



Two new species and new records of *Campsurus* Eaton (Ephemeroptera: Polymitarcyidae) in Amazon

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Abstract

Campsurus Eaton is the second most speciose genus of mayflies in South America and, until recently, one of the most problematic. The scenario was so disorganized that the description of new species was strongly discouraged. In 2010 the genus started to be revised and, after more than ten years of advances, the taxonomic impediment was drastically reduced, facilitating new researches. The new evidence allowed us to investigate specimens of this genus collected from Amapá and Mato Grosso States, Brazil, which were impossible to assign to any species in the past. As results, two new species are described, *Campsurus fortuitus* **sp. nov.** and *Campsurus froehlichii* **sp. nov.**; and new records are provided for *Campsurus cuyuniensis* Traver, *Campsurus indivisus* Ulmer, *Campsurus inusitatus* Molineri & Salles, *Campsurus jorgenseni* Esben-Petersen, *Campsurus litaninensis* Spieth, *Campsurus nessimiani* Molineri & Salles, *Campsurus pereirae* Molineri & Salles and, *Campsurus segnis* Needham & Murphy.

Key words: Campsurinae, Ephemeroidea, aquatic insects, South America, taxonomy, Neotropics

Introduction

Campsurus Eaton, 1868 is the second most speciose genus of mayflies in South America, with 37 species (Salles *et al.* 2020), but not the best known. Historically, the taxonomy of this genus was confusing, with many species described too briefly, or only from females, with few illustrations, and with some types lost (Domínguez *et al.* 2006). There were earlier attempts to improve this genus taxonomy (e.g., Needham & Murphy 1924, Traver 1947), but the first step to improve species recognition was given by Domínguez *et al.* (2006), establishing three informal groups in *Campsurus* based on male genitalia, violaceus (ex notatus), albifilum and segnis. Despite this grouping, the scenario remained so disorganized that Domínguez *et al.* (2006) strongly recommended that descriptions of new species in this genus should be avoided until a major revision was carried out.

The necessary revision of *Campsurus* initiated in 2010, resulting in taxonomic acts as synonymies, types revisions, species redescriptions and descriptions, description of unknown stages, evaluation of groups of species based on phylogenetic analysis, proposal of characters focused on male genitalia, and identification keys (e.g. Molineri & Emmerich 2010, Emmerich & Molineri 2011, Molineri & Salles 2013, 2017, Molineri *et al.* 2015, Molineri & Granados-Martinez 2019). The species in the genus are now distributed in four groups, violaceus, albifilum, segnis and major group, but only albifilum and major have been tested and recovered as monophyletic (Molineri & Salles 2013).

More than one decade of taxonomic advances drastically reduced the genus taxonomic impediment, opening

the research scenario. The new evidence allowed us to study specimens from Amapá and Mato Grosso states (Brazil) which were impossible to assign to any species in the past. The objectives of this study are, therefore, to describe two new species and to provide new geographic records for eight *Campsurus* species.

Material and methods

Digital photographs were taken using a Leica (M165C) stereomicroscope with a DFC420 digital camera, and Leica Application Suite V3.8.0 software was used to produce final images. The species records are presented followed by figures of body, wings and male genitalia.

All specimens were preserved in ethanol 80%, wings were mounted dry on slides. Male genitalia, female abdominal sternum VIII and eggs were dissected and mounted in temporary media (gel alcohol) to take photographs and make drawings. Material examined is deposited in the Invertebrate Collection of the Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, AM, Brazil; Universidade Federal de Viçosa, Viçosa (UFV), MG, Brazil; Florida A&M University, Tallahassee, USA and Instituto de Biodiversidad Neotropical (IBN), Tucumán, Argentina. Geographical coordinates are presented in decimal degrees.

Results and discussion

Campsurus cuyuniensis Traver, 1947

Campsurus cuyuniensis Traver, 1947: 387; Domínguez *et al.* 2006: 569; Molineri & Salles 2017: 312.

Material examined. One male imago (INPA) from Brazil; Amapá; Pedra Branca; Igarapé da Estrada BR 210 near to Pedra Branca; 0.62747/-51.63756; 03.viii.2011; A. Pes, P.V. Cruz, A. Fernandes cols.

Distribution. Guyana; French Guiana; Brazil: Roraima. **New Record:** Brazil: Amapá.

Remarks. The penis of the specimen here reported is bent downward and twisted (Figs 1A–B).

Campsurus indivisus Ulmer, 1942

Campsurus indivisus Ulmer, 1942: 16 (male, female); Domínguez *et al.* 2006: 572; Molineri & Salles 2017: 334.

=*Campsurus duplicatus* Spieth, 1943: 7 (male); Traver 1947: 383; Domínguez *et al.* 2006: 570; Molineri & Salles 2017: 334.

Material examined. Seven male imagos (INPA) from Brazil; Mato Grosso; Aripuanã; Rio Aripuanã, Balneário Oásis; approx -10.16661/-59.45013; 22.vi.2006; N. Hamada col.; light trap.

Distribution. Argentina; Brazil: Amazonas, Roraima, Espírito Santo, Rio de Janeiro, Rio Grande do Sul. **New Record:** Brazil: Mato Grosso.

Campsurus inusitatus Molineri & Salles, 2017

Campsurus sp. D Traver 1947: 394.

Campsurus inusitatus Molineri & Salles, 2017:332.

Material examined. One male imago (INPA) from Brazil; Mato Grosso; Aripuanã; Rio Aripuanã, Balneário Oásis; approx -10.16661/-59.45013; 22.vi.2006; N. Hamada col.; light trap.

Distribution. Guyana; Brazil: Amazonas, Roraima. **New Record:** Brazil: Mato Grosso.

***Campsurus jorgenseni* Esben-Petersen, 1912**

Campsurus jorgenseni Esben-Petersen, 1912: 333; Ulmer 1920: 116; Lestage 1923: 122; Needham & Murphy 1924:16; Ulmer 1942: 114; Domínguez *et al.* 2006: 572; Emmerich & Molineri 2011: 58.
=*Campsurus scutellaris* Needham & Murphy, 1924: 19; Traver 1947: 380; Domínguez *et al.* 2006: 578; Emmerich & Molineri 2011: 58.

Material examined. Four male imagos (INPA) from Brazil; Mato Grosso; Aripuanã; Rio Aripuanã, Balneário Oásis; approx -10.16661/-59.45013; 22.vi.2006; N. Hamada col.; light trap.

Distribution. Argentina; Brazil: Mato Grosso do Sul. **New Record:** Brazil: Mato Grosso.

***Campsurus litaninensis* Spieth, 1943**

Campsurus litaninensis Spieth, 1943: 5 (male, female); Domínguez *et al.* 2006: 573; Molineri & Salles 2017: 341.

Material examined. Six male imagos (INPA) from Brazil; Mato Grosso; Aripuanã; Rio Aripuanã, Balneário Oásis; approx -10.16661/-59.45013; 22.vi.2006; N. Hamada col.; light trap.

Distribution. Surinam; French Guiana; Brazil: Rio de Janeiro, Roraima. **New Record:** Brazil: Mato Grosso.

***Campsurus nessimiani* Molineri & Salles, 2017**

Campsurus nessimiani Molineri & Salles, 2017: 314.

Material examined. One male imago (INPA) from Brazil; Mato Grosso; Aripuanã; Rio Aripuanã, Balneário Oásis; approx -10.16661/-59.45013; 22.vi.2006; N. Hamada col.; light trap.

Distribution. Brazil: Amazonas, Roraima. **New Record:** Brazil: Mato Grosso.

Remarks. *Campsurus nessimiani* is probably a complex of species (Molineri & Salles 2017), variations in male genitalia were reported in the original description. The male studied here fits well in the range of variations reported previously, except by apex of penis rounded, in lateral view (Figs 1C–D).

***Campsurus pereirae* Molineri & Salles, 2017**

Campsurus pereirae Molineri & Salles, 2017: 321.

Material examined. Four male imagos (INPA) from Brazil; Amapá, M. Amapá; Rio Amapá Grande, Cachoeira Grande; 3 m.a.s.l.; 2.161972/-50.921472; 07.viii.2011; A. Pes, P. V. Cruz, A. Fernandes, N. Hamada cols.

Distribution. Surinam; Brazil: Goiás. **New Record:** Brazil: Amapá.

Remarks. The specimens studied have the apex of the main lobe of penis somewhat slender than the original description (Figs 1E–F).

***Campsurus segnis* Needham & Murphy, 1924**

Campsurus segnis Needham & Murphy, 1924: 19; Morgan 1929: 61; Spieth 1943: 5; Traver 1947: 380; Domínguez *et al.* 2006: 579; Molineri & Salles 2017: 338.

Material examined. One male imago (INPA) from Brazil; Amapá; Oiapoque; Balneário Rio Pantanahy (Pantanari); -3 m.a.s.l.; 3.798417/-51.801528; 08.viii.2011; A. Pes, P. V. Cruz, A. Fernandes, N. Hamada cols.

Distribution. Guyana; French Guiana; Venezuela; Brazil: Pará. **New Record:** Brazil: Amapá.

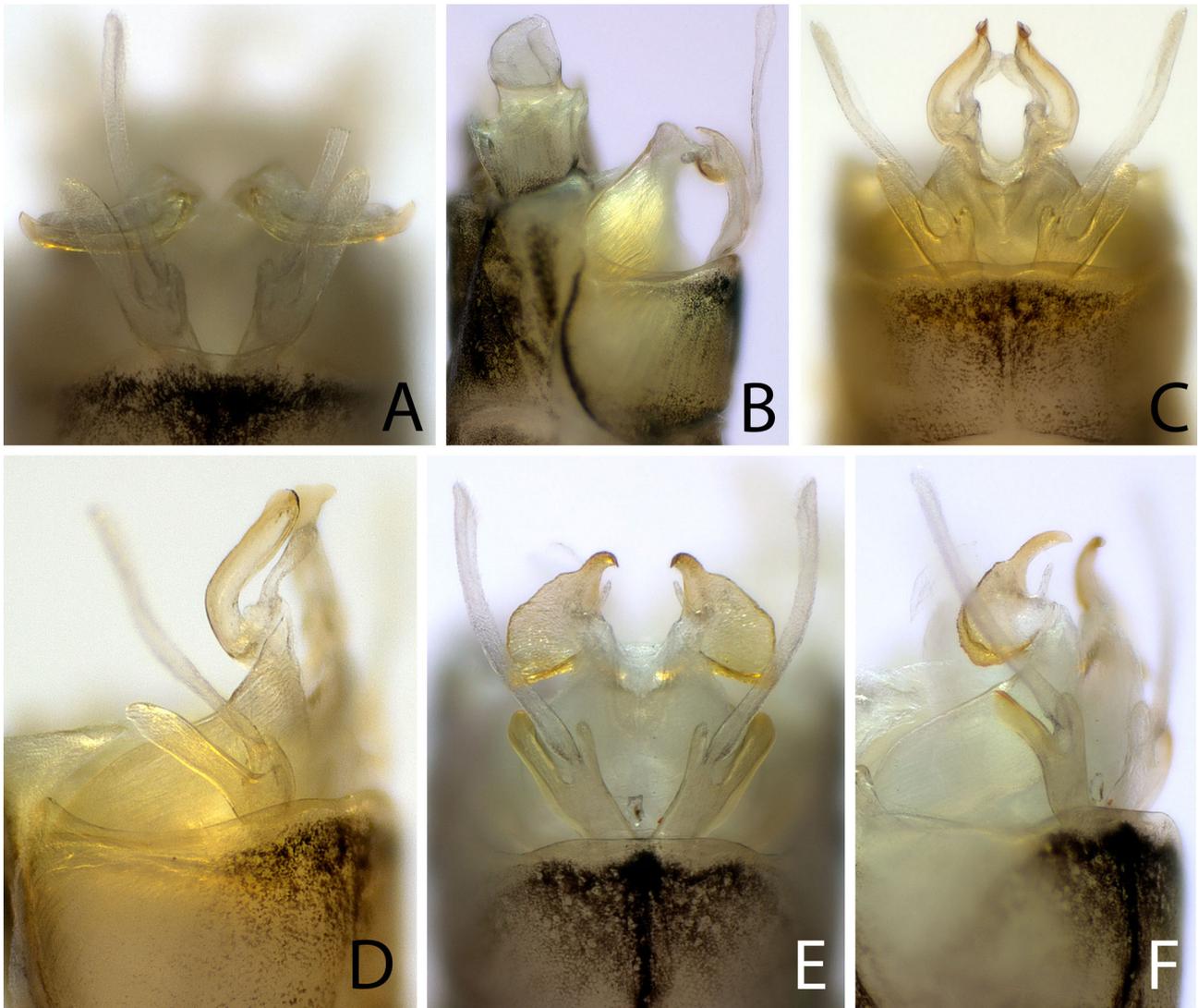


FIGURE 1. Genitalia of male imagos. A. *Campsurus cuyuniensis*, ventral view; B. *Campsurus cuyuniensis*, lateral view; C. *Campsurus nessimiani*, ventral view; D. *Campsurus nessimiani*, lateral view; E. *Campsurus pereirae*, ventral view; F. *Campsurus pereirae*, lateral view.

***Campsurus fortuitus* sp. nov.**

(Figures 2 A–I)

Material examined. Holotype: male imago (INPA) from Brazil; Amapá; Pedra Branca; Igarapé da Estrada BR 210; 0.62747/-51.63756; 03.viii.2011; A. Pes, P.V. Cruz, A. Fernandes cols. Paratypes: One male imago (INPA), same data as holotype.

Diagnosis. Male imago. 1) sternum IX with posterior margin almost straight (Fig. 2H); 2) pedestal of each side touching basally, inner projection short, thick, almost rounded, and with outer margin straight, outer projection short, slender and with apex broadly pointed (Figs 2D and 2H); 3) base of penis wide proximally, narrowing toward apex (Figs 2D and 2H); 4) main lobe of penis bladelike, slightly curved ventrally and with distoventral gonopore (Figs 2D–I); 5) penis apex with expansion curved outwards (Figs 2D–I); 6) secondary lobe completely reduced (Figs 2D–I).

Description. Male imago. Length (n=1, mm): body, 7.8; fore wing, 5.7; hind wing, 2.4. General coloration yellowish grey (Fig. 2A). Head completely shaded with black dorsally, ventrally whitish, slightly tinged with black. Antenna with scape and pedicel grey, flagellum lost. Thorax. Pronotum shaded with gray, with paler transversal line on posterior margin; prosternum whitish, propleura whitish, shaded with gray. Mesonotum yellowish white with

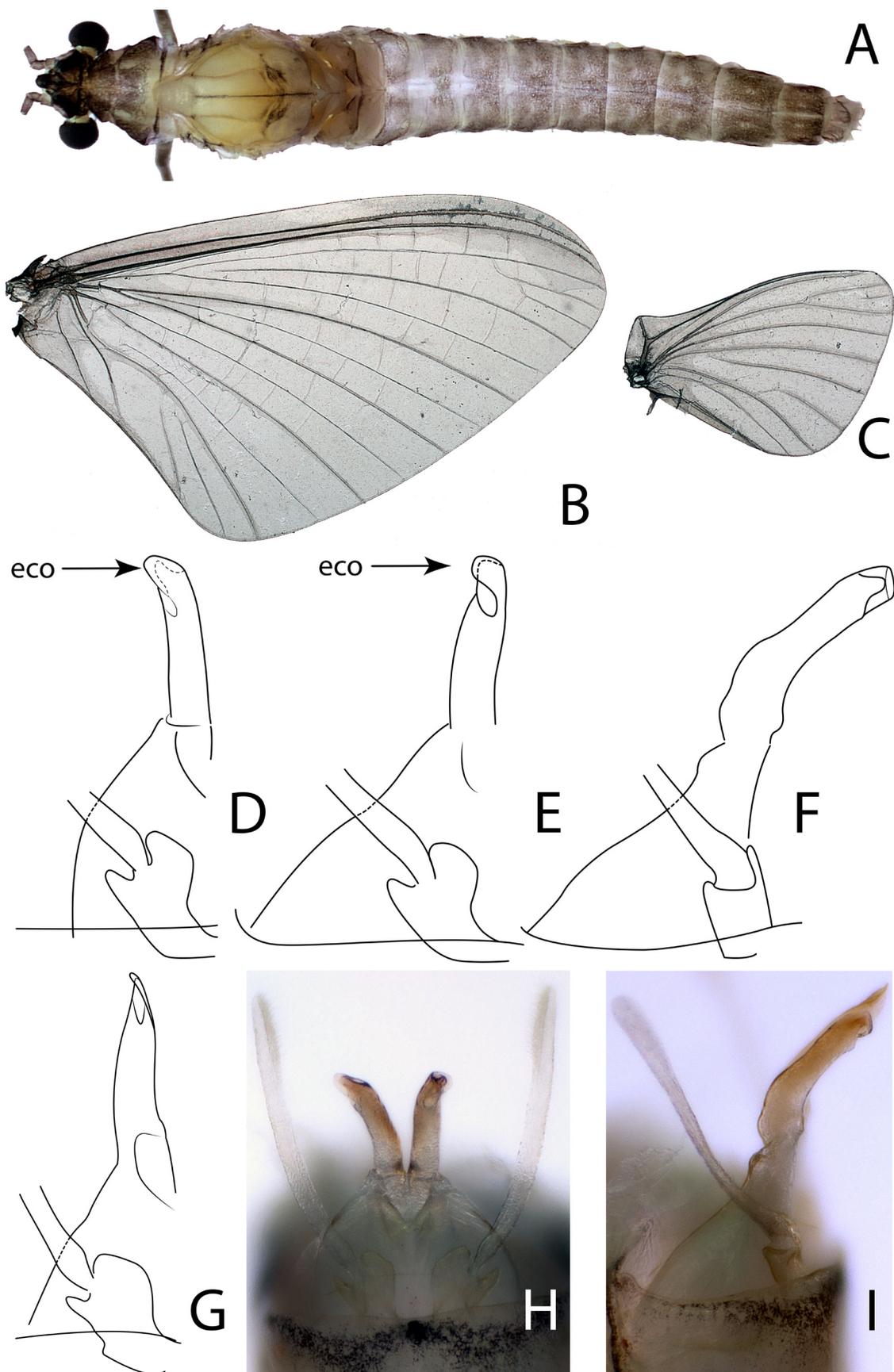


FIGURE 2. *Campsurus fortuitus* **sp. nov.** male imago. A. dorsal view; B. forewing; C. hind wing; D. half of genitalia in ventral view; E. half of genitalia in ventrolateral view; F. half of genitalia in lateral view; G. penis ventral view - twisted in stereoscope (paratype); H. genitalia in ventral view; I. genitalia in lateral view. (eco = expansion curved outwards).

blackish medial line, parapsidal suture and posteroscutal protuberance slightly shaded with gray; pleura and sterna whitish, shaded with black; and gray around coxa. Metanotum yellowish. Legs. Foreleg greyish, except distal tarsomere and claws slightly paler. Middle and hind legs yellowish. Wings (Figs 2B and 2C). Fore wing with membrane hyaline, shaded with light grey on C and Sc areas; veins grey; cross veins hyaline; MP_2 not connected to IMP, ICu_1 not connected to CuA, ICu_2 directly connected to CuA. Hind wing similar to fore wing, but paler; intercalary vein of radial sector very short. Abdomen whitish translucent, shaded with gray, except medial line, intersegmental membranes, and lateral transversal dash on terga II–VII (Fig. 2A) Abdominal sterna whitish, shaded with gray on inner margin of gill sclerites and very slightly on meson of sterna VII–IX. Genitalia (Figs 2D–I): sternum IX with almost straight posterior margin; pedestal of each side touching basally, inner projection short, thick, almost rounded, and with outer margin straight, outer projection short, slender and with apex broadly pointed; base of penis wide proximally, narrowing toward apex; main lobe of penis slender, bladeliike and sclerotized, slightly curved ventrally and with distoventral gonopore, inner margin of apex (Figures 2D and 2E) with expansion curved outwards (eco), secondary lobe completely reduced, apical half of penis orangish. (Caudal filaments broken off and lost)

Etymology. The word “fortuit” in Latin means “random”. The species was collected in a random stop in the road for snack.

Discussion. *Campsurus fortuitus* **sp. nov.** has unusual genital characteristics, similar to *Campsurus povilla* Molineri & Salles, but they can be distinguished by i) penis with wide base, narrowing distally in *C. fortuitus* **sp. nov.**, while abruptly thinning basal to penile lobes in *C. povilla*; ii) main lobe of penis slender in *C. fortuitus* **sp. nov.**, while robust in *C. povilla*; iii) main lobe of penis with inner margin apex curved outwards in *C. fortuitus* **sp. nov.**, while apex rounded in *C. povilla*; iv) secondary lobe of penis completely reduced in *C. fortuitus* **sp. nov.**, while greatly reduced but clearly present in *C. povilla*; v) pedestal in *C. fortuitus* **sp. nov.** with inner projection straighter than in *C. povilla*.

Campsurus froehlichii **sp. nov.**

(Figures 3 A–J and 4 A–G)

Material examined. Holotype: male imago (INPA) from Brazil; Amapá; Serra do Navio; Rio Cachaço, Cachoeira do Fernando; 61m.a.s.l.; 0.88856/-52.02303; 02.viii.2011; A. Pes, P.V. Cruz, A. Fernandes cols. Paratypes: Four male imagos, same data as holotype.

Additional material: 7 males and 1 female, imagos (3 males and female in IBN, 4 males in UFV) from Brazil, Amazonas, Barcelos, Serra do Aracá, (base), tributário do igarapé da Cobra, (BO6), 00° 52' 13.2" N 63° 27' 13.4" W, 147 m.a.s.l., 25–26. vii.2009, PRONEX-INPA equipe col., Pennsylvania trap. SURINAM: 11 male imagos from Brokopondo district, creek on N edge Brokopondo (5° 1' 34" N – 54° 59' 24" W), 90 m, 27.xii.1978, W.L. & J.G. Peters cols. (FAMU except 6 in IBN).

Diagnosis. Male imago. 1) sternum IX with truncated posterior margin, medial line blackish (Fig. 3D); 2) pedestal of each side touching basally, inner projection digitiform, apically rounded, outer projection slender, long and apically rounded (Figs 3D and 3G); 3) main lobe of penis with basal half expanded laterally (ear-like) and with transverse ridge (Figs 3D–I); 4) dorsal surface of penis rugose (Fig. 3F); 5) secondary lobe translucent, slender and cylindrical, almost reaching the apex of main lobe (Figs 3E–I). **Female imago.** 1) anteromedian socket oval to circular in shape, internal sclerites with two openings (Figs 4D–F).

Description. Male imago. Length (n= 2, mm): body, 6.5–7.6; fore wing, 5.5–6.5; hind wing, 2.0–2.6. General coloration yellowish, widely shaded with gray (Fig. 3A). Head completely shaded with black dorsally, brownish gray on gena, antenna with scape and pedicel brownish gray, flagellum yellowish. Thorax (Fig. 3A). Pronotum completely shaded with gray, darker on anterior portion. Mesonotum yellowish, shaded with gray on sutures. Metanotum yellowish, shaded with gray medially. Legs. Foreleg completely shaded gray, slightly paler at base of tarsomeres; middle and hind legs shaded completely with gray. Wings (Figs 3B–C). Membrane hyaline, except C and Sc areas shaded with brownish gray, veins hyaline, except C, Sc, and R_1 brownish; MP_2 not connected to IMP, ICu_1 connected to CuA, ICu_2 directly connected to ICu_1 . Hind wing hyaline, except C and Sc areas very slightly shaded with gray; intercalary vein of radial sector long. Abdomen (Fig. 3A) widely and strongly shaded with gray on terga. Abdominal sterna translucent white, shaded with gray, slightly darker on medial line and inner margin of gill sclerites. Genitalia (Figs 3D–I): yellowish whitish; sternum IX with truncate posterior margin, medial line black; pedestal of each side touching basally, inner projection digitiform, short, and apically rounded, outer projection slender,

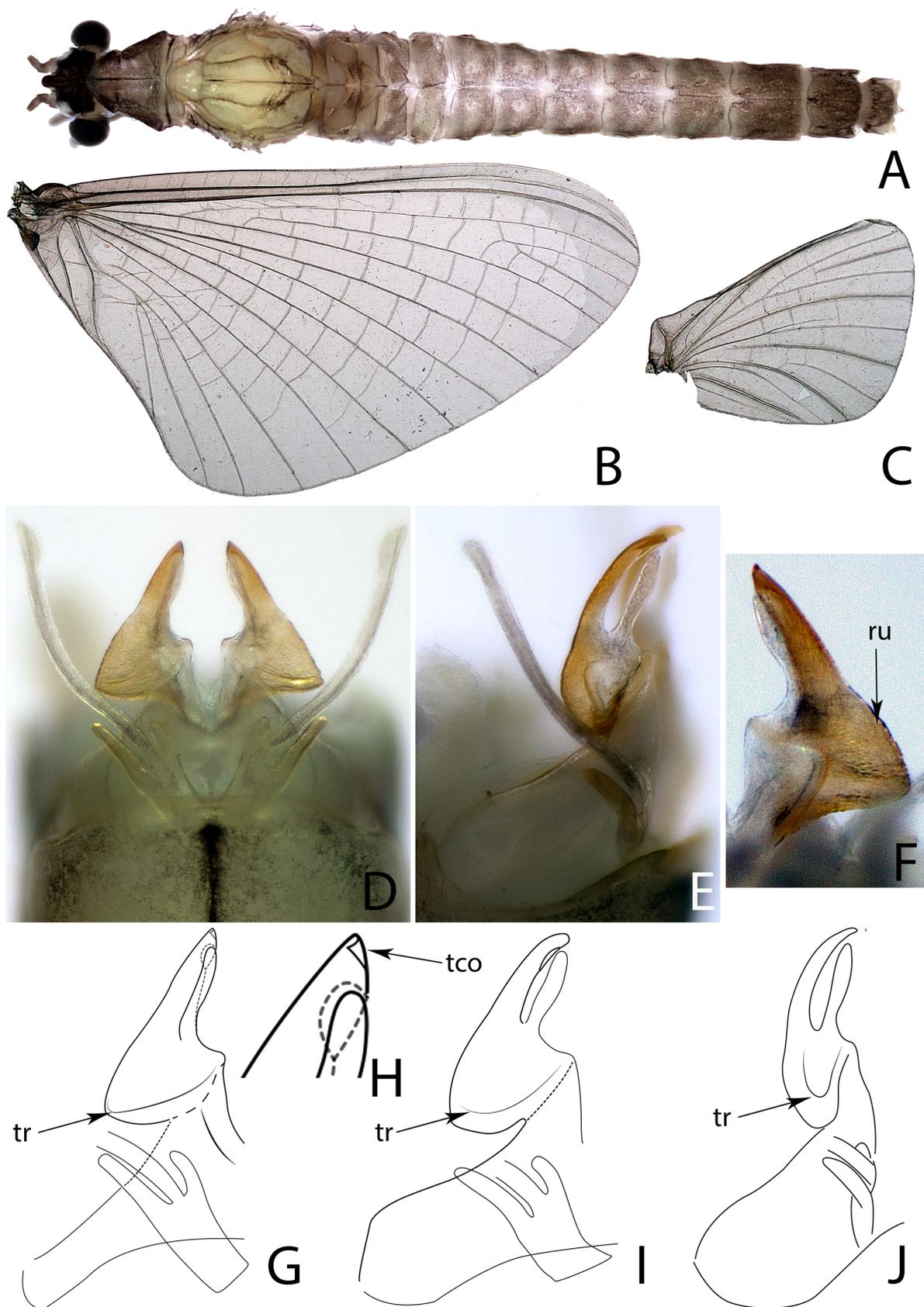


FIGURE 3. *Campsurus froehlichii* sp. nov. male imago. A. dorsal view; B. forewing; C. hind wing; D. genitalia in ventral view; E. genitalia in lateral view; F. penis in dorsal view; G. half of genitalia in ventral view; H. detail of apex of penis in ventral view; I. half of genitalia in ventrolateral view; J. half of genitalia in lateral view. (tco = tip curved outwards; tr = transverse ridge; ru = rugose surface).

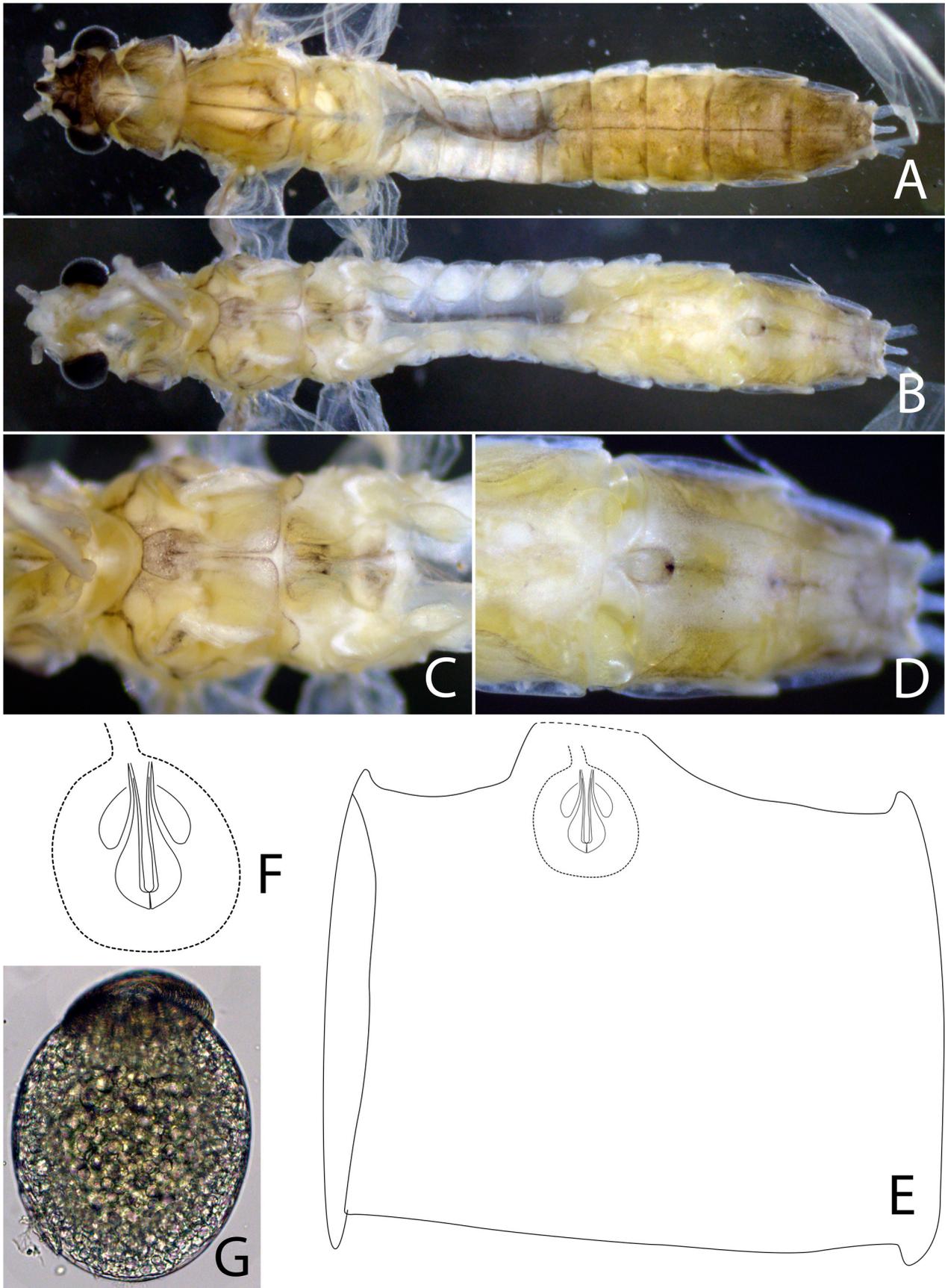


FIGURE 4. *Campsurus froehlichii* sp. nov. female imago and egg. A. dorsal view; B. ventral view; C. detail of thorax in ventral view; D. sternum VIII; E. detail of sternum VIII; F. detail of socket in sternum VIII; G. egg.

long and apically rounded; forceps short and translucent, shaded with gray; base of main lobe of penis sclerotized, basal half expanded laterally (ear-like), proximal margin of expansion forming a transverse ridge (tr in figures 3G, 3I and 3J), with rugose dorsal surface (ru in Figure 3F); apical half narrowing toward apex, apex in ventral view pointed and with tip curved outwards (tco in Figure 3H); in lateral view main lobe of penis curved ventrally, apical half thin, apex pointed; secondary membranous lobe translucent, slender and cylindrical, almost reaching the apex of main lobe. Caudal filament translucent whitish. **Female imago.** Length (n= 1, mm): body, 7.3; fore wing, 7.5; hind wing, 3.0. Coloration (Figs 4A–C) and gray marks similar to male, except shaded more slightly with gray. Abdominal sternum VIII with anteromedian socket, oval to circular in shape, internal sclerites with two openings (Figs 4D – F). **Egg.** Length 285 μ ; width 225 μ . Polar cap relatively large (Fig. 4G) formed by coiled threads. Egg yellowish bowl-shaped, granulated under photonic microscope.

Etymology. The name of this species is in honor of Dr. Claudio Gilberto Froehlich for his significant contributions to the knowledge of the aquatic insects in South America.

Discussion. *Campsurus froehlichii* **sp. nov.** belongs to a morphological group of species with the base of main lobe of penis (basal third or half) expanded (ear-like), pedestal with well-developed outer projection (long and slender or short and thick), and short and digitiform inner projection. Four species share the same scheme in the male genitalia, *Campsurus zunigae* Molineri & Salles, 2017, *Campsurus pereirae*, *Campsurus janae* Molineri & Salles, 2017 and *Campsurus cristales* Molineri & Granados-Martinez, 2019. The male imago of *C. froehlichii* **sp. nov.** can be distinguished from the ones of *C. janae* and *C. cristales* by its long and slender outer projection of pedestal; by its long secondary lobe of penis, while short in *C. pereirae*; and by its rugose dorsal surface of penis, while smooth in *C. zunigae*. The female imago of *Campsurus froehlichii* **sp. nov.** can be distinguished from the ones of *C. pereirae* and *C. cristales* by its circular socket, while subquadrate in *C. pereirae* and elongated in *C. cristales*. The female imago of *C. janae* and *C. zunigae* are unknown.

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