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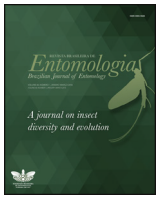

LEAq – Laboratório de Entomologia Aquática "Prof. Claudio Gilberto Froehlich" and the task of facing the biodiversity knowledge deficits on Caddisflies (Trichoptera), Bahia, Brazil

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ABSTRACT

Insects are fundamental to biodiversity conservation in almost all ecosystems, and their population decline, and extinction directly result from environmental impacts. These facts are aggravated by the lack of knowledge of insect biodiversity, the so-called biodiversity deficits, especially the Linnean and Wallacean shortfalls. In freshwater ecosystems, biodiversity loss is higher among aquatic insects, and caddisflies comprise one of the most vulnerable orders. In this way, research focusing on describing new caddisfly species and understanding their distribution ranges will increase knowledge of caddisfly biodiversity. In the past 14 years, the team from the Laboratório de Entomologia Aquática "Prof. Dr. Claudio Gilberto Froehlich" (LEAq, Universidade Federal da Bahia, Brazil) and collaborators have been addressing these issues, resulting in 55 described species of caddisflies. Taxa in other insect orders have also received attention and an additional 16 species have been described (eight mayflies, four stoneflies, four neuropteran spongillaflies, and antlions). Here, eight caddisfly species are described and illustrated (*Atopsyche froehlichi* **sp. nov.**, *Austrotinodes zeferina* **sp. nov.**, *Cernotina kariri* **sp. nov.**, *Neoathripsodes froehlichi* **sp. nov.**, *Notalina claudiofroehlichi* **sp. nov.**, *Oecetis marcus* **sp. nov.**, *Phylloicus froehlichi* **sp. nov.**, and *Polycentropus claudioi* **sp. nov.**), five of them in honor of LEAq's patron. In addition, new distributional data are presented for 10 known species. A checklist of the caddisfly fauna of Bahia state is also presented, with 138 species, around 75% and 30% of them recorded and described by the LEAq team, respectively. Currently, for caddisflies, Bahia is the fifth most species-rich state in Brazil, and the first in the Brazilian Northeast region.

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Introduction

Insects are fundamental to biodiversity conservation in terrestrial and freshwater ecosystems as well as to human survival and well-being (Dangles and Casas, 2019) because of their richness (50 to 70% of all described species) and ecological role, which have consequences on agriculture, human health, natural resource uses and conservation (Stork, 2018). On the other hand, anthropogenic modification of global landscapes has been contributing to insect population decline (Vogel, 2017; Bowler, 2021; Boyes et al., 2021), and also to their silent extinction (Dunn, 2005; Eisenhauer et al., 2019), with over 40% of insect species threatened by extinction (Sánchez-Bayo and Wyckhuys, 2019).

Freshwater ecosystems constitute one of the most diverse ecological units, hosting around 10% of the world's biodiversity, with the highest biodiversity loss rates, in only 0.01% of the Earth's water (Sánchez-Bayo and Wyckhuys, 2019; Tickner et al., 2020). Concerning aquatic insects, 33% of the species are endangered (28% among terrestrial taxa) and Ephemeroptera, Plecoptera, and Trichoptera are the most vulnerable insect orders (Sánchez-Bayo and Wyckhuys, 2019).

Biodiversity conservation strategies are constrained by the limited knowledge of biodiversity, including deficits in the knowledge of the taxonomy and distribution of species, the so-called Linnean and Wallacean shortfalls. Additional shortfalls have been recognized in our knowledge of the abundance, evolutionary patterns, abiotic tolerances, and ecological traits of species as well as their biotic interactions (Cardoso et al., 2011; Hortal et al., 2015; Calor and Quinteiro, 2017; Faria et al., 2021). The elucidation of these biodiversity shortfalls can shed some light on ways to overcome the knowledge gaps and deal with the uncertainty generated by them (Hortal et al., 2015). Maasri et al. (2022) proposed a global agenda for advancing freshwater biodiversity research, which included 15 pressing priority needs, some of those with strict relationships with biodiversity shortfalls. Improving taxonomic and ecological knowledge of freshwater organisms is needed to "increase coverage of efficient monitoring across organismal groups and geographical areas," offering a targeted approach to focus on the Linnean, Wallacean, and other shortfalls to the conservation of freshwater ecosystems.

Facing biodiversity shortfalls is a critical and urgent task, especially considering megadiverse countries, like Brazil, and regarding taxa as diverse as insects. The most important deficits are related to the insufficiency of biological knowledge about most insect species, and to their limited value to Brazilian society (Samways, 2018). The problem has been intensified by recent acceleration of habitat loss and other anthropogenic disturbances (Lewinsohn et al., 2022), but there are many other factors that act synergistically on our lack of knowledge of biodiversity [e.g., territorial extent of the country, with uneven historical research development among regions (Calor, 2011; Lewinsohn et al., 2022), widely under sampled areas (Lewinsohn and Prado, 2005), limited number of specialists (Marques and Lamas, 2006), incomplete entomological collections and non-public databases (MMA, 2002), and the lack of public policies focused on the insect conservation (Cardoso et al., 2011).

Some strategies have been proposed to accelerate the species description and inventories to mitigate the biodiversity shortfalls for insect fauna in Brazil (e.g., investments in entomology collections, integrative and public databases, reducing the distribution heterogeneity of research groups, and the training of graduate students for high-quality taxonomic research [e.g., Rafael et al., 2009; Souza et al., 2022 (both related to insects); Cardoso et al., 2011 (related to invertebrates)]. Our knowledge of insect biodiversity and future directions of insect conservation depends greatly on ongoing support for taxonomists, museums, and biodiversity studies worldwide (Lamarre et al., 2020).

The study of Trichoptera in Brazil is a direct outcome of these biodiversity investigation policies. In recent years, our knowledge of the Brazilian caddisfly fauna has consistently increased. Notably, an accelerated rate of species description (around 35 species/year) was recorded between 2009 and 2018. This effort resulted in the description of more than 400 caddisfly species from Brazil in the last two decades, which built up to around 800 known species in the country (Santos et al., 2020). Despite these great taxonomic advancements, estimates indicate that at least 50% of Brazilian caddisfly species have not been described yet (Santos et al., 2020).

Among the known Brazilian species, only about 4% have all known life history stages described, 72% only have the description of adult males, while 1% only have the adult females, and 1.3% of the species have at least one immature stage or the larval cases (compiled from Holzenthal and Calor, 2017). These data demonstrate that there is still a large Haeckelian shortfall in describing Trichoptera species based only on adult males (Pes et al., 2018). Besides the unknown species and life history stages, another knowledge gap for the caddisflies in Brazil are the species known only from one locality. Approximately 30–40% of the species in some groups of Trichoptera have the distribution restricted to their type locality, or to type locality and adjacent areas, such as the same hydrographic micro basin (Holzenthal and Calor, 2017).

Thus, it is evident that there is still much to be described, recorded, and investigated about the Brazilian caddisfly species (Santos et al., 2020). Studies indicate notable progress in the knowledge of the group (Santos et al., 2020), and some of the main reasons for these advances are the decentralization and installation of research groups in areas where biodiversity knowledge is still poorly known (Mariano et al., 2023). Also, the implementation of expansive and comprehensive projects with a taxonomic focus (e.g., PPBio Semi-arid - Brazilian Program for Biodiversity Research: semi-arid region) help to overcome biodiversity knowledge deficits (Hortal et al., 2015; Oliveira et al., 2016). One of the main consequences of these actions was the increase of the number of known species of caddisflies from 378 in 2004 (Paprocki et al., 2004) to 896 in 2023 (Santos et al., 2023).

One of the research groups that represents this decentralization is the staff of Laboratório de Entomologia Aquática "Prof. Dr. Cláudio Gilberto Froehlich" (LEAq, in English, Aquatic Entomology Laboratory), which was created in 2009 at the Instituto de Biologia, Universidade Federal da Bahia, Brazil. The name of LEAq honors Prof. Dr. Cláudio Gilberto Froehlich for his great contribution to Neotropical Aquatic Entomology through his scientific production and human resources training (Mariano et al., 2023). This foundation of this lab was a consequence of the lead author's participation in a project to survey the caddisfly fauna in the Brazilian Northeast region, coordinated by Froehlich and supported by CNPq (2008-2009), which was the first scientific effort to overcome the Linnean and Wallacean shortfalls on aquatic insect studies in the region.

In the past 14 years, the LEAq scientific production has been focusing on extant caddisfly systematics in the Brazilian Northeastern region, one of the most understudied regions of the country (Blahnik et al., 2004; Calor, 2008; Santos et al., 2020), with evident biodiversity shortfalls. This scientific production includes two books, 10 book chapters, and 44 articles, most of them (27) focused on caddisfly systematics (Calor, 2011; Quinteiro et al., 2011; Calor and Quinteiro, 2012; Quinteiro and Calor, 2012; Dumas et al., 2013; França et al., 2013; Costa and Calor, 2014; Dias et al., 2015; Quinteiro and Calor, 2015; Vilarino and Calor 2015a, 2015b, 2015c; Dias and Calor, 2016; Calor et al., 2016; Gomes and Calor, 2016; Holzenthal et al., 2016; Holzenthal and Calor, 2017; Calor and Quinteiro, 2017; Souza et al., 2017; Vilarino and Calor, 2017; Gomes and Calor, 2019; Vilarino et al., 2019; Pereira et al., 2021; Queiroz et al., 2020; 2023; Santos et al., 2020; Silva-Pereira et al., 2022; Cavalcante-Silva et al., 2022) (Fig. 1), but other taxa have received attention, such as Ephemeroptera (Campos et al., 2016, 2019; Oliveira et al., 2020; Brandão et al., 2021), Plecoptera (Duarte et al., 2014a, 2014b, 2022), and the neuropteran families Sisyridae (Assmar and Calor, 2020; Assmar et al., 2022) and Myrmeleontidae (Tavares et al., 2023).

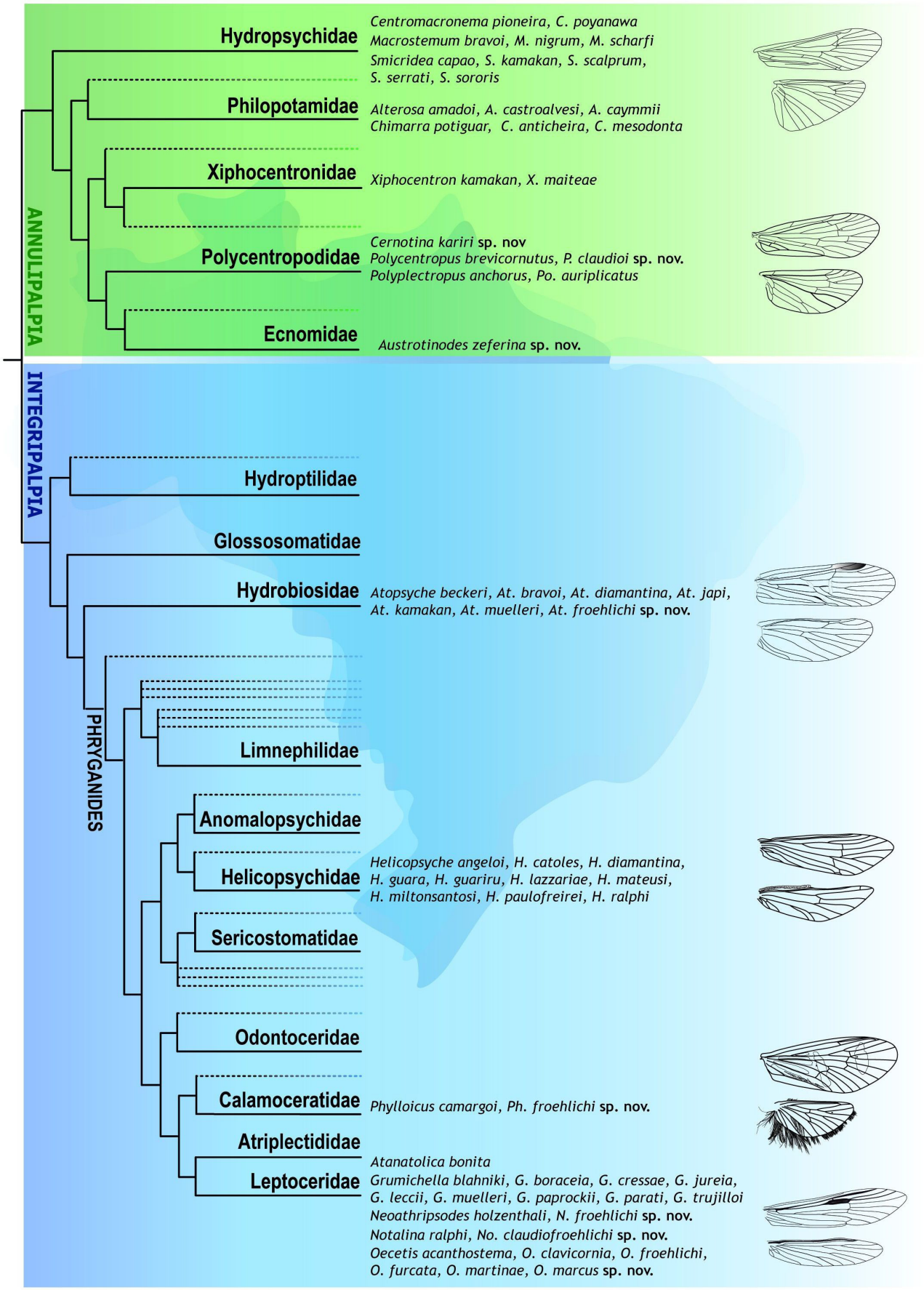

Figure 1 LEAq' scientific contribution directly related to the Linnean shortfall on the caddisfly phylogeny (simplified from Thomas et al., 2020), presenting only the 16 families which occur in Brazil. Bold to nine families with 59 species described by the LEAq team, including the eight described here, from 2009 to 2023.

Other publications reveal the connections with other scientific areas, especially aquatic ecology (Pereira et al., 2017; Pio et al., 2018; Calderón et al., 2019; Rezende et al., 2019; Boyero et al., 2021; Carvalho et al., 2023) or technical contributions (Calor and Mariano, 2012; Pereira et al., 2022).

Following a model of training new researchers combined with scientific production, as implemented by Froehlich at the Universidade de São Paulo (Mariano et al., 2023), LEAq's postgraduate members (17 MSc and five PhD students) came mainly from Bahia state, but also from other Brazilian states (Minas Gerais and Pernambuco, three students, each; Espírito Santos and São Paulo, one student, each). The collaborative network linking LEAq to other research centers has been made through co-authored papers (e.g., Dumas et al., 2013; Holzenthal and Calor, 2017; Santos et al., 2020), and by co-advisoring thesis or PhD dissertations (e.g., Duarte et al., 2022; Tavares et al., 2023). In this approach, the taxonomic problems can be investigated by exploring different areas and taxa (not only caddisflies), increasing the potential growth of scientific centers in understudied regions.

As a contribution to the continuity of Prof. Dr. Claudio Froehlich's career efforts to advance our knowledge of aquatic insect biodiversity and to overcome the Linnean and Wallacean shortfalls, we describe eight new species of caddisflies, five of them in honor of Froehlich. In addition, new distributional data for ten other caddisfly species and a checklist of caddisflies recorded in Bahia state are presented.

Material and methods

The specimens were collected in five Brazilian states (Bahia, Ceará, Pernambuco, Rio Grande do Sul, and São Paulo states), as indicated in the material examined section. The abdomen and wings of specimens were dissected and prepared following Blahnik and Holzenthal (2004) to analyze the genitalia morphology and venation, respectively. All material was deposited in the collections of Instituto Nacional de Pesquisas da Amazônia, Manaus (INPA), Museu de História Natural da Bahia, Universidade Federal da Bahia, Salvador (UFBA), Museu de Zoologia da Universidade de São Paulo, São Paulo (MZUSP), in Brazil, and University of Minnesota Insect Collection, Saint Paul, USA (UMSP). Another collection acronym cited is DZRJ (Coleção Entomológica Professor José Alfredo Pinheiro Dutra, Departamento de Zoologia, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil). The official acronyms of the Brazilian state were used.

Photographs were taken using a digital camera coupled to a microscope, and pictures were stacked using multifocus image software and used as a template for illustrations. Drawings were made in pencil using a *camera lucida* attached to a compound microscope and then scanned. Photographs or scanned pencil drawings were traced digitally using the software Adobe Illustrator CC 2017. The terminology used in the species descriptions, in general, follows Schmid (1998), with specific details for each genus adapted from Prather (2003) for *Phylloicus,* Thomson and Holzenthal (2010) for *Austrotinodes*, Schmid (1989) for *Atopsyche,* Holzenthal (1989) for *Neoathripsodes*, Holzenthal (1986) and Calor et al. (2006) for *Notalina*, Quinteiro and Almeida (2021) for *Oecetis,* Dumas and Nessimian (2011) and Hamilton and Holzenthal (2011) for *Cernotina* and *Polycentropus.* Terminology for wing venation is modified from Mosely and Kimmins (1953). Original data and literature data (exclusively from taxonomic scientific articles) were used to make the species checklist and the distribution maps, which were generated using the free software QGIS 3.10.

The distribution of species through terrestrial ecoregions (Olson et al., 2001) was used, as distinct datasets, to estimate the number of unknown species in Bahia state using non-parametric estimators. Estimators were calculated based on incidence data (presence-absence), using bioregions as sampling units, with the function 'specpool' from the 'vegan' package (Oksanen et al., 2019) in the R environment (R Core Team, 2015). This function calculates some estimators of species richness, including CHAO2 and second-order Jackknife (Kindt and Coe, 2005).

Results

Eight new species are described in five families and eight genera (Calamoceratidae, one *Phylloicus* species; Ecnomidae, one *Austrotinodes* species; Hydrobiosidae, one *Atopsyche* species; Leptoceridae, one species each of *Neoathripsodes*, *Notalina* and *Oecetis*; Polycentropodidae, one *Cernotina* species, and one *Polycentropus*) (Fig. 1). In addition, new distributional data are presented for ten known species (*Anchitrichia duplifurcata* Flint, 1983; *Flintiella pizotensis* Harris, Flint, & Holzenthal, 2002; *Hydroptila zerbinae* Souza, Santos & Takiya, 2014b; *Neotrichia falcifera* Flint, 1974; *Ochrotrichia patulosa* (Wasmund & Holzenthal, 2007); *Oxyethira circaverna* Kelley, 1983; *Rhyacopsyche dikrosa* Wasmund & Holzenthal, 2007; *Marilia fasiculata* Banks, 1913; *Marilia flexuosa* Ulmer, 1905; *Polycentropus biappendiculatus* Flint, 1974).

Taxonomy

Calamoceratidae

Phylloicus Müller, 1880

***Phylloicus froehlichi* Burgos-Miranda & Calor, sp. nov.**

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(Figs. 2A, B, 3A-E)

Diagnosis. *Phylloicus froehlichi* **sp. nov.** is diagnosed by the singular shape of sternum IX with anteroventral margin projected anterad, in lateral view; the anterior margin with two concavities separated by mesal projection, in ventral view; the tergum IX with anterolateral margins projected anterad, and the posterior margin trapezoidal, in dorsal view; the tergum X subrectangular, with basal region larger than apex, and apex acuminated, in lateral view; and the phallobase J-shaped, 2x longer than tergum X, with narrowed base, in lateral view.

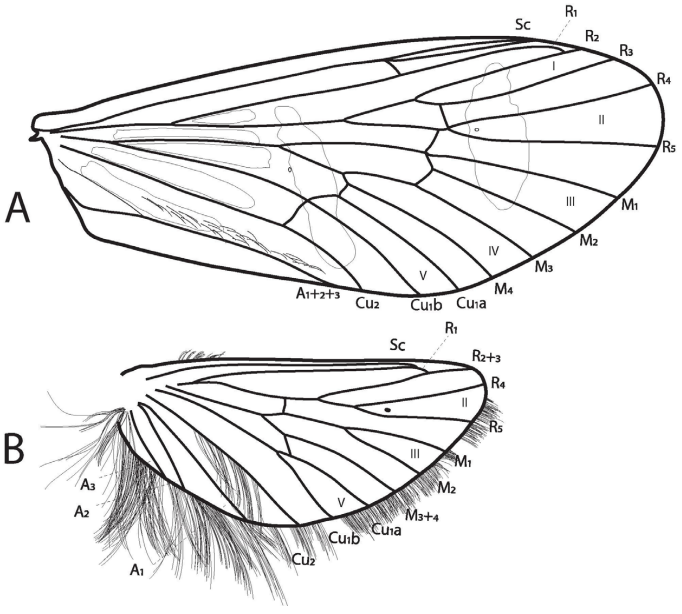

Figure 2 *Phylloicus froehlichi* new species, wings. A, forewing; B, hind wing.

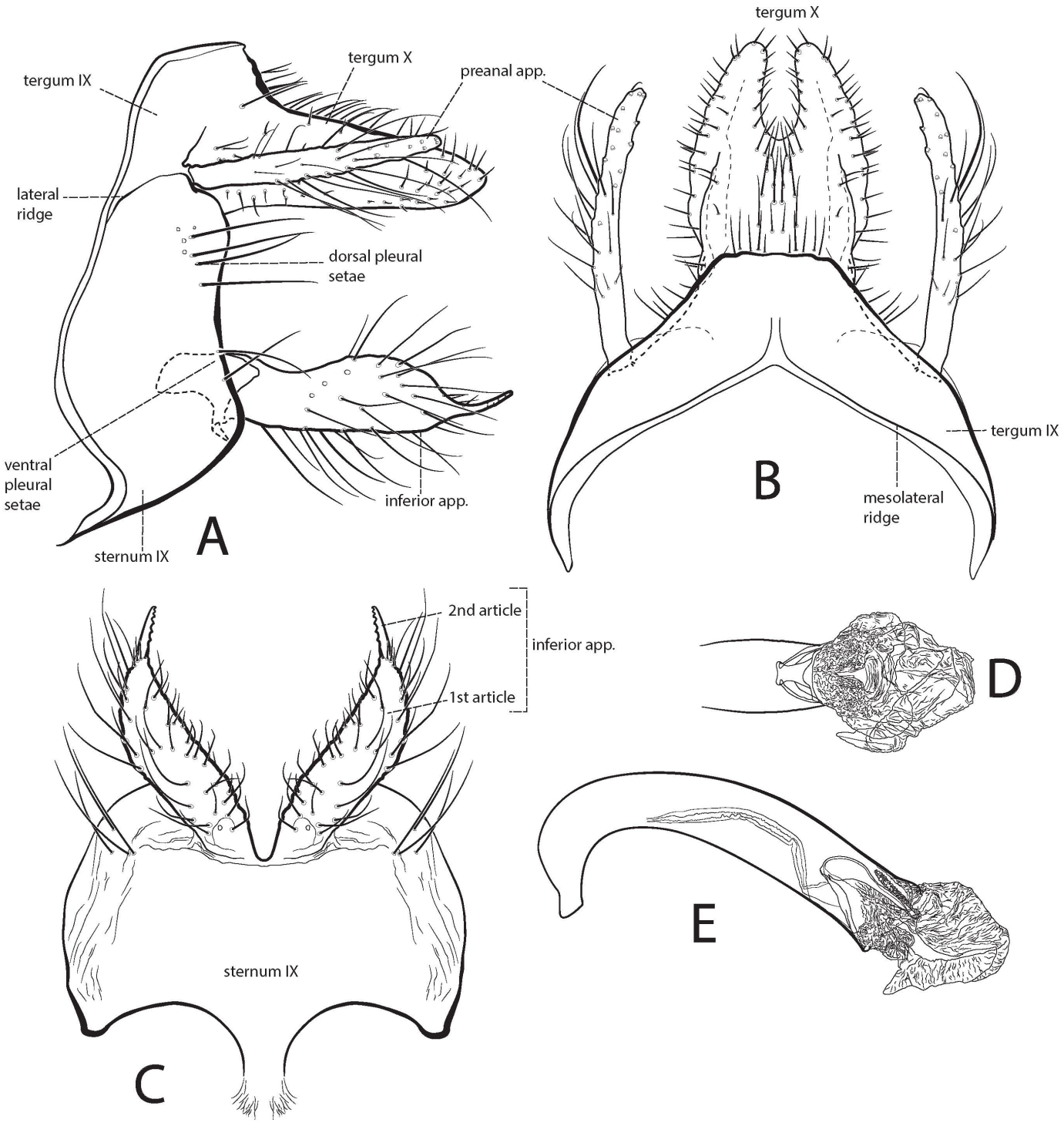

Figure 3 *Phylloicus froehlichi* new species, male genitalia. A, lateral; B, dorsal; C, segment IX and inferior appendage, ventral; D, phallic apparatus (apex), ventral; E, phallic apparatus, lateral. Abbreviation: app., appendage.

This new species resembles *P. paprockii* Prather, 2003 in the shape of tergum IX, with paired mesolateral ridges extending from the anterior notch, in dorsal view; the general shape of sternum IX and inferior appendages, in ventral view; and the shape of tergum X, notched apically. However, *P. froehlichi* **sp. nov.** differs from *P. paprockii* in the following characteristics: tergum IX with basolateral margin projected anterad (not projected in *P. paprockii*), in dorsal view; anterior margin with one and two concavities, in lateral and ventral view, respectively (absent in *P. paprockii*); tergum X without rounded setose basolateral paired projections (present in *P. paprockii*); with apex rounded (truncated in *P. paprockii*), in dorsal view; rounded (acute in *P. paprockii*), in lateral view.

Description. Length of each forewing length 10.0–10.2 mm (males, n=3). Head: Brown (in alcohol). Antennae long, about 2x length of forewings. Maxillary palps pale yellow, densely covered by dark brown setae, 5-segmented, segment III longer than others, segment IV at least 2x shorter than others. Labial palps pale yellow, densely covered by pale yellow setae, 3-segmented, segments of similar length.

Thorax: Pterothorax light brown, with dark anterior margin. Legs yellow; metatibiae and metatarsi covered by dark brown setae. Forewings dark brown; with two transverse bands; proximal band white, near posterior wing margin, at least 1/2 width of wing, distal band white, not reaching wing margin, 1/2 width of wing or less, oval; five longitudinal bands appearing from first bifurcations of veins, reaching up to about 1/3 of wing, white; with venation typical for genus: forks I–V present; discoidal cell less than half as long as thyridial cell; median cell closed; R1 fused with R2 subapically (Fig. 2A). Hind wing with basal brush; forks II, III and V present (Fig. 2B). Tibial spur formula 2,4,3. Abdomen: Coremata and modifications of abdominal terga absent. Sternum VII and VIII without modifications. Tergum IX, in dorsal view, with anterolateral margins projected anterad, paired mesolateral ridges extending from anterior notch, posterior margin trapezoidal (Fig. 3B); lateral ridge present; dorsal pleural setae approximately 8, ventral pleural setae approximately 2; sternum IX, in lateral view, with anteroventral margin projected anterad (Fig. 3A); in ventral view, two concavities on anterior margin, without ridges (Fig. 3C). Preanal appendages with approximately same length of tergum X, digitate, diametrically uniform throughout its length, bearing long setae, but not filamentous or longer than appendage (Figs. 3A, 3B). Tergum X without basal lobes; basodorsal process absent; basolateral processes absent; with dorsal surface covered by many setae on mesal and lateral regions; apex, in dorsal view, notched, notch deep and round, depth about 1/3 tergum X length (Fig. 3B); in lateral view, subrectangular shape (oblong), base slightly larger than apex, rounded apex (Fig. 3A). Inferior appendages slim, first article covered by long setae; second article much smaller than first, with serrated mesal margin (Figs. 3A, 3C). Phallobase about 2x as long as tergum X, with narrowed base, in lateral view, J-shaped, curved down; phallic endotheca, in ventral view, with cordiform apicoventral lobe; dorsal lobe long, with globous proximal region and bifurcate apex; phallotremal sclerites average size, longest dimension shorter than phallobase diameter (Fig. 3D, E).

Holotype male. BRAZIL: Bahia: Varzedo, Serra da Jibóia, Fazenda Sr. Getúlio, 12°57'45.5"S, 39°26'55"W, 24.x.2012, V Gomes, A Vilarino & R Campos cols. (MZUSP).

Paratypes. same data as holotype, except xi.2015, E Dias & R Campos cols., 1 male (UFBA); same data, except Elísio Medrado, Serra da Jibóia, Córrego do Caranguejo, 12°52'14.9"S, 39°28'32.4"W, el. 554 m, 03.xi.2016, AR Calor, I Macedo & MLS Carvalho cols., 1 male (alcohol, UFBA); same data, except Wenceslau Guimarães, Riacho do Patioba, 13°34'50"S 39°42'17"W, el. 432 m, 09.x.2010, AR Calor col., 1 male (alcohol, UFBA).

Distribution (Figs. 20A, B)**.** Brazil (BA, Atlantic Forest domain).

Remarks. The record of this new species increases to seven the number of *Phylloicus* species recorded in Bahia state (Table 1).

Table 1
Checklist of caddisflies (Trichoptera) from Bahia state, Brazil, distribution, and known semaphoronts.

Family Species	Distribution	KS
Calamoceratidae		
Phylloicus abdominalis[20]	ARG, BRA [BA, CE, MG, PR, RJ, SC, SP]	♂ ♀ P L
Phylloicus bidigitatus[20]	BRA [BA, CE, ES, MG, RJ, SP]	♂
Phylloicus froehlichi **sp. nov.**	BRA [BA]	♂
Phylloicus monneorum[20]	BRA [BA, RJ]	♂ ♀
Phylloicus obliquus[20]	BRA [BA, CE, ES, MG, RJ, SC]	♂ ♀ P L C
Phylloicus paprockii[30]	BRA [BA, MG, RJ]	♂ ♀
Phylloicus tricalcaratus[27]	BRA [BA]	♂
Ecnomidae		
Austrotinodes belchioris[30]	BRA [BA, MG]	♂ ♀
Austrotinodes taquaralis[30]	BRA [BA, ES, MG, RJ]	♂
Austrotinodes zeferina **sp. nov.**	BRA [BA]	♂
Helicopyschidae		
Helicopsyche catoles[25]	BRA [BA, RJ]	♂
Helicopsyche diamantina[14]	BRA [BA]	♂
Helicopsyche dinoprata[14]	BRA [BA, RJ]	♂
Helicopsyche guara[14]	BRA [BA, MG, RJ, SC]	♂
Helicopsyche guariru[30]	BRA [BA, MG]	♂ ♀
Helicopsyche helicoidella[28]	BRA [BA]	C
Helicopsyche mateusi[14]	BRA [BA]	♂
Helicopsyche miltonsantosi[14]	BRA [BA]	♂
Helicopsyche monda[14]	ARG, BRA [BA, CE, MG, PI, PR, RJ, SC, SP], PRY, VEN,	♂
Helicopsyche paulofreirei[14]	BRA [BA]	♂
Helicopsyche petri[14]	BRA [BA, RJ]	♂
Helicopsyche succinta[25]	VEN, BRA [BA]	♂
Helicopsyche vergelana[14]	BRA [BA, CE, MA, PE, PI, RO], BLZ, COL, CRC, ECU, GRD, GTM, GUY, HND, MEX, NIC, PAN, PRY, PER, SUR, TOB, TRI, VEN	♂

Abbreviations: KS: Known Semaphoronts (C: Case; L: Larvae; P: Pupae; ♂: Males; ♀: Females)*; Countries: ARG: Argentina; BAH: Bahamas; BOL: Bolivia; BLZ: Belize; BRA: Brazil; CAN: Canada; COL: Colombia; CRC: Costa Rica; CUB: Cuba; CUR: Curaçao; DMA: Dominica; DOM: Dominican Republic; ECU: Ecuador; GLP: Guadeloupe; GUF: French Guiana; GRD: Grenada; GTM: Guatemala; GUY: Guyana; HND: Honduras; HTI: Haiti; JAM: Jamaica; LCA: Saint Lucia; MEX: Mexico; MTQ: Martinica; NIC: Nicaragua; PAN: Panama; PRI: Puerto Rico; PRY: Paraguay; PER: Peru; SLV: El Salvador; SUR: Surinam; TOB: Tobago; TRI: Trinidad; URY: Uruguay; USA: United States of America; VCT: Saint Vincent and the Grenadines; VEN: Venezuela. Brazilian states: AC: Acre; AL: Alagoas; AP: Amapá; AM: Amazonas; BA: Bahia; CE: Ceará; DF: Distrito Federal; ES: Espírito Santo; GO: Goiás; MA: Maranhão; MT: Mato Grosso; MS: Mato Grosso do Sul; MG: Minas Gerais; PA: Pará; PB: Paraíba; PR: Paraná; PE: Pernambuco; PI: Piauí; RJ: Rio de Janeiro; RN: Rio Grande do Norte; RS: Rio Grande do Sul; RO: Rondônia; RR: Roraima; SC: Santa Catarina; SP: São Paulo; SE: Sergipe; TO: Tocantins. Holzenthal and Calor (2017); Santos et al. (2023); plus sources to the first records to Bahia state: [1]Costa and Calor (2014). [2]Costa et al. (2014). [3]Desidério et al. (2020). [4]Desidério et al. (2021). [5]Dias and Calor (2016). [6]Dias et al. (2015). [7]Dumas et al. (2013). [8]Flint et al. (1987). [9]França et al. (2013). [10]Gomes and Calor (2016). [11]Harris et al. (2002). [12]Holzenthal and Pes (2004). [13]Oláh and Flint (2012). [14]Pereira and Calor (2023). [15]Silva-Pereira et al. (2022). [16]Pictet (1836). [17]Queiroz et al. (2023) [18]Quinteiro and Calor (2015). [19]Quinteiro and Holzenthal (2017). [20]Quinteiro et al. (2014). [21]Santos (2020). [22]Souza and Santos (2017). [23]Souza et al. (2014b). [24]Souza et al. (2016). [25]Souza et al. (2017). [26]Thomson (2019). [27]Ulmer (1905). [28]Vallot (1855). [29]Vilarino and Calor (2015b). [30]Vilarino and Calor (2017). [31]Vilarino et al. (2019). [32]Vilarino and Bispo (2020). *recorded here.*

Table 1. Continued...

Family Species	Distribution	KS
Hydrobiosidae		
Atopsyche diamantina[10]	BRA [BA, MG]	♂
Atopsyche kamakan[10]	BRA [BA]	♂
Atopsyche rinconi[10]	BRA [BA, MG], VEN	♂
Hydropsychidae		
Blepharopus diaphanus[2]	ARG, BRA [AC, AM, BA, ES, MA, MG, MT, PA, PE, PI, PR, RJ, RR, SC, SP], VEN	♂ P L
Centromacronema pioneira[5]	BRA [BA]	♂ ♀
Leptonema aspersum[2]	BRA [AM, BA, MS, MT, PA, SP]	♂ ♀
Leptonema columbianum[8]	ARG, BRA [AM, BA, DF, GO, MA, MG, MS, PA, RO, SP], GUF	♂ ♀
Leptonema pallidum[2]	ARG, BRA [BA, CE, DF, ES, GO, MA, MG, RJ, SP], URY	♂
Leptonema rostratum[2]	ARG, BRA [AM, BA, MT, PA, RR], ECU, GUY, PAN, PRY, PER, SUR, VEN	♂
Leptonema sparsum[2]	ARG, BOL, BRA [AM, BA, DF, GO, MA, MG, MT, PA, PR, RJ, RN, RR, SC, SP], COL, ECU, GUY, PRY, PER, SUR, VEN	♂
Leptonema viridianum[2]	GUF, BRA [BA, CE, DF, ES, GO, MA, MG, MT, PA, PB, PE, PI, RJ, SE], GUY, SUR	♂ ♀
Macronema fragile[30]	ARG, BOL, BRA [AM, BA, RR], COL, ECU, PRY, PER, SUR, VEN	♂
Macronema hageni[25]	ARG, BOL, BRA [BA, AM, MA, MG, MT, PA, RR], COL, ECU, PRY, PER, SUR, VEN	♂
Macronema lineatum[16]	BRA [BA]	♂
Macronema partitum[25]	BRA [BA, MG, PA, RJ, SC]	♀
Macrostemum brasiliense[30]	BRA [BA, ES, MG, RJ, SP]	♂ ♀ L P
Macrostemum bravoi[9]	BRA [BA, MA, MT, PI]	♂
Macrostemum erichsoni[9]	BRA [AC, AM, BA, PA, RJ, RR], GUF, GUY, SUR	♂ ♀
Macrostemum hyalinum[9]	BRA [AC, BA, CE, ES, MA, MT, PA, PB, PE, PR, RJ, RN, SP], COL, GUY, PER, VEN	♂
Macrostemum nigrum[9]	BRA [BA]	♂
Macrostemum santaeritae[9]	ARG, BRA [AC, AM, BA, MT, PA]	♂ ♀
Smicridea aequalis[4]	BRA [AM, AP, BA, CE, DF, MA, MT, PA, PI, RR, TO], GUY, SUR	♂ ♀ L P C
Smicridea albosignata[30]	BRA [AL, BA, DF, MG, PE, PR, RJ, SE, SP, TO]	♂
Smicridea bivittata[4]	BRA [AL, AM, BA, CE, DF, ES, MG, PA, PB, PE, PI, RR, SP, TO], BOL, CRC, ECU, SLV, GTM, HND, MEX, NIC, PAN, PER, SUR, TOB, TRI, VEN	♂ ♀ L P
Smicridea caatinga[3]	BRA [BA, CE, DF, MA, PA, PI, RJ, TO]	♂
Smicridea capao[31]	BRA [BA, MG]	♂ ♀
Smicridea coronata[30]	ARG, BRA [BA, CE, ES, MG, MT, PI, RS, SP], PRY, URY	♂ ♀
Smicridea franciscana[3]	BOL, BRA [BA, CE, DF, ES, MG, MS, MT, PE, PI, PR, RJ, SP]	♂
Smicridea helenae[25]	ARG, BRA [AM, BA, MA, MT, RR]	♂ L P
Smicridea iguazu[25]	BRA [BA, ES, MG, PR, RJ, SC]	♂
Smicridea jundiai[20]	BRA [BA, ES, MG, MT, PR, RJ, SP], CRC, SLV, GTM, HND, MEX, PAN	♂
Smicridea kamakan[17]	BRA [BA]	♂
Smicridea palifera[30]	BRA [AL, BA, ES, MA, MG, MT, PB, PE, PI, RJ, RN, RR], GRD, VEN	♂ ♀ L P
Smicridea radula[25]	BRA [BA, ES, MG, PR, RJ, SP], CRC, ECU, SLV, GTM, HND, MEX, NIC, PAN	♂ ♀
Smicridea roraimense[31]	BRA [BA, ES, MA, PE, RR]	♂
Smicridea sattleri[3]	BRA [BA, ES, MG, SP]	♂
Smicridea scalprum[31]	BRA [BA]	♂
Smicridea serrati[3]	BRA [BA]	♂
Synoestropsis grisoli[2]	BRA [AM, AP, BA, MG, MS, MT, PA, RR, RS], GUY, PER, SUR, VEN	♂ ♀

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Table 1. Continued...

Family Species	Distribution	KS
Hydroptilidae		
Acostatrichia brevipenis[21]	BRA [BA, RR], GUF, SUR	♂
Anchitrichia duplifurcata *	BRA [BA, MG, RJ], PRY	♂ L P C
Ascotrichia adirecta[26]	BRA [BA, MG]	♂
Betrichia nhundiaquara[24]	BRA [BA, MG, PI, PR]	♂
Betrichia zilbra[24]	ARG, BRA [BA, SE, SC], GUY, URY	♂
Flintiella astilla[11]	BRA [BA, MT, PR, SP], CRC, ECU, PRY, PER, VEN	♂ ♀
Flintiella pizotensis *	BRA [AM, BA], COL, CRC, ECU, MEX, NIC, PAN, PER	♂ ♀
Hydroptila zerbinae[23]	BRA [AL, BA, CE, PE]	♂
Neotrichia falcifera *	BRA [BA], ARG, SUR	♂
Ochrotrichia constricta[23]	BRA [BA]	♂
Ochrotrichia igrapiuna[23]	BRA [BA, MA]	♂
Ochrotrichia manuensis[23]	BRA [BA], PER	♂ ♀
Ochrotrichia patulosa *	BRA [BA, CE, RJ]	♂ ♀
Ochrotrichia priapo[23]	BRA [BA]	♂
Oxyethira calori[22]	BRA [BA]	♂
Oxyethira circaverna[25]	ARG, BRA [AM, BA, CE, MA, PB, PI], CUR, ECU, PAN, URY	♂ L C
Oxyethira gracilianoi[22]	BRA [AL, BA, RJ]	♂ ♀
Oxyethira iannuzzae[22]	BRA [AL, BA]	♂
Oxyethira merga[25]	VEN, BRA [BA, PI, RR]	♂
Oxyethira rafaeli[22]	BRA [BA, PI]	♂
Oxyethira singularis[22]	BRA [BA]	♂
Oxyethira tica[25]	BRA [AL, AM, BA, CE, MA, MG, PB, PE, PI, RJ, SE], CRC, DMA, ECU, GUF, GRD, GLP, HND, MTQ, MEX, NIC, PAN, LCA, VCT, TRI, VEN	♂
Oxyethira una[25]	BRA [BA]	♂
Peltopsyche vegosa[13]	BRA [BA, SP], PRY	♂
Rhyacopsyche dikrosa *	BRA [BA, MG, RJ, SP]	♂ ♀
Leptoceridae		
Achoropsyche duodecimpunctata[20]	ARG, BOL, BRA [AM, BA, ES, MA, MG, MT, PA, PR, RJ, RO, RR, SC, SP], COL, ECU, GUY, PRY, PER, SUR, URY, VEN	♂ ♀
Amazonatolica hamadae[12]	BRA [AM, BA, MT, RO]	♂ ♀ L P
Atanatolica bonita[1]	BRA [BA]	♂ ♀
Grumichella rostrata[6]	BRA [BA, ES, MG, RJ, SC, SP]	♂ ♀ L P C
Nectopsyche fuscomaculata[6]	ARG, BRA [BA, PR, RJ, SC], PRY	♂ ♀
Nectopsyche splendida[20]	ARG, BOL, BRA [BA, ES, MA, MG, PI, PR, RO], COL, ECU, GUY, PRY, PER, VEN	♀
Neoathripsodes holzenthali[6]	BRA [BA]	♂ ♀
Notalina brasiliana[15]	BRA [BA, DF, MG]	♂ ♀
Notalina cipo[6]	BRA [BA, MG]	♂
Notalina claudiofroehlichi **sp. nov.**	BRA [BA]	♂
Oecetis acanthostema[18]	BRA [BA]	♂
Oecetis amazonica[18]	ARG, BOL, BRA [AM, BA, MS, MT, SP], PER, VEN	♂
Oecetis carinata[19]	BRA [BA, SP]	♂
Oecetis cassicoleata[19]	BRA [BA]	♂
Oecetis clavicornia[18]		♂
Oecetis connata[18]	BRA [AC, AM, BA, MT, PA, PI, RJ, SP], GUF, GUY, SUR, VEN	♂
Oecetis excisa[18]	ARG, BOL, BRA [BA, CE, DF, GO, MA, MG, MS, MT, PA, PE, PB, RN, SP], ECU, MEX, PRY, VEN	♂ ♀
Oecetis froehlichi[18]	BRA [BA]	♂
Oecetis furcata[18]	BRA [BA]	♂
Oecetis iguazu[18]	ARG, BRA [BA, ES, MG, PR, RJ, SC, SP], PRY	♂
Oecetis inconspicua[18]	BAH, BOL, BRA [AM, BA, MG, MT, PB, PE, PI, PR, RJ, SC, SP], CAN, COL, CRC, CUB, DOM, SLV, GTM, HTI, HND, JAM, MEX, NIC, PAN, PER, PRI, USA, VEN	♂ ♀ L P
Oecetis marcus **sp. nov.**	BRA [BA, PE]	♂
Oecetis martinae[18]	BRA [BA, MG, RJ]	♂
Oecetis paranensis[18]	ARG, BOL, BRA [AM, BA, PE, MS, MG, SP], PRY, PER	♂
Oecetis punctipennis[18]	ARG, BOL, BRA [BA, CE, MA, MG, PA, PE, RJ, RR, SP], CRC, ECU, GUF, GUY, NIC, PAN, PER, SUR, URY, VEN	♂ ♀
Triplectides gracilis[20]	ARG, BRA [BA, ES, MG, PE, PR, RJ, SC, SP], PRY, SUR	♂ ♀ L P

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Table 1. Continued...

Family Species	Distribution	KS
Odontoceridae		
Barypenthus concolor[20]	BRA [BA, ES, MG, PR, RJ, SP]	♂ L
*Marilia fasiculata**	NIC, BRA [AM, BA, PE, RO, RR]	♂ L P C
Marilia flexuosa[25]	ARG, BRA [BA,CE, SC], CAN, COL, CRC, GTM, MEX, NIC, PAN, PER, USA	♂ ♀ L
Philopotamidae		
Alterosa amadoi[7]	BRA [BA]	♂
Alterosa castroalvesi[7]	BRA [BA]	♂
Alterosa caymmii[7]	BRA [BA]	♂
Chimarra anticheira[29]	BRA [BA]	♂ ♀
Chimarra conica[30]	ARG, BRA [BA, CE, ES, GO, MT, MG, RJ, RO, SC]	♂
Chimarra hyoeides[25]	ARG, BRA [BA, ES, MG, RJ, SP], PRY, URY	♂
Chimarra kontilos[29]	BRA [BA, ES, MG, RJ, SP]	♂ ♀
Chimarra mesodonta[29]	BRA [BA]	♂ ♀
Chimarra morio[29]	BRA [BA, PR, RJ, SC, SP]	♂ ♀
Chimarra odonta[29]	BRA [BA, ES, MG, RJ, SP]	♂ ♀
Polycentropodidae		
Cernotina kariri **sp. nov.**	BRA [BA]	♂
Cernotina longispina[30]	BRA [BA, ES]	♂
Cyrnellus fraternus[30]	ARG, BRA [AM, BA, ES, MA, MG, MS, MT, PA, PE, PI, PR, RJ, RN, SC], CRC, ECU, SLV, GUF, MEX, NIC, PAN, PRY, SUR, URY, USA, VEN	♂ ♀ L
*Polycentropus biappendiculatus**	BRA [BA], SUR, VEN	♂
Polycentropus brevicornutus[29]	BRA [BA]	♂
Polycentropus claudioi **sp. nov.**	BRA [BA]	♂
Polyplectropus anchorus[29]	BRA [BA]	♂
Polyplectropus auriplicatus[29]	BRA [BA]	♂
Polyplectropus tragularius[30]	BRA [BA, ES, MG, SP], MEX, NIC	♂
Xiphocentronidae		
Xiphocentron kamakan[29]	BRA [AL, BA, MG]	♂ ♀
Xiphocentron maeteae[29]	BRA [BA]	♂
Xiphocentron maracanan[32]	BRA [BA, ES, MG, RJ]	♂

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Etymology. The specific name "*froehlichi*" is in honor of Prof. Dr. Claudio Gilberto Froehlich in recognition of his great contribution to the knowledge of the systematics and ecology of Neotropical aquatic insects.

Ecnomidae Ulmer

Austrotinodes Schmid, 1955

***Austrotinodes zeferina* Pereira, Queiroz & Calor, sp. nov.**

urn:lsid:zoobank.org:act:3975F8CD-9B47-4033-939F-711CD75B3699
(Figs. 4A, B, 5A-F)

Diagnosis. The new species is distinguished from all congeners by the two following male characteristics: inferior appendage with apical long and shallow concavity forming two acuminated apical projections, in ventral view, and the phallic guide and inferior appendage with apex truncated forming a chela, in lateral view.

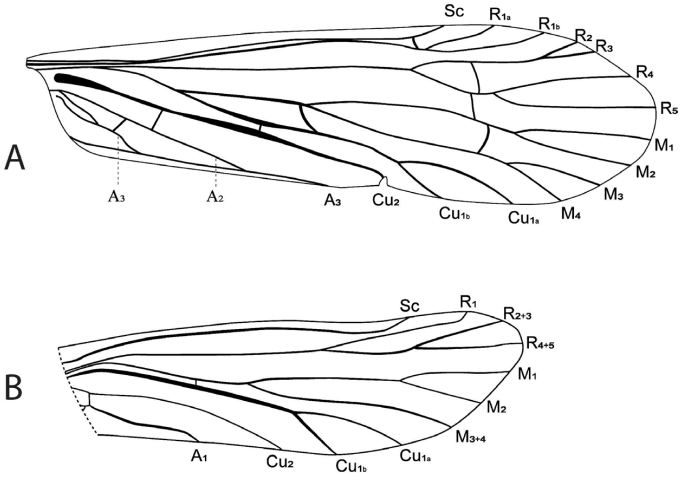

Figure 4 *Austrotinodes zeferina* new species, wings. A, forewing; B, hind wing.

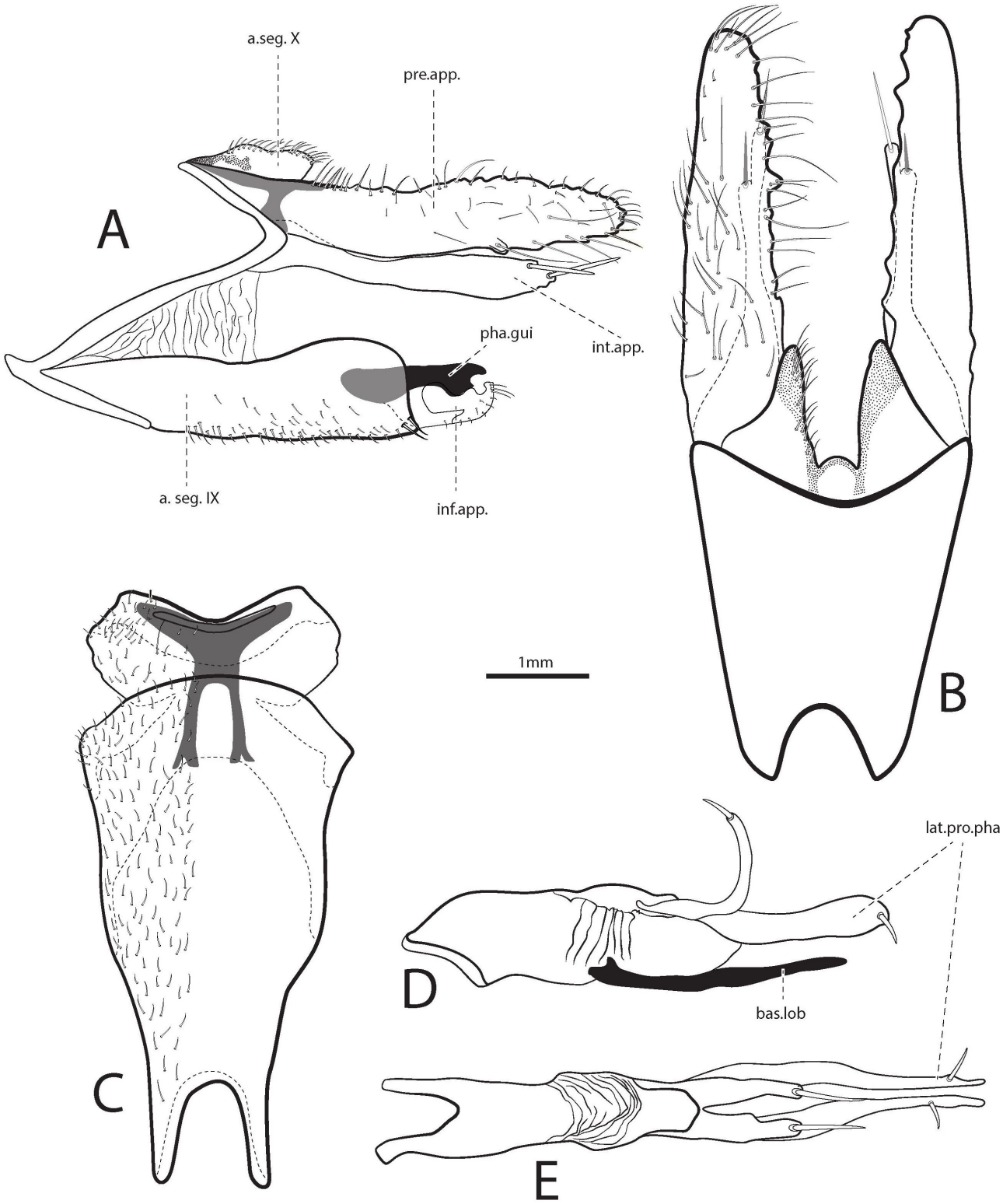

Figure 5 *Austrotinodes zeferina* new species, male genitalia. A, lateral; B, dorsal; C, segment IX and inferior appendage, ventral; D, phallic apparatus, lateral; E, phallic apparatus, dorsal. Abbreviations: a.seg.IX = abdominal segment IX; a.seg.X = abdominal segment X; pre.app = preanal appendage; int.app = intermediate appendage; pha.gui = phallic guide; inf.app = inferior appendage; bas. lob = basomesal lobe.

The new species presents characteristics of the abdominal segment X and the shape of phallic guide and inferior appendage, in lateral view, that resembles *Austrotinodes fortunata* Flint and Denning, 1989; but it can be differentiated by inferior appendage with apical concavity forming two subtriangular lobes in ventral view (*A. fortunata* abdominal segment X with convex apex and two lateral subquadrangular lobes in ventral view), by phallic guide and inferior appendage with the truncated apex in lateral view (*A. fortunata* presents phallic guide and inferior appendage with pointed distal region), and by phallic guide X-shaped, in ventral view (*A. fortunata* phallic guide inverted Y-shaped).

Description. Adult male. Forewing length 3.49–4.29 mm (n=3). Forewing with R1 forked apically, forks II–V present (Fig. 4A). Hind wing with forks II, III, and V, without discoidal cell (Fig. 4B). Body light brown, dorsum of head brown with pale yellow and light brown setae, postocular warts light brown with light brown setae; thorax light brown; leg segments with brown setae. Forewings covered with fine light brown and pale-yellow setae. Male genitalia. Abdominal segment IX long with subtriangular anterior margin, and posterior margin filiform with truncate apex, in lateral view (Fig. 5A); Anterior margin with deep concavity, ca. 1/5 of the segment length, posterior region with shallow and wide concavity ca. 1/6 of segment length, in dorsal view (Fig. 5C). Abdominal segment X subtriangular with wide base, and narrower and rounded apex, dorsal margin sinuous, in lateral view (Fig. 5A); subtriangular with wide base, and apex narrower and rounded, in dorsal view (Fig. 5C). Preanal appendage covered by setae, longer, filiform with dorsal and ventral margin sinuous, with narrower and rounded apex, in lateral view (Fig. 5A); filiform with setose margin, inner face region sinuous and apex rounded, in dorsal view (Fig. 5C). Intermediate appendage filiform narrowing at mid-region, apex wide containing two setose projections, in lateral view (Fig. 5A); basal region subtriangular, mid-region filiform and apex with two setose projections, in dorsal view (Fig. 5C). Phallic guide filiform with oval-shaped base, narrowing at mid-region, and apex with C-shaped, in lateral view (Fig. 5A); circa 1.5x length of inferior appendage, X-shaped, anterior margin with two bifid projections, with deep and wide concavity corresponding to 1/2 length, posterior margin with two lobes and shallow, wide concavity, in ventral view (Fig. 5B). Inferior appendage with dorsal margin sinuous and C-shaped apex, ventral margin rounded and without sinuosities, in lateral view (Fig. 5A); ellipsoid, with posterior long and shallow concavity forming two subtriangular lobes with concave median apodeme, in ventral view (Fig. 5B). Phallus with filiform phallobase, two dorsal projections upcurved and setose, two lateral projections as compressed as half of phallobase, filiform and rounded apex, basal lobe sclerotized, filiform, with subequal length of phallobase.

Holotype male. BRAZIL: Bahia: Salvador, Parque Municipal São Bartolomeu, Riacho do campo, 12°53'33.7"S, 38°27'46.5"W, 22-23.x.2019, UV Light Pan trap, R Pereira & M Miranda cols. (MZUSP).

Paratypes. Same as holotype, except 2 males (UFBA).

Distribution (Figs. 20A, B). Brazil (BA, Atlantic Forest domain).

Remarks. *Austrotinodes zeferina* **sp. nov.** is described based on specimens exclusively collected in the São Bartolomeu Park, a fragment of Atlantic Forest with 75 ha in a metropolitan area of Salvador city. The park constitutes a historical and cultural representation of African matrix religions nowadays, and a historical symbol of resistance against slavery in period colonial (Quilombo do Urubu). The park houses a great biodiversity, sheltering four waterfalls, mangroves and the Rio do Cobre dam. The park comprises a vulnerable area given the environmental and social degradation, in the form of pollution, irregular occupation, and poor public infrastructure (CONDER, 2013). Thus, efforts are needed to better investigate the region, in addition to actions that allow the protection of the area and conservation of the species.

Etymology. This species is named in honor of Zeferina, an Angolan woman who led "Quilombo do Urubu" around 1826, a symbol of African resistance against slavery. The noun in apposition.

Hydrobiosidae Ulmer

Atopsyche Banks, 1905

***Atopsyche froehlichi* Gomes & Calor, sp. nov.**

urn:lsid:zoobank.org:act:23B843CB-EBB7-4BEC-8F47-5AEEC18704C9
(Figs. 6A, B, 7A-E, 8A-F)

Diagnosis. This new species belongs to *A.* (*Atopsaura*) *longipennis* group as by apicomesal projection of the first article of the inferior appendage. *Atopsyche* (*Atopsaura*) *froehlichi* **sp. nov.** is similar to *A.* (*Atopsaura*) *plancki* Marlier, 1964 & *A.* (*Atopsaura*) *galharada* Santos & Holzenthal, 2012 in filipod absence, in the slender and rounded apex of parapod, in the broad first article of inferior appendage with apicodorsal projection, and in simple phallic apparatus (without projections or processes attached). *Atopsyche* (*Atopsaura*) *froehlichi* **sp. nov.** is similar to *A.* (*Atopsaura*) *plancki* on coiled aedeagus of phallic apparatus, but the new species can be distinguished from it by a slender first article of inferior appendage, by the absence of apicoventral projection, and by apicoventral projection of beaks of phallic apparatus.

Description. Length of each forewing 0.9–1.02 mm (n=3) (Fig. 6). Overall body color yellowish to light brown. Frons and vertex of head with yellow and light brown setae. Antennal scapes with some short light brown setae; pedicels yellowish, basal flagellomeres yellowish with light brown shadows, apical flagellomeres brown. Maxillary palps segments 1 and 2 with long brown setae. Dorsum of thorax without setae. Overall color of wing yellowish; setae of veins light brown setae. Forewing venation complete (Fig. 6A); R1 branched apically, covered with brown setae on pterostigma; stem of fork I equal to its length; fork II long, pediculate; stem of fork III shorter than its length; fork IV long, pedunculate; fork V long; discoidal cell long; stem of M almost straight between m-cu crossvein and first fork of M; Cu converging near fused anal veins, with crossvein at the apical region. Hind wing with Sc and R1 fused apically; forks I, III and V present, the first with stem shorter than its length, stem of fork III shorter than its length, stem of fork III very short; Cu2 long and almost straight; 1A absent; 2A long and curved (Fig. 6B). Rounded midlateral gland on sternum V (Fig. 8F). Sterna VI and VII each with posteromesal projections, lateral view (Fig. 8E); anterior projection covered by spine-like setae and about 2x longer than posterior; posterior projection covered by spine-like setae, broad, lateral view (Fig. 8E). Male genitalia. Segment IX slender, curved at anterodorsal and posterodorsal margins, lateral view (Figs. 7A, 8A). Proctiger slender, constricted at anterior region, lateral view (Fig. 7A). Parapod in anterior half and slender in posterior half, with two dorsal projections at the middle, truncate at apex, lateral and ventral views (Figs. 7A, 7D, 8D). Filipod absent. Preanal appendage uniformly rounded, lateral view (Fig. 7A), with irregular margin, ventral view (Fig. 7D). Inferior appendage, first article wide, slightly broader at apex, apicomesal projection wide at base and acute at apex, with apicodorsal projection, lateral view (Figs. 7A, 7C, 8B); second article wide at base and slightly thinner at apex, lateral and ventral views (Figs. 7A, 7B, 8C).

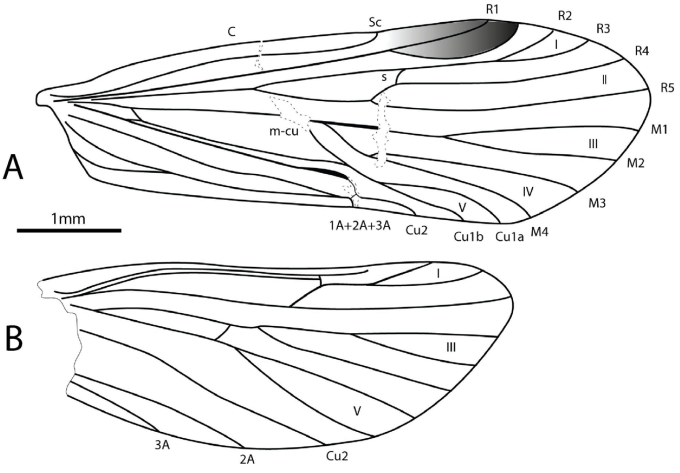

Figure 6 *Atopsyche froehlichi* new species, wings. A, forewing; B, hind wing.

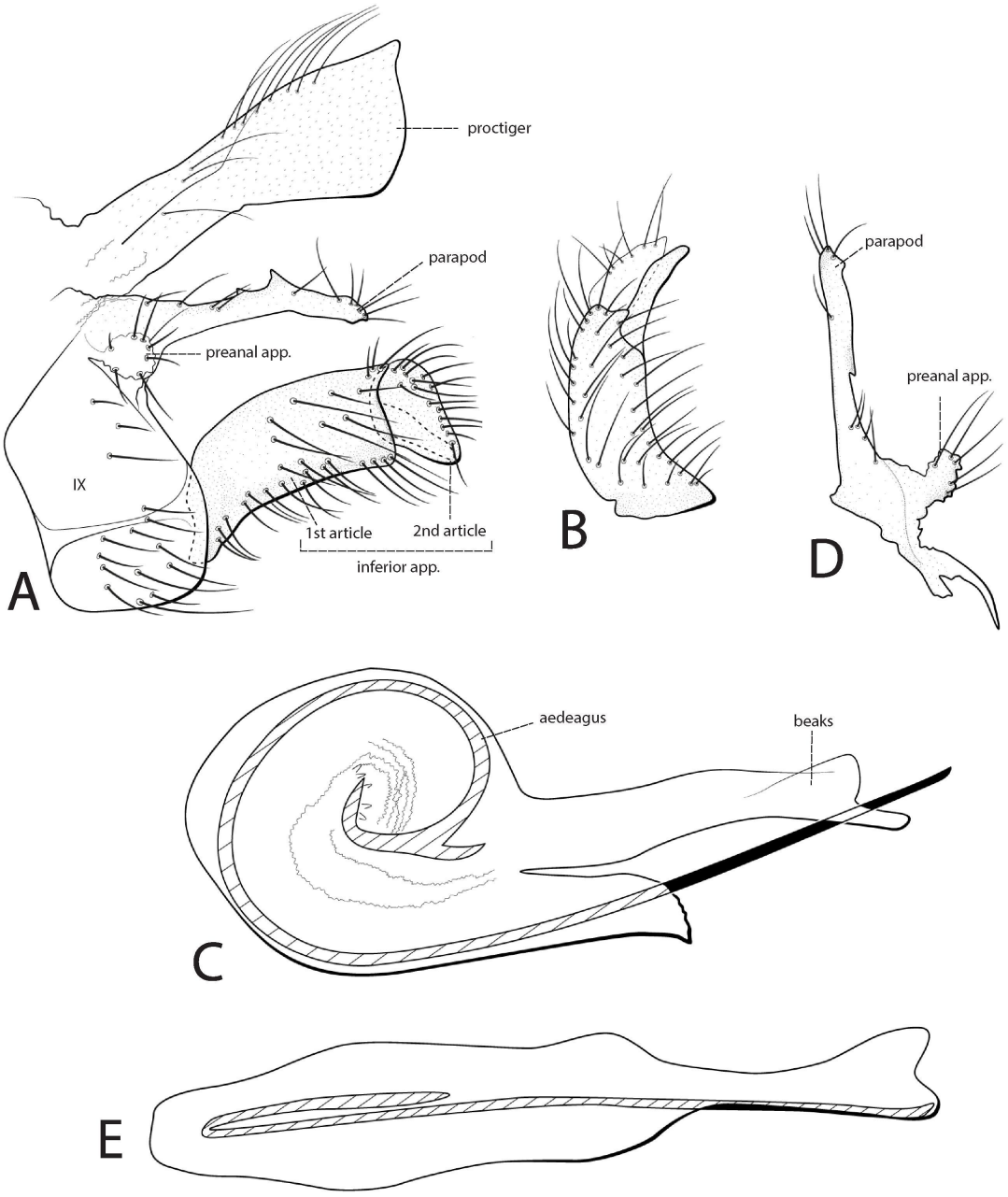

Figure 7 *Atopsyche froehlichi* new species, male genitalia. A, lateral; B, inferior appendage, dorsal; C, phallic apparatus, lateral; D, parapod and preanal appendage, dorsal; E, phallic apparatus, dorsal. Abbreviation: app., appendage.

Phallic apparatus simple, phalloteca wide, beaks with apicoventral projection, lateral view (Figs. 7C, 7E); aedeagus coiled basally, upcurved posteriorly, with upcurved apex, lateral view; coiled basally and straight in posterior half, dorsal view (Figs. 7C, 7E).

Holotype male. BRAZIL: Rio Grande do Sul: Cambará do Sul, Parque Nacional Aparados da Serra, P3 (sede), 13.i.2013, Light Pan Trap, M Carneiro col. (MZUSP).

Paratypes. Same data as holotype, except 2 males (UFBA).

Distribution (Fig. 20A)**.** Brazil (RS, Atlantic Forest domain).

Remarks. This new species is placed in *A.* (*Atopsaura*) *longipennis* Group by the apicomesal projection of the first article of the inferior appendage. *Atopsyche*(*Atopsaura*) *froehlichi* **sp. nov.** is similar to *Atopsyche* (*Atopsaura*) *plancki* in the wide first article of the inferior appendage, but differs in thickness, in the absence of the apicoventral projection, and in the apicodorsal projection of the first article of the inferior appendage.

Etymology. This new species is named in honor of Prof. Dr. Cláudio Froehlich for his distinguished contribution to our knowledge on the Neotropical aquatic insects, and the guidance of the next generation of aquatic entomologists.

Leptoceridae Leach

Neoathripsodes Holzenthal, 1989

Neoathripsodes froehlichi **Dias & Calor, sp. nov.**

urn:lsid:zoobank.org:act:D5E8ACED-3DBB-4322-BC8A-08B678F0D60F

(Figs. 9A, B, 10A-D)

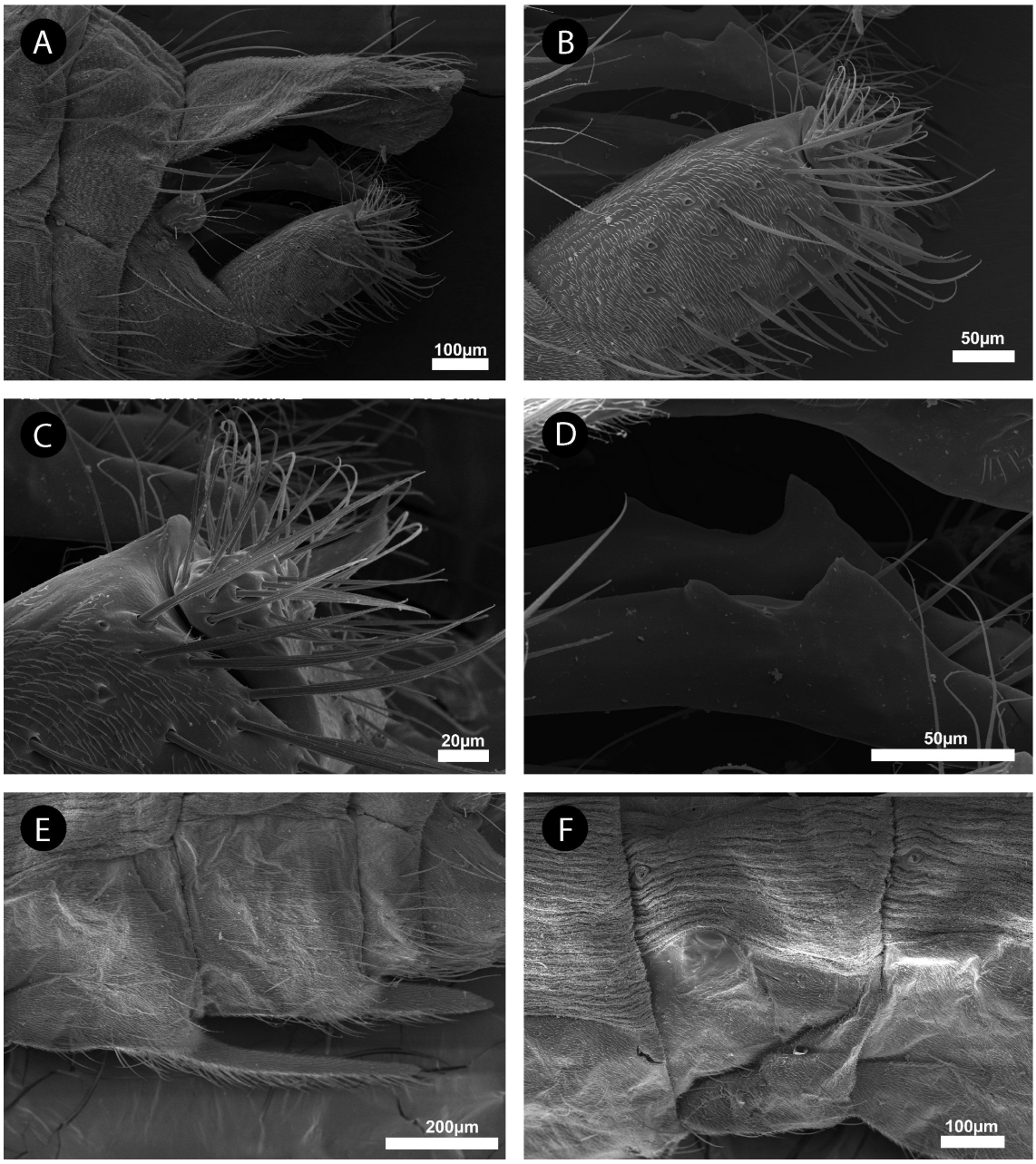

Figure 8 *Atopsyche froehlichi* new species, male genitalia MEV, lateral view. A, genitalia left lateral; B, inferior appendage; C, detail of inferior appendage apex; D, detail of parapod; E, sterna VI and VII posteromesal projections; F, sternum V midlateral gland.

Diagnosis. This new species differs from its congeners by the following characteristics: preanal appendage ventral process short, ending before the base in ventral view; distal margin of segment IX with three acute processes, one medial and two laterally; segment X thin in lateral view, and inferior appendage basoventral lobe ½ shorter than subapicodorsal lobe. *Neoathripsodes froehlichi* **sp. nov.** differs from *N. anomalus* Holzenthal, 1989 by the presence of the following characteristics: three large, acute processes on the posterior margin of segment IX in dorsal view (narrow in *N. anomalus*), and segment X thinner in lateral view, and larger in dorsal view. than *N. anomalus*. In addition, *Neoathripsodes froehlichi* **sp. nov.** distinguished from *N. holzenthali* Dias, Quinteiro & Calor, 2015 by the preanal appendage bearing a broad dorsal process, and a short ventral process in lateral view (narrowest and longest in *N. holzenthali*); presence of bifid parameres (single in *N. holzenthali*), and phallotremal sclerite broader than *N. holzenthali* in lateral view.

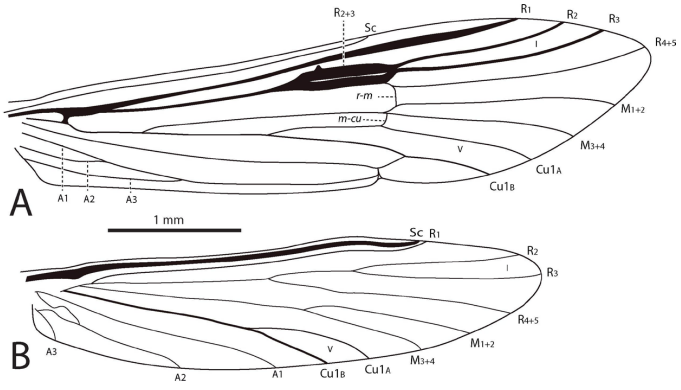

Figure 9 *Neoathripsodes froehlichi* new species, wings. A, forewing; B, hind wing.

Description. Adult male. Forewing length 5.5–6.0 mm (n=6). Hind wing length 5.0–5.5 mm (n=6). Head midcranial sulcus absent. Thorax brown, forewing vein R_1 becomes thickened, especially after discoidal cell; veins R_{2+3} and R_{4+5} very thickened; vein Cu1b little thickened; crossveins *r-m* and *m-cu* present (Fig. 9A). Hind wing vein Sc thickened; crossvein *r-m* absent (Fig. 9B). Abdomen, segment IX pointed mesoapically, with process pointed lateroapically in both sides in posterior margin in dorsal view (Fig. 10B); broad in posteroventral region, narrow in dorsal region; distal margin sinuous in lateral view (Fig. 10A). Segment X bifid at apex; enlarged at basal and middle region, narrow at apex in dorsal view (Fig. 10B); thin, apex rounded in lateral view (Fig. 10A). Preanal appendage triangular in dorsal view (Fig. 10B); oval in lateral view (Fig. 10A). Inferior appendage subapicodorsal lobe with apex robust; basoventral lobe 1/2 shorter than subapicodorsal lobe; inferior margin with process pointed in basal region in lateral in view (Fig. 10A); subapicodorsal lobe digitated; basoventral lobe short ending before base; harpago posterior margin setose in ventral view (Fig. 10D). Phallic apparatus phallobase well developed; phallicata membranous dorsally; phallotremal sclerite broad, triangular, ventral margin sinuous; parameres bifid, apical spines in each lobe in lateral view (Fig. 10C).

Holotype male. BRAZIL: São Paulo, Pico do Marins, Serra da Mantiqueira, trilha, 22°30'09"S, 45°07'16"W, el. 2421 m, entomological net, 19.i.2006, AR Calor, LC Pinho, & FO Roque cols. (MZUSP).

Paratypes. Same data as holotype, except 1 male (MZUSP), 2 males (UMSP), 2 males (UFBA).

Distribution (Fig. 20A). Brazil (SP, Atlantic Forest domain).

Remarks. *Neoathripsodes froehlichi* **sp. nov.** is described based on three specimens exclusively collected in the Pico do Maris, between Minas Gerais and São Paulo states, southeastern Brazil. Pico do Maris is a fragment of Atlantic Forest and it is in the Mantiqueira mountain range. Its summit is 2.421 meters above sea level, making it the 26th-highest peak in Brazil. Formed by a large rocky massif with steep walls.

Neoathripsodes froehlichi **sp. nov.** is the third species of the genus described and the species with the highest recorded altitude (2.421 m a.s.l.), *N. anomalus* and *N. holzenthali* are recorded in 1.180 m and 833 m a.s.l., respectively. All *Neoathrispodes* species are exclusively recorded in the Atlantic Forest domain.

Etymology. This new species is named in honor Prof. Dr. Claudio Gilberto Froehlich for his great contributions to studies of Neotropical aquatic insects.

Notalina Mosely, 1936

Notalina (*Neonotalina*) Holzenthal, 1986

***Notalina* (*Neonotalina*) *claudiofroehlichi* Desidério & Calor, sp. nov.**
urn:lsid:zoobank.org:act:FE0218EC-ED2F-422D-A686-E8CEF21B87B0
(Figs. 11A–E, 12A–F)

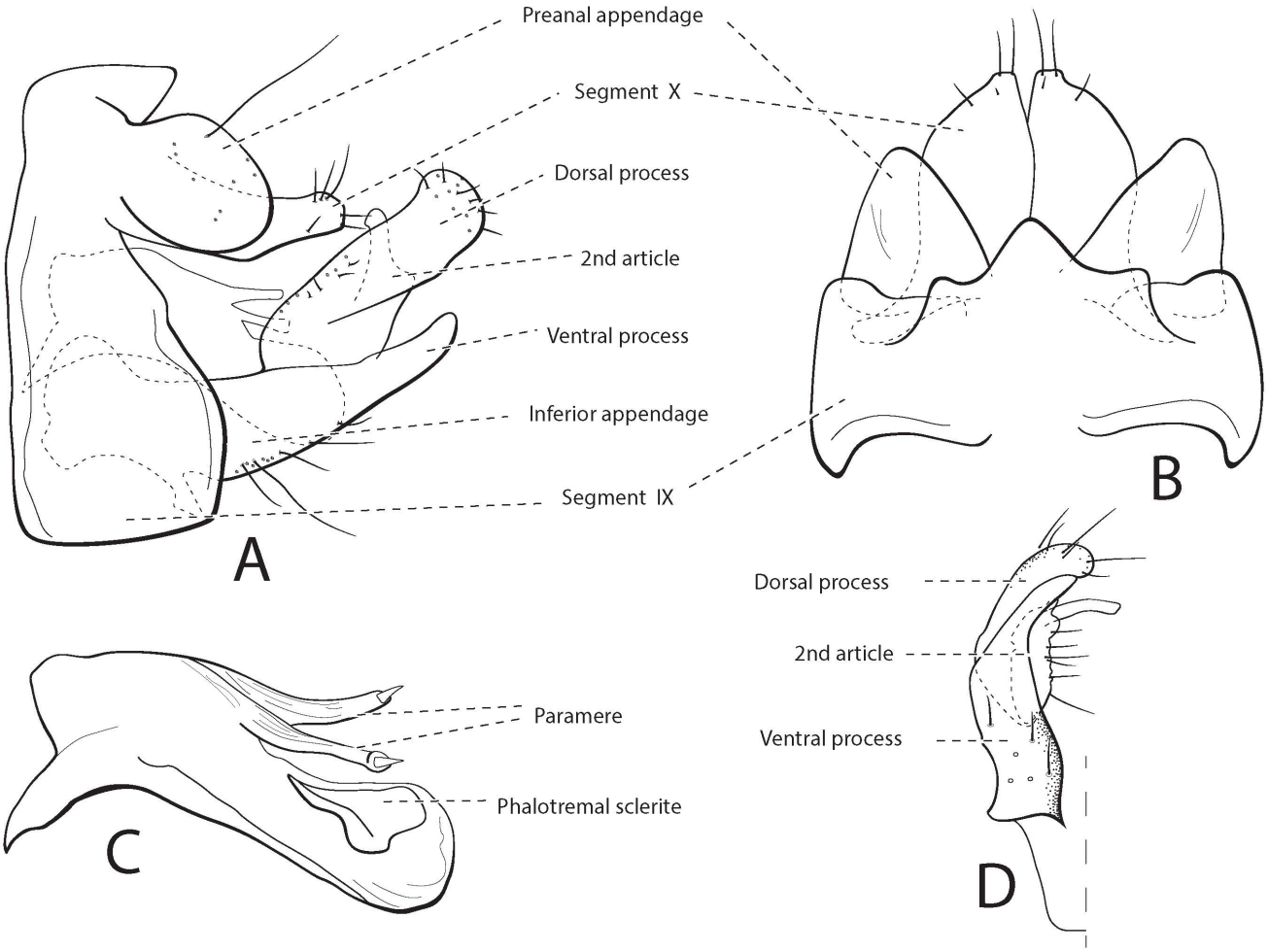

Figure 10 *Neoathripsodes froehlichi* new species, male genitalia. A, lateral; B, dorsal; C, phallic apparatus, lateral; D, inferior appendage, ventral.

Diagnosis. This new species can be easily recognized by the tergum X with medium-sized spine-like setae covering 1/3 apical; basodorsal lobe strongly sclerotized and produced in dorsal view; dorsomesal process absent; apicolateral process strongly sclerotized with the rounded apex in lateral view; and basal portion of inferior appendages very broad, subtriangular in lateral view.

Description. Adult male (n=1). Head brown; maxillary and labial palps brown; antennae pale brown (Figs. 11A, B). Thorax brown; pleuron pale brown (Fig. 11C). Forewing brown, with small hyaline spot at thyridial cell; forewing length 7.55 mm; forks I and V present (Fig. 11D); hind wing length 6.28 mm; forks I, III and V present; fork I very narrow, fork III with petiole ca. 1/3 its length (Fig. 11E). Legs pale brown (Fig. 11A); tibial spur formula 2,2,4. Male genitalia. Segment IX, in lateral view, dorsolaterally as long as ventrolaterally; anterior margin slightly concave; apicodorsal area with paired, poorly developed, closely situated protuberance; posterolateral margin strongly produced medially, bearing setae (Fig. 12A). Preanal appendages setose, long, slender, ca. 2/3 length of segment X; in dorsal view, apex rounded, bearing long setae (Figs. 12A, B). Segment X, in lateral view, saddle-shaped; anterodorsal area slightly convex; mid-dorsal area without lateral protuberance; distal area without dorsomesal and dorsolateral processes; apicolateral process strongly sclerotized, brownwish, rounded, bearing medium-sized spine-like setae (Fig. 12A); in dorsal view, with strongly sclerotized and produced basolateral lobe; U-shaped apicomesal incision extending anteriorly ca.1/2 length of segment X; with numerous medium-sized spine-like setae covering 1/3 apical its length (Fig. 12B). Inferior appendage, in lateral view, with very broad basal portion, subtriangular, apical portion elongate, digitate, setose; basodorsal process rounded, smaller than basoventral process; mesodorsal process long and broad, apex acute, directed apicodorsad (Fig. 12A); in ventral view, basoventral process well developed, symmetrical, obliquely rounded, apex directed mesad (Fig. 12C); mesoventral process, in lateral view, indistinct (Fig. 12A); in ventral view, distinctly pointed with subtruncated apex (Fig. 12C). Phallic apparatus with a pair of strongly sclerotized, acuminate phallobase flanges (Figs. 12D-F), apex directed posteroventrad (Fig. 12D); phallotremal sclerite well developed, claw-shaped in lateral view (Fig. 12D); Y-shaped, apical portion mesally directed in ventral view (Figs. 12E, F).

Holotype male. BRAZIL: Bahia: Rio dos Pires, Serra dos Barbados, Igarapé Forquilha, 13°17'25"S, 41°54'20"W, el. 1.690 m, iii.2020, Malaise trap, J Alencar, G Jorge, ECT Pereira & JO da Silva cols., 1 male (alcohol) (INPA-TRI 000138) (INPA).

Distribution (Figs. 20A, B). Brazil (BA, Caatinga domain).

Remarks. *Notalina* (*Neonotalina*) is currently divided into two species groups (*brasiliana* and *roraima*), which are defined based mainly on characters of the male genitalia (Holzenthal, 1986; Calor et al., 2006). *Notalina* (*Neonotalina*) *claudiofroehlichi* **sp. nov.** is herein assigned to the *brasiliana* group due having a complex phallic apparatus with acuminate lateral flanges at the apex and a well-developed phallotremal sclerite. It is most similar to *N.* (*Neonotalina*) *ralphi* Silva-Pereira, Oliveira, Desidério, Calor & Hamada, 2022 mainly by the tergum X with slightly convex anterodorsal area, absence of processes on the median portion and the inferior appendage with indistinct ventromesal process in lateral view. However, *N.* (*Neonotalina*) *claudiofroehlichi* **sp. nov.** has the preanal appendages with rounded apex, which are acuminate in *N.* (*Neonotalina*) *ralphi*. In the new species the incision apicomesal of segment X has U-shaped, extending anteriorly ca.1/2 of its length, whereas in *N.* (*Neonotalina*) *ralphi* this incision has V-shaped, extending anteriorly ca.1/3 length of segment. Additionally, the phallotremal sclerite of the phallic apparatus in *N.* (*Neonotalina*) *claudiofroehlichi* **sp. nov.** is claw-shaped in lateral view, while in *N.* (*Neonotalina*) *ralphi* this sclerite is Y-shaped.

Although *N.* (*Neonotalina*) *claudiofroehlichi* **sp. nov.** is a member of the *brasiliana* group, the morphology of tergum X resembles that of *N.* (*Neonotalina*) *matthiasi* Holzenthal, 1986 from Colombia, a member of the *roraima* group. Both species share the presence of spine-like setae on the tergum X, but in *N.* (*Neonotalina*) *claudiofroehlichi* **sp. nov.** these setae are medium-sized, distributed on the dorsal and lateral regions of 1/3 apical, whereas in *N.* (*Neonotalina*) *matthiasi* they are short, distributed along the lateroventral margin of the tergite and another alone seta on the apex of each apicolateral process.

Etymology. The new species is named in honor of Prof. Dr. Claudio Gilberto Froehlich (Universidade de São Paulo, Brazil) in recognition of his efforts to the advancement of the knowledge on Neotropical aquatic insects and his contributions in supervising new entomologists.

Oecetis McLachlan, 1877

***Oecetis marcus* Queiroz, Quinteiro & Calor, sp. nov.**

urn:lsid:zoobank.org:act:A2DFEE19-D856-4A05-884C-3AFAEBF4AB7E
(Figs. 13A, B, 14A-E)

Diagnosis. This new species belongs to the *Oecetis falicia*-group due to the presence of a dorsolateral process on segment IX and the tergum IX shorter than the sternum IX (Quinteiro and Holzenthal, 2017; Quinteiro and Almeida, 2021). It differs from the others in the *O. falicia*-group due to its dorsoventrally divided dorsolateral process, with a discrete pointed projection on the dorsal margin, and the dorsal lobe with a rounded apex.

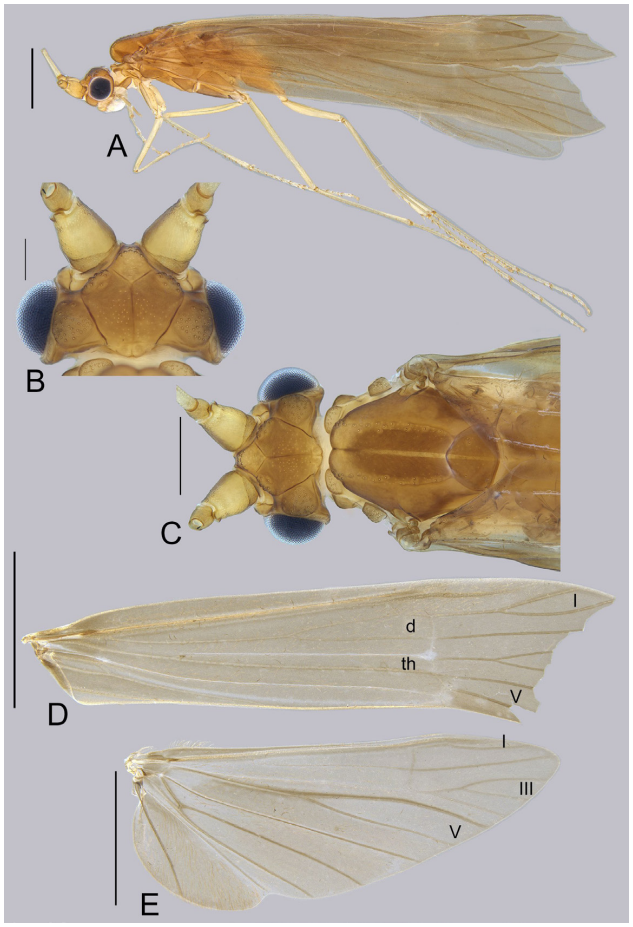

Figure 11 *Notalina* (*Neonotalina*) *claudiofroehlichi* new species, adult male. A, habitus, lateral; B, head, dorsal; C, head and thorax, dorsal; D, forewing; E, hind wing. Scale bars: 0.2 mm (B); 0.5 mm (C); 1 mm (A); 2 mm (D, E).

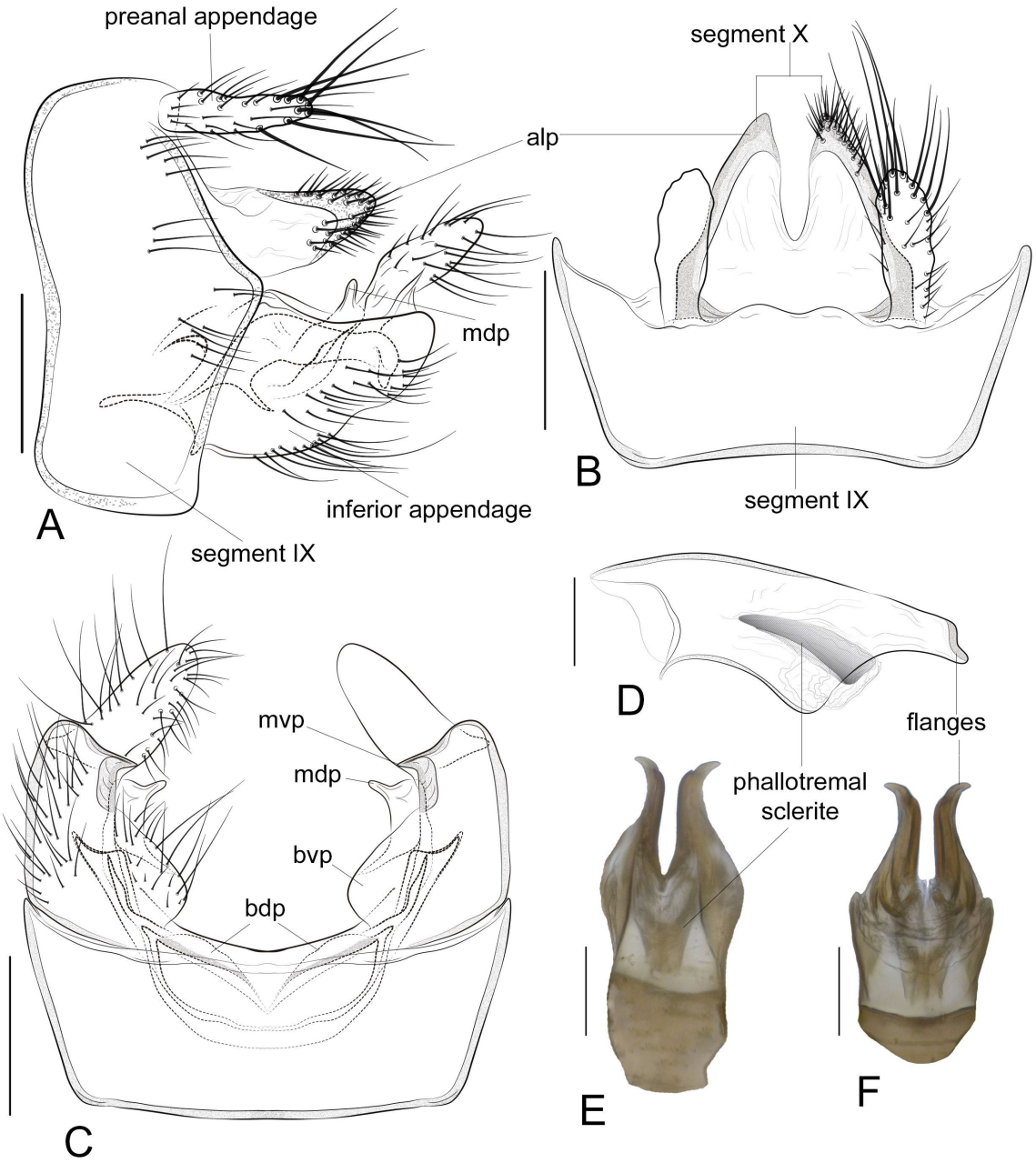

Figure 12 *Notalina* (*Neonotalina*) *claudiofroehlichi* new species, male genitalia. A, lateral; B, dorsal; C, segment IX and inferior appendage, ventral; D, phallic apparatus, lateral; E, apex of phallic apparatus (photograph), dorsal; F, apex of phallic apparatus (photograph), ventral. Abbreviations: alp, apicolateral process; bdp, basodorsal process; bvp, basoventral process; mdp, mesodorsal process; mvp, mesoventral process. Scale bars: 0.2 mm (A, B, C); 0.1 mm (D, E, F).

Additionally, the phallic apparatus presents a medial constriction on its basal third and a ventrally pointed projection right after.

Description. Adult male: Color (in alcohol): head and thorax yellowish brown. Legs, palps, and antennae yellowish brown. Tibial spur formula 0,2,2. Wings pale brown, dark spots on crossveins present; forewing with forks I and V present, rooted; hind wing with forks I and V present. Forewing length 6.09–5.54 mm (Fig. 13A). Hind wing length 4.80–5.10 mm (Fig. 13B). Male genitalia. Abdominal segment IX annular; in lateral view, anterolateral margin sinuous, convex, projected at apex; acrotergite absent; posterolateral margin slightly projected on dorsal and ventral regions, with dorsal setae; dorsolateral process elongate, forked, sclerotized, longer than tergum X, dorsal portion short, apex rounded, with small pointed projection on dorsal margin, ventral portion twice the length of dorsal portion, apex acute; Preanal appendages elongate, digitate, setose (Fig. 14A).

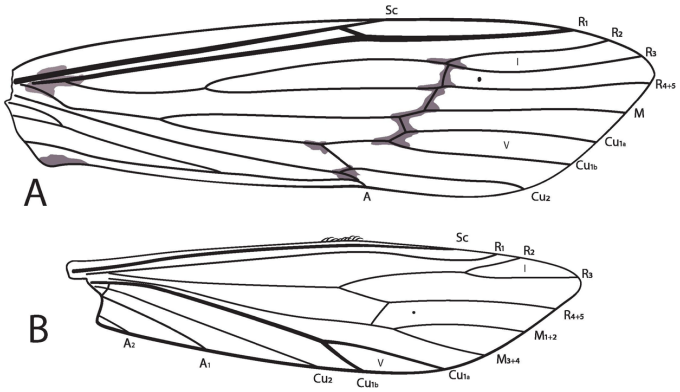

Figure 13 *Oecetis marcus* new species, wings. A, forewing; B, hind wing.

Tergum X divided in dorsal and ventral lobes; pair of mesal digitateprojections at base of dorsal lobe, short, stout dorsal lobe long, cylindrical, constricted on basal third, apex acute with two small apical setae, slightly longer than preanal appendages (Fig. 14B); ventral lobe as long as dorsal lobe, broad basally, slightly tapering apically, truncate broad apex, with one small setae apically, posteriorly directed (Fig. 14B). Inferior appendage 1-segmented, broad basally, very setose (Fig. 14A); dorsal lobe quadrangular, slightly projected (Fig. 14A); distal lobe digitate, slightly expanded subapically, setose, apex rounded, in lateral view (Fig. 14A); ventral lobe quadrangular, with ventral margin strongly projected; in ventral view, basal portion quadrate, with spine-like setae at medial region (Fig. 14C). Phallic apparatus asymmetrical, phallobase sclerotized, endotheca membranous; in lateral view, tubular, strongly curved ventrally, phallobase slightly projected ventrally, medial region with sclerotized projection directed posteroventrally (Fig. 14D); in dorsal view, rounded basally, apex broad, quadrangular, with rounded tip (Fig. 14E).

Holotype male. BRAZIL: Bahia: Mucugê, Parque Municipal de Mucugê, Medonho Stream, 13°01'42.7"S, 41°22'03.2"W, el. 984m, 24.i.2018, UV Light Pan trap, T Duarte, S Barata, I Oliveira cols. (MZUSP).

Paratypes. Same data as holotype, except Boiadeiro Stream, 12°59'46.5"S, 41°19'39.9"W el. 974 m, 01.x.2015, Malaise trap, AR Calor col., 1 male (UFBA); same data, except E Dias & R Campos cols., 1 male (UFBA); same data, except vii.2015, 11 males; same data, except 11.iv.2015, 9 males (UFBA). **Pernambuco:** Gravatá, Fazendo do TAO, TAO Waterfall, 8°16'49.5"S, 35°34'31.3"W, 17-18.vii.2022, R Pereira, G Gomes & T Silva cols., 1 male (UFBA)

Distribution (Fig. 20A)**.** Brazil (BA, PE, Caatinga domain).

Remarks. Most of *Oecetis* species recorded in the Neotropics can be placed in one of six species group: *avara*-, *punctata*-, *falicia*-, *inconspicua*-, *punctipennis*-, and *testacea*-group (Quinteiro and Holzenthal, 2017). *Oecetis marcus* **sp. nov.** belongs to the *Oecetis falicia*-group and can be diagnosed by the presence of a dorsolateral processes on segment IX and the membranous tergum IX shorter than the sternum IX (Quinteiro and Almeida, 2021).

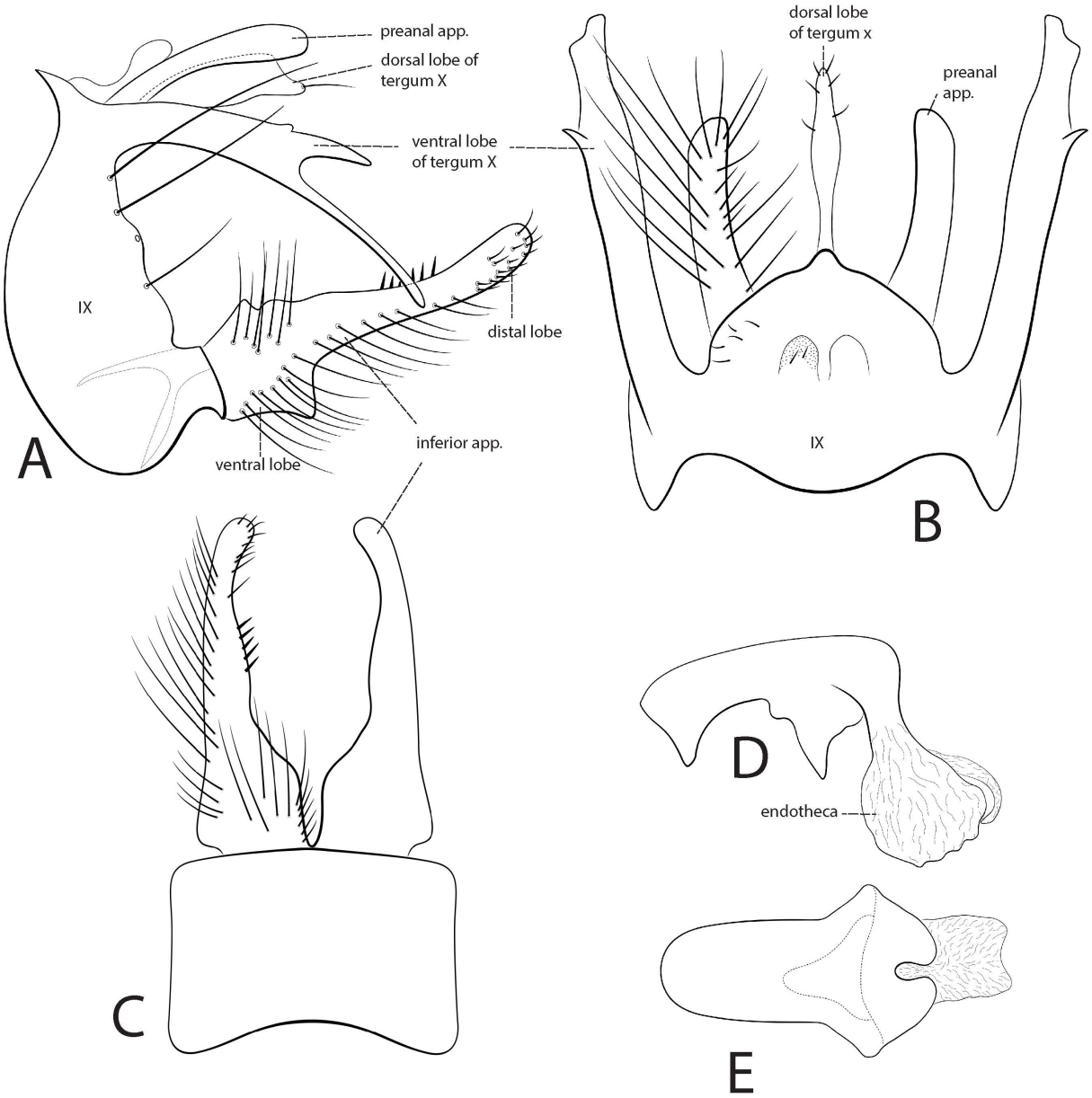

Figure 14 *Oecetis marcus* new species, male genitalia. A, lateral; B, dorsal; C, segment IX and inferior appendage, ventral; D, phallic apparatus, lateral; E, phallic apparatus dorsal. Abbreviation: app., appendage.

The digitate preanal appendages, elongated phallic apparatus, and the somewhat cylindrical distal portion of inferior appendages also seem to be recurrent additional morphological traits in the species group (Quinteiro and Almeida, 2021).

The species that most closely resemble *Oecetis marcus* **sp. nov.** are *Oecetis falicia* Denning & Sykora, 1966, for having a bifid dorsolateral process on segment IX; and *Oecetis catagua* Herinques-Oliveira, Rocha & Nessimian, 2019, due to the general shape of the inferior appendage. Although *O. marcus* **sp. nov.** and *O. falicia* have a divided dorsolateral process on segment IX, *O. marcus* **sp. nov.** has a small, flat projection on the dorsal margin of the process, while in *O. falicia* the margin is smooth, with no projections. *Oecetis marcus* **sp. nov.** presents quadrangular dorsal and ventral lobes, whereas in *O. catagua* the dorsal lobe is absent, and the ventral lobe is subquadrangular with a narrow, tapered upper portion. The tergum X of this new species has some resemblance with that in *Oecetis hydrecoi* Gibon, 2019, especially due to the quadrate ventral portion, in lateral view. However, the dorsal portion in *O. marcus* **sp. nov.** has a distinct constriction in its basal third, which is absent in *O. hydrecoi*.

Etymology. The species name is a reference to Prof. Dr. Ernst Marcus (Universidade de São Paulo) for his significant contributions to Brazilian zoology and his influential role in Prof. Froehlich's zoological studies. Noun in apposition.

Polycentropodidae Ulmer

Cernotina Ross, 1938

***Cernotina kariri* Queiroz, Vilarino & Calor, sp. nov.**

urn:lsid:zoobank.org:act:E49D0651-B0D6-4DD9-BB6B-126FC31ED54C
(Figs. 15A-C, 16A-F)

Diagnosis. *Cernotina kariri* **sp. nov.** is similar to other species with mesolateral process of preanal appendage rounded and with an elongated intermediate appendage (e.g., *C. flexuos*a Santos and Nessimian, 2008, *C. puri* Dumas and Nessimian, 2011). The new species can be diagnosed from the congeners mainly by having: foreleg with 3 tibial spurs; intermediate appendage narrow, elongate, and curved mesad; mesoventral process of preanal appendage curved ventrad and with basal finger-like lobe; basodorsal lobe of inferior appendage short; and ventral margin of inferior appendage slightly prominent.

Description. Adult male. Forewing length: 3.28 mm (n=1). General color, in alcohol, medium brown; legs and palps pale yellow; wings brown. Maxillary palp formula (I=II)<(III=IV)<V, segments III, IV 2x as long as segments I, II, segment V as long as I+II+III+IV. Tibial spur formula 3,4,4. Venation: forewing with forks II, IV and V, fork II rotted, fork V short, petiolate (Fig. 15A); hind wing with forks II and V, 3A absent (Fig. 15B). Sternum V with narrow, elongate lateral process (Fig. 15C). Male genitalia. Sternum IX in lateral view, short, subrectangular, not produced anterolaterally (Fig. 16A); anterior margin, in ventral view, with shallow, wide, concave incision, posterior margin moderately excavated (Fig. 16B). Terga IX + X, mesally semi-membranous, laterally straight, setose, surface covered by microsetae; in lateral view, slightly tapering apically, ventral margin bearing 2 strong setae directed ventrad (Fig. 16A); in dorsal view elongate, apically subrounded (Fig. 16B). Intermediate appendage, in lateral view, sclerotized, without setae, rod-like, elongate, longer than inferior appendage; in dorsal view, narrow, curved mesad, apex pointed (Figs. 16A, B). Preanal appendage: mesolateral process, in lateral view, setose, short, rounded; in dorsal view subtriangular, tapering apically (Figs. 16A, B); mesoventral process in lateral view, elongate, tongue-like, bent ventrad, apex rounded with 3 stout setae, dorsobasally bearing narrow finger-like dorsal lobe; in ventral view, intimately associate to phallus, with mesal rounded lobe with 3 stout setae and triangular flange with spine-like setae, laterally fused to other preanal structures, with finger-like lobe (Figs. 16A-C). Inferior appendage in lateral view, elongate, setose, apex truncate, with about same width of base, ventral margin basally slightly prominent, apicomesal lobe overlapped with main body of appendage (Figs. 16A, C); basodorsal lobe very short, apex rounded, bearing about 2 stout setae (Figs. 16A, C); apicomesal lobe darkly pigmented, setose, short in lateral view (Fig. 16A). Phallus in lateral view tubular, elongate, straight, ejaculatory duct posterodorsally sclerotized, phallotremal sclerite posteroventral, large, rod-like, mesally with pair of rod-like sclerotized structures (Fig. 16D); in dorsal view, tapering apically, apex bipartite (Fig. 16E); in ventral view intimately associated to ventromesal process of preanal appendage (Fig. 16F).

Holotype male. BRAZIL: Bahia: Mucugê, Medonho stream, 05.v.2023, 13º10'42.7"S, 41º22'02.2"W; UV Light Pan trap. AR Calor and MEB team cols. (MZUSP). **Paratypes.** Same data as holotype, except: 23.xi.2018, light, AR Calor et al. cols., 7 males (UFBA), 24.i.2018, T Duarte, S Barata & I Oliveira cols., 1 male (UFBA); Same data, except Boiadeiro stream, 12°59'46.5"S, 41°19'39.9"W, 11.iv.2015, Malaise trap, E Dias & R Campos cols., 1 male (UFBA).

Distribution (Figs. 20A, B). Brazil (BA, Caatinga domain)

Remarks. The tibial spur formula 2,4,4 is a diagnostic character of *Cernotina* (Oláh and Johanson, 2010; Chamorro and Holzenthal, 2010), but this species has a fully formed foreleg preapical spur. Although, the genitalia and wing venation (forewing forks II, IV, V present) fit the genus *Cernotina*. The abdominal sternum V elongate process was not previously mentioned to the genus, but it is also present in other *Cernotina* from Bahia (e.g., *C. longispina* Barcelos-Silva, Camargos, Pes & Salles, 2013, material analyzed see Vilarino and Calor (2017)) and might have been missed from other species.

Etymology. Species named in reference to the Kariri indigenous ethnic group, one of the people that originally inhabited the Chapada Diamantina region where the type specimens were collected. The name is derived from the tupi language: *kiri'ri*, meaning "silent". Named in apposition.

*Polycentropu*s Curtis, 1835

***Polycentropus claudioi* Queiroz, Vilarino & Calor, sp. nov.**

urn:lsid:zoobank.org:act:C23687A4-E714-4673-B189-207FE97CC237
(Figs. 17A, B, 18A-E)

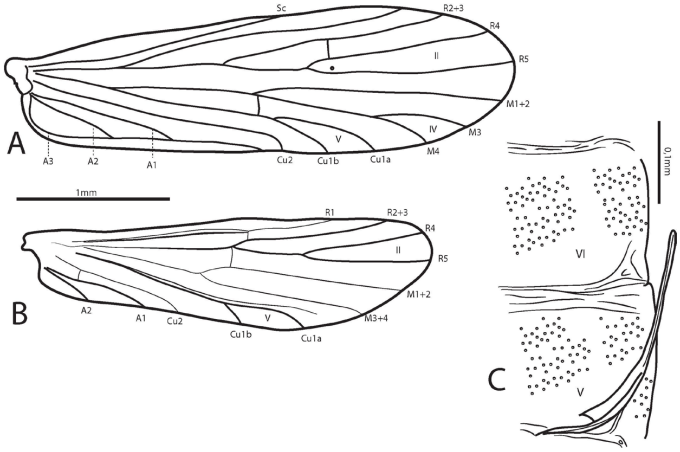

Figure 15 *Cernotina kariri* new species. A, forewing; B, hind wing; C, abdominal sternum V process.

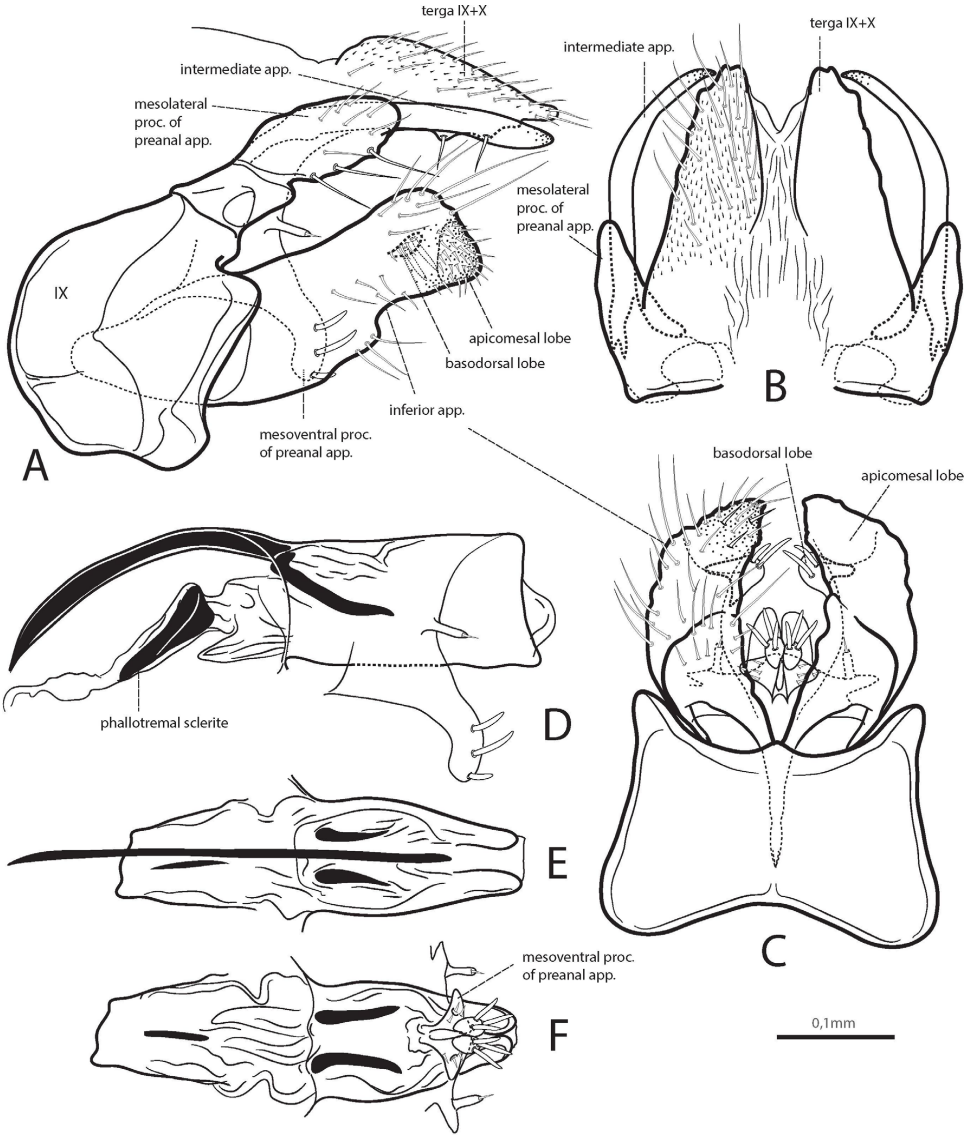

Figure 16 *Cernotina kariri* new species, male genitalia. A, left lateral; B, dorsal; C, ventral; D, phallus and mesoventral process of preanal appendage, left lateral; E, phallus dorsal; F, phallus and mesoventral process of preanal appendage, ventral. Abbreviation: app., appendage.

Diagnosis. The new species is most similar to *Polycentropus brevicornutus* Vilarino and Calor, 2015c, with both species sharing the reduced intermediate appendage. *Polycentropus claudioi* **sp. nov.** can be differentiated mainly by the narrower mesolateral and mesoventral processes of preanal appendage in lateral view; the truncate angle at the dorsal margin of inferior appendage in lateral view (straight in *P. brevicornutus*); and the wider apicoventral process of phallus in dorsal view.

Description. Adult male. Length of forewing 5.1–5.2 mm (n=2). General color medium brown; dorsum of head and thorax medium brown; legs pale yellow; wings brown (in alcohol). Venation: forewing forks I, II, III, IV and V present (Fig. 17A); hind wing forks I, II and V present (Fig. 17B). Male genitalia. Sternum IX in lateral view subtrapezoidal, about 2/3 height of segment VIII; in ventral view rectangular, anterior margin slightly concave, posterior margin with lateral edges produced posterad. Terga IX + X membranous and alongated, with 3 lobes, extending beyond mesolateral process of the preanal appendage, in lateral view (Fig. 18A). Intermediate appendage in lateral view, very short, narrow, with pointed apex not exceeding terga IX + X (Fig. 18A).

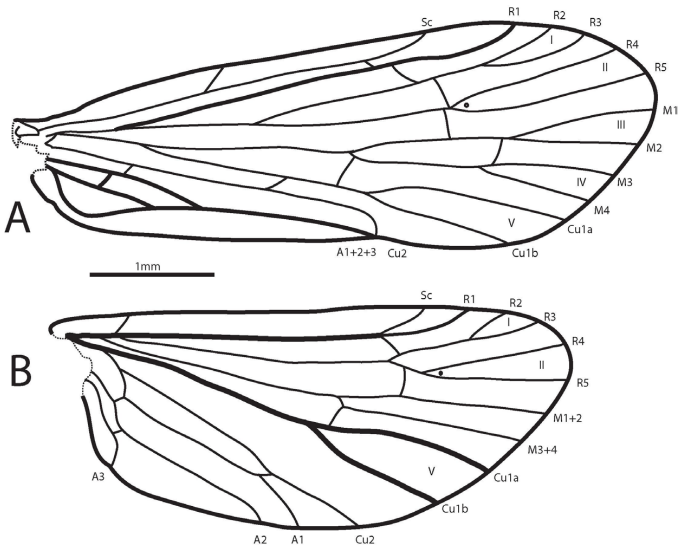

Figure 17 *Polycentropus claudioi* new species, wings. A, forewing; B, hind wing.

Preanal appendage bipartite, with mesolateral and mesoventral processes (Figs. 18A, B); mesolateral process in lateral view, setose, short, subtriangular, apex rounded, slightly wider than mesoventral process; in dorsal view about 2x as long as wide, round; mesoventral process in lateral view, setose, short, wider at base, apex round (Fig. 18A); in ventral view very short, shorter than intermediate appendage (Fig. 18C). Inferior appendage in lateral view trapezoidal, longer than processes of preanal appendage (Figs. 18A, C); dorsolateral lobe wide, setose, with sinuous dorsoapical margin and truncate apex (Fig. 18A); in ventral view dorsolateral lobe curved mesad, wide at base tapering apically, apex sclerotized, acute; basal lobe short, angulate; mesoventral spine prominent, acute (Fig. 18C). Phallus: phallobase half as long as phallus (Figs. 19D, E); in lateral view, apicoventral process about as long as 1/3 of phallus length, projecting ventrad, slightly curved, apex round (Fig. 18C); endothecal sclerotic band absent; endothecal spines absent; phallotremal sclerite subtriangular, in ventral view (Fig. 18E).

Holotype male. BRAZIL: Bahia: Mucugê. Parque Municipal de Mucugê, Boiadeiro stream, 12°59'46.5"S, 41°19'39.9"W, 01.x.2015, Malaise trap, R Campos, E Dias & AR Calor cols. (MZUSP).

Paratype. Same data as holotype, 1 male (UFBA).

Distribution (Figs. 20A, B). Brazil (BA, Caatinga biome)

Remarks. The reduced intermediate appendage shared by *Polycentropus claudioi* **sp. nov.** and *P. brevicornutus* suggests a near relationship among them in relation to congeners which have lost this appendage (*Polycentropus amphirhamphus* Hamilton & Holzenthal, 2011, *P. cachoeira* Hamilton & Holzenthal, 2011, *P. inusitatus* Hamilton & Holzenthal, 2011, *P. paprockii* Hamilton & Holzenthal, 2011, *P. rosalysae* Hamilton & Holzenthal, 2011).

Etymology. Species named in honor of Prof. Dr. Cláudio Gilberto Froehlich, the patron of LEAq.

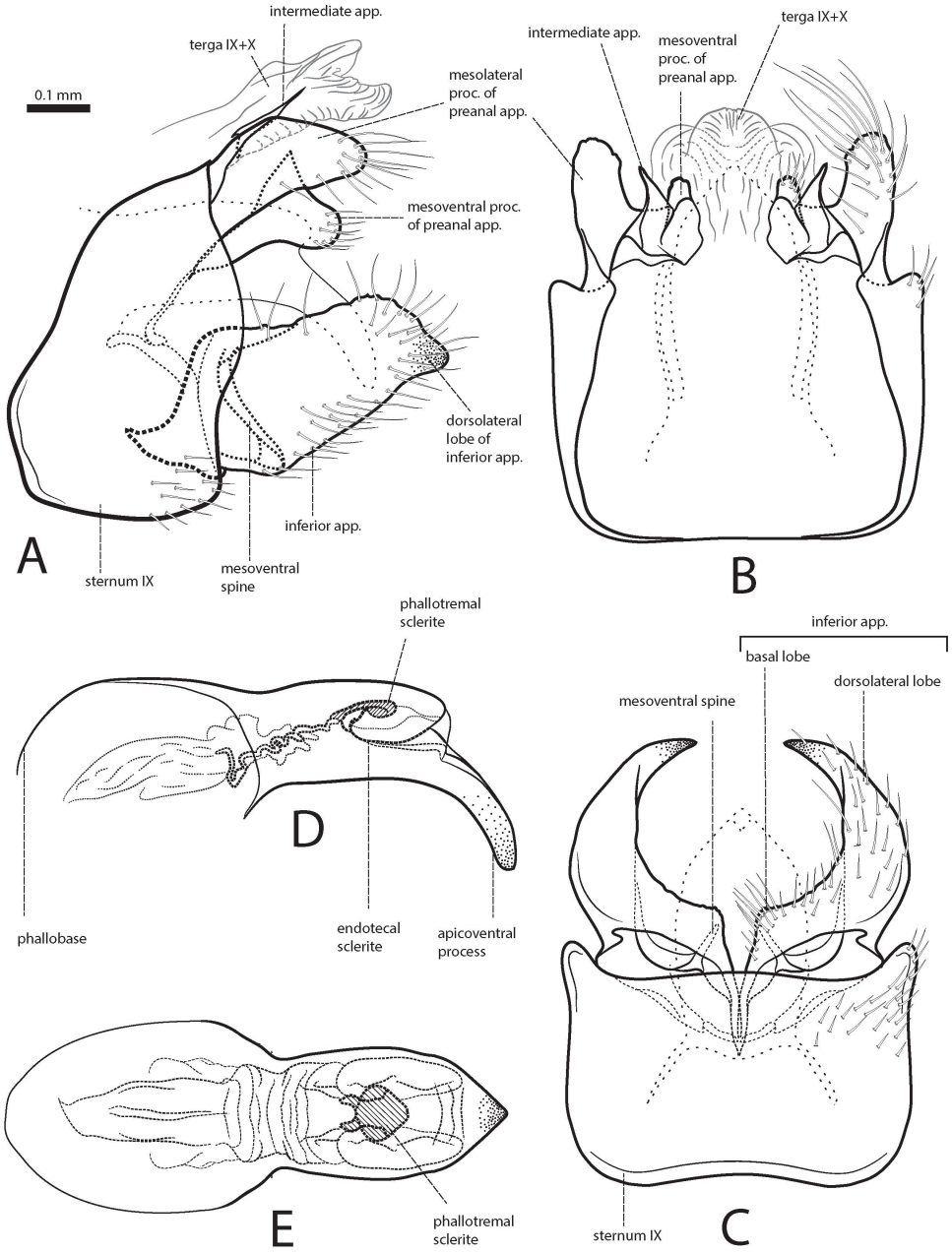

Figure 18 *Polycentropus claudioi* new species, male genitalia. A, left lateral; B, dorsal; C, ventral; D, phallus, left lateral; E, phallus, dorsal. Abbreviation: app., appendage.

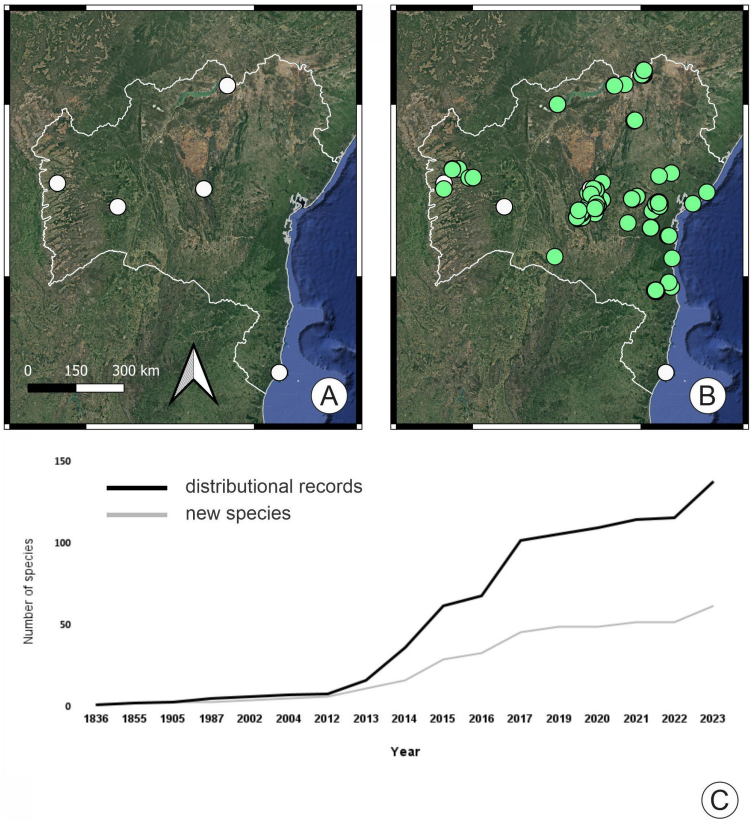

Figure 19 Caddisfly fauna from Bahia state, Brazil. A, Map of Bahia state, caddisfly records before 2009; B, Map of Bahia with caddisfly records in 2023; C, Caddisfly knowledge along time, description year of species which occur in state (gray), and first distributional records in state (black).

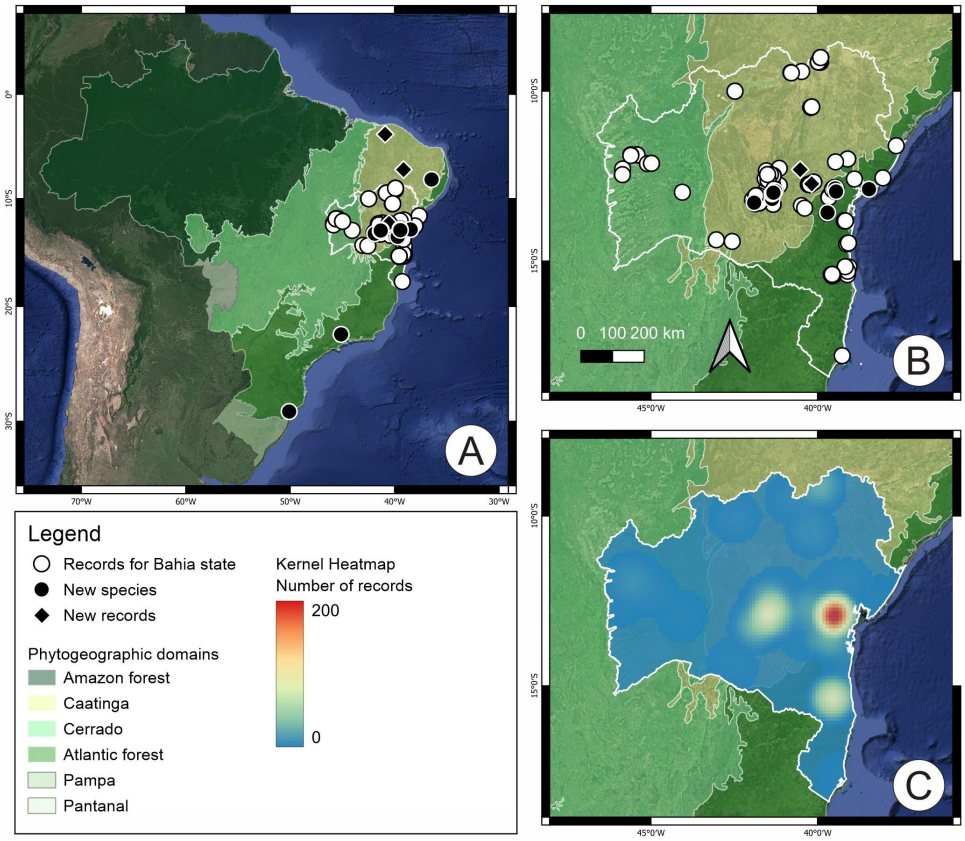

Figure 20 Distribution of the caddisfly species. A, new species, and records across the phytogeographic domains of Brazil; B, complete caddisfly record data in Bahia State; C, heatmap indicating the concentration of efforts.

New distributional data for ten valid species are presented. Taxonomic remarks are also presented to elucidate characters and, consequently, to aid subsequent identification of these taxa.

Hydroptilidae

Anchitrichia duplifurcata Flint, 1983

Literature records: Flint, 1983 [Amambay, Paraguay]; Guahyba, 1991 [Brazil: Rio de Janeiro]; Angrisano, 1999 [Argentina]; Blahnik et al., 2004 [Brazil: Minas Gerais]; Paprocki et al., 2004 [checklist]; Dumas et al., 2009 [Brazil: Rio de Janeiro]; Paprocki and França, 2014 [checklist]; Santos et al., 2016 [larva; pupa].

Material examined. BRAZIL: Bahia: Lençóis, Rio Mucugezinho, 12°27'44"S 41°25'1"W, 01.viii.2010, UV Light Pan Trap, AR Calor, L Lecci, G Arantes, FB Quinteiro, D França & P Camelier cols., 5 males (UFBA).

Distribution (Figs. 20A, B). Brazil (**BA**, MG, RJ), Paraguay.

Remarks. Currently, this is the only species of the genus *Anchitrichia* that occurs in Brazil. *Anchitrichia duplifurcata* was previously recorded only in southeastern Brazil (Guahyba, 1991; Blahnik et al., 2004; Dumas et al., 2009). With this study, this species is recorded for the first time in the Brazilian Northeast region (Bahia state).

Flintiella pizotensis Harris, Flint & Holzenthal, 2002

Literature records: Harris et al., 2002 [Costa Rica]; Dumas et al., 2010 [Brazil: Amazonas]; Paprocki and França, 2014 [checklist]; Armitage et al., 2015 [Panama]; Ríos-Touma et al., 2017 [Ecuador]; Armitage and Harris, 2018 [Panama].

Material examined. Brazil: Bahia: Piatã, Fazenda Machado, Cachoeira do Machado, 13°09'33"S, 41°47'29"W, 29.vii.2010, AR Calor, L Lecci, G Arantes, FB Quinteiro, D França & P Camelier cols., 1 male (UFBA).

Distribution (Figs. 20A, B). Brazil (AM, **BA**), Colombia, Costa Rica, Ecuador, Mexico, Nicaragua, Panama, Peru.

Remarks. This species has a broad geographic distribution, recorded from Mexico to Brazil. In Brazil, this species was previously reported only from the state of Amazonas (Amazon) by Dumas et al. (2010). In this study, we report this species for the first time in the Brazilian Northeast region and Caatinga biome.

Hydroptila zerbinae Souza, Santos & Takiya, 2014

Literature records: Souza, Santos and Takiya, 2014b [Brazil: Alagoas, Bahia, Pernambuco]; Cavalcante-Silva et al., 2022 [Brazil: Pernambuco].

Material examined. Brazil: Ceará: Missão Velha, Cachoeira, UV Light Pan Trap, 25.vii.2009, AR Calor and L Lecci cols., 1 male (UFBA).

Distribution (Fig. 20A). Brazil (AL, BA, **CE**, PE).

Remarks: This species is endemic to Brazil. Currently, it is only recorded in the Northeast region, in the Atlantic Forest and Caatinga biomes. Here, the known distribution is extended to its westernmost, in the Ceará state (Caatinga biome).

Neotrichia falcifera Flint, 1974

Literature records: Flint, 1974 [Suriname]; Angrisano, 1999 [Argentina]; Rueda-Martín and Sganga, 2021 [Argentina].

Material examined. Brazil: Bahia, Ruy Barbosa, Rio Saracura near Sangrador, UV Light Pan Trap, 7–8.iv.2023, Oliveira-Silva col., 3 males (UFBA); same except, Iaçu, Balneário Três Gameleiras, Rio Paraguaçu, 12°45'50.8"S, 40°13'54.6"W, 29.iii.2022, AR Calor and R Pereira cols., 2 males (UFBA).

Distribution (Figs. 20A, B). Argentina, **Brazil (BA)**, Suriname.

Remarks: The examined specimens match Flint's (1974) description, except for the dark, curved spine of the phallus, which in these specimens extends almost to the apex. *Neotrichia falcifera* has been recorded in Argentina and Suriname, and now has its first record in Brazil (Caatinga biome).

Ochrotrichia patulosa (Wasmund & Holzenthal, 2007)

Literature records: Wasmund and Holzenthal, 2007 [Brazil: Rio de Janeiro]; Souza et al., 2014a [Brazil: Ceará].

Material examined. BRAZIL: Bahia: Rio dos Pires, Serra dos Barbados, Igarapé Forquilha, 13°17'25"S, 41°54'20"W, el. 1690 m, 01.iii.2020, Malaise trap, J Alencar, G Jorge, ECT Pereira, JO da Silva cols., 1 male (INPA).

Distribution (Figs. 20A, B). Brazil (**BA**, CE, RJ).

Remarks: *Ochrotrichia patulosa* was previously known only from its type locality, in the Serra dos Órgãos National Park, a protected area of Atlantic Forest in the midwestern region of the Rio de Janeiro State (Wasmund and Holzenthal, 2007). Later, it was reported from the Caatinga biome, in the state of Ceará (Souza et al., 2014a). Herein, *O. patulosa* is recorded for the first time in the Bahia state, also in the Caatinga biome.

Oxyethira circaverna Kelley, 1983

Literature records: Kelley, 1983 [Ecuador, Panama]; Kelley, 1984 [checklist]; Flint, 1992 [Curaçao]; Aguila, 1992 [Panama]; Angrisano, 1995a [Uruguay]; Angrisano, 1995b [Argentina]; Angrisano, 1999 [Argentina]; Botosaneanu, 2002 [checklist]; Angrisano and Sganga, 2007 [Argentina]; Santos et al., 2009 [Brazil: Amazonas]; Manzo et al., 2014 [Argentina]; Paprocki and França, 2014 [checklist]; Armitage et al., 2015 [Panama]; Souza and Santos, 2017 [Brazil: Bahia, Paraíba, Maranhão]; Ríos-Touma et al., 2017 [Ecuador]; Rocha et al., 2017 [checklist]; Armitage and Harris, 2018 [Panama]; Moreno et al., 2020 [Brazil: Piauí].

Material examined. Brazil: Ceará: Missão Velha, Cachoeira, UV Light Pan Trap, 25.vii.2009, AR Calor and L Lecci cols., 1 male (UFBA).

Distribution (Fig. 20A). Argentina, Brazil (AM, BA, **CE**, MA, PB, PI), Curaçao, Ecuador, Panama, Uruguay.

Remarks. In Northeast Brazil, *Oxyethira circaverna* has been recorded in the Atlantic Forest, Caatinga, and Cerrado biomes (Souza and Santos, 2017; Moreno et al., 2020). In this study, the species distribution is extended, representing the first record in the state of Ceará, also in the Caatinga biome.

Rhyacopsyche dikrosa Wasmund & Holzenthal, 2007

Literature records: Wasmund and Holzenthal, 2007 [Brazil: Minas Gerais, São Paulo]; Dumas et al., 2009 [Brazil: Rio de Janeiro]; Calor, 2011 [checklist]; Dumas and Nessimian, 2012 [Brazil: Rio de Janeiro]; Paprocki and França, 2014 [checklist].

Material examined. Brazil: Bahia: Camacan, Fazenda Waldemar da Farmácia, 15°25'17"S, 39°34'01"W, 310 m, UV Light Pan trap, 28.iii.2011, AR Calor, FB Quinteiro, D França & P Barreto cols., 7 males (UFBA).

Distribution (Figs. 20A, B). Brazil (**BA**, MG, RJ, SP).

Remarks: *Rhyacopsyche dikrosa* is endemic to Brazil, recorded only in the Atlantic Forest (Minas Gerais, Rio de Janeiro, and São Paulo states), in southeast Brazil (Wasmund and Holzenthal, 2007; Dumas et al., 2009). Herein, the distributional range of *R. dikrosa* is extended to north, in the Bahia state, also in the Atlantic Forest. This is the first record for the Brazilian Northeast region.

Odontoceridae

Marilia fasiculata Banks, 1913

Literature records: Banks, 1913 [Rondônia, Brazil]; Flint, 1967 [Brazil]; Maes, 1999 [Nicaragua]; Paprocki et al., 2004 [Brazil]; Chamorro-Lacayo et al., 2007 [Nicaragua]; Souza et al. 2013 [Brazil: Pernambuco]; Paprocki and França, 2014 [Brazil]; Holzenthal and Calor, 2017 [Brazil, Nicaragua]; Camargos et al., 2020 [Brazil: Amazonas, Pernambuco, Rondônia, Roraima].

Material examined. BRAZIL: Bahia: Curaçá, 9°06'50.94"S, 39°56'11.82"W, el. 366 m, 06.v.2011, AM Silva-Neto col., 42 males, 35 females (UFBA); same data, except Recanto Campestre, Rio São Francisco, 8°59'56.7"S, 39°54'56"W, el. 357 m, luz/lençol, D França, 6 males (UFBA)

Distribution (Figs. 20A, B). Brazil (AM, **BA**, PE, RO, RR), Nicaragua.

Remarks: In Brazil, this species is known in the North region (Amazonas, Rondônia, and Roraima states) and Northeast region (Pernambuco state) of the country. In this study, the distribution is extended to the south of the São Francisco River, in the state of Bahia (Caatinga biome). Flint (1967), Souza et al. (2013) and Paprocki and França (2014) mispelled this species as "*Marilia fasciculata*".

Marilia flexuosa Ulmer, 1905

Literature records: Ulmer, 1905 [Brazil: Santa Catarina; USA]; Martynov, 1912 [Peru]; Ross, 1951 [USA]; Denning, 1964 [USA]; Flint, 1967 [Mexico, USA]; Bueno-Soria and Flint, 1978 [Argentina, Panama, Peru]; Holzenthal, 1988 [Argentina, Brazil, Canada, Costa Rica, Mexico, Parana, Peru]; Flint, 1991 [Colombia]; Aguila, 1992 [Panama]; Flint, 1996 [Peru]; Wiggins, 1996 [USA]; Muñoz-Quesada, 2000 [Colombia]; Bueno-Soria and Rojas-Ascencio, 2004 [Brazil, Canada, Colombia, Costa Rica, Guatemala, Mexico, Panama, Peru, USA]; Paprocki et al., 2004 [Brazil]; Baumgardner and Bowles, 2005 [USA]; Blinn and Ruiter, 2006 [USA]; Bowles et al., 2007 [USA]; Bueno-Soria et al., 2007 [Mexico]; Chamorro-Lacayo et al., 2007 [Nicaragua]; Rueda-Martín, 2008 [Argentina]; Blinn and Ruiter, 2009 [USA]; Ruiter and Blinn, 2009 [USA]; Bueno-Soria and Barba-Álvarez, 2011 [Mexico]; Paprocki and França, 2014 [Brazil]; Miranda and Rueda-Martín, 2014 [Argentina]; Armitage et al., 2015 [Panama]; Armitage and Cornejo, 2015 [Panama]; Holzenthal and Calor, 2017 [Argentina, Brazil, Canada, Colombia, Costa Rica, Guatemala, Mexico, Nicaragua, Panama, Peru, USA]; Souza et al., 2017 [Brazil; Bahia]; Rueda-Martín and Sganga, 2021 [Argentina].

Material examined: BRAZIL: Ceará: Serra do Ibiapaba, Parque Nacional de Ubajara, córrego Murimbeca, 3°49'18.1"S, 40°54'17.5"W, 873 alt, 28.x.2011, Gomes, V. & Duarte, T., 1 male (UFBA); Ubajara, Parque Nacional de Ubajara, Trilha Samambaia, Mirante do Gameleira, 3°50'21"S, 40°54'23"W, el. 880 m, 23.ix.2012, Pensilvânia, DMT; JTC col., 2 males (DZRJ).

Distribution (Fig. 20A). Argentina, Brazil (BA, **CE**, SC), Canada, Colombia, Costa Rica, Guatemala, Mexico, Nicaragua, Panama, Peru, U.S.A.

Remarks: *Marilia flexuosa* has the widest distributional range among the species in the genus. It is recorded from the southeast of Canada to the south of Argentina. Originally, *M. flexuosa* was described by Ulmer (1905) based on two females from Texas (U.S.A.) and Santa Catarina (Brazil). In 1912, Martynov described the male of *M. flexuosa* by comparison of coloration and characteristics present in the wings, concluding that it would be the male of the same species described by Ulmer. The male of *M. flexuosa* can be differentiated, mainly, by the presence of a dark, thick, and bulging mark in the region of the stigma, in the forewings (Flint, 1991). Here, this species is recorded for the first time in Ceará state (Brazil).

Polycentropodidae

Polycentropus biappendiculatus Flint, 1974

Literature records: Flint, 1974 [Suriname]; Hamilton, 1988 [Venezuela].

Material examined. Brazil: Bahia: Mucugê, Córrego Medonho, 13°01'42.7"S 41°22'03.2"W, 24.i.2018, UV Light Pan trap, T Duarte, S Barata, I Oliveira cols., 43 males (UFBA); same data, except Parque Municipal de Mucugê, Projeto Sempre-viva, Rio Cumbuca, 12°59'36.33"S, 41°20'30.59"W, 27.vi.2010, UV Light Pan trap, AR Calor et al. cols., 1 male (UFBA).

Distribution (Figs. 20A, B). **Brazil** (**BA**), Suriname, Venezuela.

Remarks. The specimens analyzed do not have the hind wing fork I (R_2 and R_3 fused), a diagnostic character of *Polyplectropus*, which may cause the misidentification. Despite the wing similarities with *Polyplectropus*, the genitalia presents the same morphology of *Polycentropus biappendiculatus* as it appears in the original Flint's (1974) description and in the illustrations of Hamilton (1987). The original description does not mention any distinction of wing venation. Other diagnostic characters are the forewing Cu2 vein distally not recurved towards the arculus; and the male genitalia phallotheca with an elongated, pointed, apicoventral process. These are typical characteristics of *Polycentropus* and are present in this species. Herein, *P. biappendiculatus* is recorded for the first time in Brazil.

Checklist of caddisflies (Trichoptera) from Bahia State, Brazil

Currently, 116 valid species comprising 35 genera and 11 families of caddisflies have been recorded from Bahia state, 33 of them occurring exclusively in Bahia state, Brazil (Santos et al., 2023). Considering the six new species described herein and the new records presented (seven species and four genera) from Bahia state, the caddisfly fauna in the state increases to 138 species, in 39 genera and 11 families. Of this number, 38 species were described, and 62 were recorded in studies with LEAq members as authors. Additionally, 29 species were recorded using material from UFBA (Table 1). Around 75% of the recorded fauna in the state is the result of LEAq's work and around 95% of the species recorded are from UFBA material, demonstrating their contribution to overcoming the biodiversity shortfalls in the Trichoptera fauna knowledge both locally (Fig. 19C) and nationally.

According to the species estimators, the estimated number of caddisfly species in the Bahia state is 219 to 247 species from CHAO2 (±24) and Jackknife2 (±44), respectively.

Discussion

The LEAq's contributions to caddisfly biodiversity knowledge, especially on caddisfly taxonomy, are not exclusive to Brazil or Bahia state, but they certainly focus on the regional or local fauna (Fig. 19). Fifty-one species have been described since 2009 from Brazil and other South American and Caribbean countries [Cuba (*Atopsyche beckeri* Gomes & Calor, 2019), Ecuador (*Atopsyche bravoi* Gomes & Calor, 2019), Peru (*Grumichella blahniki* Calor & Holzenthal *in* Calor et al., 2016), and Venezuela (*Grumichella cressae* Calor & Holzenthal *in* Calor et al., 2016; *G. trujilloi* Calor & Holzenthal *in* Calor et al., 2016)].

In Brazil, 46 caddisfly species were co-authored by LEAq members from the north- to southernmost states of country, including the states of Acre (*Centromacronema poyanawa* Dias & Calor, 2016; *Macrostemum scharfi* Pereira and Calor *in* Pereira et al., 2022), Distrito Federal (*Notalina ralphi* Silva-Pereira, Oliveira, Desidério,

Calor & Hamada, 2022), Paraná (*Helicopsyche lazzariae* Holzenthal, Blahnik & Calor, 2016), Pernambuco (*Helicopsyche ralphi* Cavalcante-Silva, Perreira & Calor, 2022), Minas Gerais (*Grumichella paprockii* Calor & Holzenthal *in* Calor et al., 2016; *Helicopsyche angeloi* Holzenthal, Blahnik & Calor, 2016), Rio de Janeiro (*Grumichella parati* Calor & Holzenthal *in* Calor et al., 2016), Rio Grande do Norte (*Chimarra potiguar* Queiroz, Dias & Calor, 2020), Santa Catarina (*Grumichella muelleri* Calor & Holzenthal *in* Calor et al., 2016; *Helicopsyche guara* Holzenthal, Blahnik & Calor, 2016; *Smicridea sororis* Vilarino, Dias & Calor, 2019), and São Paulo (*Atopsyche japi* Gomes & Calor, 2019; *Grumichella boraceia* Calor & Holzenthal *in* Calor et al., 2016; *G. jureia* Calor & Holzenthal *in* Calor et al., 2016; *G. leccii* Calor & Holzenthal *in* Calor et al., 2016; *Oecetis fibra* Chen & Morse *in* Quinteiro and Calor, 2012; *Phylloicus camargoi* Quinteiro & Calor in Quinteiro et al., 2011), but most of them are from Bahia state (28 species).

The new records and new species described in the present study encompass five different states and two main ecoregions: the Atlantic rainforest and the semi-arid Caatinga. Four species are described from different parts of the Atlantic Forest: *Phylloicus froehlichi* **sp. nov.** and *Austrotinodes zeferina* **sp. nov.** are described from the northern Atlantic Forest; *Neoathripsodes froehlichi* **sp. nov.** from the mid-Atlantic Forest and *Atopsyche froehlichi* **sp. nov.** from the southern Atlantic Forest. Four species are described from the Caatinga: *Cernotina kariri* **sp. nov.**, *Notalina claudiofroehlichi* **sp. nov.**, *Oecetis marcus* **sp. nov.**, and *Polycentropus claudioi* **sp. nov.**. The new species records are from the Brazilian Northeast region (Bahia and Ceará states) and include species with an Atlantic Forest range (e.g., *Anchitrichia duplifurcata, Ochrotrichia patulosa*, *Rhyacopsyche dikrosa*), Amazonian range (e.g., *Marilia fasiculata*, *Polycentropus biappendiculatus*), and widespread species (e.g., *Marilia flexuosa*, *Oxyethira circaverna*). The diverse faunistic components of Caatinga and Northeast Brazil, which combine faunas from the Amazon and Atlantic Forest, may be related to the historical links between the two forests. There is much evidence that the Amazon and Atlantic forests expanded their range over the dry vegetation (Cerrado and Caatinga ecoregions), with an older connection occurring through a southern route during the Miocene, and a more recent connection in a route through the Northeast Region during the Pliocene and Pleistocene and associated with expansions and retractions of gallery forests in the Quaternary climate changes (Batalha-Filho et al., 2013). This highlights the importance of studies in the region in order to have a comprehensive understanding of the historical connections of the South American fauna.

Currently, the caddisfly fauna from Bahia state comprises 138 species records, making it the fifth most species-rich state in Brazil, right after the states of Minas Gerais (246 species), Rio de Janeiro (226 species), Amazonas (203 species), and São Paulo (182 species) (Fig. 21). Even though there may be real biological differences in caddisfly biodiversity among the Brazilian states due to several intrinsic factors (e.g., area, density of streams, topography, forest coverage, degree of urbanization), factors related to collecting/taxonomic effort may provide a better explanation of the current data (i.e., states with historical tradition of aquatic insect taxonomic studies, and states that have received direct attention from foreign researchers present an apparent higher diversity).

Considering the historical tradition on aquatic insect taxonomy, the surveys of Prof. Dr. Claudio Froehlich in Minas Gerais and São Paulo states increased our knowledge of caddisflies in two ways, (i) supplying specimens to MZUSP, which received the attention of Dr. Oliver Flint, especially until the decade of 1990s, and (ii) contributed to the training of Brazilian researchers, especially during the development of projects on aquatic macroinvertebrates within the BIOTA-FAPESP Program (1999-2009). Other traditional research centers such as LACIA-INPA and LabEnt-UFRJ, led respectively by Dra. Neusa Hamada and Dr. Jorge Nessimian, also contributed significantly to strengthening collections bearing caddisfly specimens, description of new species, and advising new students on caddisfly taxonomy in Amazonas and Rio de Janeiro states. Dr. Nessimian authored more than 100 caddisfly species (Santos et al., 2020).

In addition, the most species-rich states in Brazil also received the direct attention of foreign researchers, as Dr. Oliver Flint (Smithsonian Institution, USA) who focused on the Amazonas state, and Dr. Ralph Holzenthal and Dr. Roger Blahnik (both University of Minnesota, USA) who focused on the South-Southern states (Santos et al., 2020). These three researchers also have examined specimens housed at INPA and MZUSP, and described more than 350 caddisfly species from Brazil (Santos et al., 2020).

Considering the richness among families of caddisflies in Brazil (Fig. 21), we observe a general dominance of five families: Hydropsychidae, Hydroptilidae, Leptoceridae, Philopotamidae, and Polycentropodidae (Santos et al., 2020), except for Glossosomatidae, which is ranked the 4th most diverse family in the São Paulo state, and Helicopsychidae which is 4th among top families in the Bahia state. These five most diverse families constitute approximately 70% of the total caddisfly species in Brazil (Santos et al., 2020).

Among the states of the Brazilian Northeast region (Fig. 21), Bahia is the most species-rich (138 species), followed by the states of Piauí, Maranhão, and Pernambuco, with 55, 53, and 47 recorded species, respectively. The five most species-rich families in the region (Hydropsychidae, Hydroptilidae, Leptoceridae, Philopotamidae, and Polycentropodidae) have a similar number of recorded species across these four states and the rest of Brazil (except for including Helicopsychidae in Maranhão and Pernambuco). It is worth noting that the family Glossosomatidae, which includes over 200 species in the Neotropics (Holzenthal and Calor, 2017), has almost no recorded species in the entire Brazilian Northeast region, except for a single record of *Mortoniella* in Pernambuco state (Souza et al., 2013), and an undetermined *Itauara* in Bahia state (Vilarino and Calor, 2017). The difference between the number of caddisfly species in Bahia and other states in the Northeast Region is strongly related to LEAq's contributions.

Four families occur in Brazil that are not recorded in Bahia state (Anomalopsychidae, Atriplectididae, Limnephilidae, and Sericostomatidae). Three of them contain just a few species, known only from Southeastern Brazil, which have been recorded especially from high mountains of the Atlantic Forest. Considering the genera recorded in Bahia state, the top 10 species-rich genera are *Smicridea* (17 species), *Oecetis* (14 species), and *Helicopsyche* (13 species. They are followed by *Oxyethira*, with nine species, *Chimarra*, *Macrostemum*, *Phylloicus*, and *Polycentropus* with six species each, *Leptonema* with five, and *Macronema* with four species. Except for *Oxyethira* and *Leptonema*, all other genera were the focus of taxonomic papers authored by the LEAq team and colleagues (e.g., França et al., 2013; Quinteiro and Calor, 2015; Vilarino and Calor, 2015b, 2015c; Queiroz et al., 2023; Pereira and Calor, 2023). Other less species-rich genera, such as *Neoathripsodes* and *Centromacronema*, were recorded for the first time in Bahia state through the description of new species (Dias et al., 2015; Dias and Calor, 2016).

According to the species estimators CHAO2 and Jackknife2, the caddisfly richness in the Bahia state is estimated to be around 219 to 247 species. Besides the increasing knowledge on the Bahian caddisfly richness in the last decade, its diversity is yet remarkably underknown, and the Linnean deficit is similar to that of Brazil, with around 50% of its caddisfly fauna yet to be discovered and described (Santos et al., 2020), a similar deficit to Ecuador (Ríos-Touma et al., 2017). Considering the diversity of ecosystems in Bahia state, the underexplored regions, especially in the south and west of the state, and the material housed at UFBA, the known caddisfly fauna of Bahia state will likely be around 200 species in the next few years.

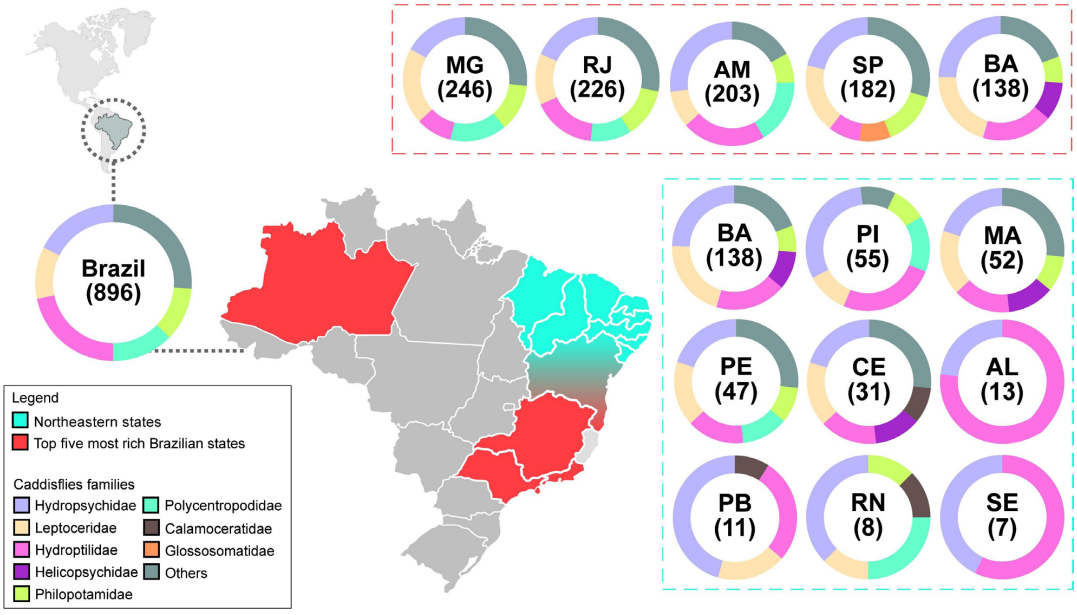

Figure 21 Map of Brazil, highlighting the five states with the most species-rich caddisflies fauna, and the states of the Brazilian Northeast region. Species numbers are presented between parentheses. Abbreviations of Brazilian states: AL=Alagoas, AM=Amazonas, CE=Ceará, MA=Maranhão, MG=Minas Gerais, PB=Paraíba, PE=Pernambuco, PI=Piauí, RJ=Rio de Janeiro, RN=Rio Grande do Norte, SE=Sergipe, SP=São Paulo.

The accumulation curves of described species in Brazil (Santos et al., 2020) and in Bahia (Fig. 19C) reveal a strong upwards trend in the last years, which can indicate that there are many more species to be described in the country as well as in the Bahia state. Santos et al. (2020), based on the large territorial area of Brazil, including phytogeographic domains with high diversity and endemism, estimated that the number of Brazilian caddisfly species could approach 2,000. Along these lines, Bahia state also presents a large area (567,295 km^2, larger than the territory of France, for example), which encompasses the Atlantic Forest, Caatinga, and Cerrado phytogeographic domains. These areas have high diversity and endemism, and a great number of rivers and streams, especially in the mountains of the Chapada Diamantina complex and the Atlantic Forest. Thus, it will not be surprising if the actual Bahian caddisfly fauna reaches 300 species. The Linnean (taxonomic) shortfall is the most fundamental one preventing a comprehensive understanding of the patterns and processes of biodiversity, as it affects all other shortfalls (Diniz-Filho et al., 2023).

Considering the Wallacean (distributional) shortfall, it is important to emphasize that most of the species recorded herein are represented by one or a few individuals, and this pattern is not uncommon to our caddisfly knowledge, which demands prioritization in collecting, especially in unexplored areas in west, north, and northwest of Bahia state (Figs 19B, 20B, 20C). These regions have few conservation units and a growing set of anthropic actions (e.g., hydrologic resources and land use by intensive agriculture), which are the main drivers of insect populations decline (Samways et al., 2020). From primary data on the occurrence of species in these unexplored regions, decision-makers can act to promote conservation policies based on robust information to support them and possibly establish future protected areas (Margules and Pressey, 2000).

The spatial coverage of records in Bahia state is still significantly biased, with the top three areas contributing over 80% of all records (Fig. 20C). The concentration of species records is Serra da Jiboia (a mosaic between Atlantic Forest and Caatinga domains), Serra Bonita and surroundings (Atlantic forest domain), and Chapada Diamantina Complex (Caatinga domain). Thus, there is a vast area to be explored in Bahia state.

Understanding biodiversity might begin with a species checklist that includes their distribution. However, other aspects, such as life history data and ecological requirements, are essential to guide protection policies and to predict the consequences of global climate changes and land use on caddisfly populations and species distribution (Ríos-Touma et al., 2017).

The Haeckelian (unknown semaphoronts) shortfall constitutes a challenge in different scales, possibly because caddisfly taxonomy is strongly based on adult males, with little or no information known of immature and female stages. In Brazil, 72% of caddisfly species have only adult males known. On the other hand, only ca. 2 to 4% of Brazilian caddisfly species have an additional one to all known semaphoronts described (Holzenthal and Calor, 2017; Queiroz et al., 2023). This knowledge gap is also true for species distributed in Bahia state (Table 1), with only 10 species [*Phylloicus abdominalis* Ulmer, 1905, *P. obliquus* Navás, 1931; *Macrostemum brasiliense* (Fischer, 1970); *Smicridea aequalis* Banks, 1920; *Smicridea bivittata* (Hagen, 1961); *Smicridea palifera* Flint, 1981; *Amazonatolica hamadae* Holzenthal and Pes, 2004; *Grumichella rostrata* Thienemann 1905; *Oecetis inconspicua* (Walker, 1852); *Triplectides gracilis* (Burmeister, 1839)] having their male, female, larvae and pupae described, but none with life-cycle duration and reproduction known.

Currently, the projects of LEAq team address questions in systematics and biogeography of caddisfly taxa (e.g., Helicopsychidae, Hydroptilidae, Leptoceridae and Xiphocentronidae), regional faunal surveys (Michelin Ecological Reserve in Atlantic Forest, and Chapada Diamantina Complex in Caatinga domain), ecological and biological aspects (microplastic pollution, decomposition of leaf litter, vertical stratification, phenology, life cycle), and systematics of fossil species. In the latter, the fossil caddisfly species described by Martins-Neto (2001), from the Crato formation of Early Cretaceous (Aptian) in Northeast Brazil's Araripe basin, have been redescribed, including the oldest record of a long-horned caddisfly (Leptoceridae) (*Araripeleptocerus primaevus* Martins-Neto, 2001). After years of obscurity due to vague descriptions (Holzenthal and Calor, 2017) or loss of type specimens, the fossil caddisfly species from Crato formation will be revisited and new taxa will be described from material housed in collections in Brazil (Universidade Federal do ABC, Universidade Federal do Ceará, and UFBA) and Germany (Staatliches Museum für Naturkunde Stuttgart).

Overcoming the biodiversity knowledge gaps begins with confronting the elementary Linnean and Wallacean shortfalls, followed by (or concurrently) addressing studies to contribute to the fulfillment of other knowledge deficits. Unraveling the puzzle of caddisfly biodiversity and its conservation will take a collaborative network of taxonomists and ecologists, bridging the gaps in both domains, in a "Froehlich' way" of doing science. This is the research approach of LEAq "Prof. Dr. Cláudio Gilberto Froehlich".

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Conflicts of interest

The authors declare no conflicts of interest.

Author contribution statement

ARC conceptualized the study. All authors provided data and specimen analysis, wrote and revised the manuscript.

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