographs of the specimens were obtained using a Leica M165C stereomicroscope with a camera attached. The Adobe Photoshop version CC 2021 software was used to edit the photos and plates. The terminology follows Chainey (2017) and Cumming & Wood (2017).

RESULTS

Esenbeckia osornoi Fairchild, 1942 (Figure 1)

Male previously described by Wilkerson (1979).

Redescription (♂)

Head (Figures 1A-C): Eyes contiguous, glabrous, ommatidia of the same size. Ocellar triangle dark brown, prominent, with yellowish pruinosity, sparse black setulae and three yellow ocelli. Subcallus covered with yellowish pruinosity. Gena and parafacial covered with yellowish pruinosity and numerous black setulae. Clypeus yellowish brown with some black setulae. Palpus porrect, orange with numerous black setulae. Orange antenna. Scape and pedicel with black setulae and yellowish pruinosity. Proboscis sclerotized, shiny, dark brown.

Thorax (Figures 1A-B): Scutum and scutellum orange-brown with black and yellow setulae. Thorax with a longitudinal midline of black integument. Legs concolor to the body with black setulae and some yellow setulae. Hind femur pale brown. Wing hyaline with yellowish costal cell and pterostigma. Short appendix at fork of vein R_{4+5}.

Abdomen (Figure 1A): Yellow-green with numerous black setulae. Tergites 4 to 7 darker.

Terminalia (Figures 1D-G): Epandrium broad and undivided, anterior region glabrous, posterior region with sparse black setulae. Cercus long, at least twice the size of the hypoproct, shorter than the epandrium, covered with short setulae and with a sharp apex. Hypoproct short, smaller than cerci. Hypandrium + gonocoxite robust, longer than wide. Gonostylus bifid with a slight curvature at the apex. Aedeagus and gonocoxal apodemes equally long.

Material examined: BRAZIL • 1 male; Tocantins, Palmas, Taquaruçu, Faz.[enda] Encantada; 10°14'57''S, 48°07'35.4''W; 03-10.viii.2012; Arm.[adilha] Malaise; Krolow, T.K. & Lima, H.I.L. leg. / BRAZIL • 1 male; Tocantins, Palmas, Natividade, Balneário Paraíso, Rio Porteira; 11°39'31.65''S; 48°3'12.62''W; 13.vi.2018; Coleta Manual, Krolow, T.K. Equipe leg. / BRAZIL • 1 male; Tocantins, Palmas, Taquaruçu, Faz.[enda] Encantada; 10°41'16.3''S, 48°22'54.7''W; 31.viii- 07.ix.2012; Krolow, T.K. & Leite, H. leg.

Distribution: Brazil (Amapá, Amazonas, Bahia, Pará, Rondônia, Tocantins), Costa Rica to Colombia, Guyana, Panamá, Surinam, Trinidad, Venezuela (Henriques 1997; Coscarón & Papavero 2009; Lima *et al.* 2015).

Comments: Wilkerson & Fairchild (1983) report that the males of only a small percentage of the species in the subgenus *Esenbeckia* are known, the authors mention that they have found reports in the literature of males of only 15 species. During the dissection process, the left margin of the epandrium suffered a small fracture and part of the gonocoxal apodemes was destroyed.

Acanthocera marginalis Walker, 1854 (Figure 2)

Male previously described by Henriques & Rafael (1995).

Redescription (♂)

Head (Figure 2A-C): Eyes contiguous, glabrous, larger ommatidia on upper 2/3 and smaller ommatidia on lower 1/3. Subcallus with whitish pruinosity. Gena, parafacial and clypeus with glossy black integument, clypeus with areas of grayish pruinosity. Palpus porrect, orange-brown, with sparse white and black setulae. Antenna with orange scape, pedicel with black setulae. Postpedicel orangish at base and black at distally, dorsal tooth straight, not curved. Proboscis short, less than head height, dark brown.

Thorax (Figures 2A-B): Dark brown with two subtle median longitudinal bands of yellow pruinosity and yellow setulae. Notopleuron, anepisternum, katepisternum and scutellum with yellowish pruinosity and numerous yellow setulae. Legs with dark brown femora, fore and hind tibiae with a brownish on the basal half and whitish on the distal half. Mid tibia white with white setulae. Tarsus orange-brown. Wing hyaline with dark brown anterior margin, covering the costal and subcostal cells and part of the radial cell and the anterior cubital cell.

Abdomen (Figures 2A-B): Abdomen dark brown with sparse black setulae. Grayish pruinosity in tergites 1 and 2. Tergites 1 to 3 and sternites 2 and 3 with a whitish integument band. Sternite 1 with numerous white setulae, other sternites with black setulae.

Terminalia (Figures 2D-G): Epandrium with anterior region glabrous, posterior region with sparse black setulae both on dorsal and ventral surface. Cercus length longer than half of the epandrium, long setulae on the dorsal and ventral surface; posterior region almost as wide as epandrium, anterior region with apex slightly pointed. Hypoproct covered by cerci. Hypandrium + gonocoxite robust, longer than wide. Gonocoxite with a small projection at the apex. Aedeagus and gonocoxal apodemes equally long.

Material examined: BRAZIL • 3 males; Tocantins, Aurora, Estrada Cachoeira do Registro; 12°30'20.32''S, 46°18'10.94''W; 14.vi.2018; Coleta Manual; Krolow, T.K. & Equipe leg.

Distribution: Bolivia, Brazil (Acre, Amapá, Amazonas, Mato Grosso, Pará, Roraima), Colombia, Ecuador (Napo, Morona Santiago), French Guiana, Guyana, Peru (Loreto), Surinam, Trinidad (Henriques & Gorayeb 1993; Henriques & Rafael 1995; Coscarón & Papavero 2009).

Comments: The genus Acanthocera was reviewed by Henriques & Rafael (1995), and of the 28 described species, 15 had completely unknown males. This species represents a new record of Tabanidae for Tocantins. One of the gonocoxal apodemes was partially destroyed and the specimen's aedeagus was lost during dissection.

Dicladocera mutata Fairchild, 1958 (Figure 3)

Description (♂)

Head (Figures 3A-C): Eyes contiguous, glabrous, larger ommatidia on upper 2/3 and smaller ommatidia on lower 1/3. Ocellar triangle brown, not very evident, with three white ocelli. Subcallus with orange integument, grayish pruinosity and some black setulae. Gena and parafacial with black integument, grayish pruinosity, with numerous black setulae. Clypeus with orange integument, grayish pruinosity, with a few black and yellow setulae. Palpus porrect, orange, with numerous and elongated black setulae. Antenna orangish. Scape and pedicel with black setulae. Postpedicel orange brown, with short dorsal tooth, style slightly darker. Proboscis dark brown with grayish pruinosity and black and yellow setulae.

Thorax (Figures 3A-B): Dark brown with two faint median longitudinal bands of grayish pruinosity and yellow setulae. Pleuron densely black setulose. Scutellum with anterior half dark brown and posterior half orange and with elongated black setulae. Legs concolorous to the thorax with many

black setulae. Wing spotted with hyaline apex and costal cell, hyaline circular areas in medial basal cell, radial basal cell, discal, anterior cubital and anal lobe.

Abdomen (Figures 3A-B): Abdomen orangish with numerous black setulae. Tergite 4 with a small tuft of white setulae posteriorly. Tergites 5 to 7 brownish. Sternites 2 and 3 with grayish pruinosity strip and whitish setulae.

Terminalia (Figures 3D-G): Epandrium slightly wider than cercus and with sparse black setulae. Cercus long and wide, with long black setulae on dorsal side and shorter on ventral side, apex slightly pointed. Hypandrium + gonocoxite robust, slightly longer than wide. Aedeagus and gonocoxal apodemes equally long.

Material examined: BRAZIL • 1 male; Tocantins, Palmas, Taquaruçu, Faz.[enda] Encantada, Cach[oeira] Raizama; 10°14'45.21''S, 48°7'24.07''W; 26-31.viii.2017; Malaise G&G; Krolow, T.K. & Equipe leg.

Distribution: Brazil (Goiás, Tocantins) (Coscarón & Papavero 2009; Lima *et al.* 2015).

Comments: Anterior margin of epandrium and hypoproct lost during dissection.

Stypommisa aripuana Fairchild & Wilkerson, 1986 (Figure 4)

Description (♂)

Head (Figures 4A-C): Eyes contiguous, glabrous, ommatidia of the same size. Ocellar triangle dark brown, not prominent. Subcallus covered by yellowish pruinosity and yellowish setulae. Gena and parafacial with gray pruinosity and black setulae. Clypeus orange, with gray pruinosity and some yellow setulae. Palpus porrect, yellow, with pale setulae and some sparse black setulae. Antenna orange, with black style. Scape and pedicel with black setulae. Proboscis orange-brown with short black setulae on the prementum and slightly longer on the labellum.

Thorax (Figures 4A-B): Dark brown with black and yellow setulae, notopleuron lighter than scutum and densely setulose. Two inconspicuous longitudinal bands of yellowish pruinosity on scutum. Scutellum concolor to the thorax with yellow setulae. Legs yellowish orange, femora with yellowish setulae, tibiae and tarsi with black setulae, hind tibiae more setulose than the remainder. Wing hyaline with yellowish pterostigma.

Abdomen (Figures 4A-B): Abdomen yellowish with numerous black setulae. Tergite 1 slightly darker. Tergites 2 to 5 with a dark brown median integumentary band. Tergites 6 and 7 brown.

Terminalia (Figures 4D-G): Epandrium with anterior region glabrous, posterior region with sparse black setulae. Cercus almost as wide as the epandrium, with quite long black setulae on the dorsal face and shorter black setulae on the ventral face. Hypoproct covered by cerci. Hypandrium + gonocoxite robust, longer than wide. Gonocoxite with a small projection at the apex. Gonocoxal apodemes slightly longer than the aedeagus.

Material examined: BRAZIL • 2 males; Tocantins, Palmas, Taquaruçu, Faz.[enda] Encantada, Cach[oeira] Raizama; 10°14'45.21''S, 48°7'24.07''W; 26-31.viii.2017; Malaise G&G; Krolow, T.K. & equipe leg. / BRAZIL • 1 male; Tocantins, São Valério da Natividade, BR 242; 08-17.vii.2010; Bragança, M.A. leg.

Distribution: Brazil (Maranhão, Mato Grosso, Pará, Rondônia, Tocantins) (Henriques & Gorayeb 1993; Coscarón & Papavero 2009; Lima *et al.* 2015).

Comments: Fairchild & Wilkerson (1986) reviewed the genus *Stypommisa* and the males of 11 of the 28 known species are still unknown. Tergite 2 in one of the specimens presents a very evident dark brown median triangle and tergites 3 and 4 are completely yellowish. These variations in the coloration of the abdomen are also observed in females. One of the gonocoxal apodemes was broken during the dissection.

Tabanus mucronatus Fairchild, 1961 (Figure 5)

Description (♂)

Head (Figures 5A-C): Eyes contiguous, glabrous, ommatidia of the same size. Ocellar triangle orange not very evident, with gray pruinosity. Subcallus yellow pruinose. Gena and parafacial with gray pruinosity and black setulae. Central region of clypeus yellowish, margins grayish. Palpus porrect, yellow, with black and yellow setulae. Antenna orange. Scape and pedicel with black setulae. Proboscis dark brown, very short and with sparse black setulae.

Thorax (Figures 5A-B): Thorax dark brown with black setulae and some sparse yellow setulae. Scutellum dark brown in the midle and orange on the apex and margins, sparse black and yellow setulae. Sternum covered with gray pruinosity. Legs brown with black setulae, tibiae with some yellow setulae, anterior trochanter whitish and covered with pale setulae, posterior trochanter whitish and with black setulae. Wing hyaline with brownish costal and subcostal cells and yellowish pterostigma.

Abdomen (Figures 5A-B): Abdomen brown, with black setulae and some yellow setulae. Tergites 4 to 7 darkened.

Terminalia (Figures 5D-G): Epandrium with anterior region glabrous, posterior region with sparse black setulae. Cercus almost as wide as the epandrium and with quite long black setulae on the dorsal surface and shorter black setulae on the ventral surface. Hypoproct covered by cerci. Hypandrium + gonocoxite robust, longer than wide. Gonocoxite with a small projection at the apex. Gonocoxal apodemes slightly longer than aedeagus.

Material examined: BRAZIL • 1 male; Tocantins, Porto Nacional, Faz.[enda] São Judas Tadeu; 27-29.iii.2015; [Malaise]; Krolow, T.K. & equipe leg.

Distribution: Bolivia (the record to Bolivia needs further confirmation), Brazil (Goiás, Maranhão, Mato Grosso, Pará, Rondônia, Tocantins) (Henriques & Gorayeb 1993; Coscarón & Papavero 2009).

Comments: In females of this species, the apex of the abdomen is notoriously tapered, the examined male does not have such a thin abdomen. In addition, females have a median band of yellowish pruinosity and white setulae on tergites 1 to 6, the examined male does not have such characteristics, which seem to have been lost after passage of the sample in ethanol.

DISCUSSION

Male specimens of Tabanidae are rare in entomological collections. Only 22 out of 489 Brazilian species, which is about 5% of the total of species, were described from males (Coscarón & Papavero 2009; Krolow & Henriques 2023). Additionally, the last species with a male holotype in the neotropics was *Acanthocera polistiformis* Fairchild, 1961, since

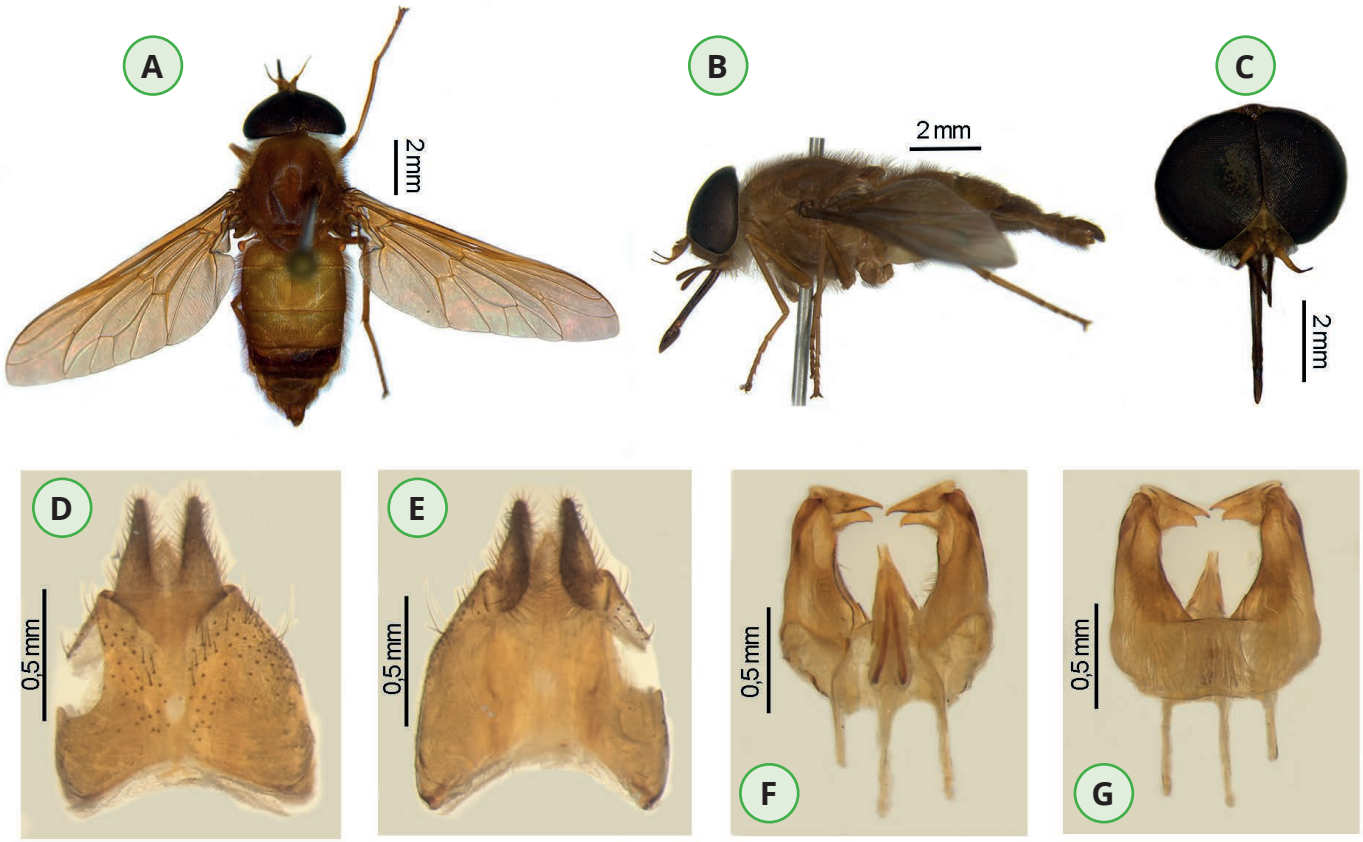

Figure 1. Male of *Esenbeckia osornoi* Fairchild, 1942. **A.** Habitus, dorsal view; **B.** Habitus, lateral view; **C.** Head, anterior view; **D-E.** Epandrium, cercus and hypoproct (dorsal and ventral views, respectively); **F-G.** Hypandrium, gonocoxite, gonostylus and aedeagus (dorsal and ventral views respectively). Source: authors.

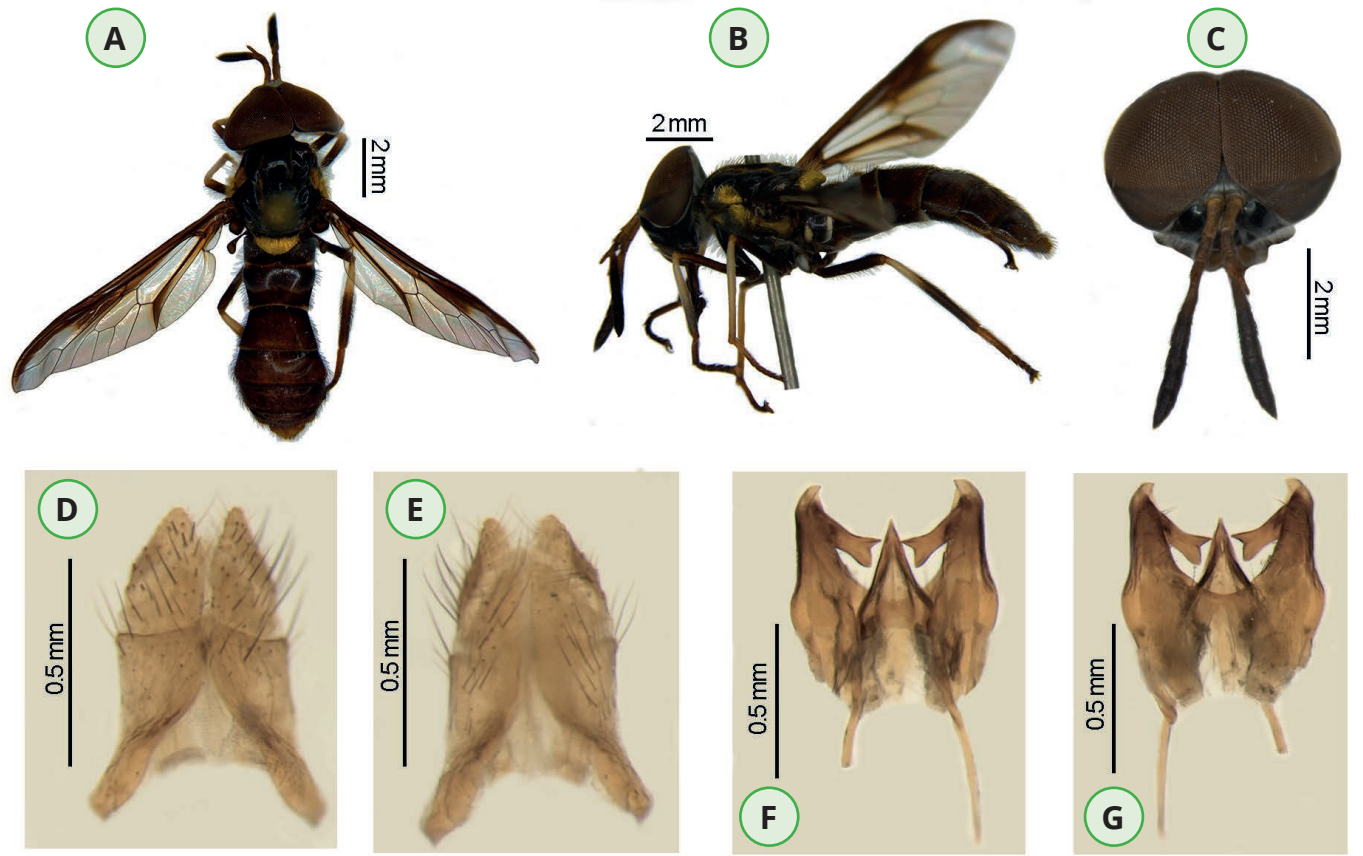

Figure 2. Male of *Acanthocera marginalis* Walker, 1854. **A.** Habitus, dorsal view; **B.** Habitus, lateral view; **C.** Head, anterior view; **D-E.** Epandrium, cercus and hypoproct (dorsal and ventral views, respectively); **F-G.** Hypandrium, gonocoxite, gonostylus and aedeagus (dorsal and ventral views respectively). Source: authors.

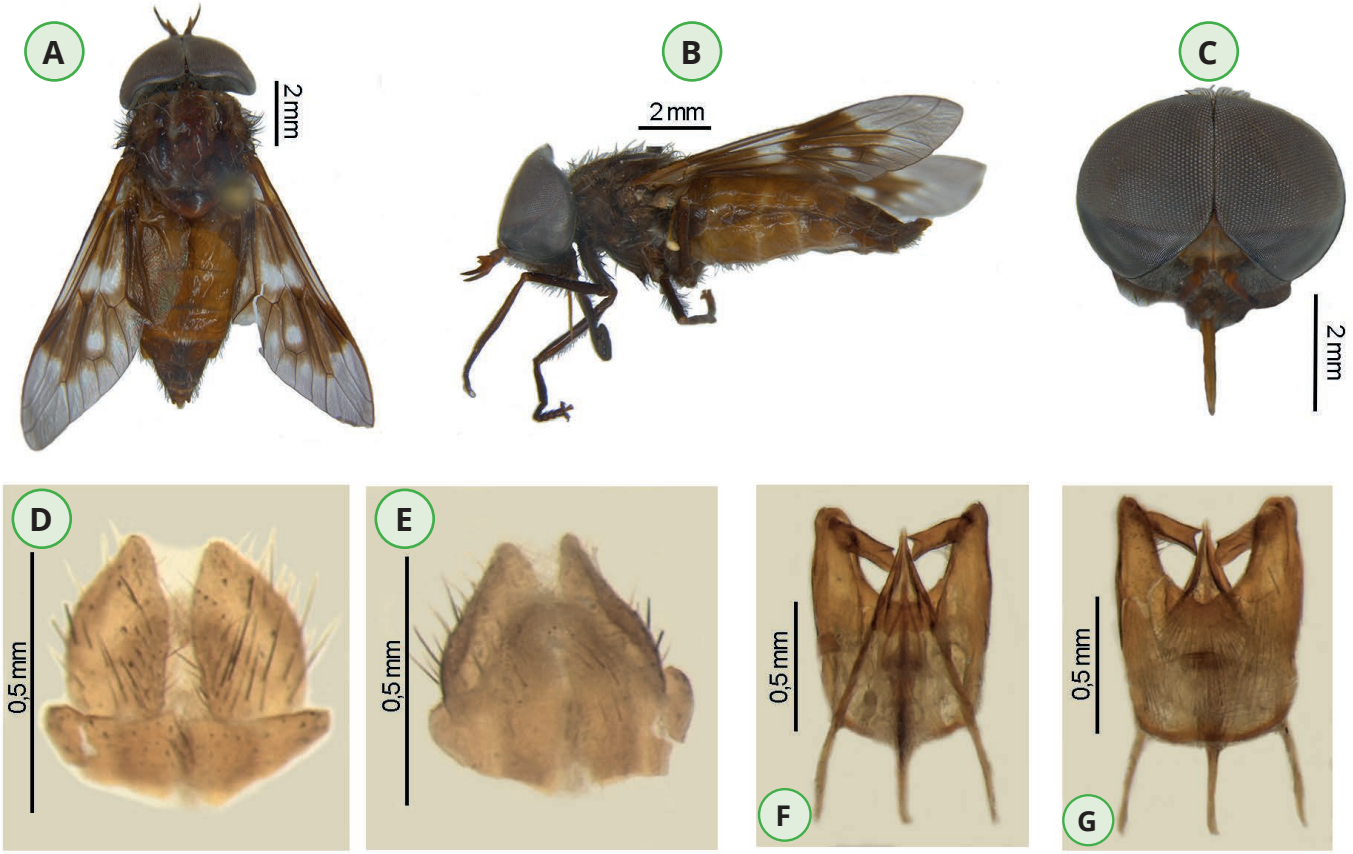

Figure 3. Male of *Dicladocera mutata* Fairchild, 1958. **A.** Habitus, dorsal view; **B.** Habitus, lateral view; **C.** Head, anterior view; **D-E.** Epandrium, cercus and hypoproct (dorsal and ventral views, respectively); **F-G.** Hypandrium, gonocoxite, gonostylus and aedeagus (dorsal and ventral views respectively). Source: authors.

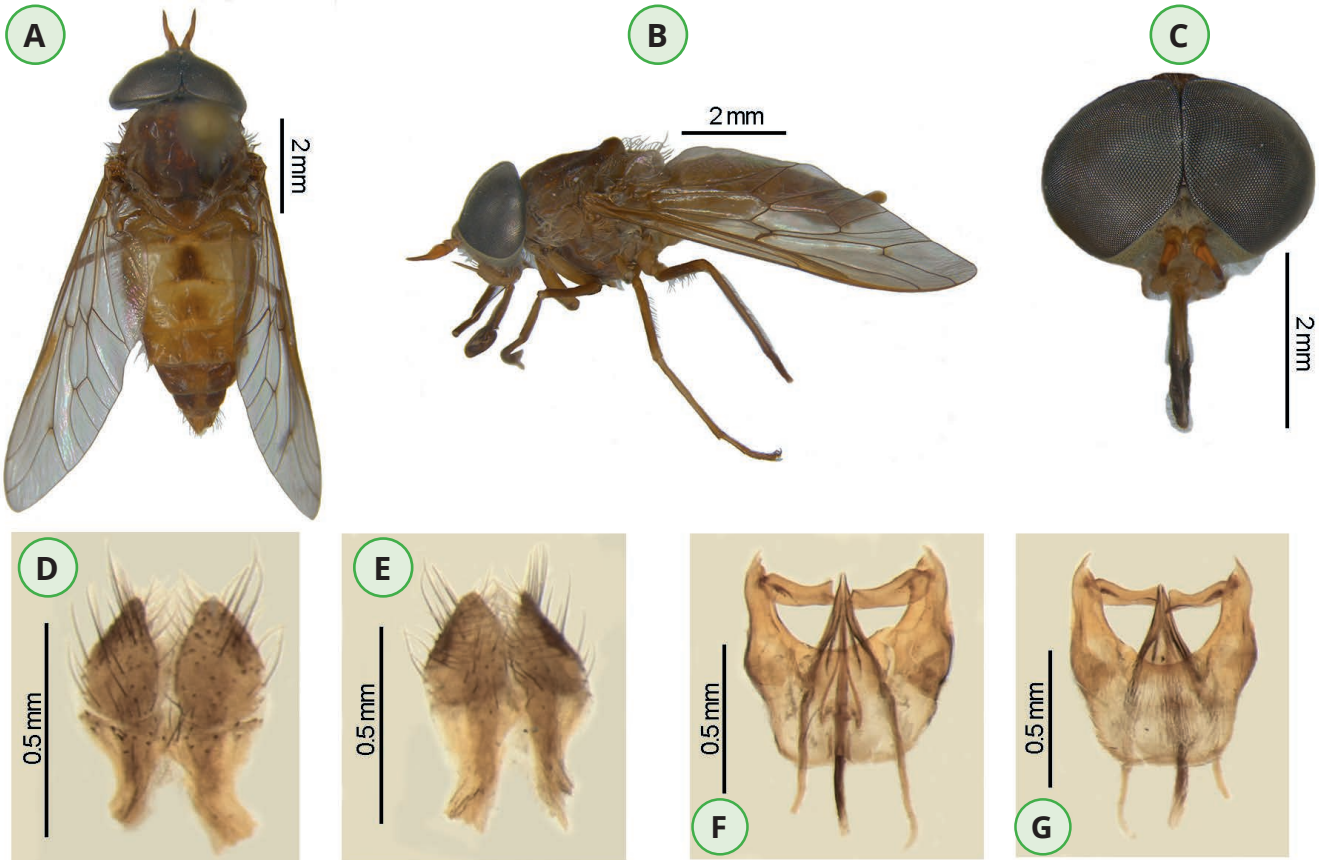

Figure 4. Male of *Stypommisa aripuana* Fairchild & Wilkerson, 1986. **A.** Habitus, dorsal view; **B.** Habitus, lateral view; **C.** Head, anterior view; **D-E.** Epandrium, cercus and hypoproct (dorsal and ventral views, respectively); **F-G.** Hypandrium, gonocoxite, gonostylus and aedeagus (dorsal and ventral views respectively). Source: authors.

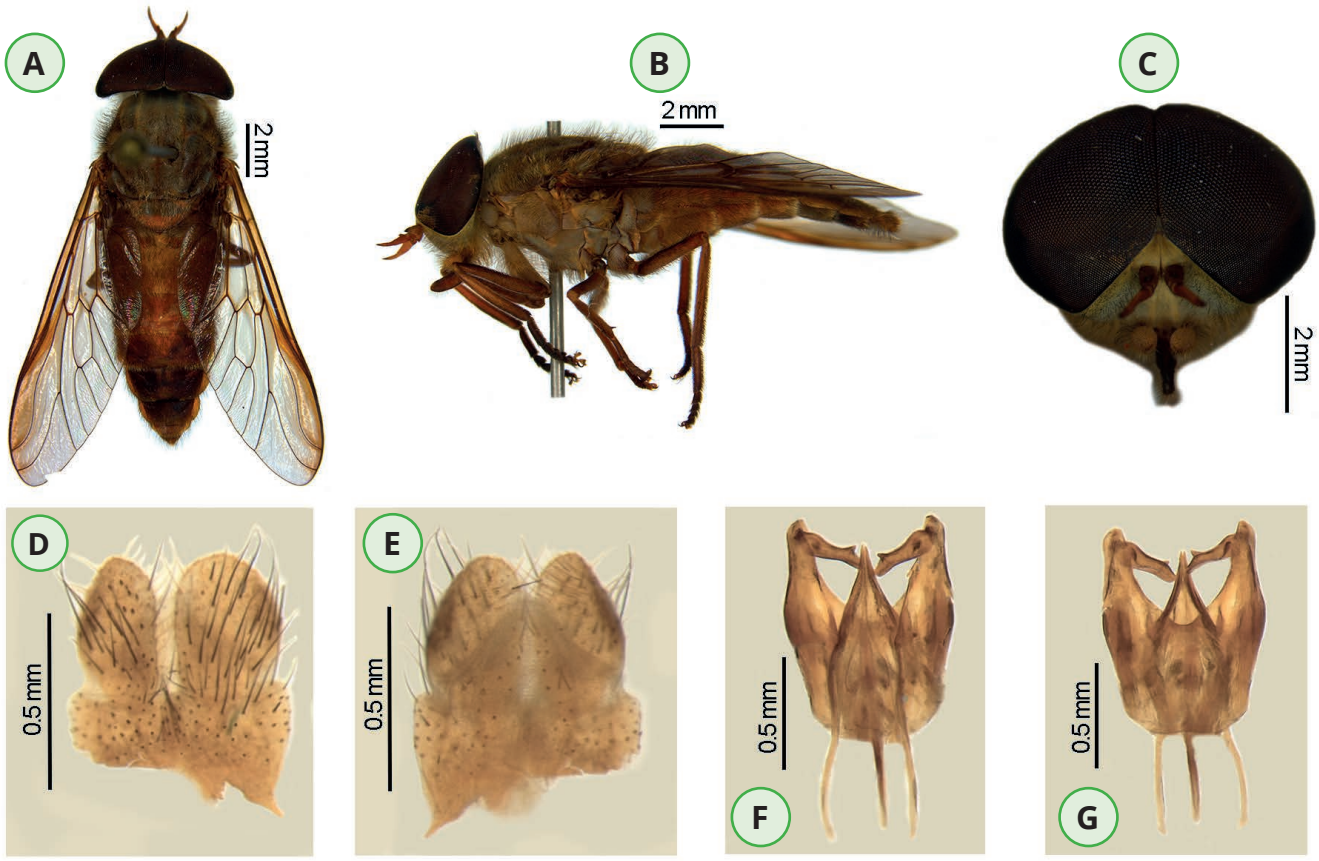

Figure 5. Male of *Tabanus mucronatus* Fairchild, 1961. **A.** Habitus, dorsal view; **B.** Habitus, lateral view; **C.** Head, anterior view; **D-E.** Epandrium, cercus and hypoproct (dorsal and ventral views, respectively); **F-G.** Hypandrium, gonocoxite, gonostylus and aedeagus (dorsal and ventral views respectively). Source: authors.

only females have been most often designated as a holotype. Although this is not a rule, it is currently not very productive to describe new species of Tabanidae using males, as the keys and revisions mostly address females, and the taxonomy of the family is largely based on female external characters. This fact may cause some strangeness among the other dipterists, either because of the use of the female, as well as the little appreciation of the male terminalia. But it is important to emphasize that this apparent "abandonment" is not unfounded. When examining terminalia of different species, Mackerras (1954) warned about the difficulty of observing consistent characters that allow to differentiate their states below the genus level, that is, he exposed the little usefulness of the male terminalia for the separation of species.

Since then, almost 70 years have passed and there has been little or no progress in the discovery of new characters related to male terminalia and the systematics of the family is still rudimentary, being largely based on intuitive schemes (Mackerras 1954) or, more recently, on molecular data (Lessard *et al*. 2013; Morita *et al.* 2016). Consequently, the relationships of many groups still need to be properly tested through phylogenetic analyzes that list the largest possible number of characters. In this sense, the present work aims to stimulate the description and search for new characters in males of Tabanidae.

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