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**Description of five new species of frog-biting midges (Diptera, Corethrellidae) from Brazil and examination of new morphological characters with utility for taxonomic and phylogenetic studies**

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**Abstract.** Family Corethrellidae has a worldwide distribution with most known extant species occurring in the Neotropics, many with only the adult stages described. Despite previous efforts, one remaining problem in the taxonomy of Corethrellidae is the challenge of delimiting species due to the current range of morphological characters included in descriptions to date. This paper discusses additional morphological evidence to distinguish species and their phylogenetic relationships. Together with fresh samples collected in Bahia, the only state in the Northeast Region with records of corethrellids, and slide-mounted specimens from other regions, five new species are described: *Corethrella pindorama* sp. nov., *C. patasho* sp. nov., *C. fuscifimbria* sp. nov. and *C. unifasciata* sp. nov. based on female adults; and *C. bifida* sp. nov. based on male and female adults, and larval and pupal exuviae. We also provide complementary descriptions comprising the novel characters for 33 previously described species, including the immature stages of nine. Fifteen species are newly recorded for Bahia and the Northeast Region, of which two are new records for Brazil. Additionally, we provide remarks about the biology of species, an updated list of species recorded in Brazil and an updated taxonomic key of New World species, modified from Borkent (2008).

**Resumo.** A família Corethrellidae possui distribuição mundial, com a maioria das espécies viventes conhecidas ocorrendo na região Neotropical, muitas com apenas os estágios adultos descritos. Apesar dos esforços anteriores, um problema que persiste na taxonomia de Corethrellidae é o desafio de delimitar espécies, devido à gama de caracteres morfológicos incluídos nas descrições atuais. Este artigo discute evidências morfológicas adicionais para distinguir espécies e suas relações filogenéticas. Cinco novas espécies são descritas com base em material fresco coletado na Bahia, único estado do Nordeste com registros de corethrelídeos, e com espécimes montados em lâminas de outras regiões: *Corethrella pindorama* sp. nov., *C. patasho* sp. nov., *C. fuscifimbria* sp. nov. e *C. unifasciata* sp. nov. com base

em fêmeas adultas; e *C. bifida* sp. nov. com base em machos e fêmeas adultos, e exúvias de larvas e pupas. Também fornecemos descrições complementares com os novos caracteres para 33 espécies descritas anteriormente, incluindo os estágios imaturos de nove. Quinze espécies são registradas pela primeira vez para a Bahia e Região Nordeste, das quais duas são novas para o Brasil. Adicionalmente, fornecemos comentários sobre a biologia das espécies, uma lista atualizada das espécies registradas no Brasil e uma chave taxonômica atualizada das espécies do Novo Mundo, modificada de Borkent (2008).

**Keywords.** *Corethrella*, Culicoidea, Anura, Neotropical, aquatic.

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## Introduction

Studies of the monotypic family Corethrellidae (genus *Corethrella* Coquillett, 1902) in Brazil have been occasional but steadily increasing since Borkent's world revision of the group (Borkent 2008), with new publications and researchers in the fields of ecology and taxonomy (Amaral & Pinho 2015; Caldart *et al.* 2016; Ambrozio-Assis *et al.* 2018; Amaral *et al.* 2019; Almeida *et al.* 2021; Toledo *et al.* 2021). These works have contributed significantly to our knowledge about the family. However, since Brazil is a megadiverse country, with 25% of its territory covered by protected areas but only 50% of these areas ever sampled (Oliveira *et al.* 2017), there is still an enormous gap to be filled. The Northeast Region is the third largest of five officially recognized regions in Brazil, comprising 18% of the national territory. It has historically been overlooked in terms of social and scientific investments, including biodiversity research, which is also reflected in the taxonomy of Corethrellidae. Although the Northeast comprises nine states, only Bahia has any records of frog-biting midges, with nine species reported.

Most of the 47 valid species known to occur in Brazil (besides four with the status of *nomina dubia*) (Appendix 1) were recorded in the South and Southeast regions due to the extensive work of John Lane from the 1930s to the 1950s, mostly in São Paulo State, and currently by our research group in Santa Catarina State. As such, within Brazil, there are more species recorded in the south than in the north. This distribution contrasts with the global trend for the family of higher richness towards the equator. However, this is most likely due to a geographical bias caused by the locations where researchers are studying the group, and a more extensive sampling effort throughout Brazil would probably reduce this gap or perhaps reverse it.

Many ecological and systematic studies (not exclusive to Corethrellidae) with adults or immatures stumble upon the difficulty of precisely identifying specimens to the species level. This often leads to the exclusion of specimens and limits the utility of associated data. Immatures of Corethrellidae have been described by Belkin (Belkin 1962; Belkin & McDonald 1955; Belkin *et al.* 1970), Cook (1956), Lane (Lane 1942, 1953; Lane & Aitken 1956; Lane & Cerqueira (1958), McKeever & French (1991), and to some degree by Borkent (2008) and Amaral & Pinho (2015). Among the 120 described extant species,

41 have their larval and/or pupal stage known (Borkent 2008; Amaral & Pinho 2015; Dorff *et al.* 2022), though most have only been partially described and some remain undescribed. Unfortunately, due to this limited knowledge about the morphological and taxonomic diversity of the group, these descriptions and diagnoses are of little use to current researchers, making it virtually impossible to reliably determine most of the species from immature individuals.

The difficulty of identifying corethrellids is related to our restricted knowledge about their biology, ecology, and phylogeny. For most described species, the immature stages and their habitats are still unknown (Amaral *et al.* 2018). Furthermore, for biting females (Fig. 1), the degree of host-specificity and the sensory cues used to locate frogs are still uncertain (Grafe *et al.* 2018; Virgo *et al.* 2021). Additionally important for frog ecology and conservation is that females are vectors of parasites, such as trypanosomes (Bernal & Pinto 2016) and possibly the fungus *Batrachochytrium dendrobatidis* Longcore, Pessier & D.K.Nichols (Toledo *et al.* 2021).

Two phylogenies for the family have been proposed (Borkent 2008; Baranov *et al.* 2016). They are very similar and both recognize the same groups of species proposed by Borkent (2008), although only a few of those species groups are well supported, while others are based on more homoplastic traits. Seven of the species groups are in the New World: the *appendiculata* and *brakeleyi* groups, each with only one defining synapomorphy; the *fulva* group, which is probably paraphyletic, with some well-supported, internal clades; the *peruviana* group, with many unique synapomorphies from adults and immatures, which is sister to a clade that comprises all of the referred groups except *rotunda*; the *rotunda* group, which is also well supported by several morphological traits of adults; the *quadrivittata* group, which has distinctive morphological features in adults and immatures; and the *wirthi* group, which is weakly supported by one homoplastic synapomorphy. Additionally, there are several unplaced species that occur in the New World.



**Fig. 1.** Female adult *Corethrella peruviana* Lane, 1939 biting a male *Boana faber* (Wied-Neuwied, 1821), Porto Seguro, Bahia, 30 Aug. 2019.

The use of morphology in taxonomy is important for several reasons and, combined with other approaches, constitutes one of the most important tools to study biodiversity. In Corethrellidae, we often deal with slide-mounted specimens collected many years or decades ago, as well as more recently described species that are only known from a single slide-mounted holotype. Morphological studies thus provide firsthand, and sometimes the only source of information on the evolution of specific features and their function. Moreover, molecular analyses are still costly, especially for researchers based in developing countries, and may not be feasible for every project involving species identification or description. Apart from pragmatic reasons, there has been some heated disagreement regarding the importance of morphological studies for taxonomy today (see Packer *et al.* 2009; Hołyński 2010; Giribet 2015; Dupérré 2020).

This paper increases what is known about Corethrellidae in Brazil, mostly based on specimens collected in the state of Bahia, and includes new distribution records, descriptions of new species, new ecological data and new morphological characters that can be used to help identify adult and immature individuals and better understand evolutionary relationships within the family.

## **Material and methods**

### **Study sites**

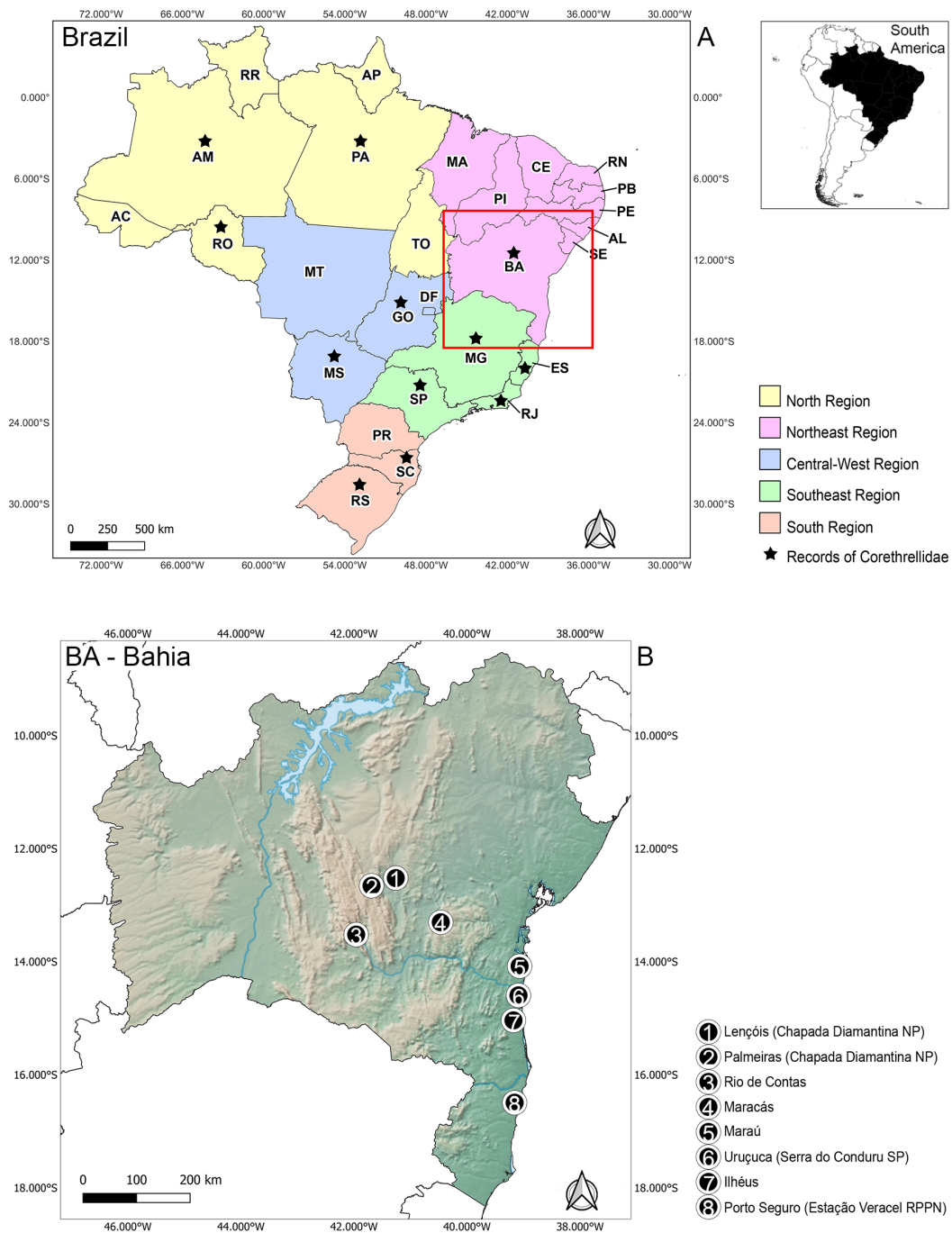
Part of the studied material was collected between May 2019 and March 2020 at eight localities (Fig. 2B) in the state of Bahia, Brazil. These locations are areas in the Atlantic forest, including the following: tropical rainforest remnants in Serra do Conduru State Park, Uruçuca and the Reserva Particular do Patrimônio Natural, Estação Veracel, Porto Seguro; a regenerating cocoa farm (cabruca) on the Universidade Estadual de Santa Cruz campus in Ilhéus and other semi-urban areas in the surroundings; and sandy coastal vegetation (restinga) in Maráu. There is also material from xeric shrubland (caatinga), rocky plains and transitional phytophysionomies in Lençóis and Palmeiras in Chapada Diamantina National Park, also in the municipalities of Rio de Contas and Maracás.

Further material was collected between 2011 and 2021 in Santa Catarina State and other localities in southern Brazil (Fig. 2A). This material is deposited in the Mítia Heusi Silveira entomological collection (CE-MHS) at the Federal University of Santa Catarina (UFSC). The localities mainly comprise areas of dense Atlantic rainforest and *Araucaria* moist forest.

### **From collection to description: techniques and tools employed**

Adults were collected via a frog-call pan trap (Amaral & Pinho 2015), CDC trap and light pan trap (Calor & Mariano 2012). Immatures were collected from ground pools, ponds, lakes, stream margins and stream-side pools with a hand net or directly collecting the surface water with a pan (Fig. 3). For bromeliads, treeholes and leaf axils, a suction bottle was used.

Each larva or pupa was reared individually to the adult stage (and euthanized 24 hours after emergence) and larvae were fed with culicid larvae (see Amaral 2020) captured from bromeliads and artificial containers. The exuviae and adults were temporarily preserved in 80% ethanol. All the analyzed and described specimens, with their respective immature exuviae (when available), were mounted on slides in Euparal® following the procedures described by Upton & Mantle (2010). Adults were previously macerated in 10% KOH. The material was examined using stereo and compound light microscopes. Photographs were taken using an inverted microscope with an attached Olympus DP73, 17MP camera. The images were processed in Adobe Photoshop CC and the illustrations were drawn in Adobe Illustrator CC. The taxonomic key in this work was modified from Borkent (2008) and includes the new species described since this work was published. It was edited using the Dkey program (Tofilski 2018). The



**Fig. 2.** Maps of the geographical scope of this paper. **A.** Map of Brazil; colors represent the official geopolitical regions; stars indicate the states with any record of Corethrellidae. **B.** Map of Bahia State indicating sampling sites: 1 = Lençóis (Chapada Diamantina National Park); 2 = Palmeiras (Chapada Diamantina National Park); 3 = Rio de Contas; 4 = Maracás; 5 = Maraú; 6 = Uruçuca; 7 = Ilhéus; 8 = Porto Seguro (Estação Veracel Private Natural Heritage Reserve). Abreviations of Brazilian states: AC = Acre; AL = Alagoas; AM = Amazonas; AP = Amapá; BA = Bahia; CE = Ceará; DF = Distrito Federal; ES = Espírito Santo; GO = Goiás; MA = Maranhão; MG = Minas Gerais; MS = Mato Grosso do Sul; MT = Mato Grosso; PA = Pará; PB = Paraíba; PE = Pernambuco; PI = Piauí; PR = Paraná; RJ = Rio de Janeiro; RN = Rio Grande do Norte; RO = Rondônia; RR = Roraima; RS = Rio Grande do Sul; SC = Santa Catarina; SE = Sergipe; SP = São Paulo; TO = Tocantins.

holotypes of the new species will be deposited in the Zoology Museum of the University of São Paulo (MZUSP). Paratypes will be deposited in the CE-MHS.

Additional material examined is deposited in CE-MHS and the Diptera Systematics Lab (LSDip) collection, both at the Universidade Federal de Santa Catarina (UFSC).

### Identification and classification

To identify the specimens, we used the keys and descriptions in Borkent (2008) and the descriptions in Amaral & Pinho (2015), Caldart *et al.* (2016), and Amaral *et al.* (2019). The phylogenetic relationships and species groups addressed in this work are based on the phylogenies proposed by Borkent (2008) and Baranov *et al.* (2016).

All descriptions are based on slide-mounted specimens, previously cleared in KOH, and immature exuviae.

### Measurement and terminology

Although many morphological aspects of Corethrellidae were addressed by Borkent (2008) and McKeever (1986, 1988) for adults, Belkin (1962, 1968) and Förster *et al.* (2016) for larvae and Borkent (2012) for pupae, there is still a considerable knowledge gap related to structure names and functions for



**Fig. 3.** Collecting immatures in Palmeiras, Bahia, 26 Feb. 2020.

either adults or immatures. For the structures that have not been studied in Corethrellidae, we resorted to the general dipteran morphology chapters in Manual of Afrotropical Diptera (Cumming & Wood 2017) and the Contributions to a Manual of Palaearctic Diptera (Courtney *et al.* 2000), then to the work on Culicidae morphology by Harbach & Knight (1980). Since the Corethrellidae and Culicidae are closely related families and their morphology is similar, most structures could be readily homologized. The questionable cases are treated in the discussion.

### **Adults**

The terms are mainly based on Borkent (2008), except for the chaetotaxy of the head and thorax, which are based on Harbach & Knight (1980). For the clypeal setae, as in Borkent (2008), only the ones present on the dorsal surface are considered.

Borkent (2008) succinctly described the setae on the adult frons (interocular space). Herein, following Harbach & Knight (1980), these setae are considered part of the paired ocular rows (Fig. 41A), which extend from the ventral margin of the interocular space to the posterior part of the head, following the margin of the compound eyes. Therefore, when Borkent (2008) mentioned, for example, “Two large setae on frons between ventromedial area of ommatidia,” we here consider these “one thick offset seta on ventral portion of ocular row.” We also describe the subocular row, which may or may not be present as a well-defined row of slender to intermediate thick setae parallel and medial to the ocular row. Some species may have additional setae on the vertex and interocular space. The postgenal row is a series of slender to intermediate setae along the posterior margin of the compound eyes, which may be contiguous with the ocular row or discretely apart. On the posterior portion of the head, specimens have one or more ventromedial setae that are distinctively thicker than the ones of the postgenal row. In some cases, the postgenal row extends to the ventromedial area; however, those setae can usually be easily distinguished by the size of the setal sockets.

The distribution of sensilla coeloconica is presented as follows: “number of sensilla in Arabic numerals (flagellomeres in Roman numerals. [Square brackets indicate variation in the number of sensilla coeloconica in the referred flagellomere])”.

The chaetotaxy of the thorax (Fig. 15B) is newly described for Corethrellidae and is mostly based on Harbach & Knight (1980). Four regions of the scutum with groups of setae of relevant taxonomic use are here distinguished: prescutal area, comprising the lateral region of the scutum anterior to the prescutal suture; antealear area, comprising the lateral portion posterior to the prescutal suture, above the paratergite; supraalar area, comprising the setae posterior to the antealear area and dorsal to the wing sclerites; and dorsocentral row, consisting of a row of dorsolateral setae, extending longitudinally along the scutum. Three relative and approximate sizes of setae are recognized from the dimension of the socket in the cuticle: slender, intermediate and thick. Several examined specimens had the thorax not in a lateral position or were somewhat crumpled. Also, in some cases it was difficult to discriminate between a thick and an intermediate seta, or between an intermediate and a slender one. For these reasons, the reader should be aware that the numbers and sizes of thoracic setae are approximate and not absolutely precise. Nevertheless, the general patterns described are constant among conspecific specimens.

The empodium has only been briefly described in previous works. We include the same description format present in a previous publication (Amaral *et al.* 2019), which did not discuss this structure in detail. The empodium varies in relation to its length, thickness and number of branches. We consider an empodium elongate when its length is greater than the width of the last tarsomere, intermediate when longer than half the width, and short when shorter than half the width. The thickness (thick, intermediate or slender) is given in comparison to the apical setae on the tarsus. As far as what has been observed in the available material, empodia are composed of bifid (sometimes trifid, rarely multifid) branches arising



from a main stem, which also has a bifid apex. The number of branches mentioned in the description includes the main stem.

Measurements are given as a mean for samples larger than two specimens, with ranges within parentheses; for sample sizes equal to or smaller than two, only ranges are given. Ta1/Ta2 and Ta3/Ta4 refer to the ratios of foreleg tarsomeres.

In some of the complementary descriptions, males and females are described together, since it was observed that there was no dimorphic variation for the described features.

### **Larvae**

For the main components of the head capsule (Fig. 15D), Courtney *et al.* (2000) and Borkent (2008) were used as a reference, and for other parts not treated in these publications we used Belkin (1962) and Harbach & Knight (1980). Since our descriptions of immatures are based on exuviae, the chaetotaxy and most aspects of the larval thorax and abdomen were disregarded. Larval exuviae are very fragile and it is often not possible to distinguish thoracic and abdominal features. For this reason, the descriptions focus on the larval cranium, anal segment and siphon, which are more easily preserved and will be more useful in future work.

The chaetotaxy of larvae has mainly been discussed by Belkin (1950, 1962; Belkin & McDonald 1955; Belkin *et al.* 1970) and is herein used as proposed by that author. An exception is the sensilla of larval mouthparts, which are not treated in the works by Belkin but are described by Harbach & Knight (1980). The abbreviations used for larval sensilla are the following: C = cranium; Mn = mandible; Mx = maxilla; S = siphon.

Apart from purely descriptive information, we added morphometric measurements of the specimens, which provide relevant intra- and interspecific variation and aid in species delimitation and recognition. Length and width of the head were given as the largest longitudinal and transversal measurements, respectively, when the cranium was sufficiently intact and in a dorsoventral position. The postmentum length was taken from the ventral base of the sclerite (disregarding the short posterior extension it has) to the base of the prementum. The width was measured at the ventral base. The teeth on the prementum were counted laterally, starting with the central tooth. The mandibular teeth were measured as the shortest free edge of each tooth.

It is important to consider (not only for larvae but also for pupae and adults) that structures are frequently not perfectly positioned on the horizontal plane and, therefore, the measurements may be somewhat approximate. Overly tilted structures were not considered.

### **Pupae**

The morphology and chaetotaxy of pupae follow Borkent (2012) (Fig. 22H). The measurements for abdominal length and the terminal process are given separately, since it was observed that they can vary independently. The terminal process width was measured at the widest part of the base. Abbreviations used for pupal sensilla are the following: D = dorsal; L = lateral; V = ventral.

### **Abbreviations**

Abbreviations used to refer to institutions and collection locations are the following:

- BMNH = Department of Life Sciences, British Museum of Natural History, London, UK
- CAPEA = Centro de Apoio à Pesquisa e Educação Ambiental (Support Center for Research and Environmental Education), Serra Furada State Park, SC, Brazil
- CEIOC = Coleção Entomológica Instituto Oswaldo Cruz, Rio de Janeiro, RJ, Brazil

- CE-MHS = Coleção Entomológica “Mítia Heusi Silveira”, Universidade Federal de Santa Catarina, Florianópolis, SC, Brazil
- CNC = Canadian National Collection of Insects, Arachnids and Nematodes, Eastern Cereal and Oilseed Research Centre, Ottawa, Ontario, Canada
- DEFS = Departamento de Epidemiologia, Faculdade de Saúde Pública, Universidade de São Paulo, São Paulo, SP, Brazil
- ILMD = Instituto Leônidas e Maria Deane, Fiocruz Amazônia, Manaus, AM, Brazil
- InDRE = Laboratorio de Entomología, Instituto de Diagnóstico y Referencia Epidemiológicos, D.F., Ciudad de México, Mexico
- INMA = Departamento de Artropodología Sanitaria, Instituto Nacional de Microbiología “Dr. Carlos G. Malbrán,” Ciudad de Buenos Aires, Argentina
- INPA = Instituto de Pesquisas da Amazônia, Manaus, AM, Brazil
- LSDip = Laboratório de Sistemática de Díptera, Universidade Federal de Santa Catarina, Florianópolis, SC, Brazil
- MNCR = Colección Entomológica, Sección de Artrópodos, Museo Nacional da Costa Rica, San José, Costa Rica
- MZUSP = Museu de Zoologia, Universidade de São Paulo, SP, Brazil
- PEST = Parque Estadual da Serra do Tabuleiro, SC, Brazil
- RPPN = Reserva Particular do Patrimônio Natural (Private Natural Heritage Reserve)
- UESC = Universidade Estadual de Santa Cruz, Ilhéus, BA, Brazil
- USNM = United States National Museum, Smithsonian Institution, Suitland, MD, USA
- ZCPB = Zoological Collection “Prof. Paulo Bührnheim”, Universidade Federal do Amazonas, Manaus, AM, Brazil

Abbreviations of Brazilian states referred: AM = Amazonas; BA = Bahia; ES = Espírito Santo; GO = Goiás; MG = Minas Gerais; MS = Mato Grosso do Sul; PA = Pará; RJ = Rio de Janeiro; RO = Rondônia; RS = Rio Grande do Sul; SC = Santa Catarina; SP = São Paulo.

## Results

Class Insecta Linnaeus, 1758  
Order Diptera Linnaeus, 1758  
Family Corethrellidae Edwards, 1932  
Genus *Corethrella* Coquillett, 1902

Subgenus *Corethrella* Coquillett, 1902

In our survey in Bahia, we collected 409 specimens representing 22 species (355 adult females, 40 adult males, 64 larvae and 94 pupae; some immatures did not reach the adult stage). With the material from the LSDip and CE-MHS collections, we recorded a total of 38 species. We describe five new species and provide complementary descriptions for the 33 remaining species, including pupal and larval stages of nine. Another 33 specimens grouped in seven morphotypes could not be accurately identified and might belong to undescribed species. An additional 284 individuals collected via frog-call traps or as immatures were only examined with a stereo microscope and are temporarily kept in vials of ethanol.

We provide a taxonomic key to the New World species (Appendix 2), which was modified from Borkent (2008) to include the five new species herein described and eleven other recently published species: *Corethrella borkenti* Amaral & Pinho, 2015; *C. cabocla* Feijó, Belchior, Marialva & Pessoa, 2021; *C. cambirela* Amaral, Mariano & Pinho, 2019; *C. kipferi* Dorff, Borkent & Curler, 2022; *C. ielemdei* Feijó, Ramires, Lima & Pessoa, 2021; *C. menini* Feijó, Picelli, Ríos-Velásquez & Pessoa, 2021;

*C. munteantaroku* Amaral, Mariano & Pinho, 2019; *C. stenostyla* Amaral, Bello-González & Pinho, 2021; *C. xokleng* Amaral, Mariano & Pinho, 2019; *C. yanomami* Amaral, Mariano & Pinho, 2019; and *C. yucuman* Caldart & Pinho, 2016. We also provide an updated list of Brazilian species (Appendix 1) that includes publications with species descriptions and the distributions of the species in Brazil. For characters newly described, see Morphology remarks (below).

Due to incomplete descriptions of immatures in many species of *Corethrella*, the diagnoses of *C. ananacola*, *C. infuscata*, *C. fulva* and *C. borkenti* are restricted to their larval habitat, the bromeliads. Despite the evidence of strong habitat specialization, there are a few exceptions reported (see “Biology and distribution patterns of Corethrellidae from Brazil” below). This weakness will be corrected once more complete descriptions of immatures are available.

### *New species*

*Corethrella (Corethrella) pindorama* Amaral & Pinho sp. nov.

[urn:lsid:zoobank.org:act:588B1BA0-A51D-4889-B3C4-76DE9118C8DE](https://zoobank.org/act:588B1BA0-A51D-4889-B3C4-76DE9118C8DE)

Fig. 4

### Diagnosis

#### Female adult

Only extant species with the following combination of characters: coronal suture elongate, reaching ventral margin of interocular space (Fig. 4B); posterior anepisternum undivided, dorsoventrally elongate; mediotergite pale with a dorsal dark spot; plain wings with narrow scales on non-marginal veins (Fig. 4J); halter distinctly lighter than scutellum (Fig. 4G). Male unknown.

### Etymology

The specific epithet – *pindorama* – is a Tupi-Guarani word regarded as the original name of the Brazilian region.

### Material examined

#### Holotype

BRAZIL – Bahia State • ♀, adult; Lençóis, Trilha Ribeirão do meio; 12°34'26" S, 41°23'28" W; 395 m a.s.l.; 19 Aug. 2019; A.P. Amaral leg.; frog-call trap (*Bokermannohyla oxente*); MZUSP.

#### Paratypes

BRAZIL – Santa Catarina State • 2 ♀♀, adults; Santo Amaro da Imperatriz, Plaza Caldas; 27°44'30" S, 48°48'07" W; 460 m a.s.l.; 31 Jan. 2013; A. Ambrozio-Assis leg.; frog-call trap (*Boana bischoffi*); CE-MHS.

### Description

#### Female adult (n = 3)

HEAD (Fig. 4A). Medium brown. Outline nearly circular in anterior view, about 1.3 times as wide as long. Coronal suture complete, reaching ventral margin of interocular space. Clypeus (Fig. 4B) wide, 1.27 times as wide as long, 3–6 dorsal setae of equal thickness. Mandibles serrate. Palpus (Fig. 4C) of same color as head, third segment clavate, about 1.2 times length of fifth. Antenna uniformly dark brown (Fig. 4D), with flagellomeres (Fig. 4E) I–III elongate. Flagellomere XIII apically bifurcated. Sensilla coeloconica distribution: 1(X–XIII), 3(I). **Sensilla:** Ocular row with 1 thick offset seta at ventral part, 11–12 more dorsally, extending posteriorly just beyond vertex. Subocular row with about 14 setae,

posteriorly past ocular row. Postgenal row with about 7 slender setae, from posterior end of ocular row to ventromedial portion. With 1 thick ventromedial seta.

THORAX (Fig. 4F–G). Medium brown, with following sclerites pale: anterior and posterior anepisterna, dorsal and ventral portions of anepimeron, ventral mediotergite, dorsal portion of metepisternum. Dorsal portions of anterior anepisternum and of mediotergite with dark spots. Prescutal suture elongate, almost reaching dorsocentral row of setae. Anterior anepisternum divided longitudinally by sinuous suture. Posterior anepisternum undivided, dorsoventrally elongate. **Sensilla** (Fig. 4H): Anteprenotum with 0–1 intermediate anterolateral seta and 4–5 slender ones along ventrolateral margin. Postpronotum with 1 thick and 3–5 slender dorsal setae. Scutum, prescutal area with 2 thick setae dorsoventrally aligned on posterior portion, 2–3 thick anteroventral setae, and 4–6 intermediate/slender setae scattered between them. Antealar area, anterior portion with 4–6 thick/intermediate setae loosely aligned dorsoventrally; 3–4 thick posterior setae, 20–24 slender setae spread from ventral to dorsal portions. Supraalar area with 3 thick anteroposteriorly aligned setae, 4–5 slender setae surrounding. Dorsocentral row, posterior portion with 2 thick and 1 slender offset setae; 19–27 thick/intermediate and 17–27 slender setae filling row. Scutellum with 8 thick setae. Posterior anepisternum with 3–4 slender setae at dorsal portion. Anepimeron with 1 intermediate and 0–1 slender seta centrally located.

WING (Fig. 4I–J). Greyish-brown, without pattern of pigmentation. Non-marginal veins with very narrow scales, resembling thick setae. Apex of  $R_2$  basal to apex of  $M_1$ . Halter lightly pigmented, distinctly lighter than scutellum.  $R_3/R_1$ : 0.64 (0.60–0.69);  $R_{2+3}/R_2$ : 0.43 (0.29–0.56).

LEGS (Fig. 4F). Medium brown. Mid-, hind trochanters pale. Apical 0.3 of hind femur, very base of hind tibia more lightly pigmented. Knees of midleg pale. Legs without scales. Midleg tarsomeres 1–3 with thick subapical setae. Tarsal claws of each leg equal to those of others; equal on each leg, simple. Empodium (Fig. 4K) thick, of intermediate length, with 7 multifid branches.  $Ta1/Ta2$ : 2.91 (2.76–3.08);  $Ta3/Ta4$ : 1.16 (1.18–1.20).

ABDOMEN (Fig. 4L). Uniformly medium/dark brown.

#### Male and immatures

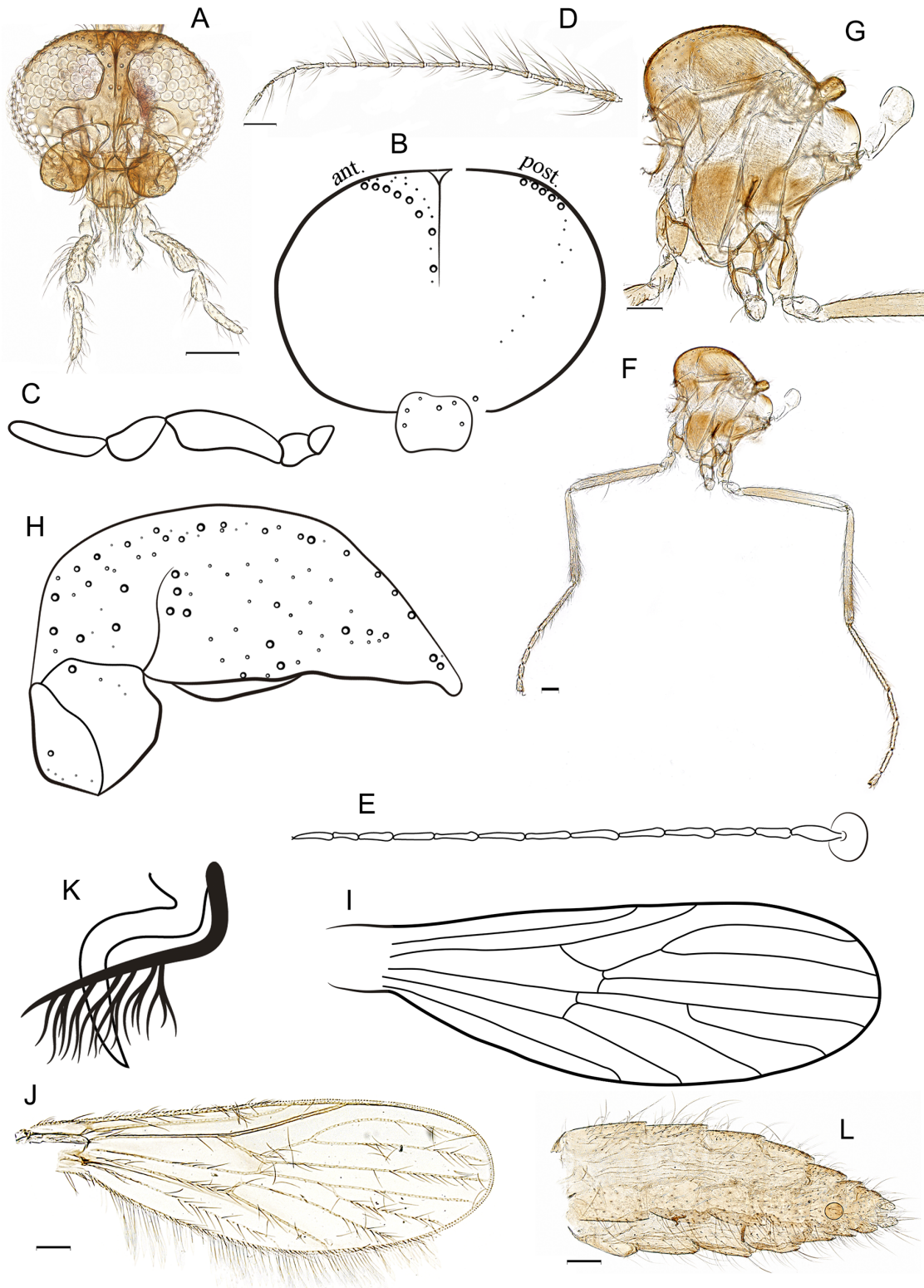
Unknown.

#### Distribution and biology

This species is known from the female holotype, collected at 395 m a.s.l. in Lençóis municipality in Chapada Diamantina National Park, Bahia, and two female paratypes collected in Santa Catarina. The holotype was collected by the margin of a brook, using a frog-call pan trap playing the call of *Bokermannohyla oxente* Lugli & Haddad, 2006, a hylid frog endemic to the locality. The specimens from Santa Catarina were also collected via frog-call, playing the call of another hylid, *Boana bischoffi* (Boulenger, 1887). The attraction to frog calls and the serrate mandibles suggest this species feeds on frog blood in nature. Attempts to collect immatures at the brook in Bahia were unsuccessful.

#### Remarks

*Corethrella pindorama* sp. nov. belongs to the well-supported *rotunda* group, established by Borkent (2008). The synapomorphies supporting the group shared by this species include the undivided posterior anepisternum, and wings and legs without patterns of dark pigmentation. The apex of wing vein  $R_2$  basal to the apex of  $M_1$ , the elongate coronal suture, wing veins without setae, flagellomeres I–IV elongate and an elongate palpus segment III suggest *C. pindorama* is sister to *C. rotunda* Borkent, 2008, or sister to *C. rotunda* plus the remaining species of the group. *Corethrella pindorama* can be promptly differentiated from *C. rotunda* by its elongate coronal suture, patterned thorax, pale halter and the thick, multifid empodium. The empodium is similar to those found in *C. xokleng* and *C. yucuman*.



**Fig. 4.** *Corethrella pindorama* sp. nov., female adult, holotype (MZUSP). **A.** Head in anterior view. **B.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **C.** Left palpus, lateral view. **D.** Flagellomeres, lateral view. **E.** Flagellomeres and pedicel, lateral view. **F.** Thorax and legs, lateral view. **G.** Detail of thorax, lateral view. **H.** Thoracic setae, lateral view. **I.** Wing veins. **J.** Wing. **K.** Hind leg claw and empodium, lateral view. **L.** Abdomen, dorsal view. Scale bars: 0.1 mm.

***Corethrella (Corethrella) bifida* Amaral & Pinho sp. nov.**  
[urn:lsid:zoobank.org:act:36201EFD-D177-4606-9EF9-5DCEA6420FF1](https://zoobank.org/urn:lsid:zoobank.org:act:36201EFD-D177-4606-9EF9-5DCEA6420FF1)

Figs 5–7

### Diagnosis

#### Male and female adult

Only extant species of *Corethrella* with the following combination of characters: plain wing (Fig. 5F); thorax uniformly medium brown (Fig. 5D); ventral portion of posterior anepisternum triangular-shaped (Fig. 5D); uniformly brown legs, except for the hind femur with about the basal 0.7 pale, trochanter of foreleg and base of forefemur equally pigmented (Fig. 5E); empodia short, slender and Y-shaped (Fig. 6E).

#### Larva

Only extant species with the following combination of characters: darkly pigmented tergal plates (Fig. 7A); a darkly colored mandibular lobe; most of head, segment X and siphon darkly colored (Fig. 7C), but postmentum pale (Fig. 7A); crown with 13–14 short spines (shorter than 0.05 mm) evenly spaced (Fig. 7B).

#### Pupa

Only extant species with the following combination of characters: a flattened, wide, trilobed respiratory organ (Fig. 7E); a strongly tapered and short abdomen, with paddles short and narrow; abdominal margins moderately expanded posterolaterally, with lateral setae well-developed, longer than each segment (Fig. 7F).

### Etymology

The specific epithet – *bifida* – refers to the bifid empodium of the adults of this species.

### Material examined

#### Holotype

BRAZIL – **Santa Catarina State** • ♂, adult, with pupal and larval exuviae; Palhoça, PEST, Lago da sede; 27°50'36" S, 48°37'25" W; 7 m a.s.l.; 29 Jun. 2013; A.P. Amaral *et al.* leg.; hand net; MZUSP.

#### Allotype

BRAZIL – **Santa Catarina State** • ♀, adult, with pupal and larval exuviae, same collection data as for holotype, except 28 Oct. 2013; V. Freitas leg.; MZUSP.

#### Paratypes

BRAZIL – **Santa Catarina State** • 1 ♀, adult, with pupal and larval exuviae; same collection data as for allotype; CE-MHS • 1 ♂, adult, with pupal and larval exuviae; same collection data as for allotype; CE-MHS • 1 ♀, adult, with pupal and larval exuviae; Santo Amaro da Imperatriz, Pagará, Colônia Santa Luzia; 27°38'31" S, 48°45'17" W; 51 m a.s.l.; 12 Feb. 2016; Pinho, Amaral and Scarpa leg.; hand net in pond; CE-MHS. – **Bahia State** • 1 ♀, adult, with pupal and larval exuviae; Maracás, Fazenda Regi Flores; 13°27'03" S, 40°20'24" W; 856 m a.s.l.; 7 Jun. 2019; A.P. Amaral leg.; hand net in pond; CE-MHS.

### Description

#### Male adult (n = 2)

HEAD (Fig. 5A). Medium/dark brown. Outline in anterior view laterally elongate, about 1.45–1.53 times as wide as long. Coronal suture complete, reaching ventral margin of interocular space. Clypeus (Fig. 5B) squarish, 1.00–1.17 as wide as long, with 19 intermediate thickness setae. Palpus (as Fig. 6A) as dark

as head, third segment swollen at midlength, 1.3 times length of fifth. Antenna: pedicel medium brown, flagellum uniformly medium brown, flagellomeres (as Fig. 6B) I very elongate, II and III moderately elongate; flagellomere XIII apically bifurcated. Sensilla coeloconica distribution: 1(II, VII–XIII), 4(I). **Sensilla** (Fig. 6C): Ocular row with 2 thick offset setae at ventral part, almost lateral to one another, and 7–9 thick setae extending shortly beyond vertex. With subocular row of 8–10 slender setae. Postgenal row with 7–8 slender setae, ranging from mid-posterior to ventrolateral portions. With 1 ventromedial thick seta.

THORAX (Fig. 5D, E). Uniformly medium brown. Prescutal suture very short. Anterior anepisternum divided longitudinally by sinuous suture. Posterior anepisternum divided by a diagonal suture, inferior portion triangular with anterodorsal margin thick. **Sensilla** (Fig. 6D): Antepronotum with 0–3 slender anterior setae. Postpronotum with 1 thick dorsal and 1 intermediate seta more posteriorly. Scutum, prescutal area with 1 thick ventral seta, 2 intermediate ones dorsally, 2 intermediate more anteriorly. Antealar area, with cluster of 3–4 thick and 5–7 intermediate setae on posteroventral portion. Supraalar area with 2 thick, 1 intermediate and 3–4 slender setae on ventral portion. Dorsocentral row, posterior part with 5 thick offset, longitudinally aligned setae; 8–12 thick and about 19–27 intermediate/slender setae filling row. Scutellum with 10–12 thick setae. Posterior anepisternum with 1–2 slender setae at dorsal part. Anepimeron 5–8 slender setae located middorsally.

WING (Fig. 5C, F). Medium brown, somewhat reddish. non-marginal veins with well-developed scales. Without pattern of pigmentation. Apex of  $R_2$  equal to apex of  $M_1$ . Halter as pigmented as scutellum.  $R_3/R_1$ : 0.61–0.65;  $R_{2+3}/R_2$ : 0.43–0.50.

LEGS (Fig. 5E). Medium brown, with hind femur basal 0.7 lighter. Tibiae, femora with well-developed scales. Midleg tarsomeres 1–3 with thick subapical setae. Apices of fore-, midtarsi bilobed. Tarsal claws of foreleg and midleg unequal, midleg ones largest, hind claws shortest. Empodium (Fig. 6E) short, slender, with 1 branch.  $Ta1/Ta2$ : 2.66–2.84;  $Ta3/Ta4$ : 1.20–1.25.

ABDOMEN. Uniformly medium brown.

GENITALIA (Fig. 5G, I). Gonocoxite pigmented, ovate; without distinctively elongate spicules on anteromedial area; dorsal row well-defined, with 5 thick setae restricted to dorsal region, 3 anterior ones with apex flattened and expanded, 2 posterior more slender; with 2 dorsomedial stout setae, anterior seta bolder, tapering at apex, located at 0.60–0.64 from base; both setae with elongate filamentous apex and united basally by sclerotized plate. Gonostylus thick, with constant width, subbasal seta simple and elongate, ventrally located; apical seta short and simple. Aedeagus (Fig. 5H) squat, with wide base, margins fused at apex.

#### **Female adult** (n = 4)

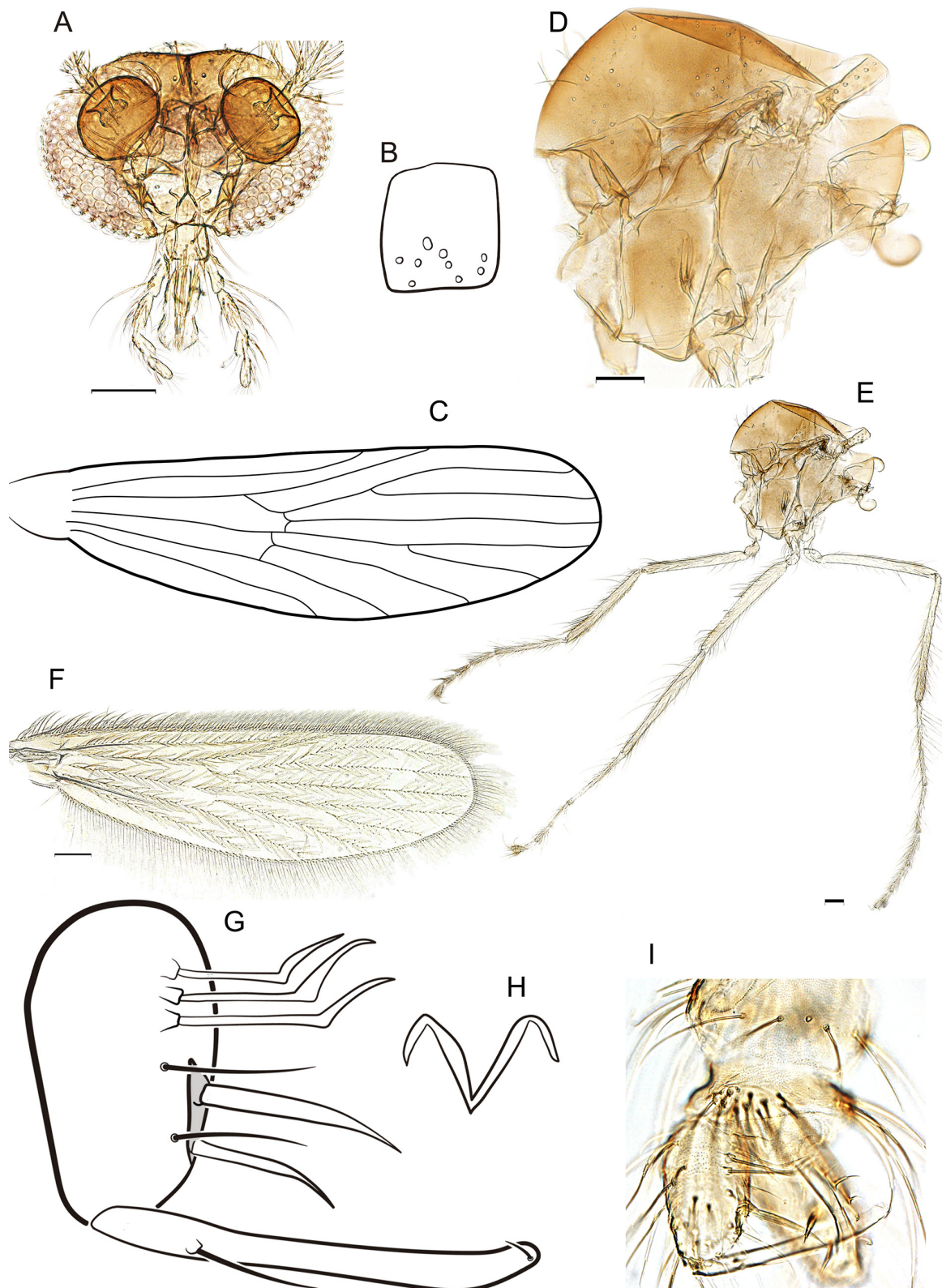
As for male, except:

HEAD (Fig. 6F). Clypeus (Fig. 6C) 1.17 (1.13–1.29) times as wide as long, with 12–15 dorsal setae, 3 central ones thickest. Mandibles serrate. Antenna as in Fig. 6G. Sensilla coeloconica distribution: 1(II, VI–XIII), 4(I).

WING (Fig. 6H–I).  $R_3/R_1$ : 0.78 (0.76–0.80);  $R_{2+3}/R_2$ : 0.33 (0.30–0.35).

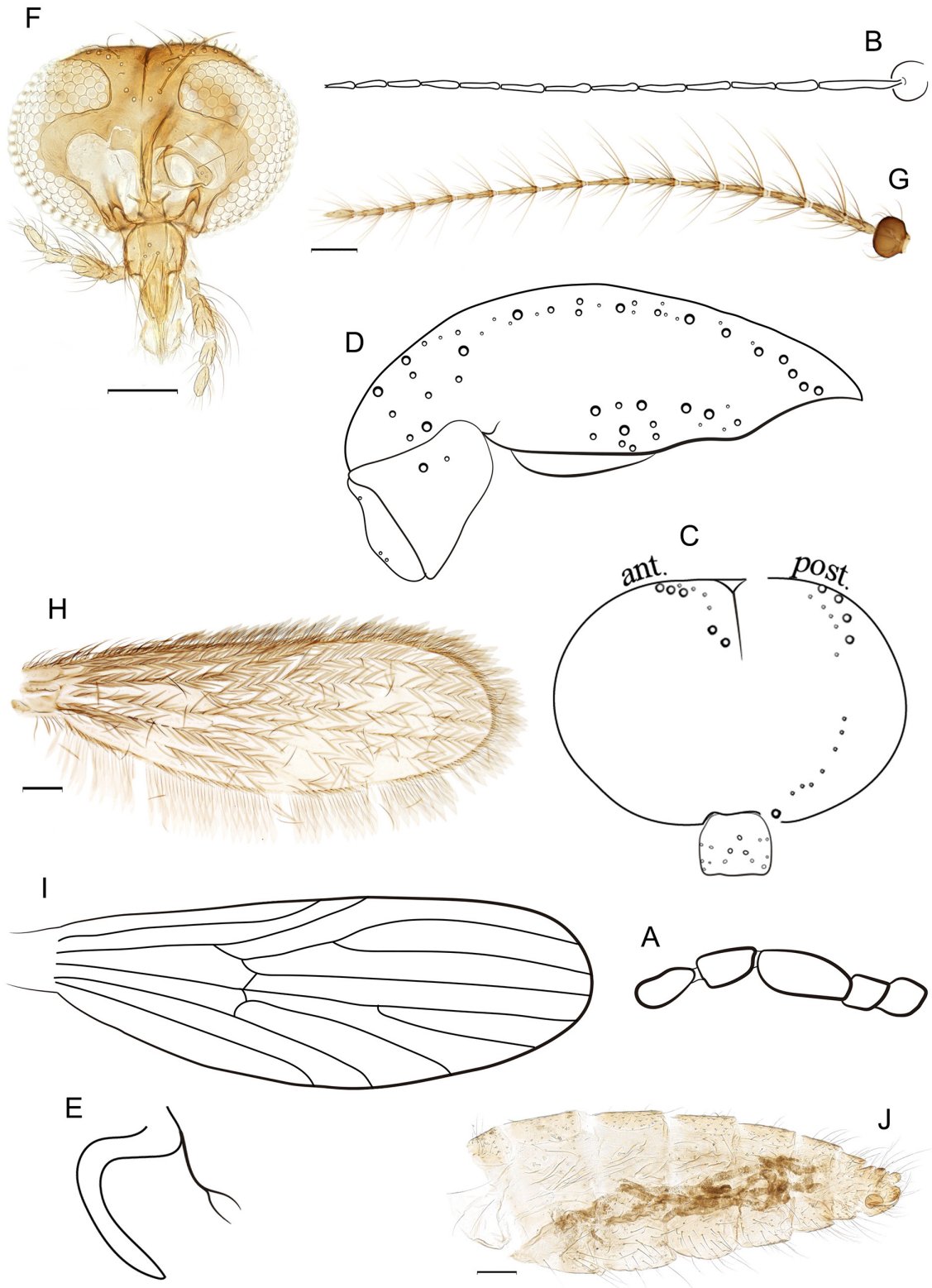
LEGS. Tarsi undivided; tarsal claws of each leg equal to those of others; equal on each leg, simple.  $Ta1/Ta2$ : 2.76 (2.64–2.84);  $Ta3/Ta4$ : 1.25 (1.18–1.32).

ABDOMEN (Fig. 6J). Uniformly medium brown.



**Fig. 5.** *Corethrella bifida* sp. nov., male adult, holotype (MZUSP). **A.** Head, anterior view. **B.** Clypeus, anterior view. **C.** Wing veins. **D.** Detail of thorax, lateral view. **E.** Thorax and legs in lateral view. **F.** Wing. **G.** Gonocoxite and gonostylus, dorsal view. **H.** Aedeagus, dorsal view. **I.** Genitalia, dorsal view. Scale bars: 0.1 mm.





**Fig. 6.** *Corethrella bifida* sp. nov., female adult, allotype (MZUSP). A. Left palpus, lateral view. B. Flagellomeres and pedicel, lateral view. C. Cranial setae, anterior and posterior views, and clypeus in anterior view. D. Thoracic setae, lateral view. E. Hind leg claw and empodium, lateral view. F. Head, anterior view. G. Antenna, lateral view. H. Wing. I. Wing veins. J. Abdomen, lateral view. Scale bars: 0.1 mm.

**Larva** (n = 6)

EXUVIA (Fig. 7A). Head, segment X, siphon dark brown; postmentum, ventral part of gena pale; mandibles darker than cranial sclerites. With dark brown tergal plates on abdominal segments I–VII.

HEAD (Fig. 7B). Elongate triangular shape in dorsoventral view, 1.20 (1.17–1.25) times as wide as long. Antenna 0.56 (0.50–0.57) times length of head; antennal groove 1.45 (1.31–1.68) times length of antenna; ventral margin of antennal groove with about 5 large denticles. Postmentum with base wide, strongly tapering, 1.84 (1.76–1.90) times as wide as long; 0.33 (0.30–0.35) times length of head. Prementum straight, with 13 triangular-shaped teeth, darkly pigmented, central one largest, remaining gently decreasing in size. Anteroventral projection of gena slightly projecting anteriorly, with anterior margin flat, surface irregular. Postcoila short, not extending to lateral margin of gena. Subgenal carina with smooth surface. Crown with 13–14 spines, regularly distributed, with two dorsalmost, two ventralmost spines smaller; largest spine 0.04–0.05 mm in length; seta 16-C situated mesially from crown. Mandible with darkly pigmented teeth; apical tooth 1.69 (1.50–1.88) times length of first dorsal tooth; seta 3-Mn 0.25 (0.22–0.29) times length of 4-Mn; lacinia mobilis with 7 blades; mandibular lobe well-developed, darkly pigmented, apart from teeth. **Sensilla**: 9-C moderately elongate, bifurcated; 10-C elongate, simple; 11-C short, fan-like; 12-C elongate, simple; 13-C short, fan-like; 14-C short, simple, thick; 15-C short, fan-like; 16-C elongate, simple. 0a-Mn short, simple; 0b-Mn elongate, simple. 6-Mx short, forked; 4-Mx short, fan-like; 5-Mx moderately elongate, fan-like.

SIPHON (Fig. 7C). 0.24 mm (0.20–0.27) long; seta 1 forked, situated at 0.28 (0.21–0.37) of length from base; 6-S, 9-S lightly pigmented; length of 6-S/9-S: 0.86 (0.84–0.88).

**Pupa** (n = 6)

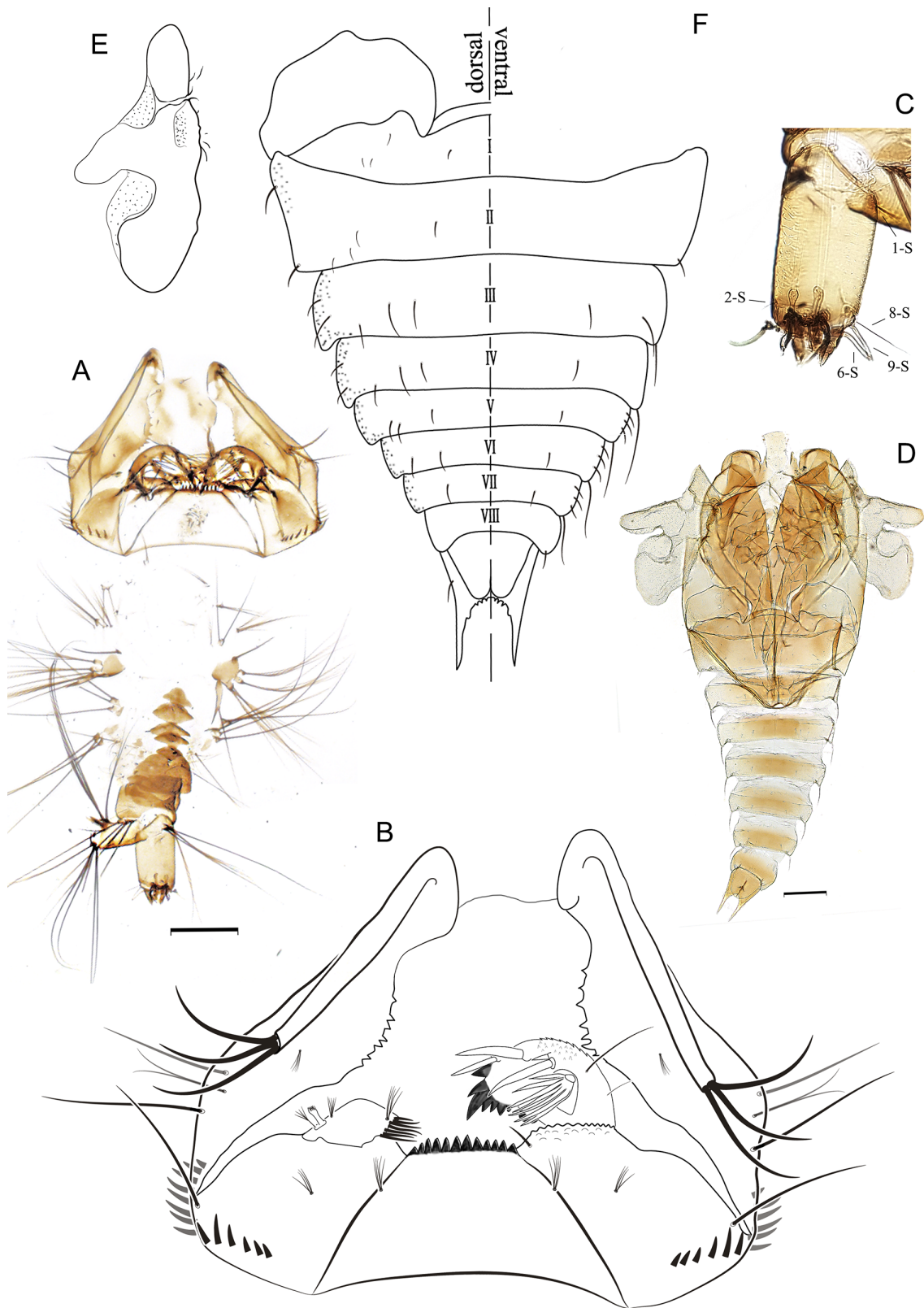
EXUVIA (Fig. 7D). Medium brown, with medial portion of abdominal segments II–VII darker; all setae lightly pigmented.

CEPHALOTHORAX. Length 1.12 mm (1.03–1.22). Respiratory organ (Fig. 7E) flattened, wide and trilobed, 0.74 mm (0.65–0.85) long longitudinally. Dorsal seta 1 short, thick, about two lengths from dorsal 2; dorsal seta 2 slender, about two times as long; both setae arising from undifferentiated cuticle. Sensilla supraalar 2, metathoracic 1–2 absent.

ABDOMEN (Fig. 7F). Short and strongly tapered posteriorly, integument rough laterodorsally; length of segments I–VIII 0.86 mm (0.78–0.94); width/length: 0.91 (0.87–0.97). Margins smooth, moderately expanded laterally, somewhat posteriorly. Setae D-2 short, about half length of respective segments, subequal from II–VII. Lateral setae L-4 long, thick from II–VII, largest on IV, 1.11 (0.99–1.28) times as long as segment. Terminal process short, basal width 0.66 (0.62–0.72) times length, with narrow paddles; D-1-IX short, located at about 0.45 from base; apical spine not articulated; lacking a ventroapical seta V-1-IX; female genital lobe tapering, occupying most of basal portion, male ovate, slightly extending beyond base. Chaetotaxy as illustrated.

**Distribution and biology**

All specimens studied were collected as immatures in ponds, at altitudes ranging from 6 to 856 m a.s.l. In Santa Catarina State, the locations comprised an area of sandy coastal vegetation (restinga) in Palhoça municipality and a small farm in Santo Amaro da Imperatriz. In Bahia, Maracás municipality, it consisted of an area of transition between rainforest (Atlantic forest biome) and xeric shrubland (caatinga biome). These data suggest a preference for oviposition in open areas, which should be confirmed with further collections. The serrate mandibles of females indicate they feed on frog blood in nature.



**Fig. 7.** *Corethrella bifida* sp. nov., larva and pupa. **A.** Larval exuvia, ventral view. **B.** Exuvia of larval head, ventral view, except mandible in dorsal view. **C.** Siphon of larva, dorsal view. **D.** Pupal exuvia, dorsal view. **E.** Pupal respiratory organ, dorsal view. **F.** Pupal metathorax and abdomen, dorsal and ventral views. Scale bars: 0.2 mm.

## Remarks

Males and females from Santa Catarina and Bahia have previously been identified as *Corethrella davisii* Shannon & Del Ponte, 1928 but were later associated through the diagnostic features of the immatures. Adults of *C. bifida* sp. nov. are very similar to those of *C. davisii*, differing in the morphology of the empodia (two branches in *C. davisii*), females without sensilla coeloconica on flagellomeres III and V, and the more distal position of the first dorsomedial seta on male genitalia, which is also the greatest distance from the base recorded for the family (this may require further confirmation, since all examined male genitalia were in poor condition and measurements could have been imprecise). Immatures, in turn, present many distinctive features, such as the pale and relatively more elongate larval postmentum, crown spines in larger number and evenly distributed (ventrally sparse in *C. davisii*), seta 9-C elongate and bifurcate (short and fan-like in *C. davisii*); pupa with a more elongate abdomen, margins expanded posterolaterally, with well-developed lateral setae on segments III–VII.

*Corethrella (Corethrella) patasho* Amaral & Pinho sp. nov.

[urn:lsid:zoobank.org:act:EA912E11-A695-43D2-B216-D329AC579AEE](https://zoobank.org/act:EA912E11-A695-43D2-B216-D329AC579AEE)

Fig. 8

## Diagnosis

### Female adult

Only extant species with the following combination of characters: coronal suture complete (Fig. 8B); ocular row with two thick offset ventral setae (Fig. 8B); flagellomeres I–III moderately elongate (Fig. 8E); flagellomeres XII and XIII each with two sensilla coeloconica; wing with a midlength band of dark scales (not present on  $R_{4+5}$  and CuP); halter as dark as scutellum (Fig. 8G); hind tibia with discrete basal and apical dark pigmentation (Fig. 8F); femora without scales.

### Male

Unknown.

## Etymology

The specific epithet – *patasho* – honors the Pataxó, indigenous people living in the area of the type locality.

## Material examined

### Holotype

BRAZIL – Bahia State • ♀, adult; Porto Seguro, RPPN Estação Veracel, mussununga; 16°21'33" S, 39°08'15" W; 92 m a.s.l.; 30 Aug. 2019; A.P. Amaral leg.; frog-call trap (chorus); MZUSP.

## Description

### Female adult (n = 1)

HEAD (Fig. 8A). Medium brown. Outline in anterior view laterally elongate, about 1.64 times as wide as long. Coronal suture elongate, almost reaching ventral margin of interocular space. Clypeus (Fig. 8B) wide, 1.50 times as wide as long, with 3 dorsal setae of equal thickness. Mandibles serrate. Palpus (Fig. 8C) pale, third segment somewhat swollen subapically, about 0.80 times length of fifth. Antenna (Fig. 8D): pedicel and flagellum uniformly light brown, with flagellomeres (Fig. 8E) I–III moderately elongate. Flagellomere XIII apically bifurcated. Sensilla coeloconica distribution: 1(II, IX–XI), 2(XII–XIII), 4(I). **Sensilla** (Fig. 8B): Ocular row with 2 thick offset setae at ventral part, 1 thick seta more dorsally; 13–15 shortly extending dorsally beyond vertex. Subocular row with 15 slender setae; additionally, a

few slender setae scattered at vertex and interocular space. Postgenal row with 7 slender setae on mid-posterior region. With 2 ventromedial thick setae.

THORAX (Fig. 8F–G). Medium brown, with posterior portion of anepimeron, metepisternum, and sclerites around wing pale. Prescutal suture elongate, ending past halfway to dorsocentral row, interrupted by area of pale cuticle. Anterior anepisternum longitudinally divided by sinuous suture. Posterior anepisternum divided by a diagonal suture, forming a triangle at inferior portion, with anterodorsal margin thick. **Sensilla** (Fig. 8H): Anteprenotum with 2 slender setae near anterodorsal margin, 3 intermediate ventrolateral setae. Postprenotum with 1 thick dorsal, 1 intermediate, and 2 slender more posterior setae. Scutum, prescutal area with 7 intermediate setae grouped anteriorly; medium portion with 3 thick setae loosely aligned dorsoventrally; 2 intermediate and 4 slender setae scattered. Antealar area with 2 thick and 3 slender anterior setae; 4 thick and 4 intermediate more posterior setae forming a U-shape on ventral margin; 19 slender posterodorsal setae. Supraalar area with 2 thick and 5 slender ventral setae. Dorsocentral row, posterior part with group of 5 thick offset setae; about 10 thick, 11 intermediate and 17 slender filling the row. Scutellum with 8 thick setae. Posterior anepisternum bare. Anepimeron with 14–16 slender setae located mid-posteriorly.

WING (Fig. 8I–J). Light/medium brown, with midlength band of dark scales present, except on  $R_{4+5}$  and CuP. Darkest scales on C, apex of Sc,  $R_1$  and  $R_{2+3}$ . Non-marginal veins with narrow scales. Halter as dark as scutellum or slightly lighter.  $R_3/R_1$ : 0.59;  $R_{2+3}/R_2$ : 0.57.

LEGS (Fig. 8F). Medium brown. Apical 0.6 of hind femur paler; hind tibia with discrete basal and apical band of darker pigmentation; apex of tibiae with darker setae; at least hind leg tarsomeres 1–4 banded. Legs without scales. Midleg tarsomeres 1–3 with thick subapical setae. Tarsal claws of each leg equal to those of others; equal on each leg, simple. Empodium (Fig. 8K) of intermediate thickness and length, with 6 branches. Ta1/Ta2: 2.74; Ta3/Ta4: 1.08.

ABDOMEN (Fig. 8L). Medium brown, with segments VIII, IX, and cercus darker.

#### Male and immatures

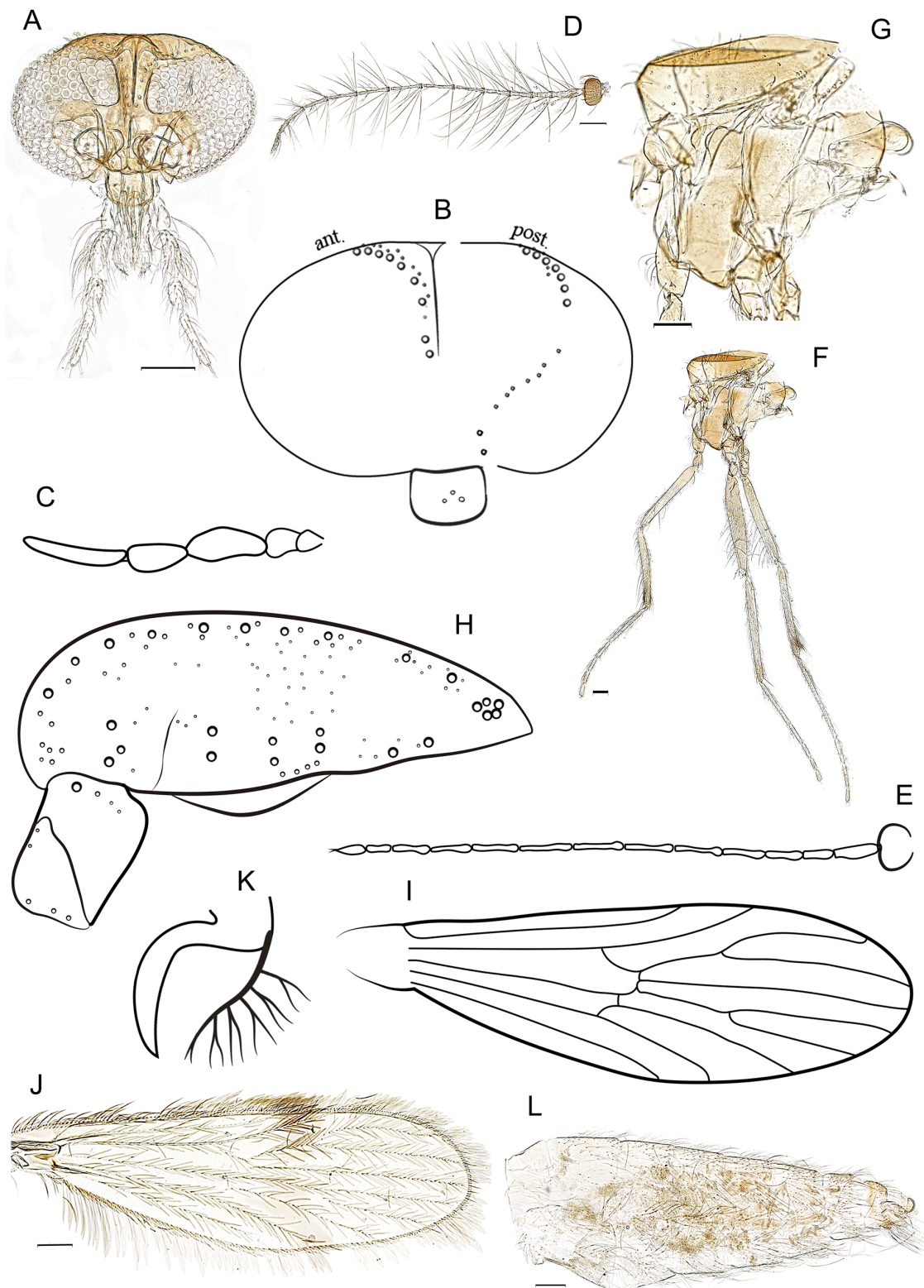
Unknown.

#### Distribution and biology

This species is known only from the single female holotype, collected with a frog-call pan trap playing a frog chorus of Atlantic forest species: *Boana faber* (Wied-Neuwied, 1821); *Physalaemus cuvieri* Fitzinger, 1826, and *P. nanus* (Boulenger, 1888). This suggests that adult females of *C. patasho* sp. nov. feed on frog blood in nature. The type locality is a white-sandy tropical savanna patch inside a fragment of lowland Atlantic forest (mussununga ecosystem) physiognomy in Porto Seguro, Bahia. The altitude recorded was 72 m a.s.l.

#### Remarks

*Corethrella patasho* sp. nov., only known as a female, has the combination of features present in species placed in the clade *guadeloupensis-fulva* (Borkent 2008), which includes having the ocular row with two strong ventral setae (four setae on the ventromedial area of the frons in Borkent's terminology), the clypeus with less than six dorsal setae and the posterior end of the dorsocentral row with a group of more than three setae. This species is similar to *C. aurita* Borkent, 2008, *C. guadeloupensis* Borkent, 2008, and *C. pillosa* Lane, 1939, which, in turn, are very similar to each other. The morphology of the empodia also resembles those of *C. aurita* and *C. pillosa* (unknown for *C. guadeloupensis*), intermediate in size with more than five bifid branches, supporting their close relationship. *Corethrella patasho*, however, differs from these species in having two sensilla coeloconica on each of flagellomeres XII–



**Fig. 8.** *Corethrellapatasho* sp. nov., female adult, holotype. **A.** Head, anterior view. **B.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **C.** Left palpus, lateral view. **D.** Antenna, lateral view. **E.** Flagellomeres and pedicel, lateral view. **F.** Thorax and legs, lateral view. **G.** Detail of thorax, lateral view. **H.** Thoracic setae, lateral view. **I.** Wing veins. **J.** Wing. **K.** Hind leg claw and empodium, lateral view. **L.** Abdomen, lateral view. Scale bars: 0.1 mm.

XIII, a medium brown thorax with the halter as pigmented as the scutellum, and a midlength wing band without dark scales on R<sub>4+5</sub>.

*Corethrella (Corethrella) fuscifimbria* Amaral & Pinho sp. nov.

urn:lsid:zoobank.org:act:26B5C6CC-46FD-49D9-A1F3-DABA9BBBFB19

Fig. 9

## Diagnosis

### Female adult

Only extant species with the following combination of characters: clypeus squarish, bearing 2–3 setae (Fig. 9B); a complete coronal suture (Fig. 9B); thorax dark brown (Fig. 9G); wings with midlength band of dark scales on all veins and a band of dark scales on apex (Fig. 9J); halter pale (Fig. 9G); hind tibia with discrete apical and basal band of dark pigmentation (Fig. 9F); femora without scales; empodia with 4 branches; and abdominal segments I–VII uniformly pigmented (Fig. 9L).

### Male

Unknown.

## Etymology

The specific epithet – *fuscifimbria* – (from Latin, ‘*fuscus*’ = ‘dark’; ‘*fimbria*’ = ‘fringe’) is a reference to the dark scales on the apex of the wings.

## Material examined

### Holotype

BRAZIL – Bahia State • ♀, adult; Rio de Contas, Parque Natural Serra das Almas, “Brejo do junco” [reed marsh]; 13°32′19″ S, 41°52′36″ W; 1202 m a.s.l.; 3 Dec. 2019; A.P. Amaral leg.; frog-call trap (chorus); slide-mounted; MZUSP.

### Paratypes

BRAZIL – Bahia State • 3 ♀♀, adults; same collection data as for holotype; CE-MHS • 1 ♀, adult; same collection data as for holotype, except 2 Dec. 2019; CE-MHS • 2 ♀♀, adults; Rio de Contas, RPPN Volta do Rio, streamside; 13°32′07″ S, 41°54′44″ W; 1318 m a.s.l.; 1 Dec. 2019, A.P. Amaral leg.; frog-call trap (*Boana faber*); CE-MHS • 3 ♀♀, adults; same collection data as for holotype, except Vale do Queiroz, “mata de galeria” [riparian woodland]; 13°31′28″ S, 41°57′24″ W; 1579 m a.s.l.; 30 Nov. 2019; CE-MHS.

## Description

### Female adult (n = 10)

HEAD (Fig. 9A). Dark brown. Outline in anterior view moderately laterally elongate, about 1.39 (1.30–1.59) times as wide as long. Coronal suture complete, reaching ventral margin of interocular space. Clypeus (Fig. 9B) square to slightly wide, 1.24 (1.11–1.43) times as wide as long, with 2–3 dorsal setae of equal thickness. Mandibles serrate. Palpus (Fig. 9C) slightly less pigmented than head, third segment with constant width, about 0.8 times length of fifth. Antenna (Fig. 9D): pedicel and flagellum uniformly dark brown, flagellomeres (Fig. 9E) I–III elongate. Flagellomere XIII apically bifurcated. Sensilla coeloconica distribution: 1(II, [VIII], IX–XIII), 4(I). **Sensilla** (Fig. 9B): Ocular row with 1 ventral, 1 more dorsal, and 13–16 thick setae from vertex to mid-posterior portion; without well-defined subocular row, few setae on vertex; postgenal row with 6–9 intermediate and about 6 slender setae on mid-posterior portion. With 2 ventromedial thick setae.

THORAX (Fig. 9F–G). Dark brown, with ventral portion of anepimeron and sclerites around wing pale. Prescutal suture elongate, almost reaching dorsocentral row of setae. Anterior anepisternum longitudinally divided by sinuous suture. Posterior anepisternum divided by a diagonal suture, forming a triangle at inferior portion, with thick anterodorsal margin. **Sensilla** (Fig. 9H): Anteprepronotum with 2 anterodorsal and 7–8 lateroventral slender setae. Postprepronotum with 1 thick dorsal, 1 intermediate, and 2–6 slender setae more posteriorly. Scutum, prescutal area with about 9–13 slender/intermediate setae anteriorly grouped; 2 thick and 1 intermediate setae near prescutal suture, dorsoventrally aligned; 8–13 scattered slender/intermediate setae. Antealar area with 4–5 thick/intermediate setae dorsoventrally aligned anteriorly, 7–9 thick/intermediate setae more posteriorly, forming a U-shape; 15–18 slender setae spread from ventral to dorsal portion. Supraalar area with 2–3 thick setae aligned longitudinally, 8–13 slender ones surrounding; 3–5 intermediate setae more anteriorly. Dorsocentral row, posterior portion with group of 4–6 thick offset setae; 17–24 thick/intermediate and 21–34 slender setae completing row. Scutellum with 8–10 thick setae. Posterior anepisternum bare. Anepimeron with 9–11 slender setae.

WING (Fig. 9I, J). Light brown, with midlength band of dark scales present on all veins. With darker scales on apex, anterobasal region and posterobasal margin. Non-marginal veins with narrow scales. Halter pale.  $R_3/R_1$ : 0.55 (0.50–0.58);  $R_{2+3}/R_2$ : 0.61 (0.53–0.74).

LEGS (Fig. 9F). Dark brown. Hind tibia with discrete basal and apical pigmentation. Mid- and foretibiae apically darker. Tarsi uniformly light brown. Legs without scales. Midleg tarsomeres 1–3 with thick subapical setae. Tarsal claws of each leg equal to those of others; equal on each leg, simple. Empodium (Fig. 9K) slender, of intermediate length, with 4 branches.

ABDOMEN (Fig. 9L). Medium to dark brown, with segments VIII, IX, and cercus darker.

#### Male and immatures

Unknown.

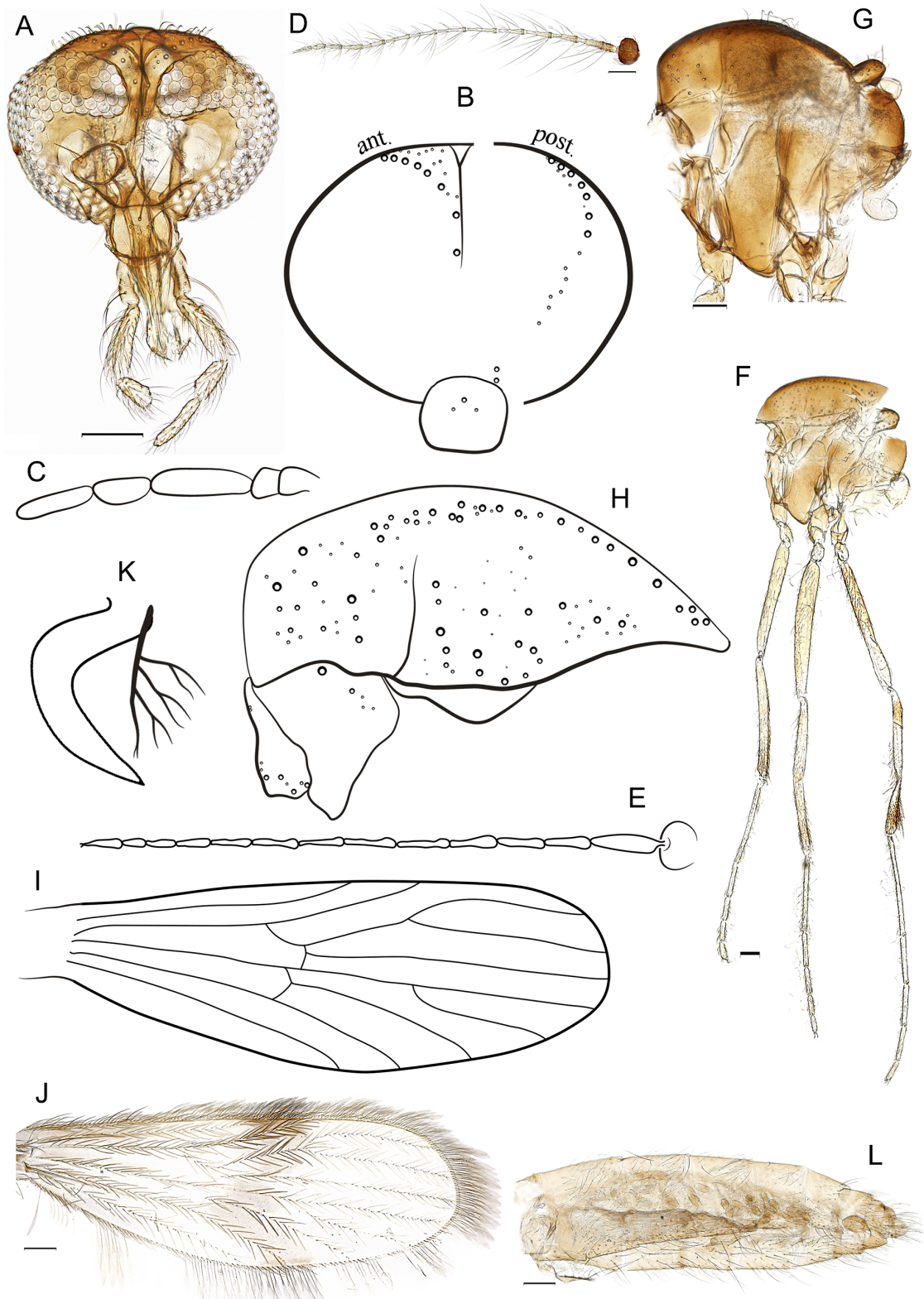
#### Distribution and biology

Adult *Corethrella fuscifimbria* sp. nov. were collected with frog-call pan traps (playing a chorus of *Boana faber*, *Physalaemus cuvieri* and *P. nanus*) in Rio de Contas municipality, Bahia, at altitudes ranging from 1202 to 1579 m a.s.l. in a large marsh area and in a streamside forest. Rio de Contas is located in the Espinhaço mountain range, a national hotspot for conservation, home to many endemic species. Even though the specimens were captured in large numbers with sound traps, attempts to collect immatures were unsuccessful. The attraction to frog-call traps and the serrate mandibles of females indicate that they feed on frog blood.

#### Remarks

The specimens of *C. fuscifimbria* sp. nov. keyed to *C. orthicola* Borkent, 2008 in Borkent (2008), but differed from it in the length of the coronal suture (short in *C. orthicola*), distribution of sensilla coeloconica (*C. orthicola* with one sensillum on each of flagellomeres I–II, VII–XIII), pigmentation pattern of the thorax, pigmentation of sternites I–II (darker than the remainder of sternites in *C. orthicola*), and the presence of an apical band on the wing, the latter being a synapomorphy of the *brakeleyi* species group. In fact, *C. fuscifimbria* is very similar to *C. ranapungens* Borkent, 2008, which belongs to the *brakeleyi* group, differing only by the lighter pigmentation of the halteres, the discrete pigmentation on the hind tibia, and the empodia with 4 branches (2 in *C. ranapungens*; Fig. 36C). Collections near the type locality retrieved four specimens of *C. ranapungens* which precisely fit the species description, enabling the comparison and distinction of *C. fuscifimbria*, which would be otherwise problematic due to the somewhat subtle differences between these two species. Borkent (2008) pointed out that *C. ranapungens* was strikingly variable and likely the name represented more than one species.





**Fig. 9.** *Corethrella fuscifimbria* sp. nov., female adult, holotype (MZUSP). A. Head, anterior view. B. Cranial setae, anterior and posterior views, and clypeus in anterior view. C. Left palpus, lateral view. D. Antenna, lateral view. E. Pedicel and flagellomeres, lateral view. F. Thorax and legs, lateral view. G. Detail of thorax, lateral view. H. Thoracic setae, lateral view. I. Wing veins. J. Wing. K. Hind leg claw and empodium. L. Abdomen, lateral view. Scale bars: 0.1 mm.

*Corethrella (Corethrella) unifasciata* Amaral & Pinho sp. nov.  
[urn:lsid:zoobank.org:act:D7FA15EB-7CA2-4A0E-8492-E0A5820D6590](https://urn.lsid:zoobank.org:act:D7FA15EB-7CA2-4A0E-8492-E0A5820D6590)

Fig. 10

## Diagnosis

### Female adult

Only extant species with the following combination of characters: most of the thorax pale, with katepisternum, mediotergite, ventral portion of posterior anepisternum and anterodorsal region of anepimeron more darkly pigmented (Fig. 10G); hind tibia pale with darker apical band (Fig. 10F).

## Etymology

The specific epithet – *unifasciata* – (from Latin, ‘*uno*’ = ‘one’; ‘*fascia*’ = ‘band’) is a reference to the pigmentation of the hind tibia, also present in related species.

## Material examined

### Holotype

BRAZIL – Bahia State • ♀, adult; Porto Seguro, RPPN Estação Veracel, “trilha escolar” [educational trail]; 16°23'10" S, 39°10'11" W; 89 m a.s.l.; 28 Aug. 2019; A.P. Amaral leg.; frog-call trap (chorus); MZUSP.

### Paratype

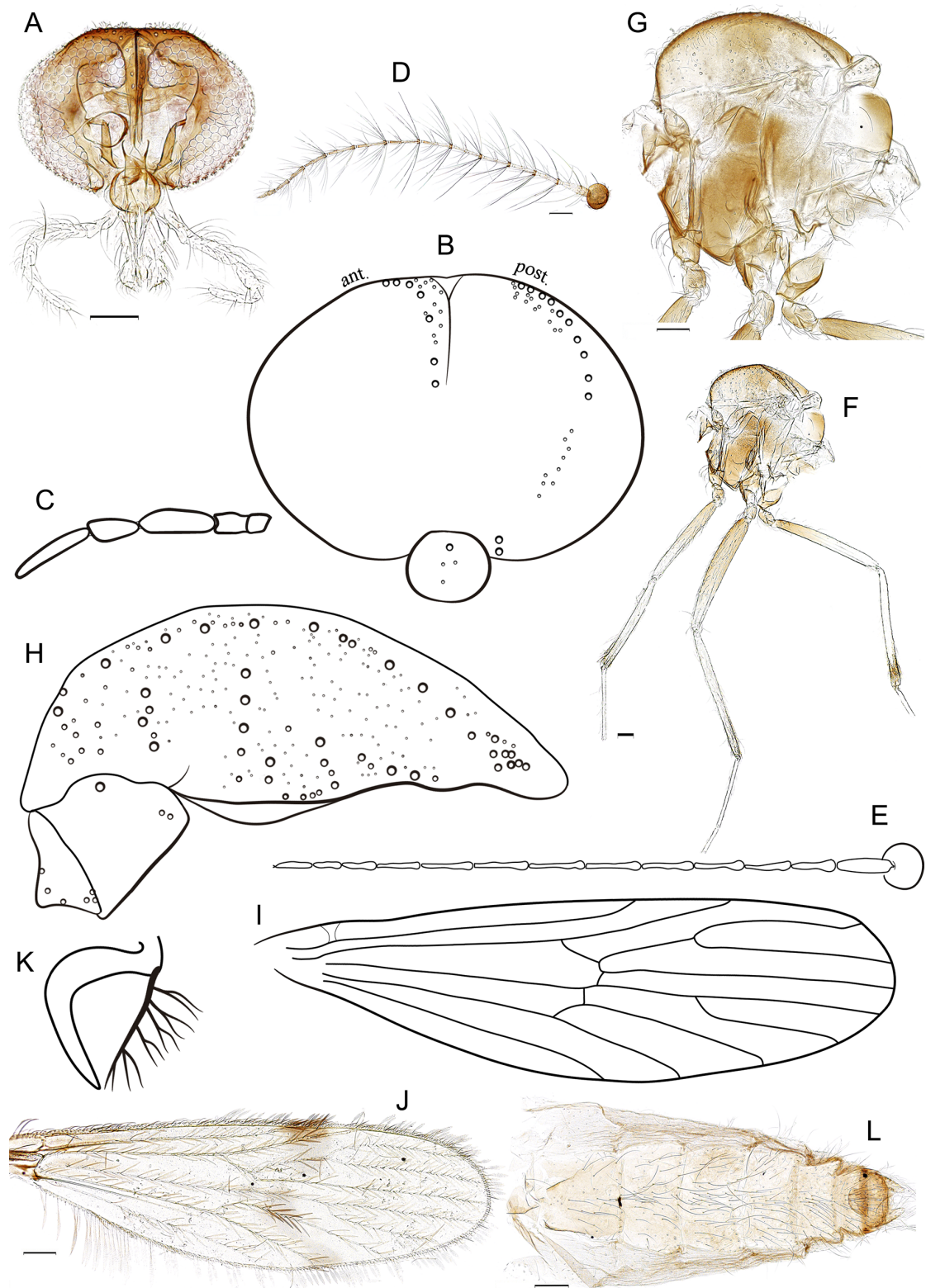
BRAZIL – Bahia State • 1 ♀, adult; same collection data as for holotype, except mussununga; 16°21'33" S, 39°08'15" W; 72 m a.s.l.; 30 Aug. 2019; CE-MHS.

## Description

### Female adult (n = 2)

**HEAD** (Fig. 10A). Medium brown. Outline in anterior view laterally elongate, 1.41–1.45 times as wide as long. Coronal suture complete, reaching ventral margin of interocular space. Clypeus (Fig. 10B) wide, 1.15–1.27 times as wide as long, somewhat rounded, with 1 thick dorsal seta and 2–3 slightly less thick ones. Mandibles serrate. Palpus (Fig. 10C) pale, third segment with constant width, of about same length as fifth. Antenna (Fig. 10D): pedicel dark brown, flagellum pale from I–VII, dark brown from VIII–XIII; flagellomeres (Fig. 10E) I–III elongate. Flagellomere XIII with apical bifurcation. Sensilla coeloconica distribution: 1(II–III, VIII–IX, XII–XIII), 2([IX], X–XI, [XII]), 4(I). **Sensilla** (Fig. 10B): Ocular row with 2 thick offset setae at ventral part, 15–19 ones more dorsally, extending posteriorly to midlength. Without well-defined subocular row; vertex with numerous slender setae. Postgenal row with 9–10 intermediate setae, restricted to mid-posterior region. With 2–3 thick ventromedial setae.

**THORAX** (Fig. 10F–G). With following sclerites medium brown: proepisternum, antepronotum, ventral portion of posterior anepisternum, katepisternum, anterodorsal portion of anepimeron, ventral portion of scutum, mediotergite and coxae; elsewhere pale. Prescutal suture very short, barely visible. Anterior anepisternum divided longitudinally by sinuous suture. Posterior anepisternum divided by diagonal suture, forming a triangle at inferior portion, with anterodorsal margin thick. **Sensilla** (Fig. 10H): Antepronotum with 5–7 intermediate setae from anterolateral to posterior margins. Postpronotum with 1 thick dorsal seta, 2–3 intermediate posterior, and 0–1 slender posteroventral setae. Scutum, prescutal area 4–5 thick posterior, dorsoventrally aligned setae; 5–6 intermediate and 12–13 slender setae more anteriorly, merging with anterior portion of dorsocentral row; about 14 slender posterodorsal setae, extending to antealar area. Antealar area, anterior portion with 3–4 thick and 2–4 intermediate setae dorsoventrally aligned; more posteriorly, 2–4 thick and 8–10 intermediate setae forming a U-shape just above paranotal suture; about 50 slender setae spread from ventral to dorsal portions. Supraalar



**Fig. 10.** *Corethrella unifasciata* sp. nov., female adult, holotype (MZUSP). A. Head, anterior view. B. Cranial setae, anterior and posterior views, and clypeus in anterior view. C. Left palpus, lateral view. D. Antenna, lateral view. E. Pedicel and flagellomeres, lateral view. F. Thorax and legs, lateral view. G. Detail of thorax, lateral view. H. Thoracic setae, lateral view. I. Wing veins. J. Wing. K. Hind leg claw and empodium, lateral view. L. Abdomen, dorsal view. Scale bars: 0.1 mm.

area, 4–6 thick/intermediate setae anteroposteriorly aligned, about 45 slender setae spread from ventral to dorsal portions. Dorsocentral row, posterior portion with group of 9–10 thick and 3 slender setae; 12 thick and about 60 slender/intermediate setae completing the row. Scutellum with 14 thick setae. Posterior anepisternum bare. Anepimeron with 15–16 slender setae posterodorsally located.

WING (Fig. 10I–J). Light brown, non-marginal veins with narrow scales. Midlength band of darker scales present, missing on  $R_{4+5}$  and CuP; distally dislocated on apex of CuA; darker on C, Sc,  $R_1$ , and  $M_4$ . Apex of  $R_2$  basal to apex of  $M_1$ . Halter as pale as scutellum.  $R_3/R_1$ : 0.48–0.49;  $R_{2+3}/R_2$ : 0.55–0.57.

LEGS (Fig. 10F). Light brown. Fore femur basal 0.6 and hind femur basal 0.3 darker; midfemur with apex slightly paler. Base of hind tibia light brown; all tibiae with dark bands on apex. Tarsomeres 2–5 somewhat darker. Legs without scales. Midleg tarsomeres 1–3 with large subapical setae. Empodium (Fig. 10K) of intermediate length and thickness, with 6 branches.  $Ta1/Ta2$ : 2.79–2.95;  $Ta3/Ta4$ : 1.19–1.19.

ABDOMEN (Fig. 10L). Light to medium brown, with segments VIII, IX, and cercus darker.

### Male and immatures

Unknown.

### Distribution and biology

The two females were collected at two neighboring localities at the RPPN Estação Veracel, Porto Seguro, Bahia, at altitudes of 72 m a.s.l. and 89 m a.s.l. with frog-call traps playing a chorus of Atlantic forest frogs (*Boana faber*, *Physalaemus cuvieri* and *P. nanus*). Extensive efforts to collect immatures were made in the areas, in ground pools and phytotelmata, retrieving immatures of other species, but not *C. unifasciata* sp. nov.

The attraction to frog-call traps and the serrate mandibles indicate that females feed on frog blood in nature.

### Remarks

*Corethrella unifasciata* sp. nov., only known for females, has character states shared by the clade formed by *C. lepida* Borkent, 2008 and *C. caribbeana* Borkent, 2008, which have the apex of  $R_2$  more basal than the apex of  $M_1$ , the ventral portion of the ocular row with two stout setae (four setae on the ventromedial area of the frons in Borkent's terminology), the posterior end of the dorsocentral row with a group of more than three thick setae, and the hind tibia basally pale. This species can be distinguished from *C. lepida* by the presence of two sensilla coeloconica on each of flagellomeres X–XI, the ocular row of setae extending to the mid-posterior part of the head, the presence of 9–10 thick offset setae on the posterior portion of the dorsocentral row, the antealar and supraalar areas with numerous slender setae, the wing band without dark scales on  $R_{4+5}$ , and the peculiar pattern of thoracic pigmentation. This species differs from *C. caribbeana* by the following features: longer flagellomeres I–III, palpus without a pigmented segment V, posterior portion of dorsocentral row with more than 5 setae, patterns of wing pigmentation, and thoracic pigmentation.

### Complementary descriptions and diagnoses

Emended descriptions of adults and immatures are given for 33 *Corethrella* species, based on additional material collected in Brazil, in order to detail new characters (see Morphology remarks, below). Diagnoses for immatures are provided. References for descriptions and pertinent taxonomic publications are found in Appendix 1. Species are ordered according to phylogenetic affinities.

*Corethrella (Corethrella) rotunda* Borkent, 2008

Fig. 11; Appendix 1

**Material examined**

BRAZIL – Santa Catarina State • 1 ♀, adult; Santo Amaro da Imperatriz, Plaza Caldas; 27°44'30" S, 48°48'25" W; 424 m a.s.l.; 9–10 Aug. 2017; L.C. Pinho *et al.* leg.; CDC trap; CE-MHS.

**Description**

**Female adult** (n = 1)

**HEAD** (Fig. 11A). **Sensilla:** Ocular row with 1 thick offset seta at ventral part, more dorsally 10 setae shortly extending posteriorly. Subocular row well-defined, with about 9 slender setae. Vertex and interocular space without additional setae. Postgenal row with 5 intermediate setae, ranging from posterior end of ocular row to ventromedially. With 2 thick ventromedial setae.

**THORAX** (Fig. 11B). **Sensilla:** Antepronotum with 1 anterodorsal and 4 slender lateral setae. Postpronotum with 1 thick dorsal, 1 slender anterior, and 3 slender more posterior setae. Scutum, prescutal area with 3 thick setae dorsoventrally aligned near prescutal suture; about 7 intermediate, slender setae grouped more anteriorly. Antealar area with 9 thick/intermediate and 7 slender setae spread on ventral and medium portions. Supraalar area with 3 thick setae, with 6 slender surrounding. Dorsocentral row, posterior part with cluster of 3 thick setae; 17 thick/intermediate and approximately 13 slender completing the row. Scutellum with 10 thick setae. Posterior anepisternum with 1 slender seta. Anepimeron with 8 intermediate setae.

**WING.**  $R_3/R_1$ : 0.64;  $R_{2+3}/R_2$ : 0.47.

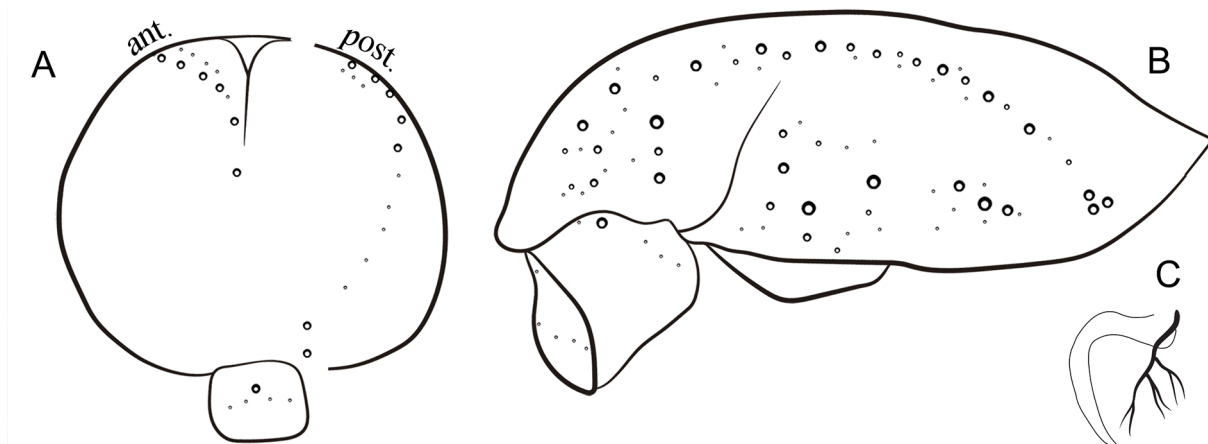
**LEGS.** Empodium (Fig. 11C) short, slender, with 3 branches.  $Ta1/Ta2$ : 2.63;  $Ta3/Ta4$ : 1.18.

**Distribution and biology**

The single specimen has previously been recorded in Amaral *et al.* (2019). It was collected via CDC trap in an area of Atlantic forest in Santa Catarina State, at an altitude of 424 m a.s.l. This species is otherwise known from Costa Rica, at altitudes ranging from 0 to 600 m a.s.l. (Borkent 2008).

**Remarks**

This female presents an unusually large number of anepimeral setae for the *rotunda* group, and those setae seem thicker than the ones present on other species. See Morphology remarks section for more details.



**Fig. 11.** *Corethrella rotunda* Borkent, 2008, female adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg empodium, lateral view.

*Corethrella (Corethrella) yucuman* Caldart & Pinho, 2016

Fig. 12; Appendix 1

**Material examined**

**Paratypes**

BRAZIL – Rio Grande do Sul State • 2 ♂♂, adults; Derrubadas, Parque Estadual do Turvo; Riacho Salto; 27°08'22" S, 53°52'52" W; 185 m a.s.l.; 14 Feb. 2014; V.M. Caldart *et al.* leg.; silent frog-call trap (CS1N, control); CE-MHS • 2 ♀♀, adults; same collection data as for preceding, except (PG1N control); CE-MHS.

**Description**

**Male and female adults (2 ♂♂, 2 ♀♀)**

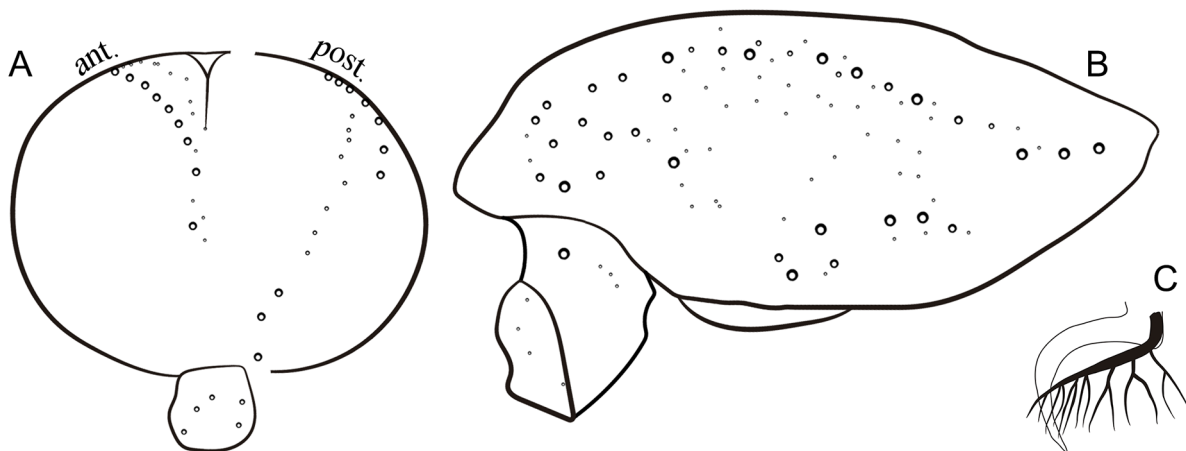
**HEAD** (Fig. 12A). **Sensilla:** Ocular row with 1 thick offset seta at ventral portion, about 15 setae more dorsally, shortly extending posteriorly. Subocular row well-defined, with about 15 slender setae; no other setae on vertex. Postgenal row with 4 intermediate setae ranging from posterior end of ocular row to mid-posterior portion of head. With 3 thick ventromedial setae.

**THORAX** (Fig. 12B). **Sensilla:** Antep pronotum with 3–5 slender setae spread on lateral portion. Postpronotum with 1 thick and 3–4 slender dorsal setae. Scutum, prescutal area with group of about 8–9 thick and 5–10 slender setae on dorsal portion, difficult to distinguish from anterior part of dorsocentral row. Antealar area with 1 thick anterodorsal, 3–4 thick ventral, and 9–24 slender setae from ventral to dorsal regions. Supraalar area with 3 thick central setae and 2–8 slender setae more dorsally. Dorsocentral row, posterior part with 3 thick and 1 slender offset setae, somewhat lateral to one another; about 16 thick and 25 slender setae filling the row. Scutellum with 6–7 thick setae. Posterior anepisternum with 1 slender dorsal seta. Anepimeron with 2–3 slender setae. Katepisternum with 1 slender posterodorsal seta.

**WING.** Non-marginal veins with setae instead of scales. Male  $R_3/R_1$ : 0.42–0.43;  $R_{2+3}/R_2$ : 1.21–1.35. Female  $R_3/R_1$ : 0.52–0.56;  $R_{2+3}/R_2$ : 0.73–0.76.

**LEGS.** Empodium (Fig. 12C) of intermediate length and thickness, with 7 branches. Male  $Ta1/Ta2$ : 3.10–3.20;  $Ta3/Ta4$ : 1.40. Female  $Ta1/Ta2$ : 2.92–3.00;  $Ta3/Ta4$ : 1.14–1.29.

**GENITALIA.** Gonostylus with one thick, subbasal seta posteroventrally located.



**Fig. 12.** *Corethrella yucuman* Caldart & Pinho, 2016, adult. **A.** Cranial setae, anterior and posterior views, and female clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg empodium, lateral view.

### Distribution and biology

The examined specimens are paratypes described in Caldart *et al.* (2016). This species has been found in Turvo State Park, Rio Grande do Sul, in an area of seasonal deciduous forest of southern Brazil near the Argentinian border. Specimens were captured with frog-call traps, playing the call of *Physalaemus* aff. *gracilis* (Boulenger, 1883), *Crossodactylus schmidti* Gallardo, 1961, *Scinax perereca* Pombal, Haddad & Kasahara, 1995 and a silent control trap (see details in Caldart *et al.* 2016). Altitudes range from 185 to 382 m a.s.l.

### Remarks

Caldart & Pinho (Caldart *et al.* 2016) described the wings as having very narrow scales. We now reinterpret this character, considering setae instead of scales to be present on wing veins. This species was also originally described as lacking a subbasal seta on the gonostylus, but the seta is actually present. *Corethrella yucuman*, together with *C. brevivena* Borkent, 2008 (Borkent 2008: 228) are the only known species with a katepisternal seta, which, along with the short flagellomere VIII, the apex of R<sub>2</sub> being more basal than the apex of M<sub>1</sub> and a short coronal suture, indicates a close relationship with the clade *C. brevivena* + *C. globosa* Borkent, 2008.

*Corethrella (Corethrella) xokleng* Amaral, Mariano & Pinho, 2019

Fig. 13; Appendix 1

### Material examined

#### Holotype

BRAZIL – Santa Catarina State • 1 ♂, adult; Grão Pará, Rio Três Barras; 28°12'44" S, 49°27'28" W; 15 Nov. 2012; L.C. Pinho, L.S. Gomes and A.L. Schlindwein leg.; light trap; MZUSP.

#### Allotype

BRAZIL – Santa Catarina State • 1 ♀, adult; same collection data as for holotype, except Rio Braço Esquerdo; 28°09'01" S, 49°21'21" W; 16 Nov. 2012; MZUSP.

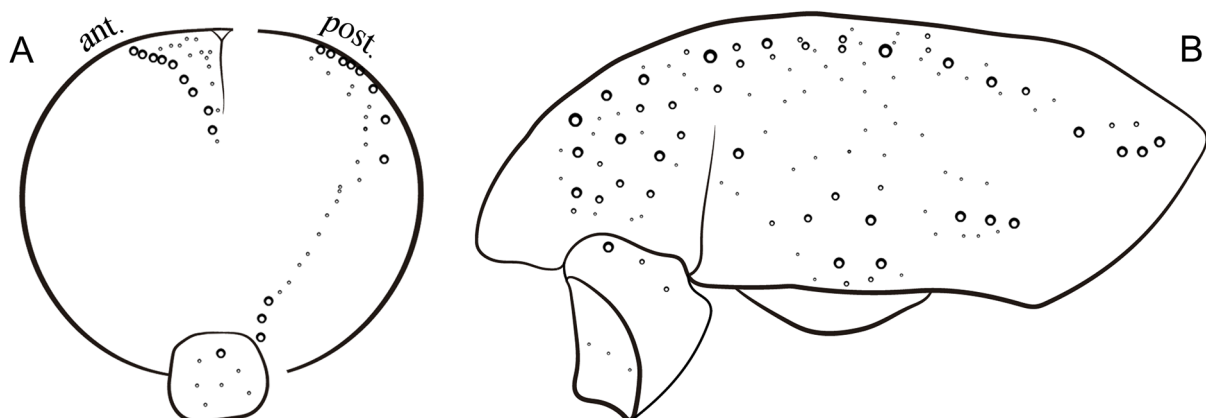
#### Paratype

BRAZIL – Santa Catarina State • 1 ♀, adult; same collection data as for allotype; CE-MHS.

### Description

#### Male and female adults (1 ♂, 2 ♀♀)

HEAD (Fig. 13A). **Sensilla:** Ocular row with 2 thick slightly offset setae at ventral portion, more dorsally about 15 setae extending to mid-posterior portion of head. Subocular row not well-defined anteriorly,



**Fig. 13.** *Corethrella xokleng* Amaral, Mariano & Pinho, 2019, adult. **A.** Cranial setae, anterior and posterior views, and female clypeus in anterior view. **B.** Thoracic setae, lateral view.

with about 10 slender posterior setae. Vertex with a few additional setae. Postgenal row with about 12 slender setae ranging from posterior end of ocular row to ventromedially. With 3 thick ventromedial setae.

THORAX (Fig. 13B). **Sensilla:** Antep pronotum with 3–4 slender lateral setae. Postpronotum with 1–2 thick and 2–5 intermediate/slender dorsal setae. Scutum, prescutal area with about 8–13 thick and 8–12 slender setae dorsally located, difficult to distinguish from anterior portion of dorsocentral row. Antealar area with 1 anterodorsal seta, 3–5 thick ventral setae, and 24–34 intermediate/slender setae spread from ventral to dorsal portions, reaching dorsocentral row. Supraalar area with 3 thick central setae, with 8–12 slender setae surrounding. Dorsocentral row, posterior part with 3 thick and 1–2 intermediate offset setae; about 20–25 thick and 24–30 slender setae filling the row. Scutellum with 6–7 thick setae. Posterior anepisternum with 4–5 slender dorsal setae. Anepimeron with 1 intermediate and 0–1 slender setae.

WING. Male  $R_3/R_1$ : 0.41;  $R_{2+3}/R_2$ : 1.14. Female  $R_3/R_1$ : 0.57–0.58;  $R_{2+3}/R_2$ : 0.48–0.49.

LEGS. Empodium (Amaral *et al.* 2019: 112, fig. 4e) elongate and thick, with 9–10 branches. Male  $Ta1/Ta2$ : 2.92;  $Ta3/Ta4$ : 1.29. Female  $Ta1/Ta2$ : 3.21–3.25;  $Ta3/Ta4$ : 1.00–1.22.

### Distribution and biology

The examined specimens belong to the type series described by Amaral *et al.* (2019): “This species is known from three individuals (two females and one male) collected in light traps from type locality, Serra Furada State Park, in Grão Pará, SC, at elevations of 355–354 m. Serra Furada is a region of Atlantic forest, interspersed with large areas of *Eucalyptus* cultivation, near the transition to *Araucaria* Forest at higher altitudes. The rivers where traps were set are gravel-bed streams, 4–6 m wide and about 1 m deep.”

### *Corethrella (Corethrella) carariensis* Borkent, 2008

Fig. 14; Appendix 1

### Material examined

BRAZIL – Santa Catarina State • 1 ♀, adult; Santo Amaro da Imperatriz, Plaza Caldas; 27°44'31" S, 48°48'27" W; 433 m a.s.l.; 19 Oct. 2013; A. Ambrozio-Assis leg.; frog-call trap (*P. cuvieri*) 2<sup>nd</sup>; CE-MHS • 1 ♂, adult; Florianópolis, Fazenda Experimental Ressacada; 27°41'03" S, 48°32'37" W; 5 m a.s.l.; 14 Aug. 2011; Fabris, Ganzer and Souza leg.; light trap; CE-MHS.

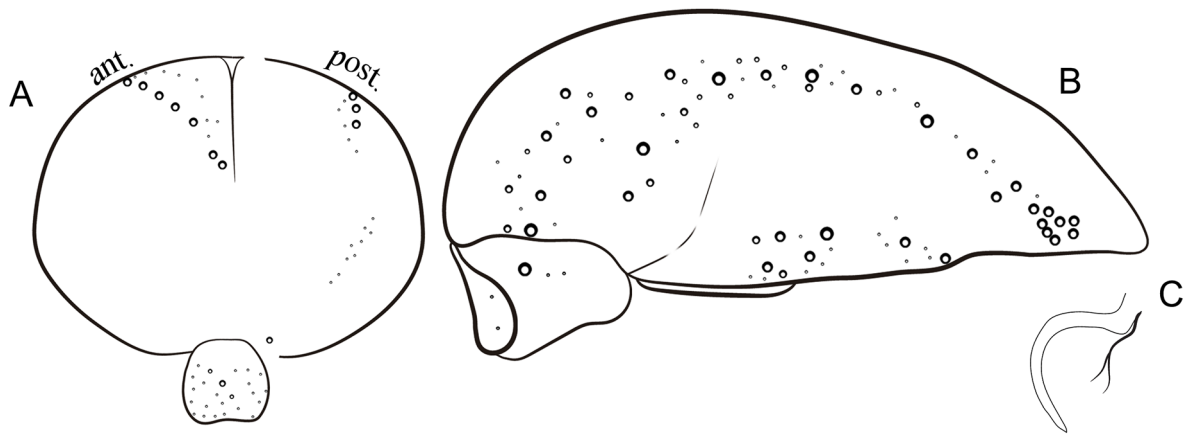
### Description

#### Male and female adults (1 ♂, 1 ♀)

HEAD (Fig. 14A). **Sensilla:** Ocular row with 2 thick offset setae on ventral part, 8–14 setae extending shortly beyond vertex. Subocular row well-defined, with 9–14 slender setae; vertex without additional setae on female, about 7 setae on male. Postgenal row with 9–15 slender setae located on mid-posterior portion of head. With 1 thick ventromedial seta.

THORAX (Fig. 14B). **Sensilla:** Antep pronotum with 0–2 slender lateral setae. Postpronotum with 1 thick subdorsal and 2–3 slender posterior setae. Scutum, prescutal area with 2 thick and 1 intermediate setae vertically arranged near prescutal suture, and 2 intermediate and 2–3 slender setae more dorsally; group of 4–6 thick/intermediate and 2–4 slender setae anteriorly. Antealar area with group of 6–11 thick/intermediate and 6 slender setae posteroventrally. Supraalar area with 2 thick setae, with 6 slender ones surrounding. Dorsocentral row, posterior part with group of 8–10 thick and 1–3 slender offset setae; about 17–24 thick/intermediate and 12–13 slender completing the row. Scutellum with 10 thick setae. Posterior anepisternum with 1 slender dorsal seta. Anepimeron bare.





**Fig. 14.** *Corethrella carariensis* Borkent, 2008, adult. **A.** Cranial setae, anterior and posterior views, and female clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg empodium, lateral view.

WING. Male  $R_3/R_1$ : 0.69;  $R_{2+3}/R_2$ : 0.38. Female  $R_3/R_1$ : 0.71;  $R_{2+3}/R_2$ : 0.34.

LEGS. Empodium (Fig. 14C) short, slender, with 1 branch. Male  $Ta1/Ta2$ : 2.68;  $Ta3/Ta4$ : 1.50. Female  $Ta1/Ta2$ : 2.43;  $Ta3/Ta4$ : 1.45.

### Distribution and biology

This species has previously been recorded from Santa Catarina by Ambrozio-Assis *et al.* (2018). The examined specimens were captured via frog-call trap (*Physalaemus cuvieri*) and light trap in the Atlantic forest of Santa Catarina at altitudes ranging from 5 to 433 m a.s.l. It is otherwise known from Costa Rica, at elevations ranging from 0 to 100 m a.s.l. (Borkent 2008).

### Remarks

The male and female specimens presented a significant difference in relation to cranial setae, with males discretely more setose. Borkent (2008) discussed the difficulty in associating male and female specimens of *Corethrella carariensis* due to great variation in pigmentation, and suggested that there may be cryptic species under the same name. *Corethrella carariensis* is a very distinctive species in the *peruviana* group, with unique diagnostic features, such as legs without scales and the setae on male genitalia. We thus consider both specimens as *C. carariensis*, though further studies may reveal more than one species.

### *Corethrella (Corethrella) alticola* Lane, 1939

Fig. 15; Appendix 1

*Corethrella alticola* – Amaral & Pinho 2015: 282, figs 25–28.

### Diagnosis

#### Larva

Only extant species with the following combination of characters: darkly pigmented tergal plates; a darkly colored mandibular lobe (Amaral & Pinho 2015: fig. 26); head uniformly light/medium brown (Amaral & Pinho 2015: fig. 26); mandible with a discretely long apical tooth (2.0–2.67 times length of first dorsal tooth) (Fig. 15F); subgenal carina covered with minute spinules (Fig. 15F).

## Pupa

Only extant species with the following combination of characters: a flattened, wide, trilobed respiratory organ (Amaral & Pinho 2015: fig. 23); exuvia lightly pigmented, yellowish (Amaral & Pinho 2015: fig. 22); abdominal segments III–VII strongly expanded lateroposteriorly, more darkly pigmented laterally (Amaral & Pinho 2015: fig. 22); abdominal setae on segments I–VIII weakly developed (this species may be difficult to distinguish from *C. manaosensis*; see Remarks).

## Material examined

BRAZIL – **Santa Catarina State** • 1 ♀, adult, with larval and pupal exuviae; Grão Pará, Parque Estadual Serra Furada, CAPEA Stream; 28°11'26" S, 49°23'30" W; 7 Apr. 2013; L.C. Pinho, A.L. Schlindwein and A.P. Amaral leg.; hand net; CE-MHS • 1 ♀, adult, with larval and pupal exuviae; same collection data as for preceding, except 7 May 2013; L.C. Pinho and V. Freitas leg.; CE-MHS • 1 ♂, adult, with larval and pupal exuviae; Orleans, Rio Minador; 28°10'43" S, 49°24'33" W; 8 Jun. 2013; LC Pinho *et al.* leg.; hand net; CE-MHS. – **Bahia State** • 1 ♂, 1 ♀, adults, with respective pupal and larval exuviae; Rio de Contas, Parque Natural Serra das Almas, Vale do Queiroz, “mata de galeria” [riparian woodland]; 13°31'28" S, 41°57'24" W; 1579 m a.s.l.; 30 Nov. 2019, A.P. Amaral leg.; hand net; CE-MHS.

## Description

### Male and female adults (2 ♂♂, 3 ♀♀)

**HEAD.** Compound eyes (of specimens in ethanol) iridescent green. Female antenna (Fig. 15A–B) medium brown, with basal half of flagellomeres I–VII pale. Flagellomere I moderately to very elongate, II–III elongate, XIII apically bifurcated. Sensilla coeloconica distribution: 1 (II–VIII), 2 ([VII, VIII], IX–XIII), 4 (I). **Sensilla** (Fig. 15C): Ocular row with 2 thick offset setae on ventral part, more dorsally 10–12 setae, extending shortly beyond vertex. Subocular row poorly defined anteriorly, with about 12 setae on posterior portion. Interocular space and vertex densely setose. Postgenal row with 18–60+ slender setae, ranging from posterior part of ocular row to ventromedially. With 1 thick ventromedial seta.

**THORAX.** **Sensilla** (Fig. 15D): Anteppronotum with 3–4 slender anterodorsal setae. Postpronotum with 1 thick dorsal and 1–3 slender setae. Scutum, prescutal area with 2–6 anterior thick/intermediate and 2 posterodorsal thick setae; about 15–28 slender setae surrounding. Antealar area with cluster of 9–11 thick/intermediate and 4–9 slender setae on posteroventral portion. Supraalar area with 2–3 thick, 2–5 intermediate, and 5–13 slender setae. Dorsocentral row, posterior part with 4–6 thick offset, longitudinally aligned setae; approximately 27–37 thick/intermediate and about 26–50 slender setae filling row. Row interrupted at level of prescutal suture. Scutellum with 8–10 thick setae. Posterior anepisternum with 1–4 dorsal setae. Anepimeron bare.

**WING.** Male  $R_3/R_1$ : 0.45–0.48;  $R_{2+3}/R_2$ : 0.57–0.60. Female  $R_3/R_1$ : 0.63 (0.61–0.65);  $R_{2+3}/R_2$ : 0.36 (0.34–0.39).

**LEGS.** Empodium (Fig. 15E) short, slender, with two branches. Male  $Ta1/Ta2$ : 2.21–2.29;  $Ta3/Ta4$ : 1.50–1.60. Female  $Ta1/Ta2$ : 2.35 (2.28–2.42);  $Ta3/Ta4$ : 1.43 (1.42–1.46).

### Larva (n = 4)

**EXUVIA** (Amaral & Pinho 2015: 282, fig. 26). Uniformly light to medium brown with more darkly pigmented tergal plates on I–VII.

**HEAD** (Fig. 15F). Roughly triangular shaped in dorsoventral view, 1.11 (1.10–1.14) times as wide as long. Antenna 0.57 (0.55–0.60) times length of head; antennal groove 1.36 (1.25–1.45) times length of antenna; ventral margin of antennal groove with about 6 moderately developed denticles. Postmentum with wide base, strongly tapering distally, 1.58 (1.50–1.67) times as wide as long; length about 0.35

(0.34–0.36) of head. Prementum almost straight, with 13–17 triangular teeth, darkly pigmented, central one largest, remaining gently decreasing in size. Anteroventral projection of gena slightly projecting anteriorly, somewhat flattened, surface smooth. Postcoila short, not extending to lateral margin of gena. Subgenal carina with multiple small spinules. Crown with 14–15 regularly distributed spines; dorsalmost and three ventralmost smaller; largest spine 0.12–0.13 mm long. Seta 16-C situated mesially from crown. Mandible with darkly pigmented teeth; apical tooth length 2.35 (2.00–2.67) times that of first dorsal tooth; seta 3-Mn 0.22 (0.20–0.24) times length of 4-Mn; lacinia mobilis with 7 blades; mandibular lobe well-developed, darkly pigmented, apart from teeth. **Sensilla**: 9-C short, fan-like; 10-C elongate, simple; 11-C short, simple; 12-C elongate, simple; 13-C short, fan-like; 14-C short, simple; 15-C moderately elongate, fan-like; 16-C elongate, simple. 0a-Mn short, bifurcated; 0b-Mn moderately elongate, simple. 6-Mx short, fan-like; 4-Mx short, fan-like; 5-Mx short, fan-like.

SIPHON. 0.41 (0.39–0.42) mm long. Seta 1 forked, situated at 0.16 (0.14–0.18) of length from base; 6-S pale, 9-S lightly pigmented; length of 6-S/9-S: 0.84 (0.76–0.97).

#### **Pupa (n = 4)**

EXUVIA (Amaral & Pinho 2015: 282, fig. 22). Lightly pigmented, yellowish, posterolateral projections of abdomen more darkly pigmented; all setae pale.

CEPHALOTHORAX. Length 1.49 mm (1.46–1.54). Respiratory organ (Amaral & Pinho 2015: 282: fig. 23) flattened, wide and trilobed, 0.71 mm (0.68–0.78) long cephalocaudad. Dorsal seta 1 short, moderately thick, about three lengths apart from dorsal 2; dorsal 2 of same thickness, about 3.5 times as long as dorsal 1; both arising from undifferentiated cuticle. Metathoracic, supraalar sensilla absent.

ABDOMEN (Amaral & Pinho 2015: 282, fig. 24). Moderately elongate, tapering, integument rough dorsolaterally; length of segments I–VIII 1.39 mm (1.27–1.44), width/length 0.65 (0.63–0.69). Margins serrate, strongly projected posterolaterally. Dorsal and lateral setae minute, equal from II–VII. Largest seta D-7-VI, 0.56 (0.46–0.60) times length of segment. Terminal process elongate, basal width 0.43 (0.37–0.47) of length, with moderately broad paddles; D-1-IX somewhat short, of intermediate thickness, at about 0.5 length from base; apical spine not articulated; lacking ventroapical seta V-1-IX; female genital lobes round, occupying most of basal portion, elongate in male, extending shortly beyond base. Chaetotaxy as illustrated.

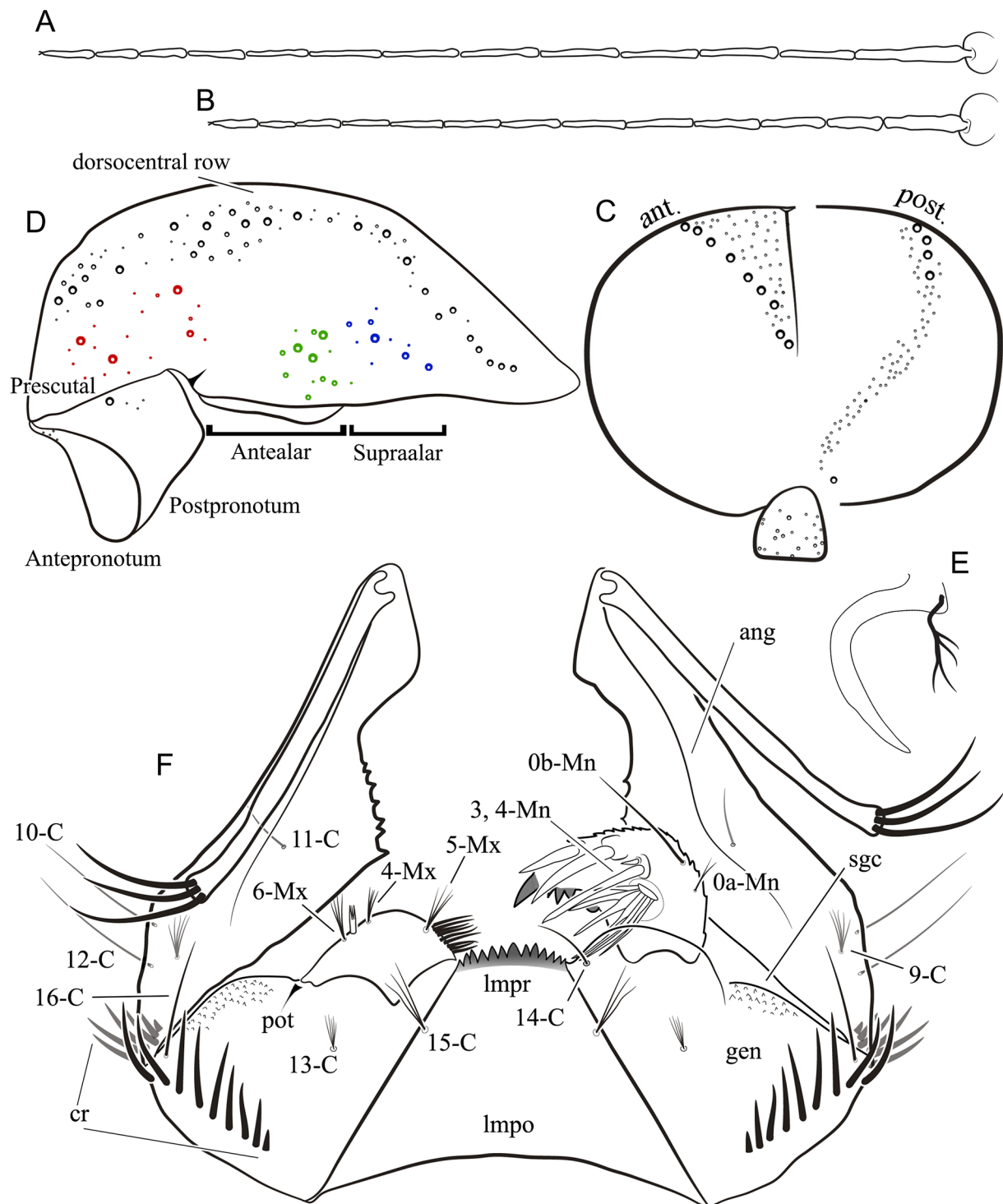
#### **Distribution and biology**

The specimens from Santa Catarina have previously been recorded in Amaral & Pinho (2015) and were collected as immatures from the margins of small streams and ground pools in forested areas. This species is newly recorded in Northeast Brazil and the state of Bahia, from two individuals collected in a small stream of a streamside forest in Rio de Contas municipality at 1579 m a.s.l. Rio de Contas is in the Espinhaço mountain range, which comprises the Chapada Diamantina National Park, a hotspot for conservation with many endemic species, with two new ones described here, *Corethrella pindorama* sp. nov. and *C. fuscifimbria* sp. nov.

*Corethrella alticola* is also known from the Brazilian states of GO, RJ, RS, SC, and SP, at altitudes ranging from 80 to 1736 m a.s.l. (Amaral & Pinho 2015; Borkent 2008).

#### **Remarks**

The pupae of *C. alticola* may be indistinguishable from those of *C. manaosensis* (not examined in the present work). From the original description in Lane & Cerqueira (1958), as well as the brief description and the photograph present in Borkent (2008), the only clear difference found was regarding the coloration of the exuviae, which can be subtle. The pupal exuviae of *C. alticola* seem to be, overall,



**Fig. 15.** *Corethrella alticola* Lane, 1939. **A.** Pedicel and flagellomeres of female adults from Santa Catarina, lateral view. **B.** Pedicel and flagellomeres of adult female from Bahia, lateral view. **C.** Cranial setae, anterior and posterior views, and female clypeus in anterior view. **D.** Adult thoracic setae, lateral view; black = dorsocentral row; red = prescutal setae; green = antealar setae; blue = supraalar setae. **E.** Hind leg claw and empodium, lateral view. **F.** Exuvia of larval head, ventral view, except mandible in dorsal view. Abbreviations: ang = antennal groove; cr = crown; gen = gena; lmpo = postmentum; lmpo = prementum; pot = postcoila; sgc = subgenal carina; 9–16-C = cranial setae; 0(a, b), 3, 4-Mn = mandibular setae, 4–6-Mx = maxillary setae.

paler (with somewhat darker abdominal projections) and to have a yellowish coloration, while those of *C. manaosensis* appear to be more darkly pigmented and brown-colored. Although Lane & Cerqueira (1958) defined the pupal abdomen as having “posterior corners with blunt point”, it does not appear to have strong lateral projections in the photograph in Borkent (2008), and the author did not consider that to be the case in his character analysis (Borkent 2008: 220, character 57). A more detailed description of *C. manaosensis* should resolve the issue.

On the other hand, adults of *Corethrella alticola* are very distinctive. They are easily recognized by their unique pigmentation pattern and size (having the second largest wingspan of the family, only shorter than that in *C. novaezealandiae* Tonnoir, 1927). Also, the compound eye coloration and the densely setose postgenal row were not found in any other examined species in the present paper. The specimens from Rio de Contas (Bahia State) do not have the postgenal row as setose as those from Santa Catarina, bearing about 18 setae, which is nevertheless a larger number than in most of the other examined species. The female specimen from Bahia also has a somewhat shorter flagellomere I (Fig. 15B). Despite the differences in the postgenal row and the antenna, no further significant variation was found between the specimens from Santa Catarina and Bahia in adults or immatures. Therefore, this variation was considered intraspecific.

***Corethrella (Corethrella) peruviana* Lane, 1939**

Figs 1, 16; Appendix 1

**Diagnosis**

**Larva**

Only extant species with the following combination of characters: darkly pigmented tergal plates (Fig. 16D); a small, darkly colored mandibular lobe (Fig. 16D); head dark brown with a pale postmentum (Fig. 16D); ventral margin of antennal groove with about ten large denticles (Fig. 16E).

**Pupa**

Only extant species with the following combination of characters: a flattened, wide, trilobed respiratory organ (Fig. 16G); abdominal segments strongly expanded laterally (Fig. 16H); segment III with two well-developed, darkly pigmented lateral setae (Fig. 16H).

**Material examined**

BRAZIL – **Bahia State** • 1 ♀, adult; Porto Seguro, RPPN Veracel, mussununga; 16°21'33" S, 39°08'15" W; 72 m a.s.l.; 30 Aug. 2019; A.P. Amaral leg.; feeding on frog (*B. faber*); CE-MHS • 1 ♀, adult; same collection data as for preceding, except frog-call trap; CE-MHS • 1 ♀, adult, with larval and pupal exuviae; same collection data as for preceding, except hand net, ground pools; CE-MHS • 1 ♀, adult; same collection data as for first, except 12 Mar. 2020; frog-call trap (chorus); CE-MHS • 1 ♀, adult; Porto Seguro, RPPN Veracel, “Rio trilha escolar” [river by educational trail]; 16°23'09" S, 39°10'14" W; 89 m a.s.l.; 13 Mar. 2020; A.P. Amaral leg.; frog call; CE-MHS • 1 ♀, adult; same collection data as for preceding, except light sheet; CE-MHS • 1 ♂, adult; same locality as for preceding; 12 Feb. 2019; M.M.L. Sousa leg.; light pan; CE-MHS • 1 ♀, adult; Igrapiúna, Estação Michelin; 13°48'14" S, 39°10'16" W; 59 m a.s.l.; 23 Mar. 2019; A.P. Amaral leg.; CDC trap; CE-MHS. – **Santa Catarina State** • 1 ♂, adult; Porto Belo, Ponta do Araçá, “Brejo de altitude” [altitude marsh]; 27°07'38" S, 48°31'20" W; 115 m a.s.l.; 25 Jul. 2011; Ganzer and Fabris leg.; light trap; CE-MHS.

**Description**

**Male and female adults** (2 ♂♂, 7 ♀♀)

**HEAD. Sensilla** (Fig. 16A): Ocular row with 2 thick offset setae at ventral part, 9–12 setae more dorsally, shortly extending posteriorly. With well-defined subocular row of 9–14 slender setae. Postgenal row with 12–18 small setae, restricted to mid-posterior region. With 1 ventromedial thick seta.

**THORAX. Sensilla** (Fig. 16B): Antep pronotum with 0–3 slender anteromedial setae. Postpronotum with 1 thick dorsal and 1–4 intermediate setae. Scutum, prescutal area with 4 anteroventral and 3 posterodorsal thick setae; 2–7 slender setae scattered in between. Antealar area with cluster of about 8–12 thick and 4–13 slender/intermediate setae on posteroventral portion. Supraalar area with 2–3 thick and 4–11 slender setae on ventral portion. Dorsocentral row, posterior part with 6–9 thick offset, longitudinally aligned setae; about 18–29 thick/intermediate and 10–22 slender setae filling row. Scutellum with 8–10 thick setae. Posterior anepisternum with 0–2 dorsal setae. Anepimeron bare.

**WING.** Male  $R_3/R_1$ : 0.59–0.61;  $R_{2+3}/R_2$ : 0.46–0.58. Female  $R_3/R_1$ : 0.67 (0.62–0.73);  $R_{2+3}/R_2$ : 0.44 (0.36–0.61).

**LEGS.** Empodium (Fig. 16C) elongate, of intermediate thickness, with 5 (bifid, trifid or multifid) branches. Male  $Ta1/Ta2$ : 2.33–2.61;  $Ta3/Ta4$ : 1.33–1.38. Female  $Ta1/Ta2$ : 2.46 (2.35–2.60);  $Ta3/Ta4$ : 1.31 (1.27–1.40).

**Larva** (n = 1)

**EXUVIA** (Fig. 16D). Head, siphon, and segment X dark brown; postmentum pale; darkly pigmented tergal plates on I–VII.

**HEAD** (Fig. 16E). Roughly triangular shape in dorsoventral view, 1.16 times as wide as long. Antenna 0.53 times length of head; antennal groove 1.58 times length of antenna; ventral margin of antennal groove with about 10 large denticles. Postmentum with base moderately wide, strongly tapering, 1.39 times as wide as long; length 0.41 of head. Prementum slightly curved, with 14 blunt teeth, darkly pigmented, central one largest, remaining gently decreasing in size. Anteroventral projection of gena somewhat projected anteriorly, flattened, surface smooth. Postcoila short, not extending to lateral margin of gena. Subgenal carina with a few minute spinules. Crown with 12 regularly distributed spines; first dorsal and first ventral shorter than remaining; largest spine 0.10 mm long. Seta 16-C situated mesially from crown. Mandible with darkly pigmented teeth; apical tooth 1.55 times as long as first dorsal tooth; seta 3-Mn 0.28 length of 4-Mn; lacinia mobilis with 7 blades; mandibular lobe small, darkly pigmented, apart from teeth. **Sensilla:** 10-C, 12-C, 13-C, and 16-C unknown; 9-C short, simple; 11-C short, fan-like; 14-C short, simple; 15-C short, fan-like. 0a-Mn short, fan-like; 0b-Mn elongate, simple. 6-Mx short, fan-like; 4-Mx unknown, 5-Mx short, fan-like.

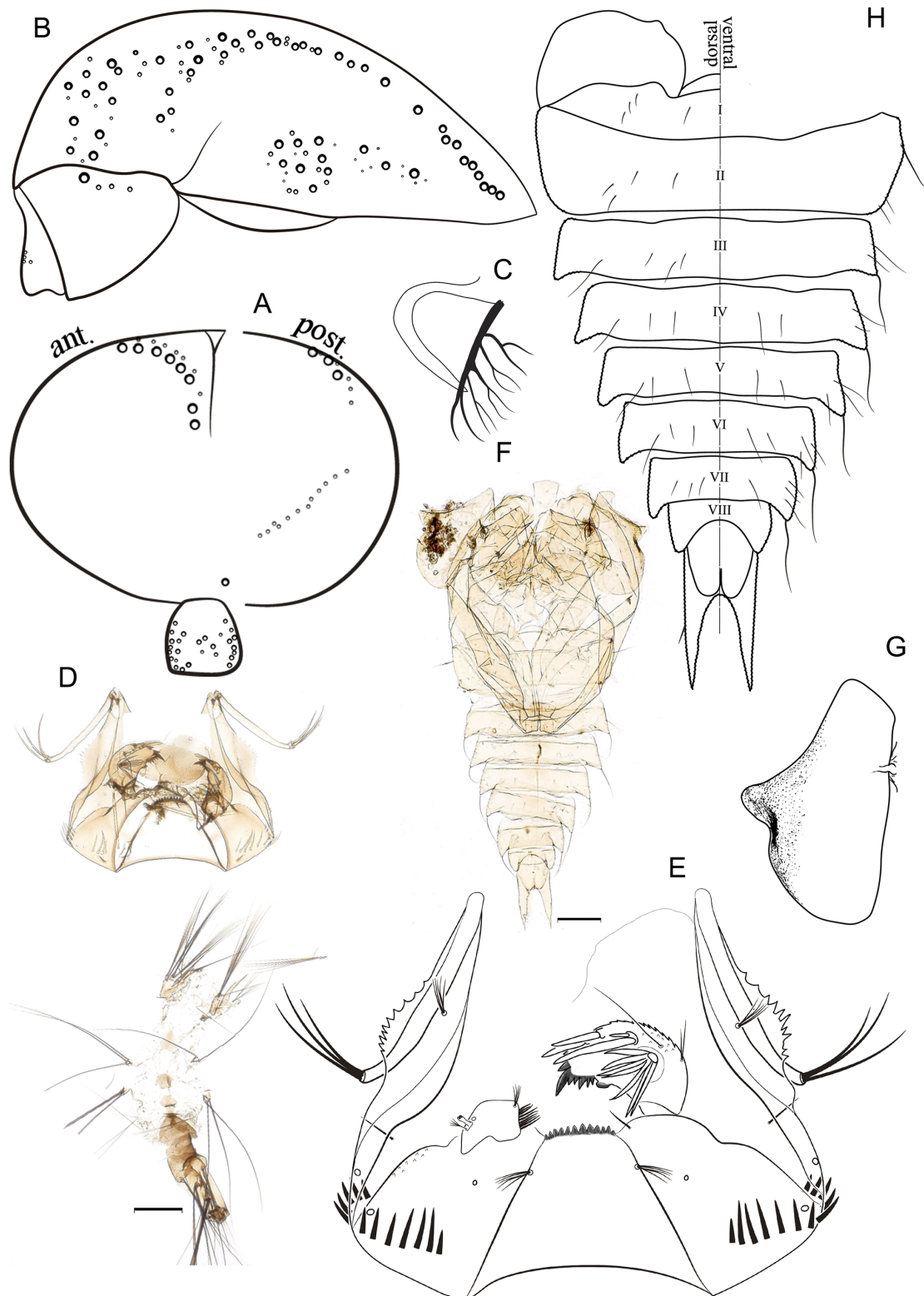
**SIPHON.** 0.30 mm long. Seta 1 fan-like, at about 0.23 of length from base. 6-S and 9-S lightly colored; length of 6-S/9-S: 0.86.

**Pupa** (n = 1)

**EXUVIA** (Fig. 16F). Uniformly light brown; setae moderately dark pigmented.

**CEPHALOTHORAX.** Length 1.01 mm. Respiratory organ (Fig. 16G) flattened, wide, somewhat bilobed, 0.53 mm long longitudinally. Dorsal seta 1 moderately elongate, thick, one length apart from dorsal 2; dorsal 2 slightly longer, less thick; both setae arising from undifferentiated cuticle. Supraalar 2 and metathoracic setae absent.

**ABDOMEN** (Fig. 16H). Moderately elongate, tapering, integument dorsolaterally rough; length of segments I–VIII 0.98 mm, width/length: 0.75. Margins serrate, strongly projected posterolaterally.



**Fig. 16.** *Corethrella peruviana* Lane, 1939. A. Adult cranial setae, anterior and posterior views, and female clypeus in anterior view. B. Adult thoracic setae, lateral view. C. Hind leg claw and empodium, lateral view. D. Larval exuvia, ventral view, in two pieces. E. Exuvia of larval head, ventral view, except mandible in dorsal view. F. Pupal exuvia, dorsal view. G. Pupal respiratory organ, dorsal view. H. Pupal methatorax and abdomen, dorsal and ventral views. Scale bars: 0.2 mm.

Dorsal setae short, about 0.25 length of respective segments, equal from III–VII. Lateral setae L-4 elongate, longer than respective segments. Largest seta L-4-VI, 1.6 length of segment. Terminal process elongate, basal width 0.42 of length, with broad paddles; D-1-IX short, at about 0.7 length from base; apical spine not articulated; lacking ventroapical seta V-1-IX; female genital lobe round, occupying almost all basal portion. Chaetotaxy as illustrated.

### Distribution and biology

This is a new record both for Bahia state and the Brazilian Northeast region. Individuals were collected as immatures in ground pools of a white-sandy tropical savanna patch inside a fragment of lowland Atlantic forest (mussununga ecosystem), and as adults in frog-call pan traps, light traps and one specimen captured biting a *Boana faber* (Fig. 1). Altitudes range from 72 to 89 m a.s.l. The specimens from Santa Catarina have previously been reported by Amaral *et al.* (2019).

*Corethrella peruviana* is otherwise recorded from Costa Rica, Panama, Colombia, Venezuela, Trinidad and Tobago, Guyana, Ecuador, Peru and the Brazilian states of PA, SC, and SP, at altitudes ranging from 0 to 269 m a.s.l. (Borkent 2008; Amaral *et al.* 2019).

### Remarks

The adult specimens here examined match the description by Borkent (2008) (see the discussion about the dorsocentral row in the Morphology remarks section). The description by Lane & Aitken (1956) of the immatures of *Lutzomiops juquiana* Lane, 1939 later considered a junior synonym of *C. peruviana* Lane, 1939 (Borkent 2008), also correspond to the specimens in hand, differing only in the number of teeth in the larval prementum (11).

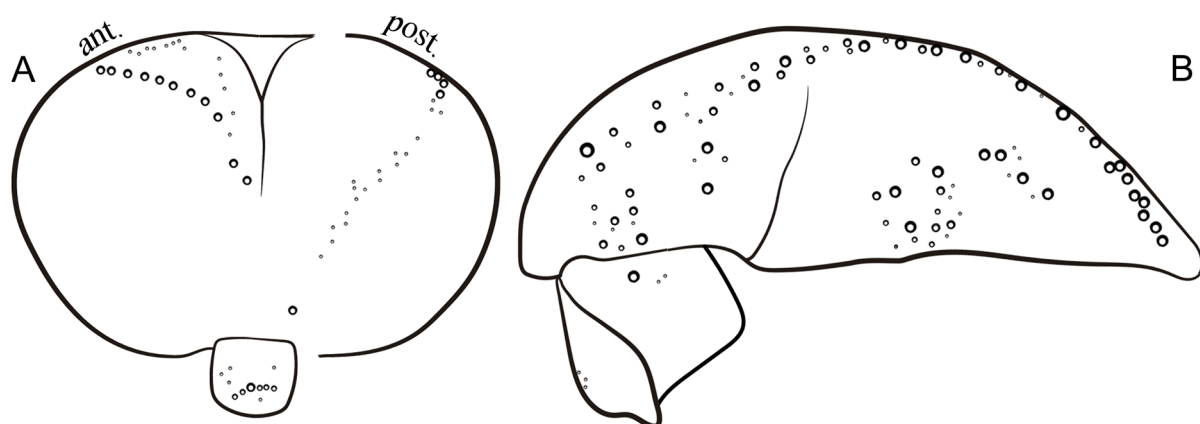
### *Corethrella (Corethrella) munteantaroku* Amaral, Mariano & Pinho, 2019

Fig. 17; Appendix 1

### Material examined

#### Holotype

BRAZIL – Amazonas State • 1 ♂, adult; Manaus, Res. Adolpho Ducke, Barro Branco; 2°55'47" S, 59°58'22" W; 73 m a.s.l.; 4–8 Nov. 2010; Pinho and Mendes leg.; Malaise, “100 m acima da ponte” [100 m ahead of the bridge]; INPA.



**Fig. 17.** *Corethrella munteantaroku* Amaral, Mariano & Pinho, 2019, male adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view.



## Description

### Male adult (n = 1)

HEAD (Fig. 17A). **Sensilla:** Ocular row with 2 thick offset setae at ventral part, 13 extending little beyond vertex. Subocular row indistinct, interocular space and vertex with few slender setae. Postgenal row with 15 slender setae, from mid-posterior to ventral portions. With 1 thick ventromedial seta.

THORAX (Fig. 17B). **Sensilla:** Anteprenotum with 3 slender setae anteriorly located. Postpronotum with 1 thick and 2 slender dorsal setae. Scutum, prescutal area with 7 thick and 3 slender setae clustered on anteroventral portion; 2 thick and 1 intermediate setae more posterodorsally. Antealar area with 11 thick/intermediate and 5 slender setae grouped posteroventrally. Supraalar area with 4 thick setae surrounded by 4 slender setae. Dorsocentral row, posterior part with 8 longitudinally aligned thick setae; additionally, 26 thick/intermediate and 9 slender setae completing the row. Scutellum with 12 thick setae. Posterior anepisternum with 3 slender dorsal setae. Anepimeron bare.

WING.  $R_3/R_1$ : 0.45;  $R_{2+3}/R_2$ : 0.63.

LEGS. Empodium (Amaral *et al.* 2019: 108, fig. 2d) of intermediate length, slender, with two branches.  $Ta1/Ta2$ : 2.00;  $Ta3/Ta4$ : 1.30.

## Distribution and biology

This study examined the holotype of *Corethrella munteantaroku* Amaral *et al.*, 2019. From the original description: “This species is known only from the single individual collected with a Malaise trap at the type locality, the Barro Branco stream, in Adolpho Ducke Forest Reserve, Manaus, AM. Barro Branco is a slow flowing, shallow stream, approximately 2m meters wide. It is surrounded by a fragment of Amazon rainforest just outside the limits of Manaus urban area.”

## Remarks

Amaral *et al.* (2019) described the posterior portion of the dorsocentral row as bearing one thick offset seta. This character is newly interpreted here. For a more detailed discussion, see Morphology remarks below. *Corethrella munteantaroku* was hypothesized as closely related to *C. blanda* Dyar, 1928 and *C. pallida* Lane, 1942, due to the presence of a wing band and anteromedial spicules on the gonocoxite (Amaral *et al.* 2019). Nevertheless, its short, slender, and two-branched empodium is more similar to the ones found in *C. alticola*, *C. amazonica* Lane, 1939, and *C. davisi*.

*Corethrella (Corethrella) blanda* Dyar, 1928

Fig. 18; Appendix 1

## Diagnosis

### Larva

Only extant ground-dwelling species with the following combination of characters: darkly pigmented tergal plates (Fig. 18D); a darkly colored mandibular lobe (Fig. 18D); head and body light brown (Fig. 18D); ventral margin of antennal groove with about 5 moderately developed denticles (Fig. 18E); subgenal carina with smooth surface (Fig. 18E).

### Pupa

Only extant ground-dwelling species with the following combination of characters: a flattened, wide respiratory organ (Fig. 18G); abdominal margins strongly expanded laterally and shortly expanded posteriorly (Fig. 18H), with pale elongate setae on apex of expansions; abdominal segment III with one elongate lateral seta (Fig. 18H).

## Material examined

BRAZIL – **Santa Catarina State** • 1 ♀, adult, with larval and pupal exuviae; Florianópolis, Rio Tavares, Morro do Lampião, Poço de captação; 27°39'56" S, 48°29'29" W; 78 m a.s.l.; 21 Feb. 2018; A.P. Amaral leg.; hand net; CE-MHS • 1 ♀, adult; Santo Amaro da Imperatriz, Plaza Caldas; 27°44'31" S, 48°48'06" W; 470 m a.s.l.; 1 Apr. 2013; A. Ambrozio-Assis leg.; frog-call trap (*Physalaemus cuvieri*) 1<sup>st</sup>; CE-MHS • 1 ♀, adult; Porto Belo, Ponta do Araçá, “brejo de altitude” [altitude marsh]; 27°07'38" S, 48°31'20" W; 115 m a.s.l.; 25 Apr. 2012; L. C. Pinho leg.; Shannon; CE-MHS • 2 ♀♀, adults; Florianópolis, Lagoa do Peri, Saquinho; 27°43'23" S, 48°30'29" W; 13 m a.s.l.; 8 Apr. 2011; A. Ambrozio-Assis leg.; CDC trap; CE-MHS.

## Description

### Female adult (n = 5)

**HEAD. Sensilla** (Fig. 18A): Ocular row with 2 thick offset setae at ventral part, about 10–14 more dorsally, extending shortly beyond vertex. Subocular row not well-defined anteriorly, with about 4 posterior slender setae; vertex with a few additional slender setae. Postgenal row with 7–13 slender setae ranging from mid-posterior portion to ventromedially. With 1 thick ventromedial seta.

**THORAX. Sensilla** (Fig. 18B): Anteppronotum without setae. Postpronotum with 1 thick dorsal and 0–3 slender, more posterior setae. Scutum, prescutal area with 3–4 ventral and 2–3 posterodorsal thick setae. Antealar area with cluster of 9–14 thick/intermediate and 3–5 slender setae on posteroventral portion. Supraalar area with 3 thick and 2–5 slender setae on ventral portion. Dorsocentral row, posterior part with 6–8 thick offset, longitudinally aligned setae; 26–35 thick/intermediate and 16–18 slender setae completing row. Scutellum with 8–10 thick setae. Posterior anepisternum with 0–2 dorsal setae. Anepimeron bare.

**WING.**  $R_3/R_1$ : 0.67 (0.65–0.73);  $R_{2+3}/R_2$ : 0.35 (0.32–0.39).

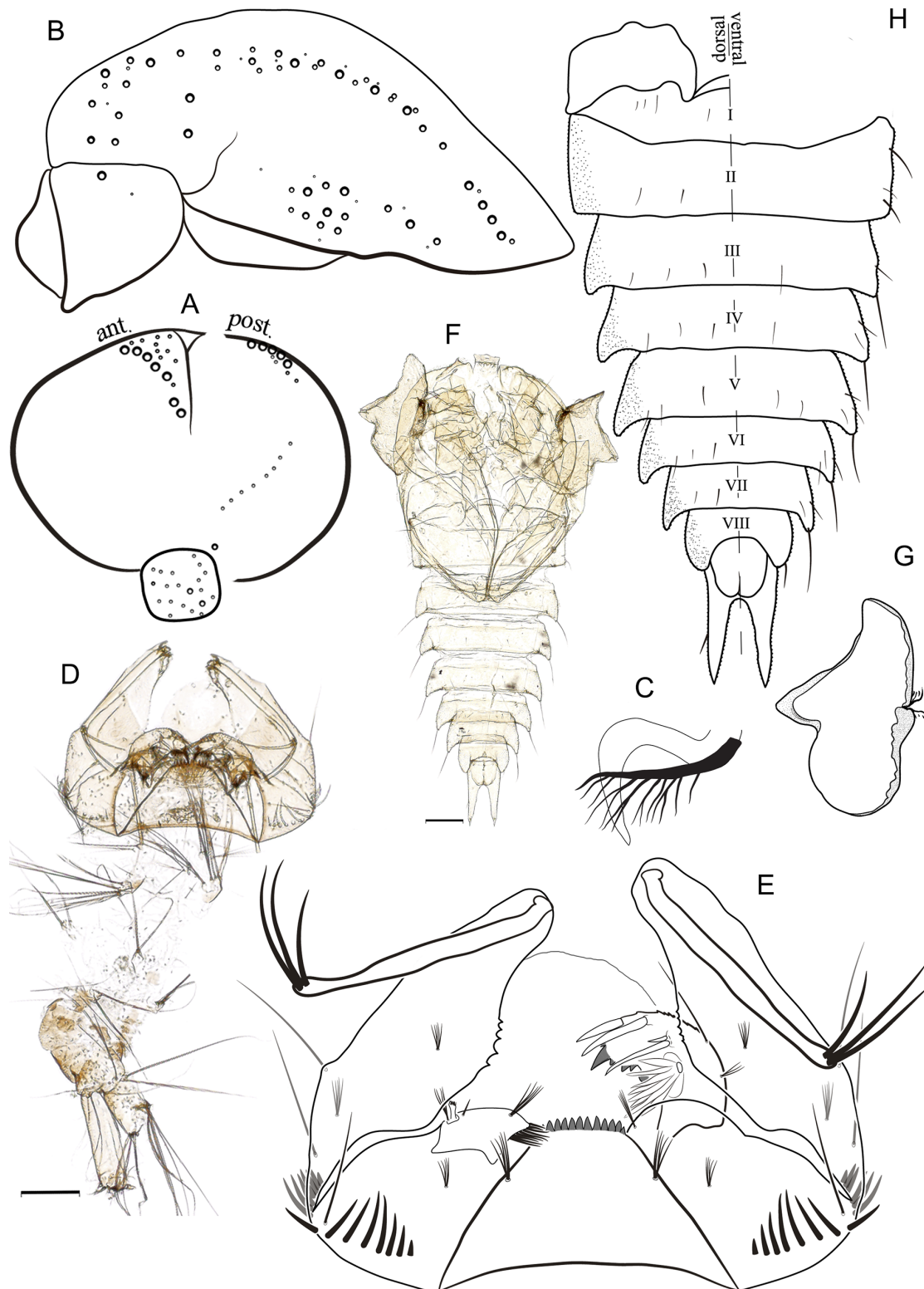
**LEGS** (Fig. 18C). Empodium of intermediate length, thick, with about 8 branches.  $Ta1/Ta2$ : 2.52 (2.28–2.67);  $Ta3/Ta4$ : 1.27 (1.09–1.38).

### Larva (n = 1)

**EXUVIA** (Fig. 18D). Uniformly light brown with darkly pigmented tergal plates on I–VII.

**HEAD** (Fig. 18E). Roughly triangular shape in dorsoventral view, 1.26 times as wide as long. Antenna length 0.59 times as long as head; antennal groove 1.31 times length of antenna. Ventral margin of antennal groove with about 5 moderately developed denticles. Postmentum with wide base, strongly tapering distally, 1.73 times as wide as long; 0.37 times length of head. Prementum straight, with 13 triangular teeth, darkly pigmented, central one largest, remaining gently decreasing in size. Anteromedial margin of gena somewhat projected anteriorly, surface smooth. Postcoila short, not extending to lateral margin of gena. Subgenal carina with smooth surface. Crown with 14 regularly distributed spines; 3 dorsalmost and 3 ventralmost smaller; largest spine 0.10 mm long. Seta 16-C situated mesially from crown. Mandible with darkly pigmented teeth; apical tooth length 1.89 of first dorsal tooth; seta 3-Mn 0.31 length of 4-Mn; lacinia mobilis with 8 blades; mandibular lobe well-developed, darkly pigmented, apart from teeth. **Sensilla**: 9-C short, fan-like; 10-C elongate, simple; 11-C short, fan-like; 12-C elongate, simple; 13-C short, fan-like; 14-C short, fan-like; 15-C short, fan-like; 16-C elongate, simple. 0a-Mn short, fan-like; 0b-Mn elongate, simple. 6-Mx moderately elongated, fan-like; 4-Mx short, simple; 5-Mx moderately elongate, fan-like.

**SIPHON.** 0.36 mm long. Seta 1 forked, at about 0.19 of length from base; 6-S pale, 9-S lightly pigmented; length of 6-S/9-S: 0.78.



**Fig. 18.** *Corethrella blanda* Dyar, 1928. A–C. Female adult. A. Cranial setae, anterior and posterior views, and clypeus in anterior view. B. Thoracic setae, lateral view. C. Hind leg claw and empodium. D. Larval exuvia, ventral view. E. Exuvia of larval head, ventral view, except mandible in dorsal view. F. Pupal exuvia, dorsal view. G. Pupal respiratory organ, dorsal view. H. Pupal methathorax and abdomen, dorsal and ventral views. Scale bars: 0.2 mm.

**Pupa (n = 1)**

EXUVIA (Fig. 18F). Uniformly light brown; all setae pale.

CEPHALOTHORAX. Length 1.24 mm. Respiratory organ (Fig. 18G) flattened, wide, trilobed, 0.65 mm long longitudinally. Dorsal seta 1 somewhat short, thick, about two lengths apart from dorsal 2; dorsal 2 slender, twice as long as dorsal 1; both setae arising from undifferentiated cuticle. Metathoracic and supraalar setae absent.

ABDOMEN (Fig. 18H). Moderately elongate, tapering, integument laterally rough; length of segments I–VIII: 1.24 mm; width/length: 0.65. Margins serrate, strongly projected posterolaterally. Setae D-2 shorter than half length of respective segments, equal from II–VII. Lateral setae L-4 elongate, longer than respective segments. Largest seta L-4-III, 1.29 times length of segment. Terminal process elongate, basal width 0.50 of length, with moderately broad paddles; D-1-IX moderately elongate, of intermediate thickness, at about 0.7 from base; apical spine not articulated; lacking ventroapical seta V-1-IX; female genital lobes broad, occupying most of basal portion. Chaetotaxy as illustrated.

**Distribution and biology**

The examined specimens have been found in the Atlantic forest of Santa Catarina State, at altitudes ranging from 13 to 470 m a.s.l. Adults were captured with CDC, Shannon and frog-call traps (playing the call of *Physalaemus cuvieri*). The single immature collected was found in a small ground pool, inside a highly disturbed forest fragment, at 78 m a.s.l. The specimens from Santo Amaro da Imperatriz have previously been recorded by Ambrozio-Assis *et al.* (2018).

*Corethrella blanda* is otherwise known from Costa Rica, Panama, Colombia, Trinidad and Tobago, French Guiana, and the Brazilian states of AM, PA, and SP, at altitudes ranging from 5 to 500 m a.s.l. (Borkent 2008).

**Remarks**

The larval exuviae here studied varied from previous descriptions in relation to the number of teeth on the prementum (10 in Dyar 1928; 11 in Lane & Cerqueira 1958), and the number of setae on the crown, described as 10 in Lane & Cerqueira 1958. Those differences are expected given the intraspecific variation observed in other species. In adults, Borkent (2008) described the posterior portion of the dorsocentral row as having two elongate setae somewhat lateral to one another. This is here recognized but differently interpreted. See Morphology remarks.

*Corethrella (Corethrella) redacta* Borkent, 2008

Fig. 19; Appendix 1

**Material examined**

BRAZIL – Bahia State • 1 ♀, adult; Uruçuca, PESC, “Fundos da sede” [behind park lodge]; 14°29'40" S, 39°08'23" W; 970 m a.s.l.; 31 Oct. 2016; V.A. Silva *et al.* leg.; light pan; CE-MHS.

**Description**

**Female adult (n = 1)**

HEAD. **Sensilla** (Fig. 19A): Ocular row with 2 thick offset setae at ventral part, 10 setae extending a little beyond vertex. Subocular row not well-defined; vertex, interocular space with few slender setae. Postgenal row with 12 slender setae located mid-posteriorly. With 1 ventromedial thick seta.

THORAX. **Sensilla** (Fig. 19B): Antep pronotum with 1 intermediate anterodorsal seta. Postpronotum with 1 thick subdorsal seta and 2 slender setae more ventrally. Scutum, prescutal area with two thick setae. Antealar area with group of 7 thick and 3 slender setae posteroventrally located. Supraalar area with 2 thick and 1 slender setae anteroposteriorly aligned. Dorsocentral row, posterior part with group of 8 thick offset setae, longitudinally arranged; about 17 thick/intermediate and 5 slender completing row. Scutellum with 10 thick setae. Posterior anepisternum and anepimeron without setae.

WING.  $R_3/R_1$ : 0.74;  $R_{2+3}/R_2$ : 0.35.

LEGS. Empodium (Fig. 19C) of intermediate length and thickness, with 2 long branches bifurcated at base, apically bent.  $Ta1/Ta2$ : 2.33;  $Ta3/Ta4$ : 1.38.

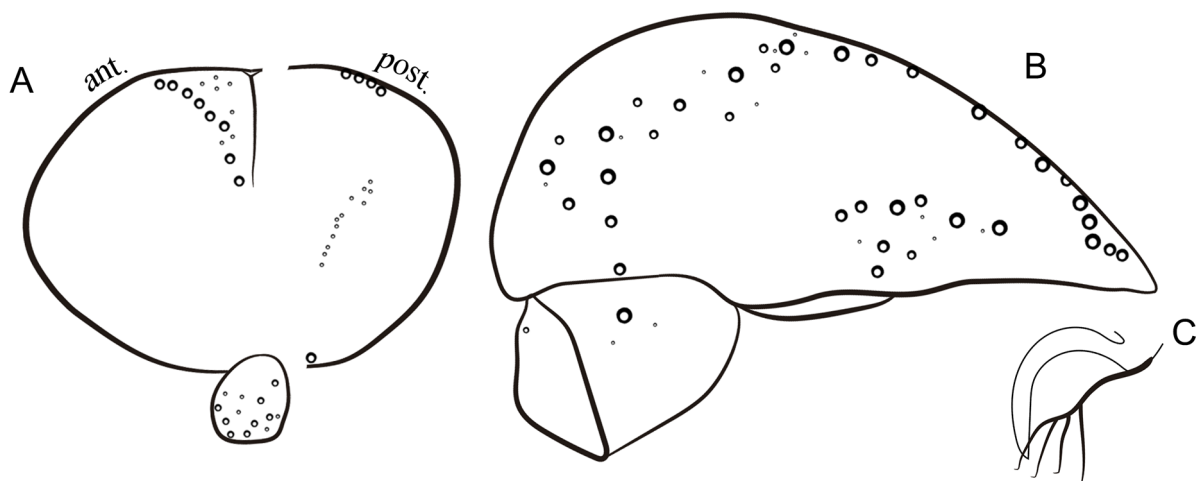
### Distribution and biology

This is the first record of *Corethrella redacta* both from the state of Bahia and from the Brazilian Northeast region. The single specimen was collected with a light trap near a small stream in an area of Atlantic forest in Serra do Conduru State Park, at an altitude of 970 m a.s.l.. This species has previously only been recorded from the type locality in the Brazilian state of Pará (Amazonian region), at an altitude of 30 m a.s.l. (Borkent 2008).

### Remarks

The shape of the empodium of this species is unique among all other examined species and differs considerably from those of other *peruviana*-group species. In the phylogeny proposed by Borkent (2008), *Corethrella redacta* appears as sister to *C. truncata* Borkent, 2008, sharing two synapomorphies. It would be interesting to examine the empodium of *C. truncata* to verify whether they also share this peculiar morphology.

The number of setae on the posterior portion of the dorsocentral row is here differently interpreted than in Borkent (2008). See Morphology remarks for more details.



**Fig. 19.** *Corethrella redacta* Borkent, 2008, female adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view.

*Corethrella (Corethrella) amazonica* Lane, 1939

Fig. 20; Appendix 1

**Material examined**

BRAZIL – **Bahia State** • 4 ♀♀, adults; Maraú, Cassange; 13°59'16" S, 38°57'03" W; 13 m a.s.l.; 28 Sep. 2019; A.P. Amaral leg.; CDC trap; CE-MHS • 1 ♀, adult; Ilhéus, Cabruca da UESC; 14°47'37" S, 39°10'25" W; 35 m a.s.l.; 16 Jul. 2019; A.P. Amaral leg.; F call trap (*Boana faber*); CE-MHS • 1 ♀, adult; Uruçuca, PESC, “Fundos da sede” [behind park lodge]; 14°29'40" S, 39°08'23" W; 970 m a.s.l.; 31 Oct. 2016; V.A. Silva *et al.* leg.; light pan; CE-MHS • 1 ♀, adult; Porto Seguro, RPPN Veracel, mussununga; 16°21'33" S, 39°08'15" W; 72 m a.s.l.; 12 Mar. 2020; A.P. Amaral leg.; frog-call trap (chorus); CE-MHS.

**Description**

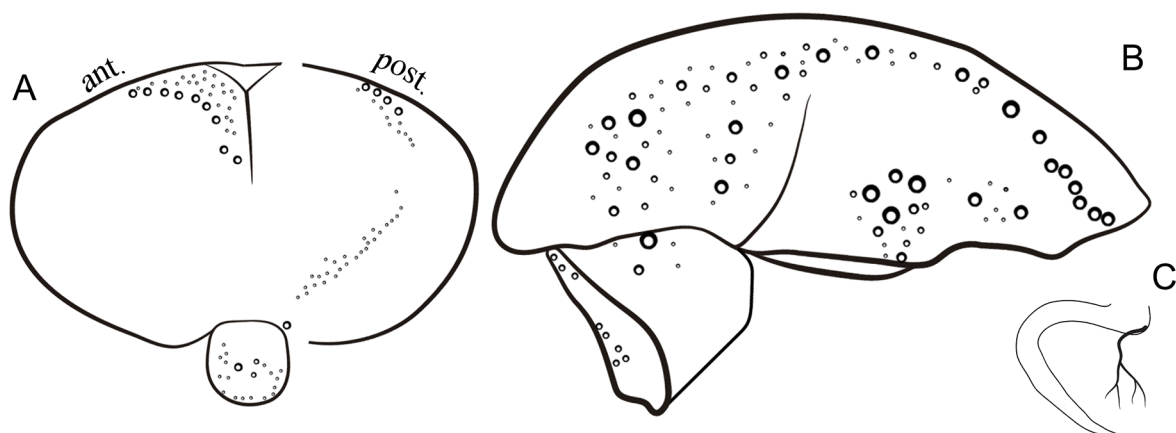
**Female adult** (n = 7)

**HEAD. Sensilla** (Fig. 20A): Ocular row with 2 thick offset setae at ventral part, 10–13 extending posteriorly. Subocular row weakly defined anteriorly, with 14–20 slender setae; vertex and interocular space with several slender setae. Postgenal row with 20–27 slender setae ranging from mid-posteriorly to ventromedially. With 1 thick ventromedial seta.

**THORAX. Sensilla** (Fig. 20B): Antep pronotum with 2–3 intermediate anterodorsal setae and 0–5 more ventral setae on anterior margin. Postpronotum with 1–2 thick dorsal and 3–6 slender setae. Scutum, prescutal area with 3 thick setae vertically arranged near prescutal suture, with 6–9 slender setae surrounding; group of about 4–5 thick/intermediate and 4–6 slender setae anteriorly, merging with anterior portion of dorsocentral row. Antealar area with 9–12 thick/intermediate and 6–8 slender setae clustered on posteroventral portion. Supraalar area with 2–3 thick setae, with 5–14 slender setae surrounding. Dorsocentral row, posterior part with group of 6–7 thick offset setae longitudinally aligned; 15–27 thick/intermediate and about 20–40 slender completing row. Scutellum with 9–12 thick setae. Posterior anepisternum with 0–4 slender dorsal setae. Anepimeron bare.

**WING.**  $R_3/R_1$ : 0.66 (0.63–0.69);  $R_{2+3}/R_2$ : 0.36 (0.32–0.43).

**LEGS.** Empodium (Fig. 20C) short, slender, with 2 branches.



**Fig. 20.** *Corethrella amazonica* Lane, 1939, female adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view.

### Distribution and biology

This is the first record of *Corethrella amazonica* both from the state of Bahia and from the Brazilian Northeast region. Specimens studied were collected via a light trap and a frog-call pan trap playing the calls of *Physalaemus cuvieri*, *P. signifer* (Girard, 1853) and *Boana faber*. Sampled locations were in the Atlantic forest area: a coastal lake, a white-sandy tropical savanna (mussununga), and a small stream in a forested area. Altitudes range from 13 to 210 m a.s.l.

This species is otherwise known from southern Mexico, Nicaragua, Costa Rica, Colombia, Trinidad and Tobago, Guyana, French Guiana, and the Brazilian states of ES, PA, RO, SC, and SP, at altitudes ranging from 0 to 500 m a.s.l. (Borkent 2008; Amaral *et al.* 2019).

### Remarks

The number of setae on the posterior portion of the dorsocentral row is here differently interpreted than in Borkent (2008). See Morphology remarks.

### *Corethrella (Corethrella) davisi* Shannon and Del Ponte, 1928

Fig. 21; Appendix 1

### Material examined

BRAZIL – **Bahia State** • 1 ♀, adult; Ilhéus, road to Lagoa Encantada; 14°38'52" S, 39°05'16" W; 2 m a.s.l.; 18 Nov. 2019; A.P. Amaral leg.; F. call trap (*H. gratiosa*, *B. faber*, *P. cuvieri*); CE-MHS • 1 ♂, adult, with larval and pupal exuviae; Ilhéus, Cabruca da UESC; 14°47'33" S, 39°10'23" W; 38 m a.s.l.; 20 Sep. 2019; A.P. Amaral leg.; stream; CE-MHS • 1 ♂, adult; same collection data as for preceding, except 4 Sep. 2019; CE-MHS • 1 ♀, adult; same collection data as for preceding, except 20 Sep. 2019; CE-MHS • 1 ♂, adult; same collection data as for preceding, except 14°47'44" S, 39°10'21" W; 35 m a.s.l.; 30 Sep. 2019; puddle; CE-MHS • 1 ♂, adult; Maráu, Lagoa Azul; 13°58'03" S, 38°56'22" W; 4 m a.s.l.; 28 Sep. 2019; A.P. Amaral leg.; bromeliad; CE-MHS. – **Santa Catarina State** • 1 ♂, adult; São Francisco do Sul, CEPA Vila da Glória, “Açude do Alojamento” [pond by the lodge]; 26°13'41" S, 48°40'55" W; 13 m a.s.l.; 21 Apr. 2018; A.P. Amaral and L.C. Pinho leg.; hand net; CE-MHS.

### Diagnosis

#### Larva

Only extant species with the following combination of characters: darkly pigmented tergal plates (Fig. 21D); a darkly colored mandibular lobe (Fig. 21D); head, siphon, and segment X medium brown (Fig. 21D), postmentum dark brown (Fig. 21D); basal width of postmentum 2.0–2.7 times its length (Fig. 21E).

#### Pupa

Only extant species with the following combination of characters: a flattened, wide, trilobed respiratory organ (Fig. 21G); a strongly tapered and short abdomen, with paddles short and narrow (Fig. 21H); abdominal margins not expanded laterally, with lateral setae weakly developed, shorter than each segment (Fig. 21H).

### Description

#### Male and female adults (4 ♂♂, 1 ♀)

HEAD. **Sensilla** (Fig. 21A): Ocular row with 2 thick offset setae at ventral part, 9–10 setae more dorsally, shortly extending posteriorly. With subocular row of about 12 slender setae. Postgenal row with 7–9 slender setae, restricted to posteroventral region. With 1 ventromedial thick seta.

THORAX. **Sensilla** (Fig. 21B): Antep pronotum with 1–3 intermediate anteromedial setae. Postpronotum with 1 thick dorsal and 2–3 slender setae. Scutum, prescutal area with 2–4 thick ventral setae and 2–3 posterodorsal setae near dorsocentral row. Antealar area with cluster of 5–9 thick/intermediate and 2–4 slender setae on posteroventral portion. Supraalar area with 3 thick and 3 slender setae on ventral portion. Dorsocentral row, posterior part with 4–5 thick offset setae, longitudinally aligned; 16–18 thick/intermediate and 6–8 slender setae filling row. Scutellum with 10 thick setae. Posterior anepisternum with 1–2 slender dorsal setae. Anepimeron with 2–3 slender setae.

WING. Male  $R_3/R_1$ : 0.64 (0.53–0.70);  $R_{2+3}/R_2$ : 0.50 (0.37–0.66). Female  $R_3/R_1$ : 0.67;  $R_{2+3}/R_2$ : 0.39.

LEGS. Empodium (Fig. 21C) short, slender, with 2 branches. Male  $Ta1/Ta2$ : 2.43 (2.07–2.77);  $Ta3/Ta4$ : 1.35 (1.29–1.50). Female  $Ta1/Ta2$ : 2.30;  $Ta3/Ta4$ : 1.17.

#### Larva (n = 5)

EXUVIA (Fig. 21D). Head, siphon, and segment X medium brown, postmentum dark brown. Darkly pigmented tergal plates on I–VII.

HEAD (Fig. 21E). Roughly triangular shape in dorsoventral view, 1.22 (1.14–1.28) times as wide as long. Antenna 0.59 (0.53–0.65) times length of head; antennal groove 1.32 (1.18–1.48) times length of antenna. Ventral margin of antennal groove with 5–8 large denticles. Postmentum with base wide, strongly tapering, 2.42 (2.05–2.69) times as wide as long; length 0.28 (0.24–0.36) of head. Prementum straight, with 11–13 triangular teeth, darkly pigmented, central one largest, remaining ones somewhat smaller and equal. Anteroventral projection of gena somewhat projected anteriorly, slightly angular laterally, surface irregular. Postcoila short, not extending to lateral margin of gena. Subgenal carina with smooth surface. Crown with 9–10 spines, more sparse ventrally, sizes growing towards lateral; largest spine 0.03–0.04 mm long. Seta 16-C situated mesially from crown. Mandible with darkly pigmented teeth. Apical tooth length 1.73 (1.38–2.16) of first dorsal tooth. Seta 3-Mn 0.26 (0.21–0.33) times length of 4-Mn. Lacinia mobilis with 7 blades. Mandibular lobe well-developed, darkly pigmented apart from teeth. **Sensilla**: 9-C short, fan-like; 10-C elongate, simple; 11-C short, fan-like; 12-C elongate, simple; 13-C short, simple; 14-C short, simple; 15-C short, fan-like; 16-C elongate, simple. 0a-Mn short, simple or fan-like; 0b-Mn elongate, simple or fan-like. 6-Mx short, bifurcated; 4-Mx short, fan-like; 5-Mx short, fan-like.

SIPHON. 0.21 mm (0.20–0.22) long. Seta 1 bifurcated, at 0.30 (0.28–0.33) of length from base; 6-S and 9-S lightly colored; length of 6-S/9-S: 0.86 (0.80–0.95).

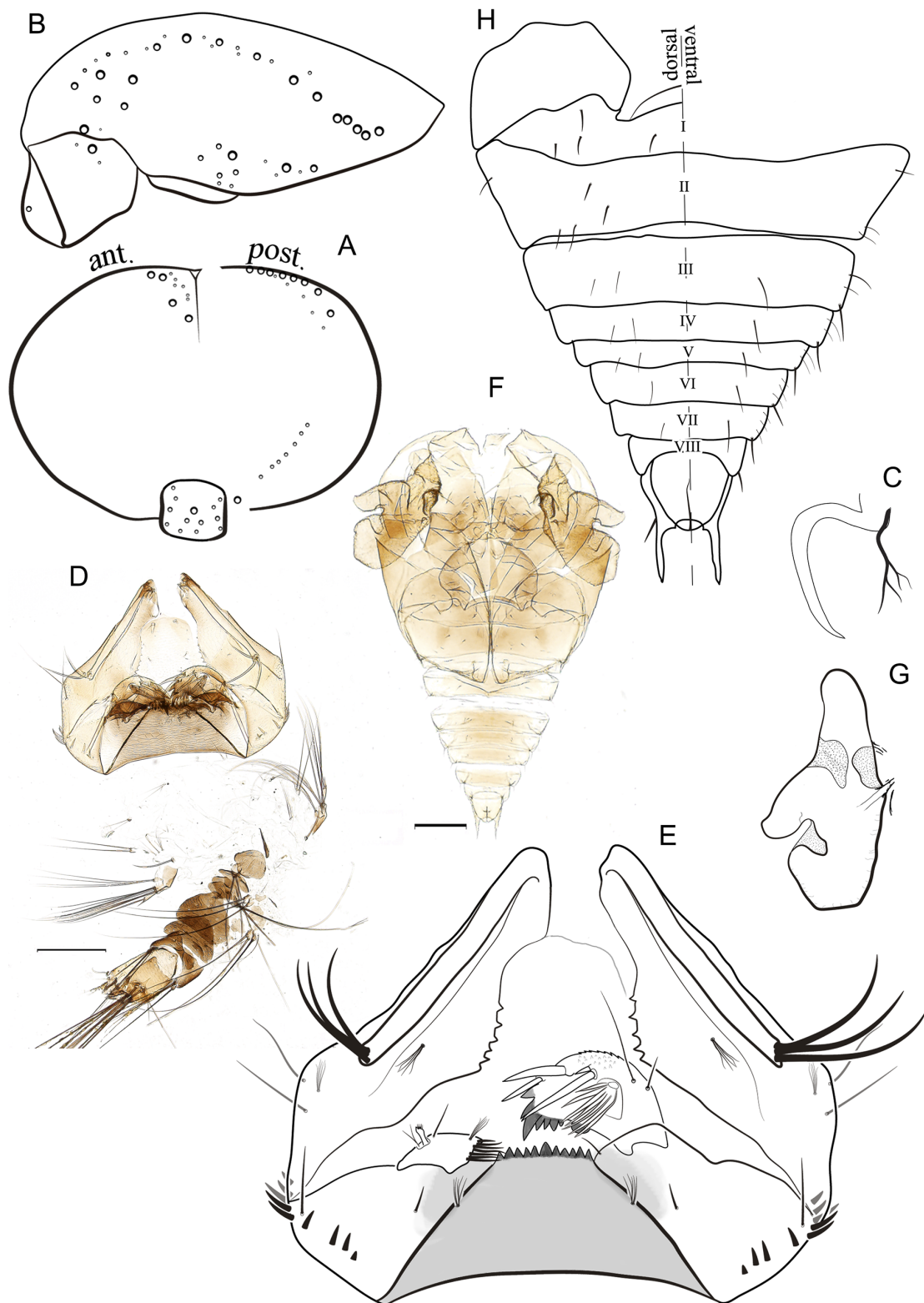
#### Pupa (n = 6)

EXUVIA (Fig. 21F). Medium to dark brown, with medial portion of abdominal segments III–VII somewhat darker; all setae lightly pigmented.

CEPHALOTHORAX. Length 0.91 mm (0.85–1.02). Respiratory organ (Fig. 21G) flattened, wide, trilobed, 0.48 mm (0.37–0.57) long longitudinally. Dorsal seta 1 short, thick, about two lengths apart from dorsal 2; dorsal 2 approximately twice as long, slender. Both setae arising from undifferentiated cuticle. Metathoracic and supraalar sensilla absent.

ABDOMEN (Fig. 21H). Short, strongly tapered posteriorly, surface smooth; length of segments I–VIII: 0.60 mm (0.51–0.73), width/length: 1.07 (0.94–1.21). Margins smooth, not expanded laterally. Setae D-2 shorter than half length of respective segments, equal from II–VII. Lateral setae L-4 short, about half length of respective segments. Largest seta V-5-III, 0.55 (0.40–0.66) times length of segment. Terminal process short, basal width 0.71 (0.65–0.80) of length, with narrow paddles, small indentation





**Fig. 21.** *Corethrella davisi* Shannon & Del Ponte, 1928. A. Adult cranial setae, anterior and posterior views, and female clypeus in anterior view. B. Adult thoracic setae, lateral view. C. Hind leg claw and empodium, lateral view. D. Larval exuvia, ventral view. E. Exuvia of larval head, ventral view, except mandible in dorsal view. F. Pupal exuvia, dorsal view. G. Pupal respiratory organ, dorsal view. H. Pupal methatorax and abdomen, dorsal and ventral views. Scale bars: 0.2 mm.

on mesial margin; D-1-IX somewhat short, located at about 0.5 from base; apical spine not articulated; lacking ventroapical seta V-1-IX; female genital lobe tapering, occupying most of basal portion; genital lobe ovate in male, slightly extending beyond base. Chaetotaxy as as illustrated.

### Distribution and biology

The examined specimens were collected as immatures in puddles, margins of small brooks, and a pond, except one which was captured in the tank of a giant ground bromeliad, *Aechmea multiflora* L.B.Sm., in Bahia. It is not clear whether this is a typical immature habitat for the species or it was an exceptional case. *Corethrella pallida* of the *peruviana* group has also been found in bromeliads, as well as in treeholes (Borkent 2008). Individuals were found at altitudes ranging from 4 to 38 m a.s.l. in Atlantic forest fragments with different degrees of disturbance in Bahia and Santa Catarina states.

This species is also known throughout Central America, northern South America, and the Brazilian states of BA, MG, MS, PA, RJ, SC, and SP, at altitudes ranging from 0 to 637 m a.s.l. (Borkent 2008; Amaral *et al.* 2019). It is possible that at least some of these records actually refer to *C. bifida* sp. nov.

### Remarks

The specimens examined here present some slight variation in relation to previous descriptions of *Corethrella davisi*, which is expected as intraspecific variation of a broadly distributed species. Those variable features are the adult scutellum with 10 thick setae (12 in Lane 1953), pupa medium/dark brown (yellowish in Lane 1953), larval prementum with 13 teeth (10 in Lane 1953) and larval antenna 0.53–0.65 times the length of the head. With respect to the latter character, Lane describes the length of the antenna as the same as that of the head, what has not been observed in any species examined in the present study. The largest relative length of the antenna observed is in *C. davisi*, but this is only 0.65 of head length. We suspect that the character was possibly misinterpreted by Lane. In adults, the elongated setae on the posterior part of the dorsocentral row are here differently interpreted than in Borkent (2008) (see Morphology remarks).

### *Corethrella (Corethrella) ananacola* Dyar, 1926

Fig. 22; Appendix 1

### Diagnosis

#### Larva

Only bromelicolous species with the following combination of characters: head mostly pale (Fig. 22D), with darker mandibles and maxillae; postmentum elongate, with margins gently tapering from base (Fig. 22E); crown with about 14 spines regularly distributed, sizes slightly growing towards lateral, with two ventralmost shorter; subgenal carina without spinules (Fig. 22E); ventral margin of antennal groove serrate (Fig. 22E).

#### Pupa

Only bromelicolous species with following combination of characters: exuvia medium brown, abdomen elongate and tapering, darker mesially; abdominal segments little expanded laterally; one dorsal and one lateral well-developed setae on each of segments II–VII (largest setae not longer than 1.67 times length of segment); dorsal setae progressively shorter from V–VII; all setae lightly pigmented; respiratory organ tubular, elongate, expanded at apex.

### Material examined

BRAZIL – Santa Catarina State • 1 ♀, adult, with pupal and larval exuviae; Santo Amaro da Imperatriz, Plaza Caldas; 27°44'01" S, 48°48'45" W; 248 m a.s.l.; 22 Jul. 2014; L.C. Pinho *et al.* leg.; bromeliad;

CE-MHS • 2 ♀♀, 1 ♂, adults, with pupal exuviae; same collection data as for preceding; CE-MHS • 2 ♂♂, adults, with pupal exuviae; same collection data as for preceding, except 7 Jun. 2014; CE-MHS.

## Description

### Male and female adults (3 ♂♂, 3 ♀♀)

**HEAD. Sensilla** (Fig. 22A): Ocular row with 1 thick offset seta at ventral part, 1 more dorsal and 13–15 extending to mid-posterior portion of head. Subocular row not well-defined anteriorly, with about 5 setae on posterior portion. Interocular space and vertex with many slender setae. Postgenal row with 9–13 slender setae, ranging from posterior part of ocular row to subventrally. With 2 thick ventromedial setae.

**THORAX. Sensilla** (Fig. 22B): Anteprepronotum with 1–3 slender dorsal setae and about 4–10 intermediate/slender ventral setae. Postpronotum with 1 thick and 1 slender dorsal setae; 1 intermediate and 4–5 slender posterior setae. Scutum, prescutal area with 2–3 thick, vertically aligned, posterior setae; 7–9 thick/intermediate and 11–15 slender setae spread. Antealar area with 3–4 thick/intermediate setae vertically aligned anteriorly and 8–10 thick/intermediate setae more posteriorly; about 15–26 slender setae distributed from ventral to dorsal portions. Supraalar area with 3–4 thick setae surrounded by about 6–15 slender setae. Dorsocentral row, posterior part with cluster of 4–5 thick and 6 slender setae; 16–20 thick/intermediate and approximately 27–45 slender setae filling row. Scutellum with 8–10 thick setae. Posterior anepisternum bare. Anepimeron with 3–12 slender mid-posterior setae.

**WING.** Male  $R_3/R_1$ : 0.44 (0.43–0.46);  $R_{2+3}/R_2$ : 0.79 (0.77–0.81). Female  $R_3/R_1$ : 0.49 (0.48–0.49);  $R_{2+3}/R_2$ : 0.78 (0.73–0.86).

**LEGS.** Empodium (Fig. 22C) of intermediate length, intermediate thickness, with 3 branches. Male  $Ta1/Ta2$ : 3.06 (3.00–3.13);  $Ta3/Ta4$ : 0.68 (0.64–0.73). Female  $Ta1/Ta2$ : 2.79 (2.67–2.88);  $Ta3/Ta4$ : 1.13 (1.09–1.20).

### Larva (n = 1)

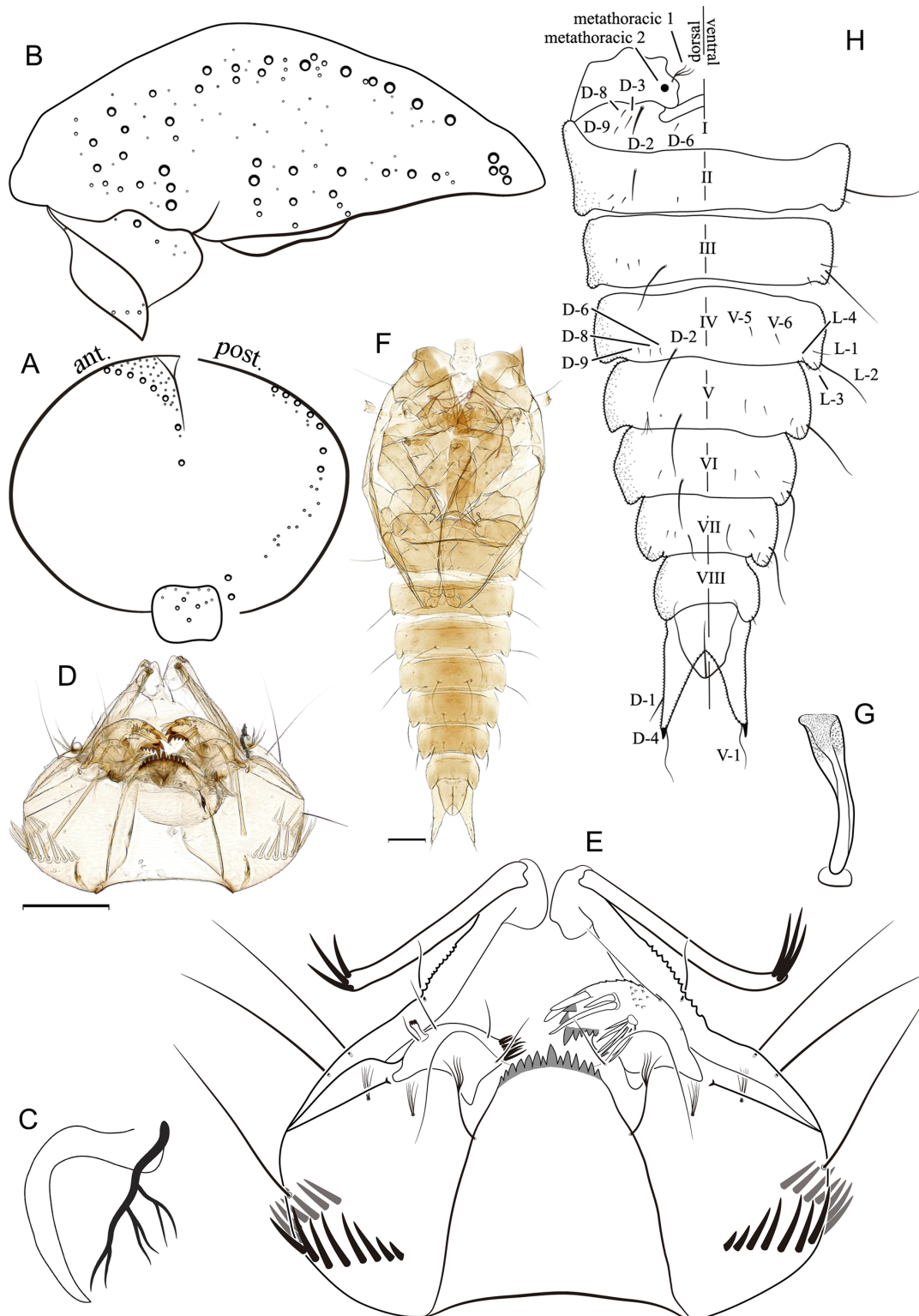
**EXUVIA** (Fig. 22D). Head mostly pale; mandible and maxilla more darkly pigmented; thorax and abdomen unknown.

**HEAD** (Fig. 22E). Wide, somewhat round in dorsoventral view, 1.18 times as wide as long. Antenna 0.46 times length of head; antennal groove 1.23 times length of antenna. Ventral margin of antennal groove serrate. Postmentum elongate, with margins gently tapering from base; 0.90 times as wide as long; head 0.55 mm long. Prementum curved, with 13 apically tapering, darkly pigmented teeth, central one largest, second small, third large and remaining ones gradually smaller. Anteroventral projection of gena strongly projected anteriorly, surface smooth. Postcoila extending to lateral margin of gena. Subgenal carina without spinules. Crown with 14 spines, regularly distributed, sizes slightly growing towards lateral, with first two ventral ones shortest; largest spine 0.07 mm long. Seta 16-C anterolateral to crown. Mandible, apical tooth length 1.29 of first dorsal tooth; seta 3-Mn 0.46 length of 4-Mn; lacinia mobilis with 7 blades; mandibular lobe well-developed, pale, contiguous to teeth. **Sensilla**: 9-C short, fan-like; 10-C elongate, simple; 11-C moderately elongate, simple; 12-C elongate, simple; 13-C short, fan-like; 14-C moderately elongate, simple; 15-C elongate, forked; 16-C elongate, simple. 0a-Mn unknown; 0b-Mn elongate, simple. 6-Mx short, simple; 4-Mx moderately elongate, simple; 5-Mx short, simple.

**SIPHON.** Unknown.

### Pupa (n = 6)

**EXUVIA** (Fig. 22F). Medium brown, with mesial portion of abdominal segments III–VII darker; all setae lightly pigmented.



**Fig. 22.** *Corethrella ananacola* Dyar, 1926. **A.** Adult cranial setae, anterior and posterior views, and female clypeus in anterior view. **B.** Adult thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view. **D.** Head of larval exuvia, ventral view. **E.** Exuvia of larval head, ventral view, except mandible in dorsal view. **F.** Pupal exuvia, dorsal view. **G.** Pupal respiratory organ, dorsal view. **H.** Pupal methathorax and abdomen, dorsal and ventral views. Scale bars: 0.2 mm. Abbreviations: D-1–9 = dorsal setae; L-1–4 = lareral setae; V-1, 5–6 = ventral setae.

CEPHALOTHORAX. Length 1.29 mm (1.24–1.37). Respiratory organ (Fig. 22G) tubular, elongate, with expanded apical opening; trachea not spiraled, 0.24 mm (0.23–0.26) long. Dorsal seta 1 pale, short, thick; one length apart from dorsal 2; dorsal 2 pale, of same basal thickness, tapering distally, about four times as long; both setae arising from undifferentiated cuticle. Metathoracic 2 and supraalar 2 sensilla present. Metathoracic seta 1 short, fan-like.

ABDOMEN (Fig. 22H). Elongate, tapering, tegument smooth. Segments I–VIII length 1.38 mm (1.17–1.51), width/length: 0.54 (0.51–0.58). Margins serrate, little expanded laterally. Setae D-2 elongate, subequal from II–IV. Lateral setae well-developed on II–VII. Largest seta D-2-III, 1.42 (1.22–1.67) length of segment. Terminal process elongate, basal width 0.65 (0.61–0.69) of length, paddles moderately broad, with small indentation on mesial margin; D-1-IX short, at about 0.70 from base; apical spine articulated; ventroapical seta V-1-IX about 3 times as long as apical spine; male and female genital lobes ovate, in male slightly extending beyond basal portion. Chaetotaxy as illustrated.

### Distribution and biology

The specimens were previously recorded by Amaral *et al.* (2019). They were collected in Atlantic forest fragments in Santa Catarina State, at altitudes ranging from 13 to 252 m a.s.l. Immatures were captured from bromeliad tanks and two adults in CDC traps.

This species is otherwise known from Costa Rica, Panama, Trinidad and Tobago, and the Brazilian states of ES and SP, at altitudes ranging from 0 to 600 m a.s.l. (Borkent 2008).

### Remarks

Immatures of *Corethrella ananacola* have previously been described by Dyar (1926), Lane (1939b, 1942, 1953), and Borkent (2008). There was only one larval exuvia available, and it lacked the thorax and abdomen. Nevertheless, the morphologies of larval head and the pupa are similar to those of *C. borkenti*, which is currently hypothesized to be phylogenetically distant. In future analyses, including immature morphology and molecular data, a closer relationship between these species may be retrieved.

### *Corethrella (Corethrella) flavitibia* Lane, 1939

Fig. 23; Appendix 1

### Material examined

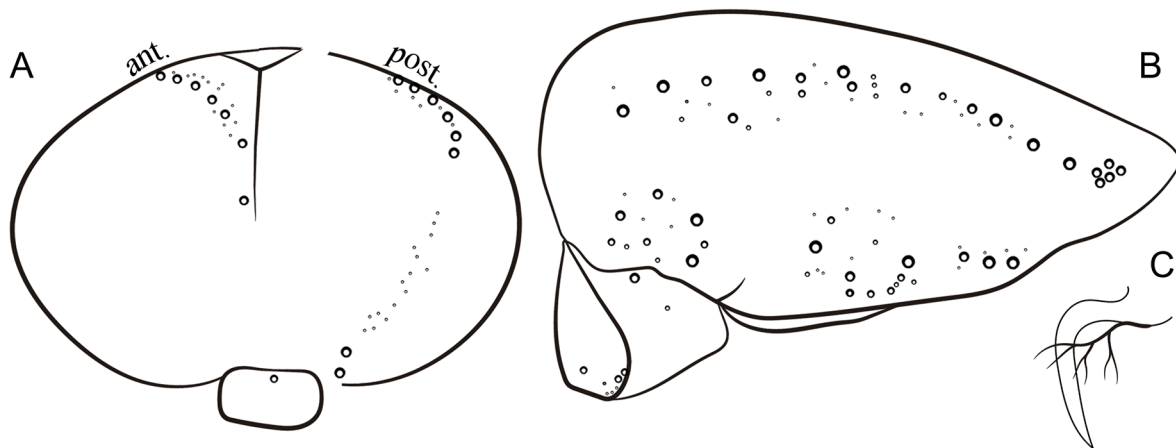
BRAZIL – Bahia State • 1 ♀, adult; Porto Seguro, RPPN Estação Veracel; 16°18'23" S, 39°06'34" W; 22 m a.s.l.; 28 Aug. 2019; A.P. Amaral leg.; light pan; CE-MHS.

### Description

#### Female adult (n = 1)

HEAD. **Sensilla** (Fig. 23A): Ocular row with 1 thick offset seta at ventral part and 12 setae shortly extending posteriorly. Subocular row well-defined, with 11 slender setae; vertex and interocular space without setae. Postgenal row with 15 slender setae ranging from mid-posteriorly to ventromedially. With 2 thick ventromedial setae.

THORAX. **Sensilla** (Fig. 23B): Anteprenotum with 3 intermediate and 4 slender posteroventral setae. Postpronotum with 1 thick dorsal and 1 more ventral intermediate setae. Scutum, prescutal area with 2 thick and 1 intermediate setae, vertically arranged near prescutal suture; group of 6 thick/intermediate and 4 slender setae anteriorly. Antealar area with 12 thick/intermediate and 6 slender setae clustered on



**Fig. 23.** *Corethrella flavitibia* Lane, 1939, female adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view.

posteroventral portion. Supraalar area with 3 thick setae, with 5 slender setae surrounding. Dorsocentral row, posterior part with group of 5 thick offset setae; about 15 thick/intermediate and 17 slender setae completing the row. Scutellum with 10 thick setae. Posterior anepisternum without setae. Anepimeron with 14 slender setae.

WING.  $R_3/R_1$ : 0.49;  $R_{2+3}/R_2$ : 0.93.

LEGS. Empodium (Fig. 23C) short, slender, with 3 branches.  $Ta1/Ta2$ : 2.31;  $Ta3/Ta4$ : 1.30.

### Distribution and biology

*Corethrella flavitibia* is newly recorded both from the state of Bahia and from the Brazilian Northeast region. The single female was collected with a light trap near a brook in the Atlantic forest reserve RPPN Estação Veracel, at an altitude of 4 m a.s.l. It was previously known only from the type locality in São Paulo, Brazil, at an altitude of 85 m a.s.l. (Borkent 2008).

### Remarks

The specimen collected diverged from the description by Borkent (2008) with respect to the number of setae on the posterior portion of the dorsocentral row and by the presence of sensilla coeloconica on flagellomeres II and IX. This variation is accepted for other species and is hence considered intraspecific variation here.

### *Corethrella (Corethrella) cardosoi* Lane, 1939

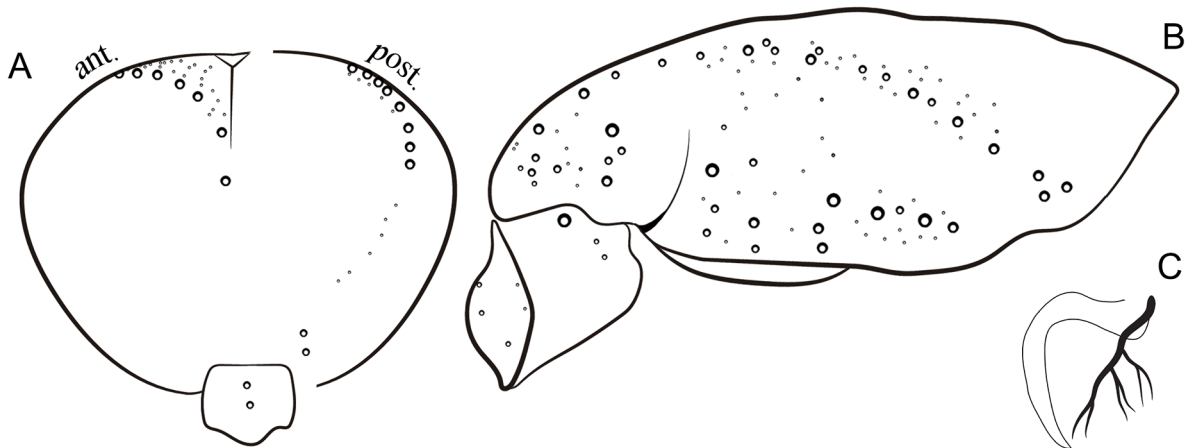
Fig. 24; Appendix 1

### Material examined

BRAZIL – **Santa Catarina State** • 1 ♀, adult; Grão Pará, Parque Estadual Serra Furada, CAPEA stream; 28°11'26" S, 49°23'30" W; 16 Nov. 2012–7 Jan. 2013; L.C. Pinho, M.C. Novaes and M.F. Haddad leg.; Malaise; CE-MHS.

### Description

**Female adult** (n = 1) (Fig. 24)



**Fig. 24.** *Corethrella cardosoi* Lane, 1939, female adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view.

**HEAD. Sensilla** (Fig. 24A): Ocular row with 1 thick offset seta at ventral part, 14 setae extending posteriorly. Subocular row not well-defined anteriorly, with 5 slender posterior setae; vertex and interocular space with several setae. Postgenal row with 6 slender setae on mid-posterior portion of head. With 2 thick ventromedial setae.

**THORAX. Sensilla** (Fig. 24B): Anteprenotum with 3 intermediate and 2 slender lateral setae. Postpronotum with 1 thick dorsal and 2 intermediate posterior setae. Scutum, prescutal area with 2 thick and 2 intermediate setae vertically arranged near prescutal suture; group of 4 intermediate and 4 slender setae anteriorly. Antealar area with group of 10 thick/intermediate and 6 slender setae spread on ventral portion; 7 slender dorsal setae. Supraalar area with 2 thick and 2 intermediate setae, with 10 slender setae surrounding. Dorsocentral row, posterior part with group of 3 thick offset setae; about 16 thick/intermediate and 27 slender setae completing row. Scutellum with 10 thick setae. Posterior anepisternum without setae. Anepimeron with 7 slender mid-posterior setae.

**WING.**  $R_3/R_1$ : 0.56;  $R_{2+3}/R_2$ : 0.61.

**LEGS.** Empodium (Fig. 24C) short, of intermediate thickness, with 3 branches.  $Ta1/Ta2$ : 2.69;  $Ta3/Ta4$ : 1.10.

### Distribution and biology

The specimen has previously been recorded by Amaral *et al.* (2019). It was collected using a Malaise trap near a small stream in Serra Furada State Park, Santa Catarina State, at 503 m a.s.l. The other records of this species are from the Atlantic forest of the Brazilian states of RJ and SP. Only the altitude from São Paulo was reported, as 603 m a.s.l. (Lane 1953; Borkent 2008).

### *Corethrella (Corethrella) amabilis* Borkent, 2008

Fig. 25; Appendix 1

### Material examined

**BRAZIL – Santa Catarina State** • 1 ♀, adult; Santo Amaro da Imperatriz, Plaza Caldas; 27°44'31" S, 48°48'06" W; 470 m a.s.l.; 1 Apr. 2013; A. Ambrozio-Assis leg.; frog-call trap (*Physalaemus cuvieri*) 1<sup>st</sup>; CE-MHS.

## Description

### Female adult (n = 1)

**HEAD. Sensilla** (Fig. 25A): Ocular row with 1 thick offset seta at ventral portion, about 15 setae shortly extending posteriorly. Subocular row poorly defined anteriorly, with 4 slender setae on posterior portion; vertex and interocular space with a few scattered slender setae. Postgenal row with 6 slender setae ranging from mid-posterior portion to ventromedially. With 2 ventromedial thick setae.

**THORAX. Sensilla** (Fig. 25B): Antepronotum with 9 slender lateral setae. Postpronotum with 1 thick dorsal and 4 slender setae more posteriorly. Scutum, prescutal area with 2 thick and 1 intermediate, vertically aligned setae near prescutal suture; 8 intermediate and 4 slender setae anteriorly, merging with anterior portion of dorsocentral row. Antealar area with 9 thick, 4 intermediate and 6 slender setae centrally located; 8 slender setae more dorsally, near dorsocentral row. Supraalar area with 1 thick and 2 intermediate setae anteroposteriorly aligned, 11 slender setae surrounding. Dorsocentral row, posterior region with 3 thick and 1 slender offset setae; about 27 thick/intermediate and 14 slender setae filling row. Scutellum with 10 thick setae. Posterior anepisternum without setae. Anepimeron with 15 slender setae.

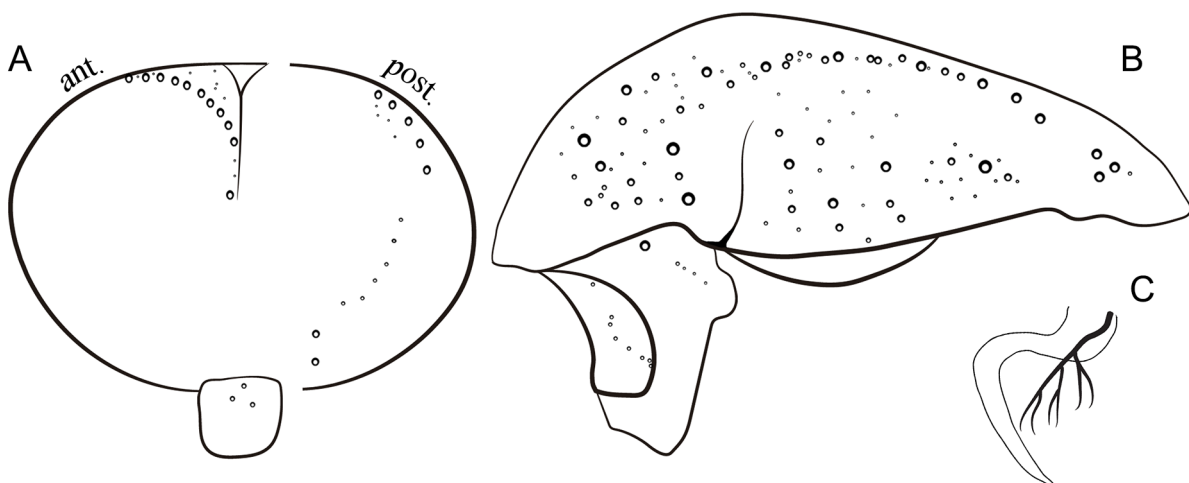
**WING.**  $R_3/R_1$ : 0.59;  $R_{2+3}/R_2$ : 0.57.

**LEGS.** Empodium (Fig. 25C) short, slender, with 3 branches.  $Ta1/Ta2$ : 2.87;  $Ta3/Ta4$ : 1.10.

### Distribution and biology

The single specimen examined was previously recorded by Ambrozio-Assis *et al.* (2018). It was collected via frog-call trap playing the call of *Boana bischoffi*, in Santa Catarina State, in an area of Atlantic forest, at an altitude of 470 m a.s.l.

This species is otherwise known only from Costa Rica, at altitudes ranging from 1800 to 1850 m a.s.l. (Borkent 2008).



**Fig. 25.** *Corethrella amabilis* Borkent, 2008, female adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view.



*Corethrella (Corethrella) lopesi* Lane, 1942

Fig. 26; Appendix 1

**Material examined**

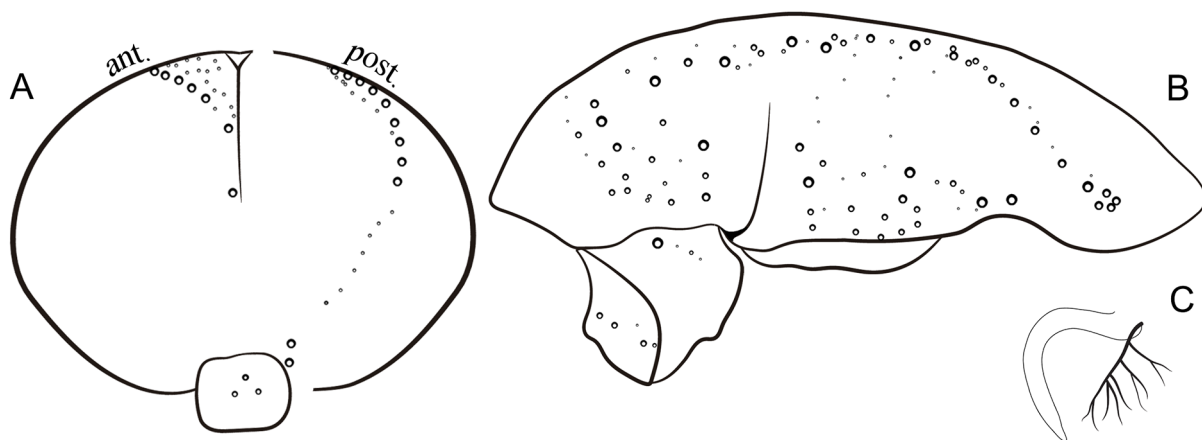
BRAZIL – **Santa Catarina State** • 1 ♀, adult; Urubici, Parna São Joaquim, Alojamento, Brejo flores; 28°08'31" S, 49°38'07" W; 1361 m a.s.l.; 24 Feb. 2014; A.P. Amaral and A. Parise leg.; frog-call tray; CE-MHS • 1 ♀, adult; Grão Pará, Parque Estadual Serra Furada; 28°11'28" S, 49°23'30" W; 13 Oct. 2012; L.C. Pinho, A.C. Ganzer, L.S. Gomes, and A.G. Parise leg.; entomology net; CE-MHS • 1 ♂, adult; same collection data as for preceding, except CAPEA stream; 28°11'26" S, 49°23'30" W; 6 Sep.–5 Oct. 2012; Malaise trap; CE-MHS • 1 ♀, adult; Porto Belo, Ponta do Araçá, “Brejo de altitude” [altitude marsh]; 27°07'38" S, 48°31'20" W; 115 m a.s.l.; 25 Jul. 2011; Ganzer and Fabris leg.; light trap; CE-MHS. – **Rio Grande do Sul State** • 1 ♀, adult; Derrubadas, “Parque Estadual do Turvo” [Turvo State Park], Riacho Salto; 27°08'21.6" S, 53°52'52.4" W; 12 Feb. 2014; V. Caldart leg.; frog-call trap (*Physalaemus* aff. *gracilis*); CE-MHS. – **Bahia State** • 1 ♂, adult; Camacan, RPPN Serra Bonita, “Córrego Sede” [stream by the lodge]; 29 Jan. 2005; Calor *et al.* leg.; light trap; CE-MHS.

**Description**

**Male and female adults** (2 ♂♂, 4 ♀♀)

**HEAD. Sensilla** (Fig. 26A): Ocular row with 1 thick offset seta at ventral part, 13–18 setae extending to mid-posterior portion of head. Subocular row well-defined, with about 14 slender setae; vertex with a few additional slender setae. Postgenal row with 6–8 slender setae, ranging from posterior end of ocular row to ventromedially. With 2 thick ventromedial setae.

**THORAX. Sensilla** (Fig. 26B): Anteprenotum with 3–4 thick/intermediate and 1–2 slender lateral setae. Postpronotum with 1 thick dorsal, 0–1 intermediate, and 3–4 slender, more posterior setae. Scutum, prescutal area with 3 thick setae dorsoventrally aligned near prescutal suture and about 6–10 intermediate setae grouped more anteriorly, reaching anterior portion of dorsocentral row. Antealar area with 4–5 thick/intermediate setae dorsoventrally aligned and 8–9 thick/intermediate setae more posteriorly, forming a U-shape; 5–7 slender setae scattered dorsally. Supraalar area with 2–3 thick setae, with 5–6 intermediate/slender setae more anteriorly. Dorsocentral row, posterior part with cluster of 3–5 thick and 1 slender setae; 21–28 thick/intermediate and approximately 14 slender setae filling row. Scutellum with 12–14 thick setae. Posterior anepisternum bare. Anepimeron with 12–15 slender setae.



**Fig. 26.** *Corethrella lopesi* Lane, 1942, adult. **A.** Cranial setae, anterior and posterior views, and female clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view.

WING. Male  $R_3/R_1$ : 0.43–0.44;  $R_{2+3}/R_2$ : 0.81–0.86. Female  $R_3/R_1$ : 0.51 (0.48–0.55);  $R_{2+3}/R_2$ : 0.72 (0.62–0.79).

LEGS. Empodium (Fig. 26C) of intermediate length, slender, with 3 branches. Male Ta1/Ta2: 3.06–3.17; Ta3/Ta4: 0.73–0.82. Female Ta1/Ta2: 3.00 (2.89–3.11); Ta3/Ta4: 1.24 (1.18–1.30).

### Distribution and biology

The examined individuals were collected via sweeping, and Malaise, light and frog-call traps (playing the calls of *Boana faber*, *Physalaemus cuvieri*, and *P. nanus*) in Santa Catarina and Bahia states. Sampling areas consisted of marshes and the surroundings of small streams in the Atlantic forest, at altitudes ranging from 115 to 1356 m a.s.l.

*Corethrella lopesi* is also known from the Atlantic forest of the Brazilian states of BA, RJ, RS, SC, and SP, at altitudes ranging from 43 to 637 m a.s.l. (Borkent 2008; Caldart *et al.* 2016; Ambrozio-Assis *et al.* 2018).

### Remarks

In three different expeditions, using frog-call traps and Malaise traps, six individuals of a particular morphotype (*Corethrella* sp. 1 in Ambrozio-Assis *et al.* 2018) have been collected along with typical specimens of *Corethrella lopesi*. Those midges key out to *C. lopesi* Lane, 1942 and reasonably match its description, but are discretely larger, more darkly pigmented, and have approximately 30 setae on the postgenal row. No further distinctive features were found in order to confidently separate the species; however, they are probably not conspecific. One male individual captured via light trap in Uruçuca, Bahia, keyed out to *C. lopesi* but was significantly smaller and had different proportions of the wing veins and tarsomeres. It could represent intraspecific variation but was left out of our analysis.

*Corethrella (Corethrella) pillosa* Lane, 1939  
Fig. 27; Appendix 1

### Material examined

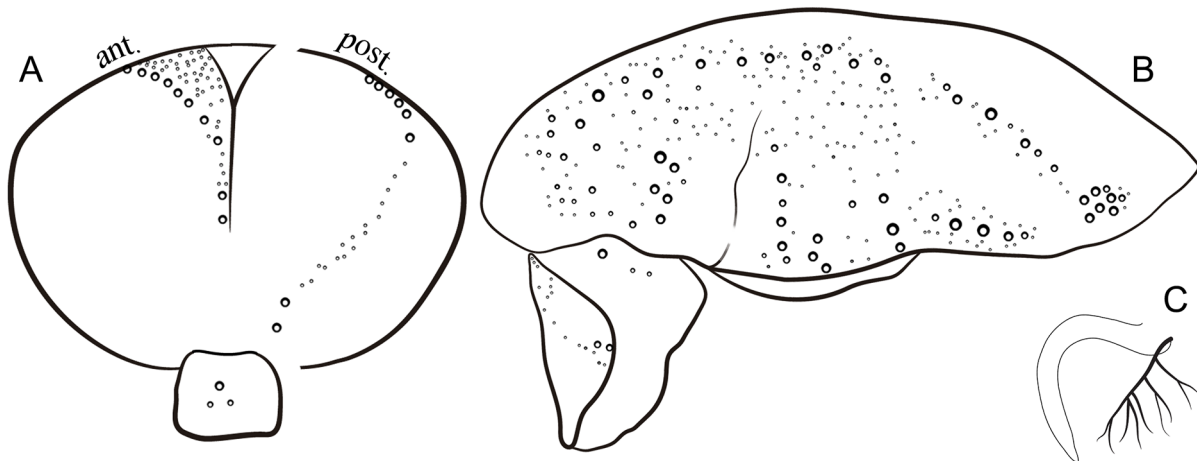
BRAZIL – **Santa Catarina State** • 1 ♀, adult; Bom Retiro, RPPN Grande Floresta das Araucárias, “Riacho do paredão” [stream by the scarp]; 27°53'48" S, 49°26'14" W; 960 m a.s.l.; 18 Nov. 2017; L.C. Pinho *et al.* leg.; CDC trap; CE-MHS • 1 ♀, adult; same collection data as for preceding, except “Brejo alojamento” [marsh near lodge]; 27°53'59" S, 49°25'24" W; 17 Nov. 2017; CE-MHS • 1 ♀, adult; Grão Pará, Parque Estadual Serra Furada, CAPEA stream; 28°11'26" S, 49°23'30" W; 6 Apr. 2013; L.C. Pinho, A.L. Schlindwein, and A.P. Amaral leg.; frog-call trap (*Scynax perereca*); CE-MHS • 1 ♀, adult; Porto Belo, Ponta do Araçá; 27°07'38" S, 48°31'20" W; 115 m a.s.l.; 25 Apr. 2012; L.C. Pinho leg.; Shannon; CE-MHS • 1 ♀, adult; Santo Amaro da Imperatriz, Plaza Caldas; 27°44'31" S, 48°48'26" W; 426 m a.s.l.; 23 Apr. 2013; A. Ambrozio-Assis leg.; frog call trap (*Physalaemus cuvieri*) 2<sup>a</sup>5; CE-MHS.

### Description

#### Female adult (n = 5)

HEAD. **Sensilla** (Fig. 27A): Ocular row with 2 thick offset setae at ventral part, 14–16 setae shortly extending posteriorly. Subocular row not well-defined; interocular space and vertex with multiple slender setae. Postgenal row with 13–16 slender setae ranging from posterior end of ocular row to ventromedially. With 2 thick ventromedial setae.

THORAX. **Sensilla** (Fig. 27B): Antep pronotum with 2–4 intermediate lateral setae, row of 11–14 slender setae ranging from anterodorsal to posterolateral margin. Postpronotum with 1 thick dorsal seta and



**Fig. 27.** *Corethrella pillosa* Lane, 1939, female adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view.

2–3 intermediate posterior setae. Scutum, prescutal area with 5 thick setae arranged dorsoventrally on posterior portion and 13–16 slender intermediate setae more anteriorly, merging with anterior portion of dorsocentral row; about 20 scattered slender setae, more concentrated on dorsal portion. Antealar area with 4–6 thick/intermediate setae vertically aligned on anterior portion, 3 thick setae on medium portion, 3 thick setae vertically aligned on posterior portion; 12–19 slender setae spread on ventral portion, about 40 dorsally located. Supraalar area with 3 thick and 2 intermediate setae surrounded by about 23–36 slender setae. Dorsocentral row, posterior part with cluster of 7–8 thick and 3–5 slender setae; about 24–31 thick/intermediate and 70 slender filling row. Scutellum with 14–16 thick setae. Posterior anepisternum bare. Anepimeron with 29–36 slender setae.

WING.  $R_3/R_1$ : 0.48 (0.46–0.50);  $R_{2+3}/R_2$ : 0.66 (0.60–0.77).

LEGS. Empodium (Fig. 27C) of intermediate length, slender, with 5 branches.  $Ta1/Ta2$ : 2.76 (2.65–2.90);  $Ta3/Ta4$ : 1.21 (1.14–1.30).

### Distribution and biology

The examined specimens were collected via Shannon, CDC and frog-call traps (playing the calls of *Physalaemus cuvieri* and *Scinax perereca*). Sampled locations included coastal and mountainous areas of Atlantic forest in Santa Catarina State, near marshes and small streams, at altitudes ranging from 115 to 960 m a.s.l. The female from Santo Amaro da Imperatriz has previously been recorded by Ambrozio-Assis *et al.* (2018).

This species is otherwise known from the Atlantic forest of São Paulo State, at altitudes ranging from 85 to 603 m a.s.l. (Borkent 2008).

### *Corethrella (Corethrella) aurita* Borkent, 2008

Fig. 28; Appendix 1

### Material examined

BRAZIL – **Bahia State** • 2 ♀♀, adults; Rio de Contas, RPPN Volta do Rio, stream; 13°32'07" S, 41°54'44" W; 1318 m a.s.l.; 1 Dec. 2019; A.P. Amaral leg.; frog-call trap (*Boana faber*); CE-MHS • 2 ♀♀, adults; Rio de Contas, Parque Natural Serra das Almas, “brejo do junco” [reed marsh];

13°32'19" S, 41°52'36" W; 1202 m a.s.l.; 2 Dec. 2019; A.P. Amaral leg.; frog-call trap (chorus); CE-MHS • 1 ♀, adult; same collection data as for preceding, except 3 Dec. 2019; CE-MHS.

## Description

### Female adult (n = 5)

**HEAD. Sensilla** (Fig. 28A): Ocular row with 2 thick offset setae at ventral part, 1 more dorsal, and 16–18 setae extending to mid-posterior portion of head. Subocular row not well-defined anteriorly, with 3 setae shortly extending posteriorly; interocular space and vertex with multiple slender setae. Postgenal row with 9 intermediate and 7 slender setae, located at mid-posterior portion. With 2 thick ventromedial setae.

**THORAX. Sensilla** (Fig. 28B): Anteppronotum with 3–6 slender anterodorsal setae; 3–4 thick and 4–9 slender setae along ventrolateral margin. Postpronotum with 2 thick dorsal setae and 3–5 slender posterior ones. Scutum, prescutal area with 3 thick setae near prescutal suture, 5–9 dorsal slender setae, reaching dorsocentral row; group of 8–12 intermediate and 6–15 slender setae more anteriorly, merging with anterior portion of dorsocentral row. Antealar area with 4–6 thick/intermediate setae vertically aligned on anterior portion; 6–9 thick and 12–15 slender setae ventrally located; 16–30 slender setae more dorsally, reaching dorsocentral row. Supraalar area with 4–5 thick setae surrounded by 12–20 slender setae. Dorsocentral row, posterior part with cluster of 4–5 thick setae; 19–24 thick/intermediate and 41–55 slender setae filling row. Scutellum with 11–12 thick setae. Posterior anepisternum bare. Anepimeron with 15–20 slender setae.

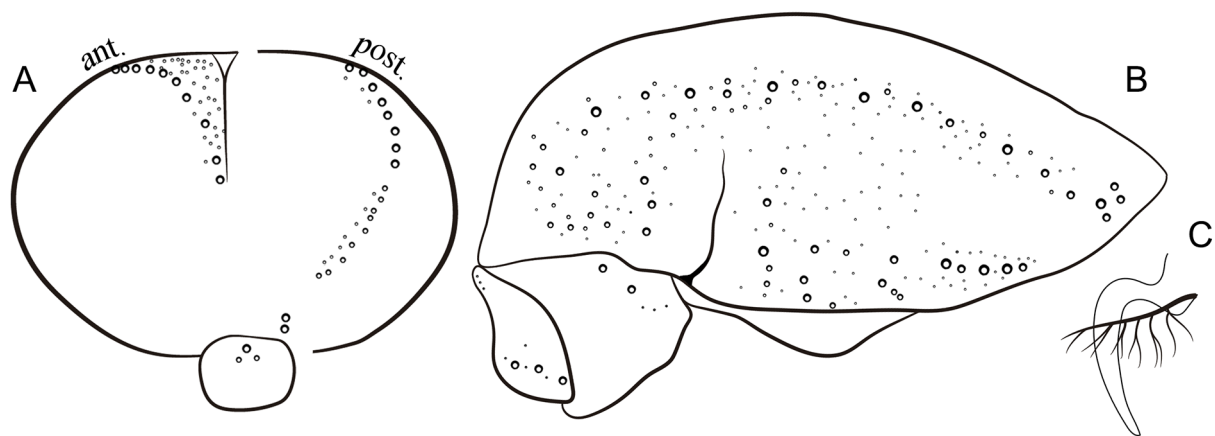
**WING.**  $R_3/R_1$ : 0.49 (0.47–0.53);  $R_{2+3}/R_2$ : 0.71 (0.62–0.76).

**LEGS.** Empodium (Fig. 28C) of intermediate length and thickness, with 6 branches.  $Ta1/Ta2$ : 2.63 (2.59–2.72);  $Ta3/Ta4$ : 1.05 (1.00–1.09).

## Distribution and biology

This is the first record of *Corethrella aurita* in Brazil. Specimens were collected with frog-call pan traps in Rio de Contas, Bahia, playing the calls of *Boana faber*, *Physalaemus cuvieri* and *P. nanus* near a large marsh area and a small stream. The sampled areas are part of the Espinhaço mountain range, in xeric shrubland (caatinga biome). Altitudes range from 1202 to 1318 m a.s.l.

This species was previously known only from the type locality in Panama, at an altitude of 27 m a.s.l. (Borkent 2008).



**Fig. 28.** *Corethrella aurita* Borkent, 2008, female adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view.

**Remarks**

Even though the specimens closely match the species description (Borkent 2008: 122), the extension of its distribution and altitudinal range is remarkable, as *Corethrella aurita* was previously known only from Panama at an altitude of 27 m a.s.l.

In fresh specimens a darkly pigmented heart-shaped spot on the posterior portion of the scutum was observed, and it is not known whether that pattern is present on the type specimens. The description mentions a patterned scutum, which might be the case.

***Corethrella (Corethrella) lepida* Borkent, 2008**

Fig. 29; Appendix 1

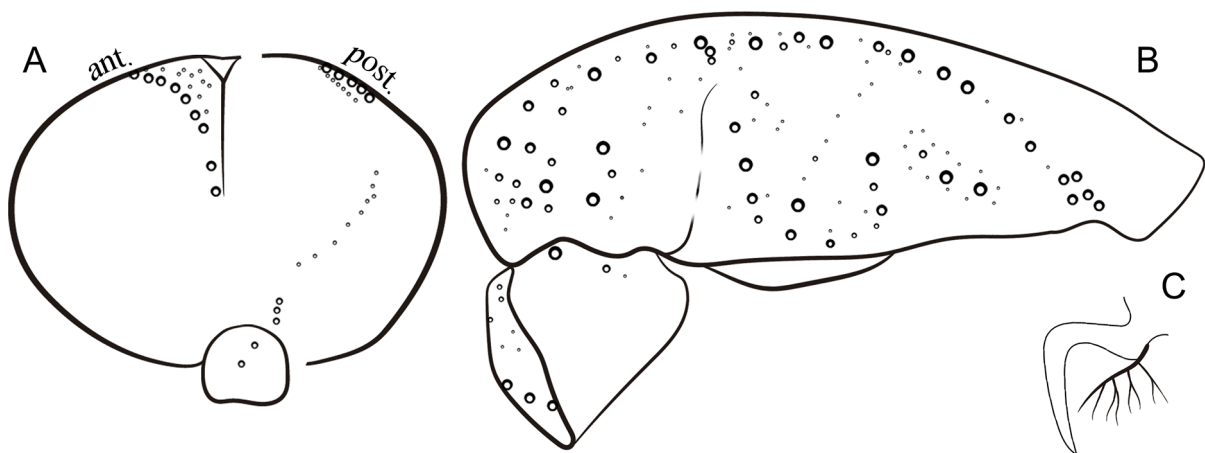
**Material examined**

BRAZIL – **Bahia State** • 2 ♀♀, adults; Maraú, Cassange; 13°59'16" S, 38°57'03" W; 13 m a.s.l.; 28 Sep. 2019; A.P. Amaral leg.; frog-call trap (chorus); CE-MHS • 1 ♀, adult; same collection data as for preceding, except frog-call trap (*Physalaemus signifer*); CE-MHS • 2 ♀♀, adults; same collection data as for preceding, except CDC trap; CE-MHS • 1 ♀, adult; Ilhéus, Cabruca da UESC; 14°47'37" S, 39°10'25" W; 35 m a.s.l.; 16 Jul. 2019; A.P. Amaral leg.; frog-call trap (*Boana faber*); CE-MHS.

**Description****Female adult** (n = 6)

**HEAD. Sensilla** (Fig. 29A): Ocular row with 2 thick offset setae at ventral part and 12–15 setae extending shortly beyond vertex. Subocular row well defined, with about 14 slender setae; vertex and interocular space with several setae. Postgenal row with 5–9 slender setae located mid-posteriorly. With 2–3 thick ventromedial setae.

**THORAX. Sensilla** (Fig. 29B): Anteppronotum with 3 thick ventrolateral setae and 6 slender/intermediate setae more dorsally. Postpronotum with 1 thick dorsal seta; 1 intermediate and 1 slender seta more posteriorly. Scutum, prescutal area anterior portion with group of about 10 thick/intermediate setae; 3 thick/intermediate setae loosely aligned dorsoventrally near prescutal suture; row of 7 slender, more posterior setae from ventral to dorsal portion. Antealar area with 3–5 thick/intermediate setae vertically



**Fig. 29.** *Corethrella lepida* Borkent, 2008, female adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view.

aligned near prescutal suture; more posteriorly with 4–6 thick and 3–4 intermediate setae forming a U-shape on ventral region; about 13–20 slender setae spread in between. Supraalar area with 2 thick and 1 intermediate setae anteroposteriorly aligned, with 14–16 slender surrounding. Dorsocentral row, posterior part with group of 5 thick offset setae; 18–22 thick/intermediate and 20–27 slender setae completing the row. Scutellum with 12–14 thick setae. Posterior anepisternum bare. Anepimeron with 8–15 slender setae.

WING.  $R_3/R_1$ : 0.51 (0.49–0.54);  $R_{2+3}/R_2$ : 0.61 (0.50–0.67).

LEGS. Empodium (Fig. 29C) short, slender, with 3 branches.  $Ta1/Ta2$ : 2.57 (2.47–2.75);  $Ta3/Ta4$ : 1.05 (1.00–1.11).

### Distribution and biology

This is the first record of *Corethrella lepida* both from the state of Bahia and from the Brazilian Northeast region. The specimens studied were captured with frog-call pan traps (playing the calls of *Boana faber* and *Physalaemus signifer*) and a CDC trap. Trapping sessions were near a pond, a coastal lake, and a small stream in the Atlantic forest at altitudes ranging from 13 to 35 m a.s.l.

This species is otherwise known from Costa Rica, Trinidad and Tobago, Guyana, and French Guiana, at altitudes ranging from 5 to 100 m a.s.l. (Borkent 2008).

### Remarks

Examined specimens closely matched the description of *C. lepida*, only lacking a sensillum coeloconicum on flagellomere VIII.

### *Corethrella (Corethrella) infuscata* Lane, 1939 Fig. 30; Appendix 1

### Diagnosis

#### Larva

(Possibly indistinguishable from *Corethrella tarsata* Lane, 1942; see Discussion). Only bromeliculous species with the following combination of characters: head, segment X, and siphon light to medium brown (Fig. 30D); postmentum elongate, with margins tapering from base (Fig. 30E); prementum with 13–14 darkly pigmented teeth, mesial one largest, remaining teeth subequal (Fig. 30E); ventral margin of antennal groove smooth (Fig. 30E).

#### Pupa

Only bromeliculous species with the following combination of characters: exuvia medium brown, with medial portion of abdominal segments III–VII slightly darker (Fig. 30F); abdomen somewhat ovate (Fig. 30H); dorsal setae not well-developed (shorter than respective segments), lateral setae weakly developed on III–IV, moderately developed on V–VIII (Fig. 30H); respiratory organ short tubular, expanded at apex, with trachea spiraled (Fig. 30G).

### Material examined

BRAZIL – **Santa Catarina State** • 1 ♀, 1 ♂, adults, with larval and pupal exuviae; Grão Pará, Parque Estadual Serra Furada; 28°11'26" S, 49°23'30" W; 9 Jun. 2013; L.C. Pinho, A.P. Amaral, M.O. Bessel and A. Will leg.; bromeliad; CE-MHS • 1 ♀, adult, with larval and pupal exuviae; Palhoça, PEST; 27°50'36" S, 48°37'25" W; 7 m a.s.l.; 16 Aug. 2013; V. Freitas leg.; bromeliad; CE-MHS • 1 ♀, adult, with larval and pupal exuviae; Rebio Arvoredo; 27°17'32" S, 48°21'41" W; 155 m a.s.l.; 18 Feb.

2016; L.C. Pinho *et al.* leg.; bromeliad (*Nidularium innocentii*); CE-MHS. – **Bahia State** • 1 ♂, adult, with larval and pupal exuviae; Maraú, Estrada para Saquairá; 13°59'16" S, 38°57'03" W; 21 m a.s.l.; 27 Sep. 2019, A.P. Amaral leg.; bromeliad; CE-MHS • 1 ♂ with larval and pupal exuviae; Maraú, Pontal; 14°15'60" S, 38°59'55" W; 4 m a.s.l.; 27 Sep. 2019; A.P. Amaral leg.; bromeliad; CE-MHS • 1 ♀, adult, with larval and pupal exuviae; Maraú, Lagoa Butterfly House; 14°01'39" S, 38°57'02" W; 9 m a.s.l.; 28 Sep. 2019; A.P. Amaral leg.; bromeliad; CE-MHS.

## Description

### Male and female adults (3 ♂♂, 3 ♀♀)

**HEAD.** **Sensilla** (Fig. 30A): Ocular row with 2–3 thick offset setae at ventral part, more dorsally 18–22 setae extending to mid-posterior portion of head. Subocular row poorly defined anteriorly, with about 15 setae on posterior portion; interocular space and vertex with variable number of slender setae. Postgenal row with 6–14 slender setae, ranging from posterior part of ocular row to ventromedially. With 2 thick ventromedial setae.

**THORAX.** **Sensilla** (Fig. 30B): Anteppronotum with 1 intermediate lateral and 0–7 slender ventral setae. Postpronotum with 1 thick dorsal seta; 1–2 intermediate and 2–3 slender posterior setae. Scutum, prescutal area with about 4–8 intermediate and 3–6 slender setae grouped anteriorly, central cluster of 5–8 thick and 2–4 slender setae. Antealar area with 4–5 thick/intermediate setae vertically arranged next to prescutal suture, 8–11 thick/intermediate ventral setae more posteriorly, forming a U-shape; 14–29 setae surrounded by 12–15 slender setae. Dorsocentral row, posterior part with cluster of 16–23 thick setae, inserted in shallow cuticular depression; 17–19 thick/intermediate and approximately 44–50 slender setae filling row. Scutellum with 12–14 thick setae. Posterior anepisternum bare. Anepimeron with 3–7 slender setae.

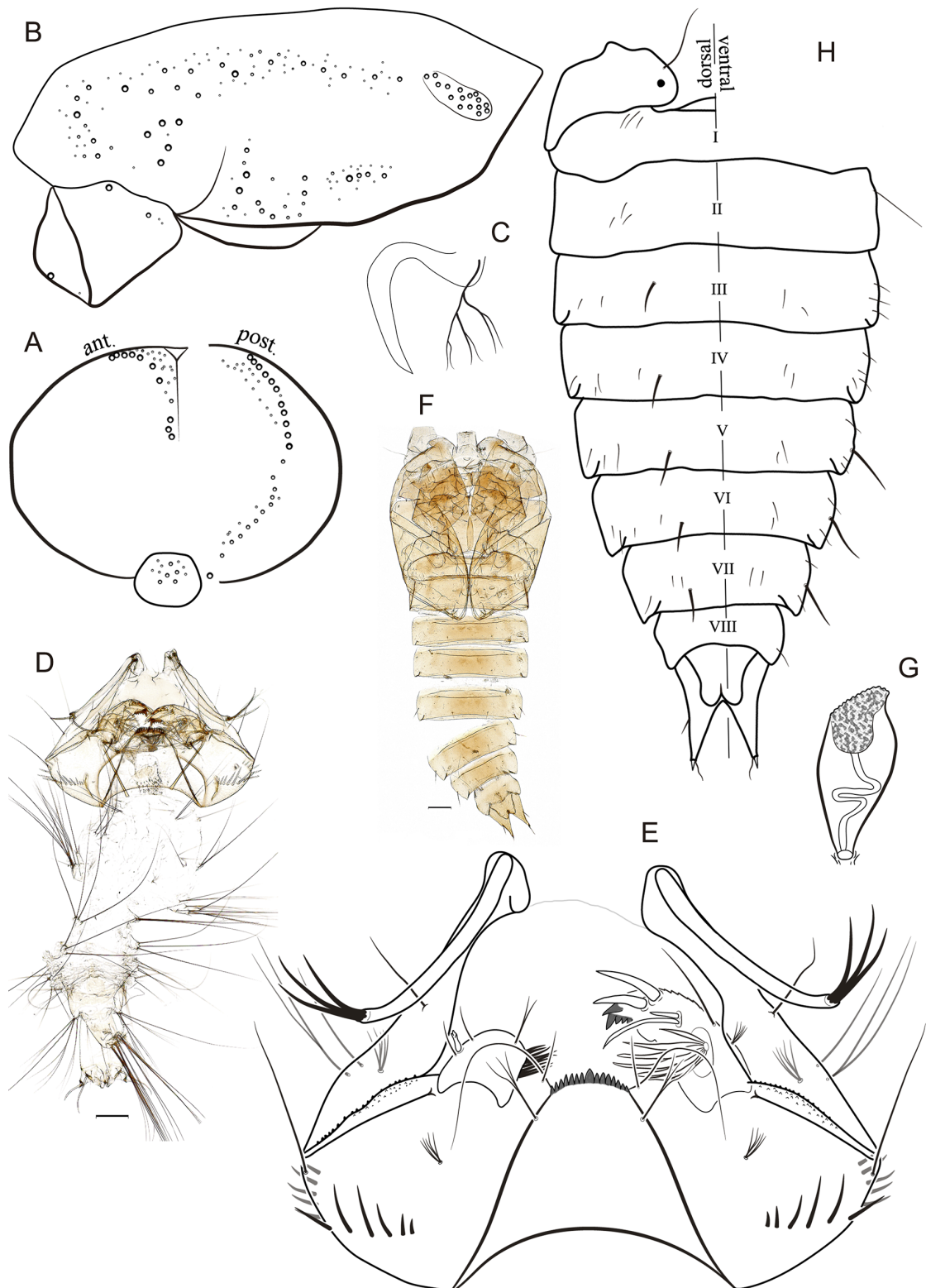
**WING.** Male  $R_3/R_1$ : 0.40 (0.39–0.41);  $R_{2+3}/R_2$ : 0.86 (0.82–0.90). Female  $R_3/R_1$ : 0.46 (0.46–0.47);  $R_{2+3}/R_2$ : 0.65 (0.59–0.70).

**LEGS.** Empodium (Fig. 30C) of intermediate length, slender, with 3 branches. Male  $Ta1/Ta2$ : 2.87 (2.68–3.10);  $Ta3/Ta4$ : 0.75 (0.73–0.80). Female  $Ta1/Ta2$ : 2.69 (2.60–2.82);  $Ta3/Ta4$ : 1.03 (1.00–1.08).

### Larva (n = 6)

**EXUVIA** (Fig. 30D). Uniformly light to medium brown; without tergal plates.

**HEAD** (Fig. 30C). Wide, triangular in dorsoventral view, 1.26 (1.13–1.37) times as wide as long. Antenna 0.57 (0.54–0.61) times length of head; antennal groove 1.20 (0.98–1.35) length of antenna. Ventral margin of antennal groove without denticles. Postmentum elongate, tapering from base, 1.25 (1.11–1.45) times as wide as long; length 0.43 (0.39–0.49) of head. Prementum curved, with 13–14 ogival teeth, darkly pigmented, central one largest, remaining ones slightly decreasing in size. Anteroventral projection of gena strongly projected anteriorly, surface smooth. Postcoila extending to lateral margin of gena. Subgenal carina with multiple small spinules. Crown with 11–14 spines, more sparse ventrally, sizes growing towards lateral; largest spine 0.08–0.13 mm long. Seta 16-C somewhat anterolateral to crown. Mandible with darkly pigmented teeth; apical tooth length 1.53 (1.33–1.86) of first dorsal tooth; seta 3-Mn 0.37 (0.34–0.40) times length of 4-Mn; lacinia mobilis with 7–8 blades; mandibular lobe well-developed, pale, contiguous to teeth. **Sensilla**: 9-C short, fan-like; 10-C elongate, simple; 11-C elongate, simple, bifurcated or forked; 12-C elongate, simple; 13-C short, fan-like; 14-C moderately elongate, simple; 15-C moderately elongate, bifurcated or forked; 16-C elongate, simple. 0a-Mn short, fan-like, or moderately elongate bifurcated; 0b-Mn elongate, simple. 6-Mx short, simple; 4-Mx short, simple; 5-Mx moderately elongate, bifurcated.



**Fig. 30.** *Corethrella infuscata* Lane, 1939. **A.** Adult cranial setae, anterior and posterior views, and female clypeus in anterior view. **B.** Adult thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view. **D.** Larval exuvia, ventral view. **E.** Exuvia of larval head, ventral view, except mandible in dorsal view. **F.** Pupal exuvia, dorsal view. **G.** Pupal respiratory organ, dorsal view. **H.** Pupal metathorax and abdomen, dorsal and ventral views. Scale bars: 0.2 mm.



SIPHON. 0.41 mm (0.37–0.44) long. Seta 1 forked, at 0.17 (0.13–0.21) of length from base; 6-S pale, 9-S darkly pigmented; length of 6-S/9-S: 0.59 (0.50–0.67).

#### **Pupa (n = 6)**

EXUVIA (Fig. 30F). Medium brown, with medial portion of abdominal segments III–VII slightly darker; setae moderately pigmented, with cephalothorax dorsal 1 apparently lighter.

CEPHALOTHORAX. Length 1.52 mm (1.46–1.59). Respiratory organ (Fig. 30G) tubular, short, swollen at midlength, with enlarged apical opening and spiraled trachea; 0.14 mm (0.11–0.17) long. Dorsal seta 1 short, slender, about two lengths apart from dorsal 2; dorsal 2 slender, about three times as long; both setae arising from undifferentiated cuticle. Metathoracic 2 and supraalar 2 sensilla present. Metathoracic seta 1 elongate, simple.

ABDOMEN (Fig. 30H). Elongate, somewhat ovate, gently tapering from IV–VII, anterolateral surface of tergites rough; segments I–VIII length 1.57 mm (1.46–1.66), width/length: 0.60 (0.54–0.70). Margins smooth, not expanded laterally. Setae D-2 about half of length of respective segments, equal from III–VII. Lateral setae moderately elongate on I and V–VII, over half length of respective segments. Largest seta L-1-I, 0.69 (0.46–0.90) times length of segment. Terminal process short, basal width 0.79 (0.73–0.84) of length, with paddles strongly tapering from base; D-1-IX short, located at about 0.65 from base; apical spine articulated; ventroapical seta V-1-IX about 3 times as long as apical spine; female genital lobe tapering at midlength; genital lobe elongate in male, extending through approximately 0.85 of terminal process. Chaetotaxy as illustrated.

#### **Distribution and biology**

*Corethrella infuscata* is newly recorded both from the state of Bahia and from the Brazilian Northeast region. The examined specimens were reared from immatures, collected from bromeliad tanks of *Aechmea* sp. and *Aechmea multiflora* L.B.Sm. in Bahia, and *Nidularium innocentii* Lem. on Arvoredo Marine Biological Reserve, a small island in Santa Catarina State. Vegetation types were sandy coastal vegetation (restinga) and subtropical Atlantic forest, with altitudes ranging from 4 to 155 m a.s.l. The other records of this species are from the Atlantic forests of the Brazilian states of RJ, SC, and SP, at altitudes ranging from 0 to about 400 m a.s.l. (Borkent 2008; Ambrozio-Assis *et al.* 2018).

#### **Remarks**

The studied adult specimens keyed out to, and fairly matched the description of, *Corethrella infuscata*; however, there was considerable variation with respect to the chaetotaxy. Three individuals possessed two thick ventral setae in the ocular row (four elongate setae on the frons, in Borkent's terminology; Borkent 2008). The number of those setae is frequently used as a diagnostic feature and is usually constant among species. Apparently, at least *C. infuscata* has some variation, or it may be that those specimens belong to an unrecognized species. Other relevant differences in relation to previous descriptions are the number of setae on the scutellum (10 in Lane 1942) and the posterior setae on dorsocentral row (described as 12 by Borkent 2008). Despite those differences, immatures and adults satisfactorily match the descriptions. A unique feature, present in adults of *Corethrella infuscata*, *C. fulva* Lane, 1939 and possibly *C. tarsata* Lane, 1942 and *C. unisetosa* Borkent, 2008 due to their close relationship, is the posterior setae on the dorsocentral row being situated inside a cuticular depression, delimited by a faint margin.

Lane & Aitken (1956) described the immatures of *Corethrella tarsata* and, from the illustration and details provided, it was not possible to distinguish the larva from that of *C. infuscata*. A more detailed description should enable such a distinction in the future.

*Corethrella (Corethrella) fulva* Lane, 1939  
Fig. 31; Appendix 1

**Diagnosis**

**Larva**

Only bromeliculous species (one record of a ground-dwelling specimen) with the following combination of characters: exuvia pale (Fig. 31D); postmentum elongate, with margins tapering from base (Fig. 31E); prementum with 13 darkly pigmented teeth, mesial one largest, alternating laterally between larger and smaller teeth (Fig. 31E).

**Pupa**

Only New World species with cephalothorax darkly pigmented and pale abdomen (Fig. 31F); abdominal dorsal setae III–IV longer than respective segments, remaining weakly developed (Fig. 31H).

**Material examined**

BRAZIL – **Santa Catarina State** • 1 ♂, adult, with pupal exuvia; Bombinhas, Zimbros, Praia vermelha; 27°12'06" S, 48°34'13" W; 18 m a.s.l.; 15 Oct. 2011; Fabris and Ganzer leg.; bromeliad; CE-MHS • 1 ♂, adult; Rebio Arvoredo; 27°17'30" S, 48°22'01" W; 26 m a.s.l.; 17 Feb.–9 Apr. 2016; L.C. Pinho *et al.* leg.; Malaise trap; CE-MHS • 1 ♂, adult, with pupal exuvia; Santo Amaro da Imperatriz, Plaza Caldas, weir; 27°44'01" S, 48°48'47" W; 22 Jul. 2014; L.C. Pinho, A.P. Amaral, V. Gonçalves and P.L. Scarpa leg.; bromeliad; CE-MHS. – **Bahia State** • 1 ♂, adult, with pupal exuvia; Porto Seguro, RPPN Veracel, muçununga, pools; 16°21'33" S, 39°08'15" W; 72 m a.s.l.; 31 Aug. 2019; A.P. Amaral leg.; hand net; CE-MHS • 1 ♀, adult, with larval and pupal exuviae; Porto Seguro, RPPN Estação Veracel, Trilha 12-09; 16°19'36" S, 39°07'26" W; 74 m a.s.l.; 28 Aug. 2019; A.P. Amaral leg.; bromeliad; CE-MHS • 1 ♀, adult, with larval and pupal exuviae; Ilhéus, Cabruca da UESC; 14°47'33" S, 39°10'23" W; 38 m a.s.l.; 5 Sep. 2019; A.P. Amaral leg.; stream; CE-MHS • 1 ♀, adult, with larval and pupal exuviae; Ilhéus, Jóia do Atlântico; 14°38'27" S, 39°03'55" W; 6 m a.s.l.; 15 Apr. 2020; A.P. Amaral leg.; bromeliad; CE-MHS.

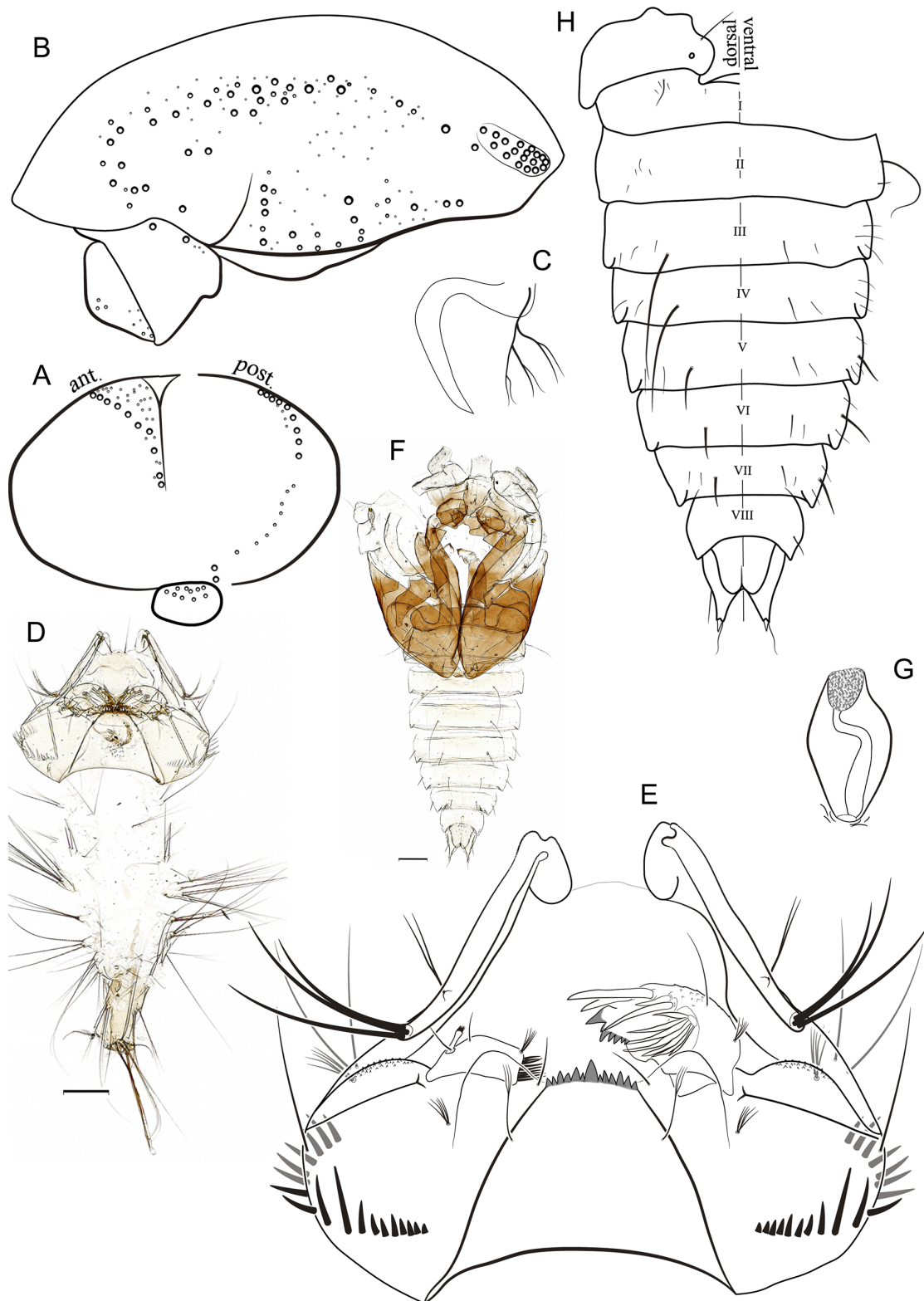
**Description**

**Male and female adults** (4 ♂♂, 3 ♀♀)

**HEAD.** **Sensilla** (Fig. 31A): Ocular row with 2 thick offset setae at ventral part, more dorsally with 15–18 setae extending to mid-posterior portion of head. Subocular row poorly defined anteriorly, with about 4–6 setae on posterior portion. Interocular space and vertex with many slender setae. Postgenal row with 7–9 slender setae, ranging from posterior part of ocular row to ventromedially. With 2–3 thick ventromedial setae.

**THORAX.** **Sensilla** (Fig. 31B): Antep pronotum with 4–10 intermediate, slender ventral setae. Postpronotum with 1 thick dorsal seta; 1 thick and 0–3 slender setae more posteriorly. Scutum, prescutal area with about 3–7 thick/intermediate setae grouped anteriorly; 1 thick ventral and 2 thick dorsal setae more posteriorly. Antealar area with 6–7 thick/intermediate setae vertically arranged, next to prescutal suture; 7–9 thick/intermediate ventral setae more posteriorly, forming a U-shape; 11–20 spread slender setae, with a group near dorsocentral row. Supraalar area with 2–3 thick and 1–2 intermediate setae longitudinally aligned, surrounded by about 7–15 slender setae. Dorsocentral row, posterior part with cluster of 15–21 thick setae, inserted in a shallow cuticular depression; 23–28 thick/intermediate and approximately 28–40 slender ones filling row. Scutellum with 13–14 thick setae. Posterior anepisternum bare. Anepimeron with 5–9 slender setae.

**WING.** Male  $R_3/R_1$ : 0.41 (0.38–0.46);  $R_{2+3}/R_2$ : 0.80 (0.65–0.90). Female  $R_3/R_1$ : 0.50 (0.49–0.51);  $R_{2+3}/R_2$ : 0.58 (0.50–0.63).



**Fig. 31.** *Corethrella fulva* Lane, 1939. A. Adult cranial setae, anterior and posterior views, and female clypeus in anterior view. B. Adult thoracic setae, lateral view. C. Hind leg claw and empodium, lateral view. D. Larval exuvia, ventral view. E. Exuvia of larval head, ventral view, except mandible in dorsal view. F. Pupal exuvia, ventral view. G. Pupal respiratory organ, dorsal view. H. Pupal metathorax and abdomen, dorsal and ventral views. Scale bars: 0.2 mm.

LEGS. Empodium (Fig. 31C) of intermediate length, slender, with 3 branches. Male Ta1/Ta2: 3.26 (3.13–3.53); Ta3/Ta4: 0.70–0.70. Female Ta1/Ta2: 3.00 (2.94–3.06); Ta3/Ta4: 1.05 (1.00–1.09).

**Larva** (n = 3)

EXUVIA (Fig. 31D). Uniformly pale; without tergal plates.

HEAD (Fig. 31E). Wide, roughly triangular in dorsoventral view, 1.20 (1.17–1.25) times as wide as long. Antenna 0.51 (0.50–0.52) times length of head; antennal groove 1.23 (1.14–1.31) times length of antenna. Ventral margin of antennal groove without well-developed denticles, with a few minute spinules. Postmentum elongate, gently tapering from base to midlength and more abruptly distally; 1.14 (1.09–1.19) times as wide as long; length 0.47 (0.46–0.49) of head. Prementum somewhat curved, with 13 triangular darkly pigmented teeth, central one largest, second small, third large, fourth smaller, fifth large and remaining gradually smaller. Anteroventral projection of gena strongly projected anteriorly, surface smooth. Postcoila extending to lateral margin of gena. Subgenal carina with multiple small spinules. Crown with 14–18 spines, regularly distributed, sizes growing towards lateral, ventral spines shortest; largest spine 0.10–0.12 mm long. Seta 16-C somewhat anterolateral to crown. Mandible with darkly pigmented teeth; apical tooth length 2.06 (2.00–2.17) times that of first dorsal tooth; seta 3-Mn 0.43 (0.39–0.49) times length of 4-Mn; lacinia mobilis with 7 blades; mandibular lobe well-developed, pale, contiguous to teeth. **Sensilla**: 9-C moderately elongate, fan-like; 10-C elongate, simple; 11-C elongate, bifurcated; 12-C elongate, simple; 13-C short, fan-like; 14-C moderately elongate, simple; 15-C moderately elongate, simple or forked; 16-C elongate, simple. 0a-Mn short, fan-like; 0b-Mn elongate, simple. 6-Mx short, simple; 4-Mx short, simple; 5-Mx short, fan-like.

SIPHON. 0.23 mm (0.21–0.24) long. Seta 1 bifurcated, at about 0.30 of length from base; 6-S pale, 9-S darkly pigmented; length of 6-S/9-S: 0.58 (0.55–0.61).

**Pupa** (n = 6)

EXUVIA (Fig. 31F). Cephalothorax dorsally pale, dark brown ventrally; metathorax and segments I and II uniformly dark brown; segments III–VIII and terminal process light/medium brown, more darkly pigmented mesially; setae moderately pigmented, with cephalothorax dorsal 1 apparently paler.

CEPHALOTHORAX. Length 1.38 mm (1.20–1.44). Respiratory organ (Fig. 31G) tubular, short, swollen at midlength, with narrow apical opening; trachea not spiraled; 0.11 mm (0.10–0.13) long. Dorsal seta 1 short, somewhat thick; about two lengths apart from dorsal 2; dorsal 2 slender, about three times as long; both setae arising from undifferentiated cuticle. Metathoracic 2 and supraalar 2 sensilla present. Metathoracic seta 1 elongate and simple.

ABDOMEN (Fig. 31H). Elongate, somewhat ovate, gently tapering from IV–VII, surface of tergites smooth; length of segments I–VIII: 1.38 mm (1.17–1.51), width/length: 0.54 mm (0.51–0.58). Margins smooth, not expanded laterally. Setae D-2 elongate on III–IV, shorter on V–VII. Lateral setae slender and elongate on I, somewhat elongate and thick on V–VII. Largest seta D-2-III, 1.78 (1.56–1.94) times length of segment. Terminal process short, basal width 0.83 (0.65–0.91) of length, with paddles strongly tapering from base; D-1-IX elongate, located at about 0.60 from base; apical spine articulated; ventroapical seta V-1-IX about two times as long as apical spine; female genital lobe tapering at midlength; genital lobe elongate in male, extending almost to level of apical spine. Chaetotaxy as illustrated.

**Distribution and biology**

The examined specimens of *Corethrella fulva* were reared from immatures collected from tanks of both epiphytic and ground level *Aechmea* sp. and *Vriesea* sp. bromeliads, and from ground pools. Sampled localities were Atlantic forest areas in Bahia and Santa Catarina states, at altitudes ranging from 18 to 72m a.s.l. The specimens from Santa Catarina have previously been reported by Amaral *et al.* (2019).

It has also been recorded from the Atlantic forest in the states of BA, RJ, SC, and SP, at altitudes ranging from 0 to 880 m a.s.l. (Borkent 2008; Amaral *et al.* 2019).

This is the first record of this species occurring in ground pools. Borkent (2008: 251) discussed the habitat diversification of Corethrellidae, arguing that species are restricted to certain types of habitats, distinguished by him as ground-dwelling or phytotelmata. These records, along with the specimen of *C. davisii* found in a bromeliad, may indicate that at least some species may be more flexible than previously thought, or that more than one species may be represented under the same name. Further collections should help solve these questions.

### Remarks

Lane (1953) described the pupal respiratory organ as apically expanded; however, in the specimens examined here and in the type specimens deposited in DEFS, it appears to be narrowed at its apex. This difference may be due to preservation, but we consider the morphology of the respiratory organ an important diagnostic feature of the species. Six individuals collected in Lençóis (Chapada Diamantina National Park), Bahia, keyed out to *Corethrella fulva* but were not included in this study as they may represent an undescribed species, with a uniformly medium brown pupa and one sensillum coeloconicum on each of the flagellomeres (I–II, X–XIII). Two individuals collected in Maraú, Bahia, not included here, also keyed out to this species but had two sensilla coeloconica on each of flagellomeres XII–XIII, as well as uniformly colored pupae. Currently it is not possible to confidently determine whether those individuals are members of *C. fulva* or a different species.

### *Corethrella (Corethrella) appendiculata* Grabham, 1906

Fig. 32; Appendix 1

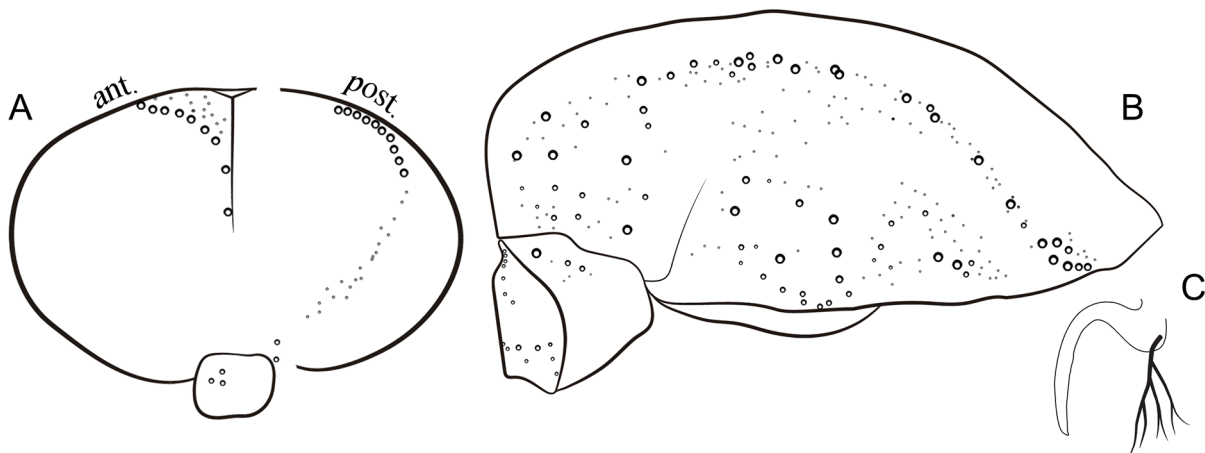
### Material examined

BRAZIL – Santa Catarina State • 1 ♂, 1 ♀, adults; Indaial, Morro Geisler; 26°54'00" S, 49°13'00" W; 100–280 m a.s.l.; 27 Jan. 2016; C.B. Marcondes leg.; CDC trap; CE-MHS.

### Description

**Male and female adults** (1 ♂, 1 ♀)

**HEAD. Sensilla** (Fig. 32A): Ocular row with 1 thick, slightly offset seta at ventral portion, 1 more dorsal, and row of 16 setae shortly extending posteriorly. Subocular row not well-defined. Vertex with several setae. Postgenal row with 16–19 slender setae ranging from posterior end of ocular row to ventromedially. With 2 ventromedial thick setae.



**Fig. 32.** *Corethrella appendiculata* Grabham, 1906, adult. **A.** Cranial setae, anterior and posterior views, and female clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view.

THORAX. **Sensilla** (Fig. 32B): Antep pronotum with 2 intermediate ventrolateral and 10–13 intermediate lateral setae. Postpronotum with 1 thick dorsal and 2–4 intermediate more posteriorly, with 4–13 slender setae in between. Scutum, prescutal area with 2 thick and 1 intermediate vertically aligned setae near prescutal suture; 4–7 intermediate and 10–14 slender setae anteriorly. Antealar area with 5–7 thick, 10–12 intermediate, and 10–12 slender setae centrally located; 18–40 slender setae more dorsally, near dorsocentral row. Supraalar area with 2–3 thick ventral setae, with 3–8 intermediate and 27–34 slender setae surrounding. Dorsocentral row, posterior region with 6–7 thick and 5–7 slender offset setae; 18–25 thick/intermediate and about 60 slender setae filling row. Scutellum with 14 thick setae. Posterior anepisternum without setae (see discussion below). Anepimeron with 22–23 slender setae.

WING. Male  $R_3/R_1$ : 0.40;  $R_{2+3}/R_2$ : 0.85. Female  $R_3/R_1$ : 0.52;  $R_{2+3}/R_2$ : 0.68.

LEGS. Empodium (Fig. 32C) of intermediate length and thickness, with 3 branches. Male  $Ta1/Ta2$ : 3.25;  $Ta3/Ta4$ : 0.67. Female  $Ta1/Ta2$ : 2.94;  $Ta3/Ta4$ : 1.00.

### Distribution and biology

The specimens studied have previously been recorded by Amaral *et al.* (2019). They were collected with CDC traps in a fragment of Atlantic forest in Indaial, northern Santa Catarina State. The precise altitude was not reported by the collector, but altitudes in the sampled area range from 100 to 280 m a.s.l.

This species has otherwise been recorded from the southern United States, Mexico, Central America and the Caribbean, Venezuela, French Guiana, northern Argentina, and the Brazilian states of AM, BA, GO, and SP, at altitudes ranging from 0 to 1700 m a.s.l. (Borkent 2008).

### Remarks

Adults of *Corethrella appendiculata* have an unusually large number of slender supraalar setae, not observed in any other species. Borkent (2008) recorded the presence of posterior anepisternal setae in some specimens of *C. appendiculata*, but that was not observed in the individuals examined here. This species has a large intraspecific variation and a widespread distribution and, for these reasons, Borkent (2008) conjectured the possibility that the name included more than one species; thus, the presence of cryptic species in Brazil is possible.

*Corethrella (Corethrella) vittata* Lane, 1939  
Fig. 33; Appendix 1

### Material examined

BRAZIL – Santa Catarina State • 1 ♂, 4 ♀♀, adults; Porto Belo, Ponta do Araçá, Brejo do Guinho; 27°07'31" S, 48°31'21" W; 92 m a.s.l.; 26 Apr. 2011; L.C. Pinho and Assis leg.; Shannon trap; CE-MHS • 1 ♂, adult; Brusque, RPPN Chácara Edith, stream/wier; 27°05'55" S, 48°53'33" W; 685 m a.s.l.; 4–5 May 2018; L.C. Pinho leg.; CDC trap; CE-MHS.

### Description

**Male and female adults** (2 ♂♂, 4 ♀♀)

HEAD (Fig. 33A). Female antenna uniformly light brown, with flagellomeres (Fig. 33B) I–III elongate. 13<sup>th</sup> flagellomere apically bifurcated. Sensilla coeloconica distribution: 1(IX–X), 2(XI–XIII), 4(I). **Sensilla**: Ocular row with 2 thick offset setae at ventral portion, more dorsally 11–14 setae extending posteriorly. Subocular row loosely defined, with about 7 slender setae. Vertex and interocular space with

a few slender setae. Postgenal row with 6–11 intermediate setae, ranging from misposterior portion to ventromedially. With 2 thick ventromedial setae.

THORAX (Fig. 33C). **Sensilla:** Antep pronotum with 1 intermediate posteroventral and 2–7 slender scattered setae. Postpronotum with 1 thick and 2–4 slender dorsal setae. Scutum, prescutal area with group of 3 thick, dorsoventrally aligned setae, near prescutal suture, 7–13 intermediate/slender setae more anteriorly. Antealar area with 10–12 thick/intermediate and 5–14 slender setae centrally located. Supraalar area with 1 thick, 3 intermediate, and 4–10 slender setae on ventral part. Dorsocentral row, posterior part with 4 thick and 2–5 slender offset setae; 16–25 thick/intermediate and 30–35 slender setae completing row. Scutellum with 10–11 thick setae. Posterior anepisternum bare. Anepimeron with 3–5 slender setae.

WING. Male  $R_3/R_1$ : 0.48–0.49;  $R_{2+3}/R_2$ : 0.64–0.73. Female  $R_3/R_1$ : 0.54 (0.53–0.56);  $R_{2+3}/R_2$ : 0.57 (0.53–0.60).

LEGS. Empodium (Fig. 33D) of intermediate length and intermediate thickness, with 5 branches. Male  $Ta1/Ta2$ : 2.32–2.47;  $Ta3/Ta4$ : 0.50–0.58. Female  $Ta1/Ta2$ : 2.50 (2.42–2.59);  $Ta3/Ta4$ : 1.05 (1.00–1.09).

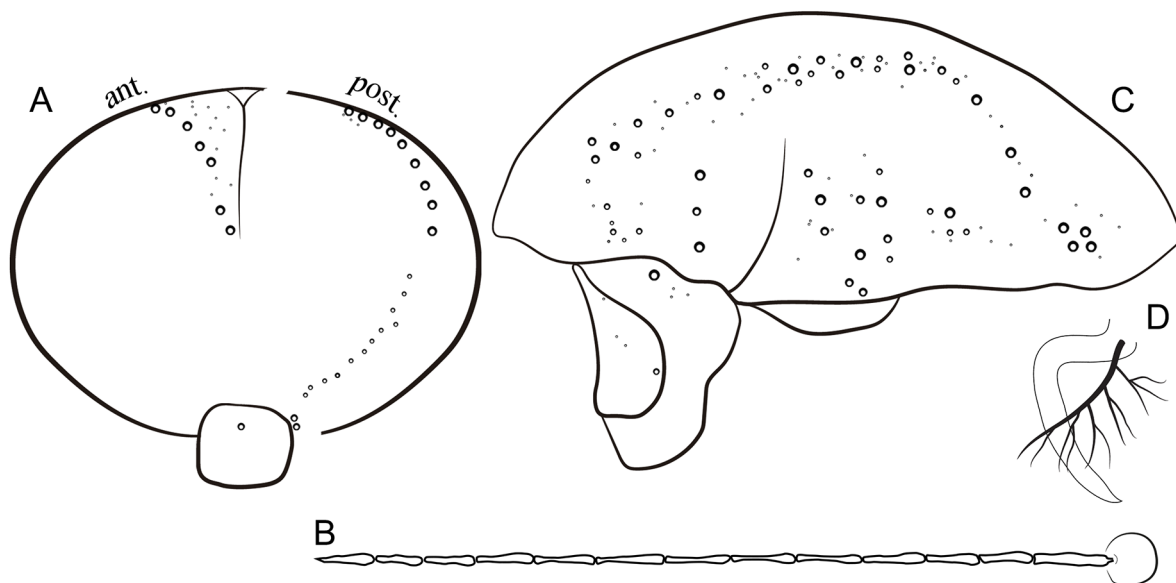
### Distribution and biology

Specimens were collected with CDC and Shannon traps, in Santa Catarina State, in areas of Atlantic forest. Altitudes range from 45 to 685 m a.s.l. The specimens from Porto Belo have previously been recorded by Amaral & Pinho (2015).

*Corethrella vittata* is also known from Puerto Rico, Guyana and the Brazilian Atlantic forest of ES, SC, and SP states, at altitudes ranging from 5 to 85 m a.s.l. (Borkent 2008).

### Remarks

In his redescription of the species, Borkent (2008) reported that the female antenna was missing from the examined material; thus, we here describe and illustrate it. *Corethrella vittata* seems to be the only species in the *quadrivittata* group with two sensilla coeloconica on each of flagellomeres XI–XIII in both males and females.



**Fig. 33.** *Corethrella vittata* Lane, 1939, adult. **A.** Cranial setae, anterior and posterior views, and female clypeus in anterior view. **B.** Pedicel and flagellomeres, lateral view. **C.** Thoracic setae, lateral view. **D.** Hind leg claw and empodium, lateral view.

*Corethrella (Corethrella) edwardsi* Lane, 1942  
Fig. 34; Appendix 1

**Diagnosis**

**Larva**

Only species with the following combination of characters: exuvia uniformly light brown (Fig. 34D); prementum and mandibular teeth lightly pigmented (Fig. 34D); siphon with seta 2-S very thick and located at midlength (Fig. 34F).

**Pupa**

Only species with the following combination of characters: respiratory organ tubular (Fig. 34H), elongate, and expanded subapically, without an apical opening, reticulate on distal half; lacking campaniform sensilla supraalar 2 and metathoracic 2 (Fig. 34I).

**Material examined**

BRAZIL – **Bahia State** • 2 ♂♂, adults, with larval and pupal exuviae; Maracás, Sítio do Pidi, pool; 13°17'30" S, 40°35'23" W; 425 m a.s.l.; 8 Jun. 2019; A.P. Amaral leg.; CE-MHS • 1 ♀, adult, with pupal exuvia; same collection data as for preceding; CE-MHS • 1 ♀, adult; Porto Seguro, RPPN Veracel, muçununga; 16°21'33" S, 39°08'15" W; 72 m a.s.l.; 30 Aug. 2019; A.P. Amaral leg.; frog-call trap (chorus); CE-MHS.

**Description**

**Male and female adults** (1 ♂, 3 ♀♀)

**HEAD. Sensilla** (Fig. 34A): Ocular row with 2 thick offset setae at ventral part, more dorsally 10–12 setae shortly extending posteriorly. Subocular row well-defined, with about 12–14 setae from anterodorsal to posterodorsal portions. Vertex with several slender setae. Postgenal row with 12–15 intermediate setae, ranging from mid-posterior part of head to ventromedially. With 1 ventromedial thick seta.

**THORAX. Sensilla** (Fig. 34B): Proepisternum with 4–12 intermediate setae. Antep pronotum with 1 thick anteroventral, 3–4 slender anterodorsal, and 4–6 slender lateral setae. Postpronotum with 1 thick and 2–6 slender dorsal setae. Scutum, prescutal area with 4–5 thick/intermediate anterior setae, 3 thick setae more posteriorly, and 6–7 slender setae in between. Antealar area with about 10–12 thick/intermediate setae anteriorly grouped and 9–10 slender setae scattered from ventral to dorsal portions. Supraalar area with 2–3 thick seta, with 5–7 slender setae surrounding; 4 intermediate setae anteriorly. Dorsocentral row, posterior part with 3 thick and 2 slender offset setae; 23–27 thick/intermediate and 20–31 slender setae filling row. Scutellum with 10 thick setae. Posterior anepisternum bare. Anepimeron with 5–9 slender setae.

**WING.** Male  $R_3/R_1$ : 0.48;  $R_{2+3}/R_2$ : 0.74. Female  $R_3/R_1$ : 0.55 (0.54–0.57);  $R_{2+3}/R_2$ : 0.53 (0.50–0.56).

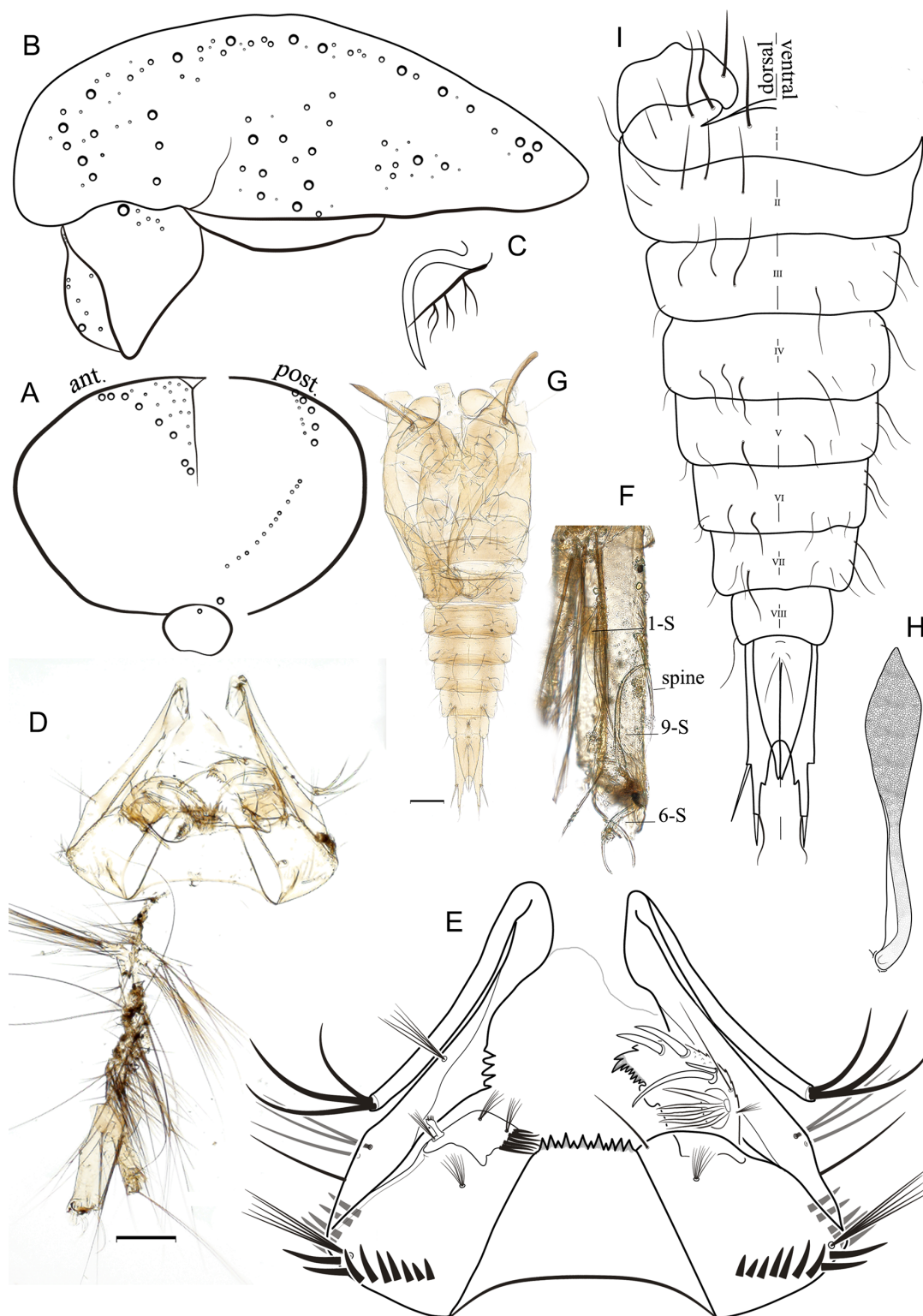
**LEGS.** Empodium (Fig. 34C) of intermediate length and intermediate thickness, with 4 branches. Male  $Ta1/Ta2$ : 2.81;  $Ta3/Ta4$ : 0.55. Female  $Ta1/Ta2$ : 2.52 (2.42–2.65);  $Ta3/Ta4$ : 1.13 (1.08–1.20).

**Larva** (n = 2)

**EXUVIA** (Fig. 34D). Uniformly light brown; without tergal plates.

**HEAD** (Fig. 34E). Roughly triangular in dorsoventral view, 1.18–1.24 times as wide as long. Antenna 0.59–0.64 times length of head; antennal groove 1.27–1.32 times length of antenna. Ventral margin of antennal groove with about 5 well-developed denticles. Postmentum wide, tapering from base,





**Fig. 34.** *Corethrella edwardsi* Lane, 1942. **A.** Adult cranial setae, anterior and posterior views, and female clypeus in anterior view. **B.** Adult thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view. **D.** Larval exuvia, ventral view. **E.** Larval head, ventral view, except mandible in dorsal view. **F.** Larval siphon, dorsal view. **G.** Pupal exuvia, dorsal view. **H.** Pupal respiratory organ, dorsal view. **I.** Pupal metathorax and abdomen, dorsal and ventral views. Scale bars: 0.2 mm. Abbreviations: 1, 6, 9-S = siphon setae.

1.45–1.63 as wide as long; length 0.36–0.39 of head. Prementum straight, with 12–13 triangular teeth, lightly pigmented, central one largest, second small, third large, fourth smaller, fifth and sixth large. Anteromedial margin of gena not projected anteriorly, surface smooth. Postcoila indistinct, present as a faint line reaching lateral portion of head. Subgenal carina with multiple small spinules. Crown with 15–17 spines, regularly distributed, sizes growing posteriorly, ventral teeth shortest; largest spine 0.11–0.13 mm long. Seta 16-C mesial to crown. Mandible with lightly pigmented teeth; apical tooth length 1.20–1.30 of first dorsal tooth; seta 3-Mn 0.34–0.47 times length of 4-Mn; lacinia mobilis with 5 blades; mandibular lobe well-developed, pale, apart from teeth. **Sensilla:** 9-C elongate, bifurcated; 10-C elongate, simple; 11-C elongate, fan-like; 12-C elongate, simple; 13-C short, fan-like; 14-C elongate, simple; 15-C moderately elongate, forked; 16-C elongate, fan-like. 0a-Mn short, fan-like; 0b-Mn elongate, simple. 6-Mx elongate, fan-like; 4-Mx moderately elongate, fan-like; 5-Mx short, fan-like.

SIPHON (Fig. 34F). 0.39 mm (0.38–0.40) long. Seta 1 stout and forked, situated at 0.30 (0.28–0.32) of length from base; a thick and spine-like seta located at midlength; 6-S pale, 9-S lightly pigmented; 6-S/9-S: 0.70 (0.69–0.72).

#### **Pupa** (n = 3)

EXUVIA (Fig. 34G). Uniformly medium brown; setae on metathorax and abdominal segments I–II darkly pigmented and directed anteriorly; cephalothorax dorsal setae and abdominal setae III–VIII lightly pigmented.

CEPHALOTHORAX. Length 1.26 mm (1.22–1.32). Respiratory organ (Fig. 34H) tubular, elongate, expanded subapically, without apical opening, reticulate on apical half; 0.47 mm (0.42–0.49) long. Dorsal seta 1 moderately short, thick; about one length apart from dorsal 2; dorsal 2 of same length and thickness; both setae arising from elevated tubercle. Metathoracic 2 and supraalar 2 sensilla absent. Metathoracic seta 1 elongate, simple, moderately thick.

ABDOMEN (Fig. 34I). Elongate, gently tapering from II–VII, surface of tergites somewhat corrugated; length of segments I–VIII: 1.32 mm (1.24–1.37), width/length: 0.55 (0.53–0.57). Margins smooth, not expanded laterally. Setae D-2 moderately elongate, subequal from II–VII. Lateral setae short. Largest seta D-2-I, length 0.19–0.20 mm. Terminal process distinctly elongate, basal width 0.35 (0.34–0.36) of length, with paddles broad and spine-like process on mesial margin; D-1-IX thick, elongate, at about 0.70 from base; apical spine articulated; ventroapical seta V-1-IX about 1.3 times as long as apical spine; female genital lobe tapering, shorter than basal portion of terminal process; genital lobe in male elongate, tapering, extending shortly past basal portion. Chaetotaxy as illustrated.

#### **Distribution and biology**

This species is newly recorded both from the state of Bahia and from the Brazilian Northeast region. Immatures were collected from small ground pools in Maracás, an area of xeric shrubland (caatinga). Two individuals were captured with frog-call pan traps in the Atlantic forest of Porto Seguro. Altitudes range from 72 to 425 m a.s.l.

*Corethrella edwardsi* is also known from Costa Rica to Colombia, Guyana, and the Brazilian states of ES, MG, and MS, Central-West and Southeast regions, at altitudes ranging from 5 to 180 m a.s.l. (Borkent 2008).

#### **Remarks**

The immatures of *Corethrella edwardsi* have not previously been formally described. Borkent (2008) briefly described the pupa, adding photographs of the abdomen and respiratory organ which match the specimens studied here. The pupal respiratory organ is unique among the species studied, without an

apical opening and with pores distributed on the outer surface. The terminal process is also peculiar, distinctively elongate (the lowest average value of width/length), seta D-1-IX relatively long and thick, and apical spine also elongate. The pupa, similarly to the others of the *peruviana* group, lacks campaniform sensilla supraalar 2 and metathoracic 2, although, differing from that group of species, it has a metathoracic 1 seta, a trait shared with *C. quadrivittata* Shannon & Del Ponte, 1928 and *C. whartoni* Vargas, 1952 (Borkent 2008). Curiously, the pupae examined here and the photograph in Borkent (2008) show the metathoracic and abdominal I–II setae directed anteriorly, with the rest of the setae directed laterally and posteriorly. Since this has not been observed in other species, we conclude it is peculiar of *C. edwardsi*.

On the larval siphon, the thick, spine-like seta at midlength was also not seen in any other examined species but is possibly present in *C. quadrivittata* (and perhaps other species in the *quadrivittata* group), as suggested by the illustration in Balseiro & Spinelli (1984).

Additionally, adults of *Corethrella edwardsi* and *C. quadrivittata* are the only species in the study with proepisternal setae. The *quadrivittata* species group is restricted to the Neotropical Region and has several unique synapomorphies, some revealed in the present study. When immature stages of other members of the group are discovered, it should be possible to better interpret their biogeographic history and the evolution of those characters, and further establish the position of the group within the family.

***Corethrella (Corethrella) quadrivittata* Shannon & Del Ponte, 1928**

Fig. 35; Appendix 1

**Material examined**

BRAZIL – **Santa Catarina State** • 1 ♀, adult; Bom Retiro, RPPN Grande Floresta das Araucárias, “Lago da casa grande” [pond by the lodge]; 27°53'39" S, 49°27'43" W; 942 m a.s.l.; 18 Nov. 2017; L.C. Pinho *et al.* leg.; CDC trap; CE-MHS. – **Bahia State** • 1 ♀, adult; Porto Seguro, RPPN Veracel, “trilha escolar” [educational trail]; 16°23'10" S, 39°10'11" W; 89 m a.s.l.; 28 Aug. 2019; A.P. Amaral leg.; frog-call trap; CE-MHS.

**Description**

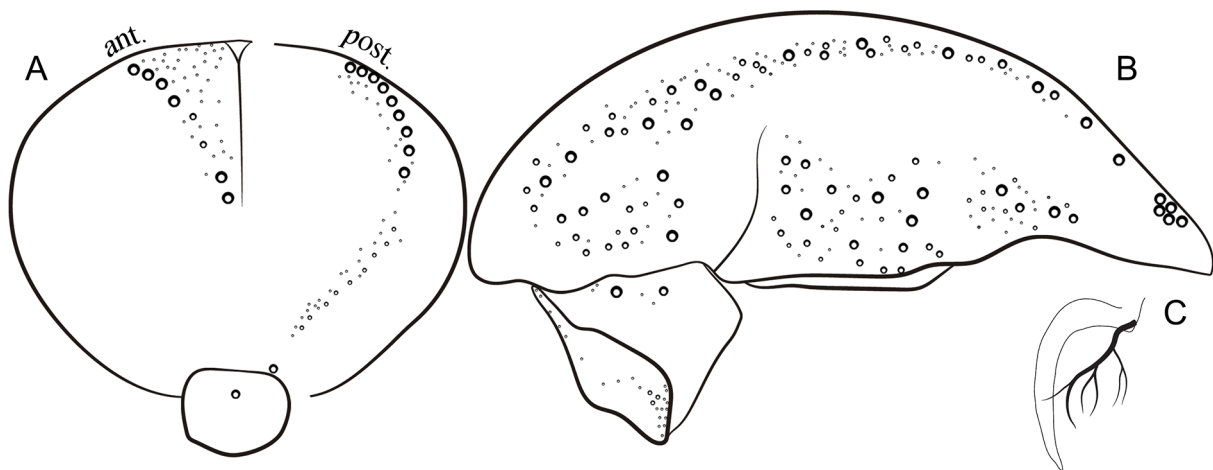
**Female adult** (n = 2)

**HEAD.** **Sensilla** (Fig. 35A): Ocular row with 2 thick offset setae on ventral portion, more dorsally about 13–14 setae extending posteriorly. Subocular row weakly defined anteriorly, with about 15 slender setae on posterior part. Vertex with multiple slender setae. Postgenal row with 9–11 intermediate and about 15 slender setae, ranging from end of ocular row to ventral portion of head. With 2 thick ventromedial setae.

**THORAX.** **Sensilla** (Fig. 35B): Proepisternum with 25–50 slender/intermediate setae. Anteprepronotum with 20–28 slender setae, most on posteroventral portion. Postpronotum with 2 thick and 4–5 slender dorsal setae. Scutum, prescutal area with 3 thick posterior setae dorsoventrally aligned, 18–23 intermediate/slender setae grouped on ventral portion. Antealar area with 7–15 thick and 24–28 intermediate/slender setae concentrated on ventral portion. Supraalar area with 4 thick setae, with about 23 intermediate/slender setae surrounding. Dorsocentral row, posterior part with 5 thick offset setae; 30 thick/intermediate and 45 slender setae filling row. Scutellum with 12 thick setae. Posterior anepisternum bare. Anepimeron with 10–11 slender setae.

**WING.**  $R_3/R_1$ : 0.52–0.54;  $R_{2+3}/R_2$ : 0.56.

**LEGS.** Empodium (Fig. 35C) of intermediate length and thickness, with 4 branches.  $Ta1/Ta2$ : 2.47–2.59;  $Ta3/Ta4$ : 1.08–1.17.



**Fig. 35.** *Corethrella quadrivittata* Shannon & Del Ponte, 1928, female adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view.

### Distribution and biology

The specimen from Santa Catarina has previously been recorded by Amaral *et al.* (2019). It was collected with a CDC trap near a pond, in an open area of *Araucaria* moist forest (942 m a.s.l.). The specimen from Bahia was collected with a frog-call pan trap, in an area of Atlantic rainforest (at 89 m a.s.l.). These records show the broad altitudinal and ecological range of the species, otherwise known from Mexico, Costa Rica, Suriname to Argentina and southern Brazil, in arid and humid climates, and at altitudes ranging from 0 to 1400 m a.s.l. (Borkent 2008). This might indicate the presence of cryptic species.

### Remarks

*Corethrella quadrivittata* and *C. edwardsi* are the only studied species that have setae on the proepisternum. Furthermore, *C. quadrivittata* has a uniquely setose anteprepronotum. Two specimens not included in this study, collected in Rio de Contas, Bahia, keyed out to *C. quadrivittata* but probably represent a different species. They had two sensilla coeloconica on each of flagellomeres XII–XIII, a bare proepisternum and three small setae on the hind coxa. These were the only specimens which had more than one tiny seta on the hind coxa. See Morphology remarks for more details.

### *Corethrella (Corethrella) ranapungens* Borkent, 2008

Fig. 36; Appendix 1

### Material examined

BRAZIL – Bahia State • 3 ♀♀, adults; Rio de Contas, Parque Natural Serra das Almas, “Brejo do Junco” [reed marsh]; 13°32'19" S, 41°52'36" W; 1202 m a.s.l.; 3 Dec. 2019; A.P. Amaral leg.; frog-call trap (chorus); CE-MHS • 1 ♀, adult; Lençóis, Trilha Ribeirão do meio; 12°34'26" S, 41°23'28" W; 395 m a.s.l.; 18 Aug. 2019; A.P. Amaral leg.; frog-call trap (*Bokermanohyla oxente*); CE-MHS.

### Description

**Female adult** (n = 4)

**HEAD. Sensilla** (Fig. 36A): Ocular row with 1 thick offset seta at ventral part and 11–14 setae extending posteriorly. Subocular row not well-defined; vertex and interocular space with several setae. Postgenal row with 5–6 slender setae located mid-posteriorly. With 2–3 thick ventromedial setae.

THORAX. **Sensilla** (Fig. 36B): Anteppronotum with 4–7 intermediate setae on anterior margin, with 1 intermediate and 3–4 slender setae laterally. Postpronotum with 1 thick dorsal seta, with 1 intermediate and 2–4 slender more posteriorly. Scutum, prescutal area with 2 thick and 0–1 intermediate setae loosely aligned dorsoventrally, near prescutal suture; 2–3 intermediate and 3 slender setae more anteriorly. Antealar area with 3 thick/intermediate setae vertically aligned near prescutal suture, 6–7 thick/intermediate setae clustered posteroventrally; 15–18 slender setae spread from ventral to dorsal portions. Supraalar area with 1 thick and 2 intermediate setae anteroposteriorly aligned, with 4–6 slender setae surrounding. Dorsocentral row, posterior part with group of 3–4 thick offset setae; 17–24 thick/intermediate and approximately 15–23 slender completing row. Scutellum with 10 thick setae. Posterior anepisternum bare. Anepimeron with 6–10 slender setae.

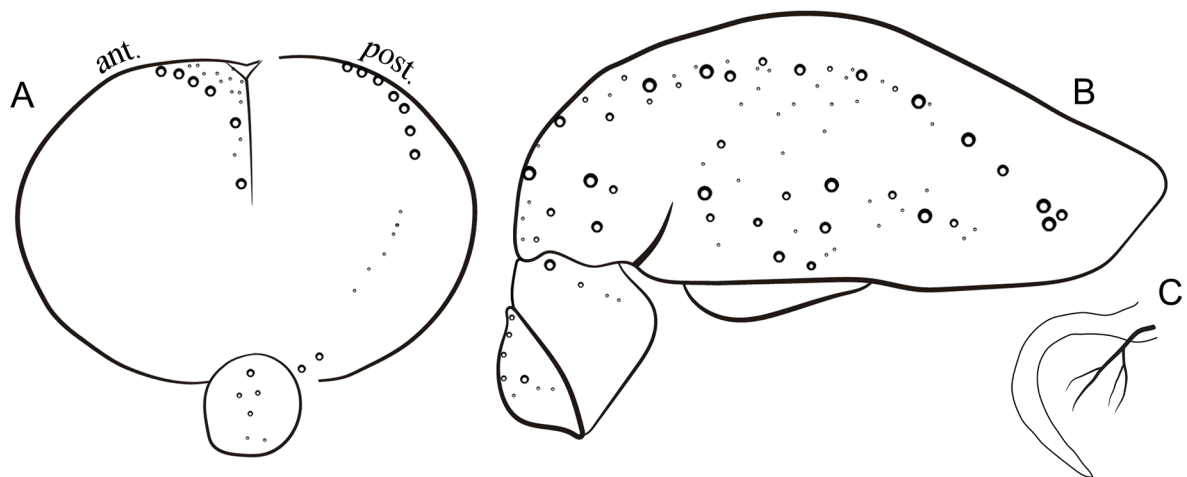
WING.  $R_3/R_1$ : 0.64 (0.62–0.67);  $R_{2+3}/R_2$ : 0.53 (0.47–0.60).

LEGS. Empodium (Fig. 36C) short, slender, with 2 branches.  $Ta1/Ta2$ : 2.86 (2.77–2.93);  $Ta3/Ta4$ : 1.15 (1.11–1.25).

### Distribution and biology

This is the first record of *Corethrella ranapungens* both from the state of Bahia and from the Brazilian Northeast region. The examined specimens were collected in Lençóis and Rio de Contas municipalities. Collection methods were frog-call pan traps playing the call of *Bokermannohyla oxente* Lugli & Haddad, 2006 and a chorus of *Boana faber*, *Physalaemus cuvieri* and *P. nanus*. Sampled localities included areas of marsh and a small stream in the Espinhaço mountain range. Elevations ranged from 395 to 1202 m a.s.l.

This species has a broad distribution and has also been recorded from Mexico, Costa Rica, Panama, Guyana, French Guiana, Trinidad and Tobago, and Brazil (Pará State, Amazonian region), at altitudes ranging from 3 to 1800 m a.s.l. (Borkent 2008).



**Fig. 36.** *Corethrella ranapungens* Borkent, 2008, female adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view.

*Corethrella (Corethrella) curta* Borkent, 2008  
Fig. 37; Appendix 1

**Material examined**

BRAZIL – Bahia State • 1 ♀, adult; Uruçuca, PESC, “Fundos da sede” [behind park lodge]; 14°29'40" S, 39°08'23" W; 970 m a.s.l.; 31 Oct. 2016; V.A. Silva *et al.* leg.; light pan; CE-MHS.

**Description**

**Female adult** (n = 1)

**HEAD. Sensilla** (Fig. 37A): Ocular row with 1 thick offset seta at ventral part and 15 setae extending posteriorly. Subocular row not well-defined; vertex and interocular space with many slender setae. Postgenal row with 5 intermediate and 18 slender setae ranging from mid-posteriorly to ventromedially. With 2 thick ventromedial setae.

**THORAX. Sensilla** (Fig. 37B): Anteppronotum with 5 thick and 6 intermediate ventrolateral setae. Postpronotum with 1 thick dorsal seta, 2 intermediate and 2 slender ones more posteriorly. Scutum, prescutal area with 3 thick setae vertically arranged near prescutal suture; group of about 7 thick/intermediate setae anteriorly, reaching anterior portion of dorsocentral row. Antealar area with 2 thick and 2 intermediate setae dorsoventrally aligned on mid-ventral portion; 4 thick and 2 slender setae grouped posteroventrally. Supraalar area with 3 thick setae, with 4 slender setae surrounding. Dorsocentral row, posterior part with group of 8 thick offset setae; about 24 thick/intermediate and 8 slender completing the row. Scutellum with 10 thick setae. Posterior anepisternum bare. Anepimeron with 10 slender setae.

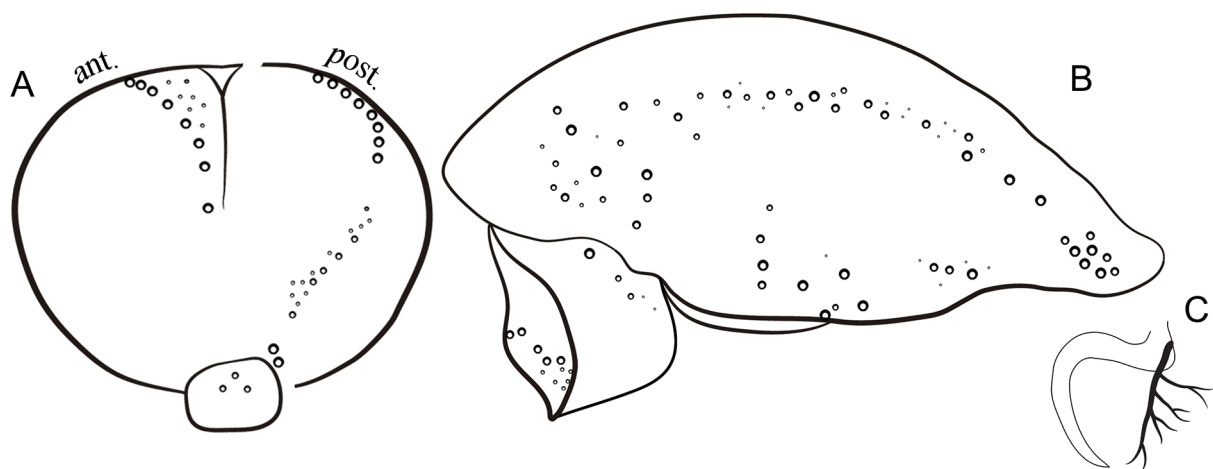
**WING.**  $R_3/R_1$ : 0.45;  $R_{2+3}/R_2$ : 0.73.

**LEGS.** Empodium (Fig. 37C) of intermediate length and thickness, with 5 branches.  $Ta1/Ta2$ : 2.67;  $Ta3/Ta4$ : 1.08.

**Distribution and biology**

*Corethrella curta* is newly recorded from Brazil. The single female was collected with a light trap near a small stream, in the Atlantic forest of Serra do Conduru State Park, at an altitude of 210 m a.s.l.

This species was previously known only from Costa Rica, at altitudes ranging from 500 and 1850 m a.s.l. (Borkent 2008).



**Fig. 37.** *Corethrella curta* Borkent, 2008, female adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view.

## Remarks

The identification of this specimen is somewhat tentative, since the female individual presents some differences compared to the original description. These are: the number of posterior setae in the dorsocentral row (3 setae, according to Borkent 2008); the presence of a sensillum coeloconicum on flagellomere VIII; discrete pigmentation on the hind tibiae. These variations, although significant, are not enough to sustain a hypothesis of a new species and are therefore considered intraspecific variations.

### *Corethrella (Corethrella) longituba* Belkin, Heinemann & Page, 1970

Fig. 38; Appendix 1

## Material examined

BRAZIL – São Paulo State • 1 ♂, adult; Campos do Jordão, Córrego Canhambora; 22°41'44" S, 45°29'30" W; 1538 m a.s.l.; M. Spiez leg.; 4 Oct. 2005; light sheet; CE-MHS.

## Description

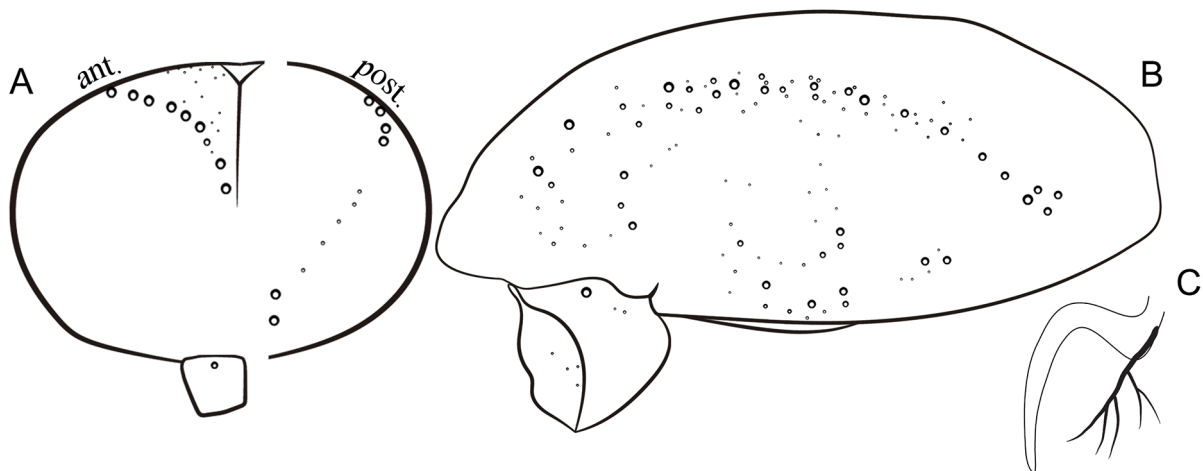
### Male adult (n = 1)

**HEAD. Sensilla** (Fig. 38A): Ocular row with 1 thick offset seta at ventral part, 12 setae shortly extending posteriorly. Subocular row not well-defined; vertex with about 15 scattered setae. Postgenal row with 5 slender setae on mid-posterior portion of head. With 2 thick ventromedial setae.

**THORAX. Sensilla** (Fig. 38B): Anteppronotum with 4 slender lateral setae. Postpronotum with 1 thick dorsal and 2 slender posterior setae. Scutum, prescutal area with 2 thick and 1 intermediate setae vertically aligned near prescutal suture, 3 slender setae more dorsally; group of 7 slender setae anteriorly. Antealar area with group of 10 thick/intermediate and 6 slender setae ventrally; 10 slender setae dorsally located. Supraalar area with 2 thick setae, with 4 slender setae surrounding. Dorsocentral row, posterior part with group of 4 thick offset setae; about 28 thick/intermediate and 25 slender completing row. Scutellum with 11 thick setae. Posterior anepisternum without setae. Anepimeron with 10 slender setae.

WING.  $R_3/R_1$ : 0.43;  $R_{2+3}/R_2$ : 0.74.

LEGS. Empodium (Fig. 38C) of intermediate length, slender, with 3 branches.  $Ta1/Ta2$ : 3.33;  $Ta3/Ta4$ : 0.53.



**Fig. 38.** *Corethrella longituba* Belkin, Heinemann & Page, 1970, male adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view.

### Distribution and biology

This specimen has previously been recorded in Amaral *et al.* (2019). It was collected with a light trap near a stream in an area of *Araucaria* moist forest in Campos do Jordão State Park, São Paulo. The altitude recorded was 1538 m a.s.l.

This species is otherwise known from the Bahamas, Cayman Islands, Jamaica, Dominican Republic, and Puerto Rico at altitudes ranging from 1 to 150 m a.s.l. (Borkent 2008).

### Remarks

The individual differs from the description by Borkent (2008) in the presence of one sensillum coeloconicum on flagellomere IX.

### *Corethrella (Corethrella) incompta* Borkent, 2008

Fig. 39; Appendix 1

### Material examined

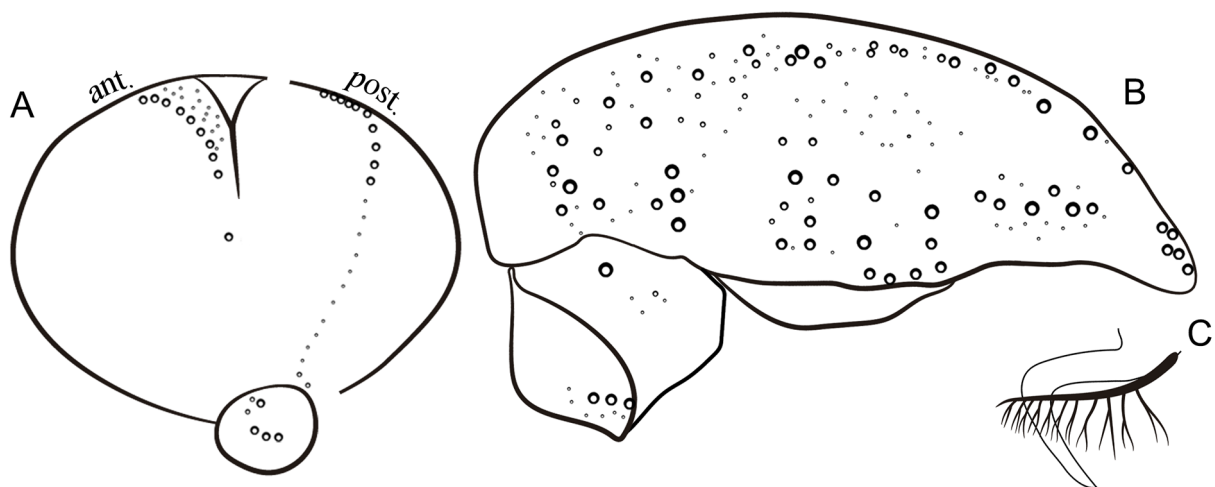
BRAZIL – Bahia State • 1 ♀, adult; Porto Seguro, RPPN Veracel, muçununga; 16°21'33" S, 39°08'15" W; 72 m a.s.l.; 30 Aug. 2019; A.P. Amaral leg.; frog-call trap; CE-MHS.

### Description

#### Female adult (n = 1)

**HEAD. Sensilla** (Fig. 39A): Ocular row with 1 thick offset seta at ventral part, 19 setae extending posteriorly. Subocular row not well-defined; vertex and interocular space with many slender setae. Postgenal row with 13 slender setae ranging from posterior end of ocular row to ventromedially. With 2 thick ventromedial setae (see discussion below).

**THORAX. Sensilla** (Fig. 39B): Anteprenotum with 3 thick and 6 slender setae on ventrolateral margin. Postpronotum with 1 thick dorsal seta and 4 slender, more ventral ones. Scutum, prescutal area with 3 thick setae vertically arranged near prescutal suture, 1 thick seta more anteriorly; about 6 thick/intermediate setae anteriorly, reaching anterior portion of dorsocentral row; 6 slender setae scattered on ventral portion. Antealar area with 8 thick/intermediate setae loosely aligned dorsoventrally on anterior portion and 8 thick/intermediate setae more posteriorly, forming a U-shape; additionally, a group of 18



**Fig. 39.** *Corethrella incompta* Borkent, 2008, female adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view.



slender setae on dorsal portion. Supraalar area with 6 thick setae anteroposteriorly aligned, 11 slender setae surrounding. Dorsocentral row, posterior part with group of 5 thick offset setae; about 34 thick/intermediate and 25 slender completing row. Scutellum with 10 thick setae. Posterior anepisternum bare. Anepimeron with 10 slender setae.

WING.  $R_3/R_1$ : 0.55;  $R_{2+3}/R_2$ : 0.55.

LEGS. Empodium (Fig. 39C) elongate and thick, with 12 branches.  $Ta1/Ta2$ : 3.07;  $Ta3/Ta4$ : 1.11.

### Distribution and biology

*Corethrella incompta* is newly recorded both from the state of Bahia and from the Brazilian Northeast region. A single individual was collected via frog-call pan trap at an area of white-sandy tropical savanna patch inside a fragment of lowland Atlantic forest (mussununga ecosystem), at RPPN Estação Veracel.

It is otherwise known from Mexico, Cayman Islands, Costa Rica, Ecuador, French Guiana, and Brazil (state of Pará, Amazonian region), at altitudes ranging from 0 to 269 m a.s.l. (Borkent 2008).

### Remarks

The studied female individual matched the original description of *Corethrella incompta* fairly well, but seems to differ in relation to the empodia. Borkent (2008) did not describe the empodium in detail, defining it only as slender. There is, however, a general correspondence between what he considered to be slender, of intermediate thickness or thick with the classification here used. The large and highly branched empodium of the specimen examined is in accordance with other species in the *wirthi* group. Since this is the only major difference found from the original description, the individual is considered as *Corethrella incompta* and the empodium redescribed.

The number of ventromedial setae on the head is difficult to interpret. The postgenal row appears to be continuous with the ventromedial setae, making it difficult to discriminate one from the other.

### *Corethrella (Corethrella) atricornis* Borkent, 2008

Fig. 40; Appendix 1

### Material examined

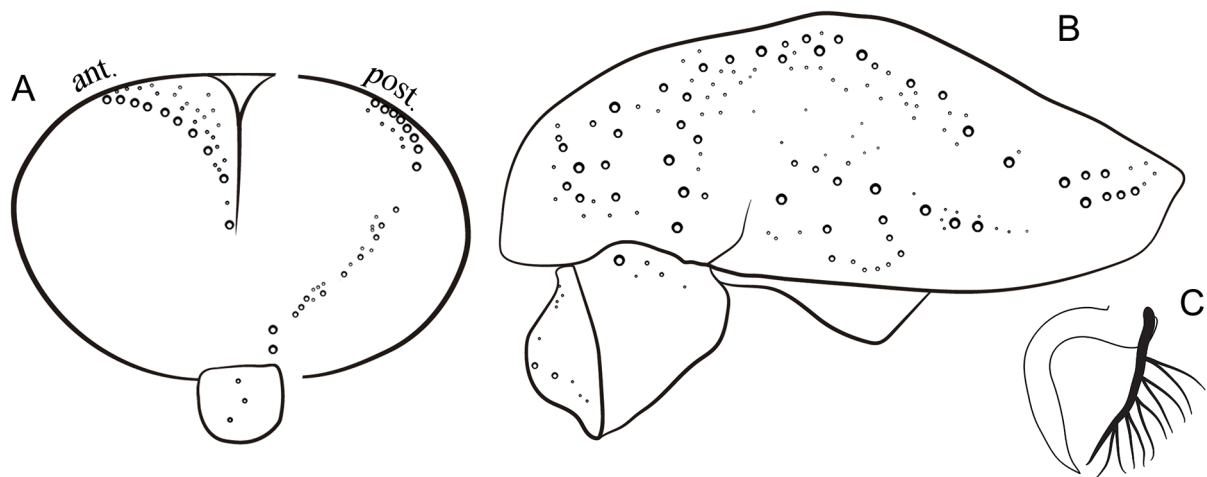
BRAZIL – **Rio Grande do Sul State** • 1 ♀, adult; Derrubadas, Parque Estadual do Turvo, Riacho Salto; 27°08'22" S, 53°52'52"W; 8 Oct. 2013; V. Caldart leg.; frog-call trap (*Scinax perereca*); CE-MHS • 1 ♀, adult; same collection data as for preceding, except 16 Dec. 2013; RB2N, control; CE-MHS.

### Description

#### Female adult (n = 2)

HEAD. **Sensilla** (Fig. 40A): Ocular row with 1 thick offset seta on ventral portion, more dorsally with 17 setae shortly extending posteriorly. Subocular row well-defined, with 16 slender setae. Vertex with a few additional setae. Postgenal row with 9–10 intermediate and 10 slender setae ranging from mid-posteriorly to ventromedially. With 2 thick ventromedial setae.

THORAX. **Sensilla** (Fig. 40B): Antepronotum with 2–3 intermediate ventrolateral setae and 6–8 slender setae along anterolateral and ventrolateral margins. Postpronotum with 1 thick dorsal, 2 intermediate, and 2–3 more posterior slender setae. Scutum, prescutal area with 3 thick, 2 intermediate, and 2 slender setae loosely aligned vertically near prescutal suture; group of 6 intermediate and 6 slender setae more anteriorly, merging with anterior portion of dorsocentral row. Antealar area with 1 thick, 2 intermediate, and 3 slender setae anteriorly; group of about 7 thick/intermediate and 4 slender setae forming a U-shape more posteriorly; with 9 slender dorsal setae. Supraalar area with 3 thick anteroposteriorly aligned



**Fig. 40.** *Corethrella atricornis* Borkent, 2008, female adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view.

central setae, 9 slender setae surrounding. Dorsocentral row, posterior portion with 7 thick and 4 slender offset setae; 23 thick/intermediate and 36 slender setae completing row. Scutellum with 11–13 thick setae. Posterior anepisternum without setae. Anepimeron with 21 slender setae.

WING.  $R_3/R_1$ : 0.51–0.58;  $R_{2+3}/R_2$ : 0.57–0.71.

LEGS. Empodium (Fig. 40C) elongate, of intermediate thickness, with 5 branches.  $Ta1/Ta2$ : 2.76;  $Ta3/Ta4$ : 1.10.

### Distribution and biology

The studied specimens have previously been recorded by Caldart *et al.* (2016). They were captured using a frog-call trap playing the call of *Physalaemus* aff. *gracilis* and by a silent control trap. The traps were set near a pond in Turvo State Park, Rio Grande do Sul State, in an area of seasonal deciduous forest in southern Brazil, near the Argentinian border. The altitude was about 185 m a.s.l. This species is otherwise recorded from the type locality in the Atlantic forest of São Paulo State, at an altitude of 603 m a.s.l (Borkent 2008).

### Remarks

The two examined individuals differ slightly from the original species description with regard to the number of anepimeral and posterior dorsocentral setae, originally described as 15 and 5, respectively. One of them also had a long coronal suture. These differences, however, are considered intraspecific variation.

### *Corethrella (Corethrella) borkenti* Amaral & Pinho, 2015

Fig. 41; Appendix 1

### Diagnosis

#### Larva

Only bromeliculous species with the following combination of characters: head mostly pale, but mandible, maxilla, segment X, and siphon more darkly pigmented (Amaral & Pinho 2015: fig. 19); postmentum elongate, with margins almost parallel up to basal 0.6, strongly tapering distally (Fig. 41D);

prementum with 12–14 darkly pigmented teeth (Fig. 41D); central tooth large, second small, third large and remaining ones gradually decreasing in size (Fig. 41D); seta 15-C bifurcated or forked.

### Pupa

Only bromeliculous species with the following combination of characters: exuvia medium brown (Amaral & Pinho 2015: fig. 16), abdomen elongate and tapering, darker mesially; abdominal segments little expanded laterally, with one dorsal and one lateral well-developed setae (Amaral & Pinho 2015: fig. 18) on each of segments II–VII (these setae longer than respective segments, largest ones about twice as long); dorsal setae progressively shorter from V–VII; all setae darkly pigmented; respiratory organ tubular, very elongate, expanded at apex (Amaral & Pinho 2015: fig. 17).

### Material examined

BRAZIL – **Bahia State** • 1 ♂, adult; Ilhéus, UESC Max de Menezes; 14°47'54" S, 39°10'24" W; 21 May 2019; A.P. Amaral leg.; Mirco's bromeliad; CE-MHS • 1 ♀, adult, with larval and pupal exuviae; Ilhéus, Cabruca da UESC; 14°47'48" S, 39°10'20" W; 35 m a.s.l.; 16 May 2019; A.P. Amaral leg.; bromeliad; CE-MHS • 1 ♀, adult, with larval and pupal exuviae; Porto Seguro, RPPN Estação Veracel, Trilha 12-09; 16°19'38" S, 39°07'22" W; 73 m a.s.l.; 28 Aug. 2019; A.P. Amaral leg.; bromeliad; CE-MHS. – **Santa Catarina State** • 1 ♀, adult; Grão Pará, Parque Estadual Serra Furada, CAPEA stream; 28°11'26" S, 49°23'30" W; 16 Nov. 2012–7 Jan. 2013; L.C. Pinho, M.C. Novaes and M.F. Haddad leg.; Malaise trap; CE-MHS • 1 ♀, adult, with larval and pupal exuviae; Florianópolis, Pantanal, Rua Sulcar; 27°36'35" S, 48°30'57" W; 53 m a.s.l.; 21 Jul. 2016; A.P. Amaral leg.; bromeliad; CE-MHS.

### Description

#### Male and female adults (1 ♂, 4 ♀♀)

**HEAD. Sensilla** (Fig. 41A): Ocular row with 1 thick offset seta at ventral part and 1 more dorsally, followed by 13–15 setae shortly extending posteriorly. Subocular row well-defined with about 20 slender setae from interocular space to posterior portion. Vertex with a few scattered setae. Postgenal row with 6–15 slender setae, ranging from mid-posterior portion of head to ventromedially. With 2 thick ventromedial setae.

**THORAX. Sensilla** (Fig. 41B): Anteprenotum with 1–2 dorsal and 3–7 anteroventral intermediate setae. Postpronotum with 1 thick dorsal, 1 slender anterodorsal, and 4–5 more ventrally located setae. Scutum, prescutal area with 2 thick and 2–4 intermediate setae, dorsoventrally aligned near prescutal suture; 0–7 intermediate/slender anterior setae. Antealar area with cluster of about 5–7 thick, 4–8 intermediate, and 6–9 slender setae located ventrally; 11–25 slender dorsal setae. Supraalar area with 3–4 thick and 0–1 intermediate setae aligned longitudinally, about 6–9 slender setae surrounding. Dorsocentral row, posterior part with cluster of 4–6 thick and about 3–7 slender setae; approximately 17–23 thick/intermediate and 38–41 slender filling row. Scutellum with 12–14 thick setae. Posterior anepisternum bare. Anepimeron with 5–17 slender setae.

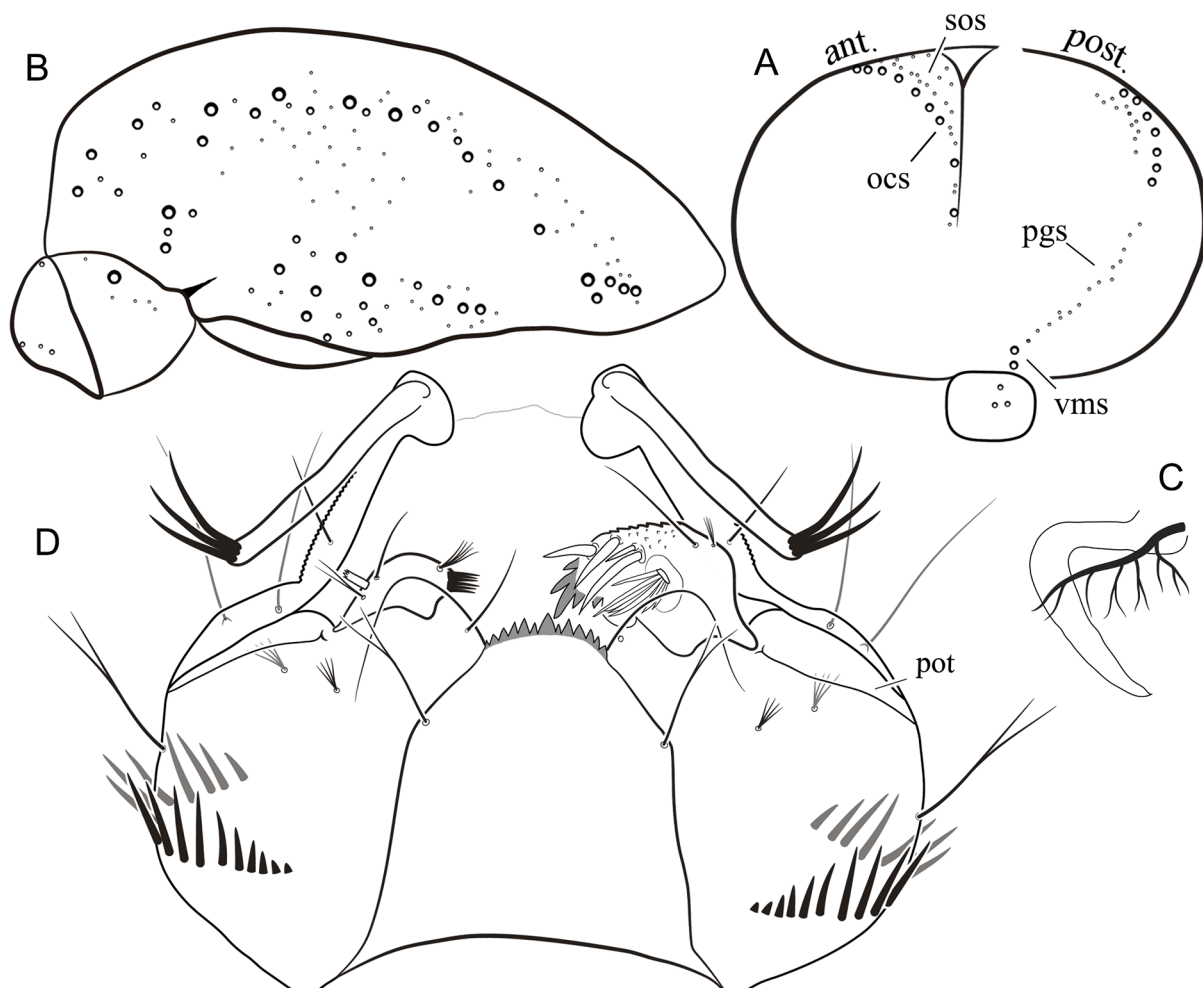
**WING.** Male  $R_3/R_1$ : 0.40;  $R_{2+3}/R_2$ : 0.94. Female  $R_3/R_1$ : 0.51 (0.47–0.55);  $R_{2+3}/R_2$ : 0.66 (0.59–0.73).

**LEGS.** Empodium (Fig. 41C) of intermediate length and thickness, with 5 branches. Male  $Ta1/Ta2$ : 3.00;  $Ta3/Ta4$ : 1.60. Female  $Ta1/Ta2$ : 2.90 (2.71–3.00);  $Ta3/Ta4$ : 1.09 (1.08–1.13).

#### Larva (n = 3)

**EXUVIA** (Amaral & Pinho 2015: fig. 19). Head mostly pale; mandible, maxilla, segment X, and siphon more darkly pigmented; without tergal plates.

HEAD (Fig. 41D). Wide, somewhat round in dorsoventral view, 1.22 (1.19–1.25) times as wide as long. Antenna 0.41 (0.40–0.41) times length of head; antennal groove 1.36 (1.25–1.48) times length of antenna. Ventral margin of antennal groove serrate. Postmentum elongate, with margins almost parallel until basal 0.6, strongly tapering distally; 1.13 (1.11–1.14) times as wide as long; length 0.58 (0.57–0.59) of head. Prementum (Amaral & Pinho 2015: figs 21–22) curved, with 12–14 darkly pigmented teeth; central tooth largest, second tooth small, third large, remaining ones gradually smaller. Anteroventral projection of gena strongly projected anteriorly, surface smooth. Postcoila extending to lateral margin of gena. Subgenal carina without spinules. Crown with 13–17 regularly distributed spines, sizes growing towards lateral, ventral spines shortest; largest spine 0.08 mm (0.07–0.09) long. Seta 16-C anterolateral to crown. Mandible, apical tooth 1.62 (1.43–1.83) times length of first dorsal tooth; seta 3-Mn 0.43 (0.42–0.43) times length of 4-Mn; lacinia mobilis with 8 blades; mandibular lobe well-developed, pale, contiguous to teeth. **Sensilla**: 9-C short, fan-like; 10-C elongate, simple; 11-C elongate, simple or forked; 12-C elongate, simple; 13-C short, fan-like; 14-C moderately elongate, simple; 15-C moderately elongate, bifurcated or forked; 16-C elongate, bifurcated. 0a-Mn short, fan-like; 0b-Mn elongate, simple. 6-Mx short, bifurcated; 4-Mx moderately elongate, simple; 5-Mx short, fan-like.



**Fig. 41.** *Corethrella borkenti* Amaral & Pinho, 2015. **A.** Adult cranial setae, anterior and posterior views, and female clypeus in anterior view. **B.** Adult thoracic setae, lateral view. **C.** Hind leg claw and empodium, lateral view. **D.** Exuvia of larval head, ventral view, except mandible in dorsal view. Abbreviations: ocs = ocular row of setae; pgs = postgenal row of setae; pot = postcoila; sos = subocular row of setae; vms = ventromedial setae.

SIPHON (Amaral & Pinho 2015: fig. 28). 0.32 mm (0.30–0.34) long. Seta 1 forked, situated at 0.19 (0.11–0.26) of length from base; 6-S pale, 9-S darkly pigmented; length of 6-S/9-S: 0.54 (0.48–0.60).

**Pupa** (n = 3)

EXUVIA (Amaral & Pinho 2015: fig. 16). Medium brown, with abdominal segments II–VII darker mesially; setae darkly pigmented, except cephalothorax dorsal 1, setae on terminal process lightly pigmented.

CEPHALOTHORAX. Length 1.32 mm (1.17–1.61). Dorsal seta 1 pale, short, moderately thick; about one length apart from dorsal 2; dorsal 2 darkly pigmented, of same basal thickness, about four times as long; both setae arising from undifferentiated cuticle. Metathoracic 2 and supraalar 2 sensilla present. Metathoracic seta 1 short, simple.

ABDOMEN (Amaral & Pinho 2015: fig. 18). Elongate, tapering from IV–VII, dorsal tegument smooth; length of segments I–VIII: 1.37 mm (1.17–1.73), width/length: 0.54 (0.49–0.58). Margins serrate, moderately expanded laterally, somewhat posteriorly from VI–VIII. Largest seta L-2-II, 1.79 (1.68–1.94) times length of segment. Terminal process moderately elongate, basal width 0.70 (0.67–0.72) of length, with paddles moderately tapering from base; D-1-IX short, at about 0.50 from base; apical spine articulated; ventroapical seta V-1-IX about 3 times as long as apical spine; female genital lobe tapered at midlength, distinctly narrower than base of paddles; genital lobe elongate in male, slightly tapering, extending to half length of paddles. Chaetotaxy as illustrated.

**Distribution and biology**

Examined individuals with their associated exuviae were collected as larvae from bromeliads in the Atlantic forest of Santa Catarina and Bahia states. Adults were collected with light traps (Amaral *et al.* 2019). This species has been recorded at altitudes ranging from 35 to 248 m a.s.l.

**Remarks**

In the original description, Amaral & Pinho (2015) recognized as a diagnostic feature of the species the exceptionally elongate pupal respiratory organ, with a length 13–18 times its basal width. The specimens examined here show a less elongated respiratory organ, with a length/width ratio ranging from 9.5 to 13. The other diagnostic features of immatures and adults, however, made it possible to confidently identify the specimens. Moreover, in the original description, the long lateral seta on the abdomen of the pupa is indicated as L-4, but we here reinterpret it as an L-2 seta. One of the specimens seems to have trifid branches on the empodium, although the position of the legs on the microscope slide make it difficult to confirm this.

***Corethrella (Corethrella) cambirela* Amaral, Mariano & Pinho, 2019**

Fig. 42; Appendix 1

**Material examined**

**Holotype**

BRAZIL – **Santa Catarina State** • ♂, adult; Santo Amaro da Imperatriz, Plaza Caldas; 27°44'30" S, 48°48'25" W; 424 m a.s.l.; 9–10 Aug. 2017; L.C. Pinho *et al.* leg.; CDC trap; MZUSP.

**Allotype**

BRAZIL – **Santa Catarina State** • ♀, adult; Santo Amaro da Imperatriz, Plaza Caldas; 27°44'35" S, 48°48'27" W; 433 m a.s.l.; 25 Apr. 2013; A. Ambrozio-Assis leg.; frog-call trap (*Physalaemus lateristriga*) 2<sup>a</sup>3; MZUSP.

### Paratypes

BRAZIL – Santa Catarina State • 2 ♂♂, adults; same collection data as for holotype; CE-MHS. • 1 ♀, adult; same collection data as for allotype, except 31 Mar. 2013; frog-call trap (*Hypsiboas poaju*); CE-MHS.

### Description

#### Male and female adults (3 ♂♂, 2 ♀♀)

HEAD. **Sensilla** (Fig. 42A): Ocular row with 1 thick offset seta at ventral part, 1 more dorsal, and 14 setae shortly extending posteriorly. Subocular row not well-defined, interocular space and vertex with a few slender setae. Postgenal row with 5–6 intermediate setae at mid-posterior portion. With 2 thick ventromedial setae.

THORAX. **Sensilla** (Fig. 42B): Anteppronotum with 4–7 slender setae along anterior and ventral margins. Postpronotum with 1 thick, 1 intermediate, and 2–3 slender dorsal setae. Scutum, prescutal area with 3 thick setae near prescutal suture and 7–12 slender/intermediate setae near anterior portion of dorsocentral row. Antealar area with 3 thick and 0–2 intermediate setae vertically aligned on anterior portion, 6–8 thick/intermediate setae ventrally located, forming a U-shape; 4–6 scattered slender setae. Supraalar area with 2–3 thick setae surrounded by 6–8 slender setae. Dorsocentral row, posterior part with cluster of 3–4 thick and 1–3 slender setae; about 15–22 thick/intermediate and approximately 13–19 slender completing row. Scutellum with 10–11 thick setae. Posterior anepisternum bare. Anepimeron with 4–7 slender setae.

WING. Male  $R_3/R_1$ : 0.52 (0.50–0.54);  $R_{2+3}/R_2$ : 0.63 (0.58–0.68). Female  $R_3/R_1$ : 0.59–0.63;  $R_{2+3}/R_2$ : 0.44–0.52.

LEGS. Empodium (Amaral *et al.* 2019: 115, fig. 7f) of intermediate length and thickness, with 3 branches. Male  $Ta1/Ta2$ : 2.67 (2.56–2.86);  $Ta3/Ta4$ : 0.54 (0.50–0.57). Female  $Ta1/Ta2$ : 2.71–2.78;  $Ta3/Ta4$ : 1.08–1.09.

### Distribution and biology

The specimens studied here constitute the type series recorded in Amaral *et al.* (2019): “This species is known from two females collected in frog-call traps playing the call of *Physalaemus lateristriga* (Steindachner) and *Boana poaju* (Garcia, Peixoto & Haddad), and five males collected using a CDC

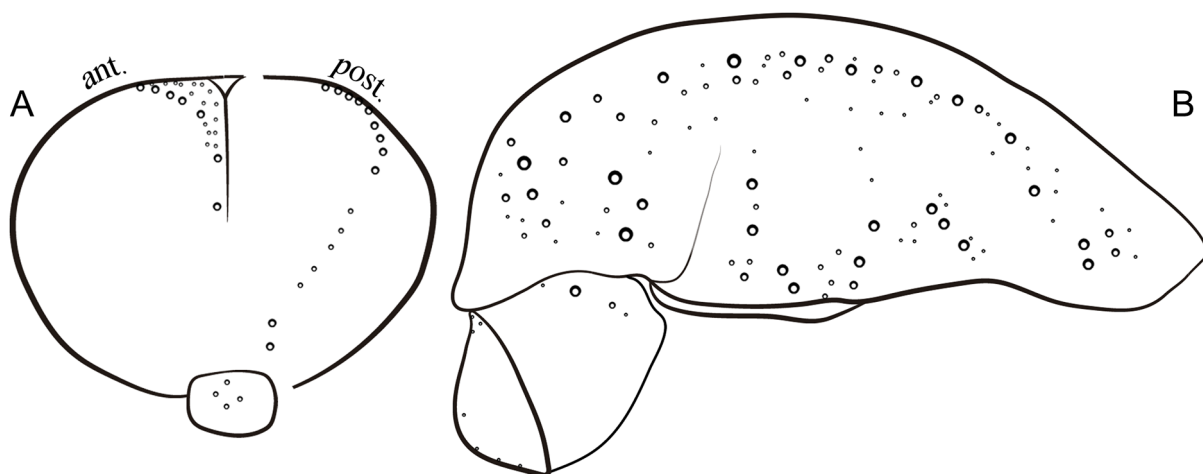


Fig. 42. *Corethrella cambirela* Amaral, Mariano & Pinho, 2019, adult. A. Cranial setae, anterior and posterior views, and female clypeus in anterior view. B. Thoracic setae, lateral view.

trap. So far this species is restricted to Serra do Tabuleiro State Park, in Santo Amaro da Imperatriz, SC, at elevations of 425–434 m.”

### Remarks

In the original description, Amaral *et al.* (2019) stated that three posterior setae are present in the dorsocentral row. This study interprets this character differently, now considering it as 4 thick setae. The position of this species in the phylogeny is not certain, although, considering the three-branched empodium, male abdominal segment VIII pale and the setae on the antealar area, it might belong within the *ananacola-fulva* clade (Borkent 2008). The absence of a pigmentation pattern on the wing is a synapomorphy for a more inclusive clade, the *tarsata-fulva* clade, although *Corethrella cambirela* does not have other apomorphic states shared by the species in this clade, such as two bold ventral setae in the ocular row, the scutellum with a dark anteromedial spot, or the gonocoxite more darkly pigmented posteriorly or posterolaterally.

*Corethrella (Corethrella) yanomami* Amaral, Mariano & Pinho, 2019  
Fig. 43; Appendix 1

### Material examined

#### Holotype

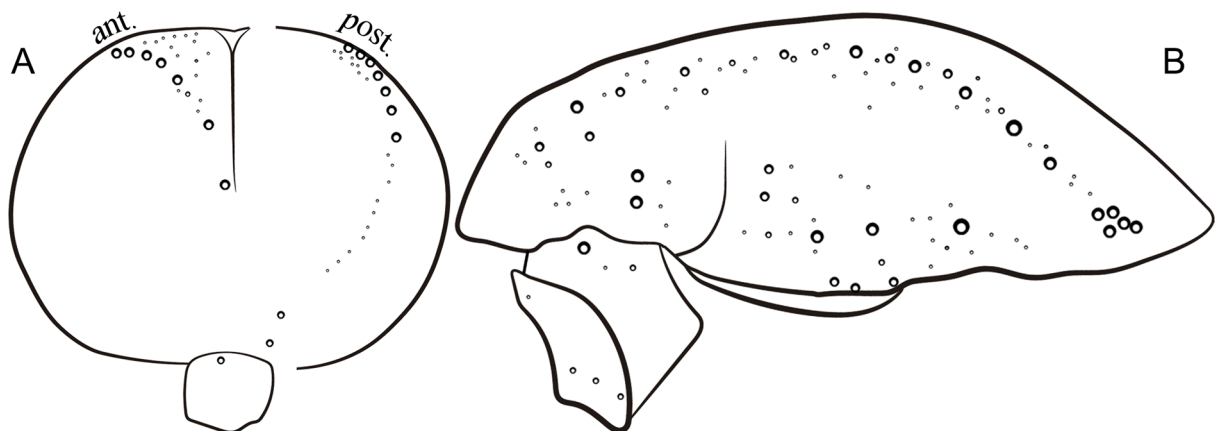
BRAZIL – Amazonas State • ♀, adult; Barcelos, Parque Estadual Serra do Aracá, Igarapé da anta (banho), S02; 00°54'30" N, 63°26'24" W; 1105 m a.s.l.; 25 Jul. 2009; N. Hamada *et al.* leg.; Pennsylvania trap; INPA.

### Description

#### Female adult (n = 1)

**HEAD** (Fig. 43A). **Sensilla:** Ocular row with 1 thick offset seta on ventral part, 1 more dorsal, and 12 setae shortly extending posteriorly. Subocular row not well-defined anteriorly, with 8 slender posterior setae; vertex with a few additional slender setae. Postgenal row with 10 slender setae, ranging from posterior end of ocular row to subventrally. With 2 thick ventromedial setae.

**THORAX** (Fig. 43B). **Sensilla:** Antep pronotum with 1 slender anterodorsal seta and 4 intermediate setae ventrolaterally. Postpronotum with 1 thick, 1 intermediate, and 1 slender dorsal setae. Scutum, prescutal area with 2 thick setae near prescutal suture and 3 slender ones more posteriorly; anterior portion with



**Fig. 43.** *Corethrella yanomami* Amaral, Mariano & Pinho, 2019, female adult. **A.** Cranial setae, anterior and posterior views, and clypeus in anterior view. **B.** Thoracic setae, lateral view.

4 slender ventral setae. Antealar area with 10 thick/intermediate and 7 slender setae scattered on ventral part. Supraalar area with 1 thick seta, surrounded by 9 slender setae. Dorsocentral row, posterior part with cluster of 5 thick setae; about 18 thick/intermediate and approximately 31 slender setae completing row. Scutellum with 8 thick setae. Posterior anepisternum bare. Anepimeron with 5 slender setae.

WING.  $R_3/R_1$ : 0.59;  $R_{2+3}/R_2$ : 0.59.

LEGS. Empodium (Amaral *et al.* 2019: 115, as fig. 7f) of intermediate length and thickness, with 3 branches.  $Ta1/Ta2$ : 2.86;  $Ta3/Ta4$ : 1.25.

### Distribution and biology

The specimen examined is the holotype, described in Amaral *et al.* (2019): “This species is known from a single female specimen collected with a light trap in Barcelos municipality, Amazonas state. Aracá State Park is in a mountainous region of Amazon forest, the Tepuis, near the Brazilian border with Venezuela.” The altitude recorded was 1105 m a.s.l.

### Remarks

Four specimens collected with light trap in Uruçuca, Bahia keyed out to *Corethrella yanomami* but differed with regard to the number of clypeal setae (3–4), posterior dorsocentral setae (3–4), flagellomere VIII without a sensillum coeloconicum, and empodium with two branches. These differences may represent intraspecific variation, but conservatively, they were not included in the present study. Since *C. yanomami* was described based on a single specimen, it is important to try to collect more individuals at the type locality in order to better assess the morphological variation of the species.

## Discussion

### Morphology remarks

Several morphological characters are newly described for adults and immatures in this paper. Some have already proven useful, serving as species diagnostics and as distinctive steps in the modified taxonomic key (modified from Borkent 2008), although their phylogenetic interpretation requires a larger sample of species and outgroup comparison. We expect that the detailed descriptions of immatures provided here will be sufficient to properly identify species without associated adults. Character states as well as variation in the examined species and previously published descriptions are discussed below.

#### Adults

**Head.** The setae on the head (Fig. 41A) are highly variable among species groups and even closely related species, and we could not recognize any strong pattern reflecting phylogenetic affinities. The **ocular row** of all examined species varied from nine setae in *C. bifida* sp. nov. to 25 in *C. infuscata*. The **subocular row** is poorly defined in many species, often only distinguishable from its posterior portion. Members of the *rotunda* and *peruviana* (except *C. alticola* and *C. amazonica*) groups have a reduced number of these setae. For species with a setose vertex, in many cases it was only possible to distinguish the posterior portion.

The **postgenal row** is quite variable in the genus, ranging from a single row of four setae intermediate in relative thickness in *C. yucuman* to over 60 slender setae in two rows in *C. alticola*. The number of setae and the extension of the row do not follow the proposed phylogenetic affinities between species, but they seem rather useful in distinguishing species because there is relatively low intraspecific variation. Ventral to the postgenal row are the **ventromedial setae**. The number of these setae is somewhat variable, but all members of the *peruviana* group bear only one in that region. *Corethrella xokleng* and *C. yucuman* both



have three ventromedial setae, which differs from other species in the *rotunda* group, such as *C. rotunda* with two and *C. pindorama* sp. nov. with one.

*Thorax.* Thoracic setae are commonly present on the scutum, scutellum, antepronotum, postpronotum, posterior anepisternum, and anepimeron. Only a few species had setae on the proepisternum and katepisternum. Some intraspecific variation could not be completely described due to reasons explained in the Methods section. Despite this, many patterns could be recognized, and the general aspect of thoracic setae seems constant among species and groups of species (i.e., the presence of setae on a given region of the thorax, the approximate number and position of thick and slender setae).

All specimens that have setae on the **posterior anepisternum** belong to the *peruviana* or *rotunda* group. This character was also observed by Borkent (2008: 291), who reported the absence of these setae in three Old World clades: *Corethrella novaezealandiae*, the *marksae* group, and the *drakensbergensis* group. He also recorded the presence of these setae on some specimens of New World species (*C. appendiculata*, *C. melanica* Lane & Aitken, 1956, and *C. belkini* Borkent, 2008). It is not known whether the presence of anepisternal setae in the *peruviana* and *rotunda* groups is plesiomorphic or apomorphic, considering its distribution within the genus, although they are present in many Culicidae, Chaoboridae and Dixidae.

Borkent (2008: 228) mentioned a unique autapomorphic character for *Corethrella brevivena*, i.e., the presence of a **katepisternal seta**. This trait is also present in *C. yucuman* and is further evidence (synapomorphy) of a sister species relationship between these species.

*Corethrella quadrivittata* and *C. edwardsi* are the only known species with setae on the **proepisternum**. The number of setae ranges from 4–12 in *C. edwardsi* to 25–50 in *C. quadrivittata*. *Corethrella whartoni*, the sister species of *C. quadrivittata*, might also have these setae. If confirmed, this would be another synapomorphy supporting the clade *C. edwardsi* + (*C. quadrivittata* + *C. whartoni*).

Species in the *peruviana* group, except *C. davisii* and *C. bifida* sp. nov., lack **anepimeral** setae. This condition is also present in other, more distantly related species (such as *C. solomonis* Belkin, 1962, *C. evenhuisi* Borkent, 2008, and *C. canningsi* Borkent, 2008), but as Borkent (2008: 211, 218) argued, early lineages (represented in the present study by the *peruviana* and *rotunda* species groups) tend to have these setae in smaller numbers, ranging from 0 to 3 in the *peruviana*, *rotunda*, and *drakensbergensis* groups; exceptions are the four Australian species in the *marksae* group, with 5–19 setae. This trend is confirmed here, apart from a female specimen identified as *C. rotunda*, which had eight setae. Moreover, the setae on species of the *rotunda* group are thicker than those of other species.

The setae on the **scutum** revealed patterns that corroborate some of the previously proposed phylogenetic relationships. Members of the *peruviana* group had the following: a reduced number of thoracic setae; the antealar area with only a cluster of setae posteroventrally located (also present in *C. flavitibia* Lane, 1939, likely independently evolved); and the posterior portion of the dorsocentral row with a group of longitudinally aligned setae. For all members of the species group, Borkent (2008) described the posterior part of the dorsocentral row as bearing “2 elongate setae situated somewhat lateral to one another.” However, we observed the posterior part of the dorsocentral row as having several setae that were longitudinally aligned and not contiguous with the row, with only the posteriormost pair more or less positioned side by side, but sometimes indistinctly. This different interpretation further enables us to interpret variation of this feature, e.g., with *C. davisii* and *C. bifida* sp. nov. having only 4–5 setae, while *C. carariensis* has 8–10.

Seven species in the *fulva* group (*C. lopesi*, *C. lepida*, *C. infuscata*, *C. fulva*, *C. patasho* sp. nov., *C. fuscifimbria* sp. nov., *C. unifasciata* sp. nov.), *C. appendiculata* (*appendiculata* group), *C. atricornis*, *C. incompta* (both *wirthi* group) and *C. cambirela* (unplaced, but possibly in the *fulva* group) have a

characteristic arrangement of thick and intermediate setae dorsoventrally aligned on the anterior portion of the **antealar area**, with more posterior setae arranged in a U-shape on the ventral portion. This arrangement is partially present in *C. amabilis*, *C. ananacola*, *C. flavitibia*, *C. pillosa*, *C. aurita* (all in the *fulva* group) and *C. yanomami* (unplaced), which have either the anterior row or the inferior part of the “U” poorly defined. *Corethrella curta* (*brakeleyi* group) also has a vertical row of thick setae on the antealar area, but it is located more posteriorly and may not be homologous. At this moment it is not possible to interpret the phylogenetic significance of this variation.

The closely related species *C. fulva* and *C. infuscata* have the setae on the posterior portion of the dorsocentral row located inside a shallow depression, which is delimited by a faint margin. This trait was not seen in other species and may be further evidence of the phylogenetic proximity of these species. A female specimen not included in this paper, labeled as *C. aff. tarsata*, also had this feature. The clade *tarsata-fulva* is composed of *C. tarsata* + (*C. infuscata* + (*C. fulva* + *C. unisetosa*)). If also present in *C. tarsata* and *C. unisetosa*, this trait would be another synapomorphy of this well supported group, which shares distinctive synapomorphies, such as wings without darkly pigmented scales and the adult male with sternites III–VII posteriorly banded.

*Wings.* Two ratios of wing vein lengths were measured and calculated. The species in the *peruviana* group had a pattern with relatively more elongate  $R_2$  and  $R_3$  veins, with the highest values for the  $R_3/R_1$  ratio (males 0.45–0.70; females 0.61–0.80) and some of the lowest for the  $R_{2+3}/R_2$  ratio (males 0.45–0.70; females 0.30–0.61). Species in the *fulva* group showed the opposite trend, with the reduction of those veins and a relatively more elongate  $R_{2+3}$ , with minimum and maximum values for  $R_3/R_1$  (males 0.39–0.54; females 0.46–0.59) and  $R_{2+3}/R_2$  (males 0.65–0.90; females 0.61–0.80), respectively. The species in the *rotunda* group had intermediate  $R_3/R_1$  values (males 0.41–0.43; females 0.52–0.69) and females showed overall low  $R_{2+3}/R_2$  values (0.29–0.76), including the absolute lowest (i.e., the longest  $R_2$  in relation to  $R_{2+3}$ ). Males of *C. xokleng* and *C. yucuman* (*rotunda* group), with their remarkably short  $R_2$  vein, had the highest  $R_{2+3}/R_2$  ratios and the only values above 1 (1.14–1.35).

*Legs.* The **Ta1/Ta2** ratio, for both males and females, has the lowest values in the *peruviana* and *quadrivittata* groups (below 2.60). One exception is *Corethrella bifida* sp. nov. (*peruviana* group) that had values above 2.64. Other species groups mostly had values above 2.60. The **Ta3/Ta4** ratio was recognized by Borkent (2008: 210, character 16) in males, with two apomorphic states, the first for values lower than 1.60 and the other lower than 0.83. The latter is a synapomorphy of the large clade which comprises more than half of the family and is sister to the *peruviana* group. We confirm the pattern observed by Borkent (2008) and add measurements for females, which do not exhibit a pattern as strong as that in males. However, the mean values for the *peruviana* and *rotunda* groups are also the highest.

All the species examined have a nude hind coxa, bearing only a minute apicolateral seta, which is usually difficult to observe. The only exceptions found were two unidentified specimens, similar to *C. quadrivittata*, which had three small setae. This condition has not been studied in non-Neotropical species, although, as illustrated by Belkin (1968), it seems to be the case for *C. novaezealandiae*. For other Culicomorpha families, at least Culicidae, Chaoboridae, Chironomidae and Dixidae have a hind coxa with more setae (or scales). Further examination of other lineages and species, extant and fossil, could confirm this as a synapomorphy of Corethrellidae.

The morphology of the **empodia** is very useful for taxonomy and potentially informative in phylogenetic terms. The structure presents little intraspecific variation and, in many cases, corroborates species groups proposed for the family.

In the *rotunda* group, three out of four species examined (*Corethrella pindorama* sp. nov., *C. xokleng*, and *C. yucuman*) have an empodium that is thick or of intermediate thickness, with at least seven branches, a condition otherwise found only in some members of the *peruviana* and *wirthi* groups. The thick empodium with several multifid branches in *Corethrella pindorama* sp. nov. is unique in the group.

In the *peruviana* group, two distinct types of empodia are recognized. *Corethrella peruviana* and *C. blanda* have intermediate to thick empodia with multiple branches (often trifold). Borkent (2008) described the thickness of the empodium of two related species — *C. inornata* Borkent, 2008 and *C. pallida* Lane, 1942 — as being intermediate, which, in our interpretation, corresponds to a thick empodium. These four species plus *C. ramentum* form a clade, supported by two or three synapomorphies (55–56 in Borkent 2008: 220; see character 57 of pupae discussed below). *Corethrella alticola*, *C. amazonica*, *C. carariensis*, *C. davisii*, *C. munteantaroku*, and *C. bifida* sp. nov., which are spread out among the species in the group, have a short and slender empodium with one or two branches. This shape has only been found in the *peruviana* group and *C. ranapungens* (not closely related and likely independently evolved), and might be a synapomorphy of the *peruviana* group. The shape of the empodium of *C. redacta* is also unique within the studied material.

Eight out of 14 examined species from the *fulva* group have empodia of short/intermediate length and slender/intermediate thickness, with three branches (*Corethrella amabilis*, *C. ananacola*, *C. cambirela*, *C. cardosoi*, *C. flavitibia*, *C. fulva*, *C. infuscata*, and *C. lopesi*). Similar empodia are found in more or less related species inside the clade, as well as in other species groups (such as *C. appendiculata*, *C. rotunda*, and *C. longituba*). Interestingly, the empodium of *Corethrella* (*Fossicorethrella*) *cretacea* Szadziewski, 1995, a Lebanese amber fossil, considered sister to all extant species, is also slender and bears three branches; however, judging from the illustration, it seems more elongate than the ones of extant species. Four related species in the *fulva* group (*C. aurita*, *C. pillosa*, *C. patasho* sp. nov., and *C. unifasciata* sp. nov.), which share the apomorphic state of character 46 in Borkent's phylogeny (adult frons with 4–6 strong ventromedial setae), bear empodia that are intermediate in size and thickness, with 5–6 branches. The phylogenetic relevance of those characters will be better understood when the morphology is described for more species and is included in new cladistic analyses.

Species in the *wirthi* group also share similarities in the morphology of their empodia. They have intermediate to thick, elongate empodia, with 5–12 branches, distinguishing them from other related species groups, which have more slender and less branched empodia. The *wirthi* group is considered weakly supported and currently based on a single homoplastic synapomorphy, which is the presence of a sensillum coeloconicum on flagellomere III. The unique morphology of the empodium, in contrast to that of related clades may be another synapomorphy of the *wirthi* group.

The meristic variation of cranial and thoracic setae, as well as the morphology of empodia does not seem to present sexual dimorphism, meaning that these traits could be useful for the association of male and female conspecifics. A more extensive examination of male specimens, which were in small number in the present work, could confirm this observation.

### Larvae

The **postcoila** is still undescribed for Corethrellidae and was defined by Harbach & Knight (1980) as:

“In most insects, the part of the cranial surface articulating with the postartus of the mandible, including the adjacent specialized, usually thickened cranial cuticle; often forming an acetabulum. In mosquito larvae, a small anteroventral marginal cranial process along with the adjacent short longitudinal apodematous ridge; the maxillary palpus is secondarily associated with it basally.”

We observed two distinct variants of this structure. In species of the *peruviana* group, it is similar to the condition of Culicidae (Harbach & Knight 1980), with a thickening of the cuticle in the region of the postartis (Fig. 15D). However, in *Corethrella ananacola*, *C. borkenti*, *C. fulva*, and *C. infuscata* it is a sclerotized rod that extends laterally through the head capsule to the lateral margin of the gena (Fig. 41D). *Corethrella edwardsi* (Fig. 34E) and possibly other species of the *quadrivittata* group except *C. belkini* have an intermediate condition, with a discrete thickening at the postartis area and a very faint line extending laterally. The presence of a rod-like postcoila extending to the lateral portion of the head seems to be another synapomorphy of the large clade sister to the *peruviana* group (as in Borkent 2008).

The shape of the **postmentum** varies among species with three distinct patterns: 1) trapezoid, with margins strongly tapering from the base and a flat prementum (as in Figs 21E, 34E); 2) ogival, with margins gently tapering from the base and more strongly subapically, with a curved prementum (as in Figs 22E, 31E); and 3) hexagonal, with margins parallel at the base and abruptly tapering subapically, with a flat or slightly curved prementum (as in Fig. 41D).

Based on our observations and descriptions by other authors, it appears that members of the *peruviana* and *quadrivittata* groups (*C. edwardsi*; *C. quadrivittata* as illustrated in Balseiro & Spinelli 1984) have the first type of postmentum, as well as *C. wirthi* (somewhat uncertain; McKeever & French 1991). The second type occurs in members of the *brakeleyi* group (*Corethrella aridicola* Borkent, 2008 (as *C. laneana* in Belkin & McDonald 1955), *C. brakeleyi* Coquillett, 1902 (in Cook 1956), *C. longituba* in Belkin *et al.* 1970), and the *fulva* group (*C. ananacola*, *C. fulva*, *C. infuscata*, *C. badia* (as *C. jenningsi* Lane, 1942 in Lane & Aitken 1956), *C. tarsata* in Lane & Aitken 1956). The third type is found in *C. borkenti* (currently assigned to the *wirthi* group: Amaral & Pinho 2015; Baranov *et al.* 2016), *C. appendiculata* (*appendiculata* group, as in McKeever & French 1991), and possibly *C. flavitibia* (Lane & Aitken 1956) and *C. solomonis* (Belkin 1962).

*Corethrella solomonis* is sister to all the referred species and may represent, with *C. borkenti*, *C. appendiculata* and *C. flavitibia*, the plesiomorphic shape. If true, then the second type of postmentum may be a synapomorphy of the *brakeleyi* and *fulva* groups, which presently lie in a polytomy along with the *appendiculata*, *quadrivittata*, and *wirthi* groups. The similar shape in the species of the *quadrivittata* and *peruviana* groups would, thus, be homoplastic, as the latter shares many synapomorphies with other species groups.

*Corethrella kipferi* of the *rotunda* group has a uniquely shaped postmentum, somewhat convex basally, with almost straight margins, with a V-shaped furrow apex. The larvae of this species, and potentially others from the *rotunda* group, are highly distinctive, probably due to adaptations to life in the hyporheic zone.

The **prementum** of most species have a large central tooth, a small second tooth, a third tooth that is large but shorter than the central one, and the remaining teeth variable. Species of the *peruviana* group have a second tooth that is as large as the other teeth; the central tooth is only inconspicuously larger in some species. Outside the *peruviana* group, the only species we found with a relatively large second tooth are *C. infuscata* and *C. tarsata* (as drawn in Lane & Aitken 1956). Some species have unique arrangements, such as *C. fulva* (Fig. 31E) and *C. edwardsi* (Fig. 34E), while maintaining the short second tooth. A large second tooth is another synapomorphy of the *peruviana* group and may be a synapomorphy of the clade of four species which includes *C. infuscata* and *C. tarsata*, although further study is required to confirm this.

Another newly described character is the presence of denticles or serration on the **ventral margin of the antennal groove**. All species in the *peruviana* group (as in Fig. 21E), *Corethrella edwardsi* (Fig. 34E), and *C. quadrivittata* (Balseiro & Spinelli 1984) have large denticles in this region, which vary

in their number and degree of development. *Corethrella fulva* and *C. infuscata* (Figs 30E, 31E) have a smooth margin. Some other species have a serrate margin, namely *C. borkenti* (Fig. 41D), *C. ananacola* (Fig. 22E), *C. solomonis* (as described and illustrated in Belkin 1962), and possibly *C. brakeleyi* (from drawings in Cook 1956) and *C. flavitibia* (vaguely drawn in Lane & Aitken 1956). Most of the drawings and descriptions are not sufficiently detailed to determine the presence or absence of these denticles. Therefore, it is not possible to make further generalizations about the states of this character based solely on drawings. Further study is needed.

The **anteromedial portion of the gena** (Fig. 15D) varies among species in two ways: 1) flat or slightly curved and somewhat pronounced anteriorly; and 2) deeply curved and conspicuously pronounced anteriorly, with a lateral ridge extending basally. The first form is found in *C. edwardsi* (Fig. 34E), *C. quadrivittata*, possibly *C. aridicola* (as seen on drawing in Belkin & McDonald 1955), all species of the *peruviana* group (as in Figs 15D, 21E), and *C. solomonis* (as in Belkin 1962). The second type (as in Figs 22E, 31E, 41D) is found in *Corethrella ananacola*, *C. appendiculata*, *C. borkenti*, *C. brakeleyi*, *C. fulva*, *C. infuscata*, *C. kipferi*, *C. longituba*, and *C. wirthi* Stone, 1968. These species are not all closely related but, except for *C. kipferi* (*rotunda* group), are distributed in the diverse clade sister to the *peruviana* group (as in the phylogeny in Borkent 2008). The first form differs from the second in being seemingly continuous to the margin of gena, not having the ridge extending basally, while the second type appears like an adjacent structure overlapping the underlying gena. It is uncertain whether this structure is actually part of the gena or the labium. Similar structures, the paralabial plates, are found in the larvae of Chironomidae. It is not possible to interpret the phylogenetic significance of this character until its state is described for more species.

The mandibles of larvae are generally very similar. The most significant variations we found were related to the proportion between the **3-Mn** and **4-Mn** setae and the degree of sclerotization and size of the mandibular lobe (as in Figs 15D, 31E). In members of the *peruviana* group, the 3-Mn seta is much shorter than the 4-Mn, with an average ratio of lengths of 0.25 (0.21–0.33), which contrasts with an average of 0.40 (0.34–0.47) in all other examined species. In previous descriptions, these setae were not well described, but it was possible to infer through the illustrations that in *C. brakeleyi*, *C. flavitibia*, *C. melanica* and *C. quadrivittata* the 3-Mn seta is at least 0.5 times the length of 4-Mn. The **mandibular lobe** in the *peruviana* group differs from that of others in being darkly pigmented and somewhat smaller. More data is needed to interpret this variation phylogenetically.

The chaetotaxy of the head does not seem to have much phylogenetic relevance, since the sensillum types vary considerably among closely related species and there is little variation in the position of the sensilla between different lineages. It can be useful for distinguishing species (e.g., in *C. bifida* sp. nov. the 13-C seta is fan-like, while in *C. davisii* it is simple). However, this should be used carefully because there can be some intraspecific variation in the seta types and only a small sample was examined in this study. One remarkable trait is the position of seta **16-C**, which is located mesially to the ventral part of the crown in the *peruviana* group (Fig. 15F) and *C. edwardsi* (possibly also in *C. quadrivittata*), while in the remaining species it is more anteriorly located, anterolateral to the range of the crown (as in Figs 22E, 41D). The position of this seta is related to the shape of the ventral portion of the gena (which is where it is attached), the length of the antenna, and the posterior extension of the antennal groove, and seems very susceptible to homoplasy, due to many possible variations in the cranial sclerites.

The setae **6-S** and **9-S** (on the siphon) are lightly pigmented in the *peruviana* group and in *C. edwardsi*, while in *C. borkenti*, *C. fulva*, and *C. infuscata* the 9-S is discretely darkly pigmented (feature undescribed in other species). The relative length of 6-S seems informative, varying between 0.76 and 0.97 times the length of the 9-S in the *peruviana* group, 0.69–0.72 in *C. edwardsi* and 0.48–0.67 in *C. borkenti*, *C. fulva*, and *C. infuscata*. Due to the small sample in which those traits could be observed, it is not possible to interpret these variations phylogenetically.

The larva of *Corethrella edwardsi* bears a thick spine at midlength (Fig. 34F), which has not been observed in any other species (see Fig. 7C). Due to the poor condition of the two available exuviae, it is not clear whether this spine is a modified 2-S or 8-S seta, or yet a new structure. This spine also seems to be present in *C. quadrivittata*, as illustrated by Balseiro & Spinelli (1984), and is potentially another synapomorphy of the *quadrivittata* group.

### Pupae

The shape of the pupal **respiratory organ** varies widely and is taxonomically informative. Individuals of the *peruviana* group can promptly be recognized by the strongly modified, flattened organ that is horizontally oriented with pores distributed along the outer margin. This structure is a synapomorphy of the clade and is unique among the Culicomorpha (Borkent 2008: 218). In *Corethrella ananacola* and *C. borkenti* (and many other species in the family; see Borkent 2008: 408–410) the respiratory organ is an elongate tube with an apical opening, where the porous area is located. *Corethrella fulva* and *C. infuscata* (as well as some closely related and other less related species) have a short tube that is expanded at midlength. In *C. edwardsi* and other known members of the *quadrivittata* species group, it is basally tube-like and apically flattened, lacking an apical opening, with the pores distributed on the reticulate surface of the distal half. An undescribed morphotype (*C. sp.* 12) similar to *C. selvicola* Lane, 1939, *C. blantoni* Borkent, 2008, and *C. dicosimoae* Borkent, 2008 has a trumpet-shaped, curved and distally swollen respiratory organ, with the pinna located on the apicolateral portion, which is identical to the condition illustrated for *C. dicosimoae*, *C. librata* Belkin *et al.*, 1970, and *C. solomonis*, as well as many Culicidae and Chaoboridae. This may represent the plesiomorphic form.

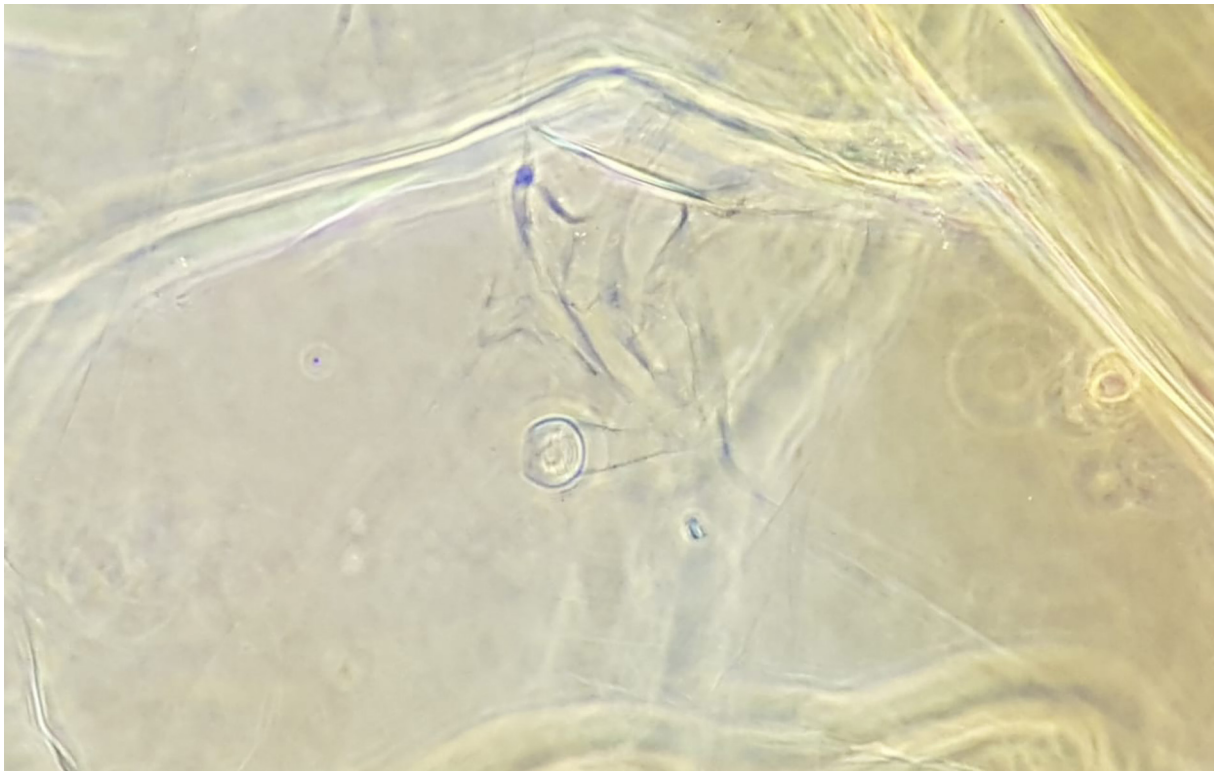
In his phylogeny, Borkent (2008: 220) defined character 57 as the presence or absence of lateral expansions on the pupal abdomen. The apomorphic state (segments greatly expanded laterally) was attributed to a clade composed of *Corethrella inornata* Borkent, 2008, *C. pallida*, and *C. blanda*. With the descriptions of the pupae of *C. alticola* and *C. peruviana*, both with lateral projections, we now understand this character to be more inclusive and that it is a synapomorphy of the *alticola-davisi* clade. It is probably also apomorphic in *C. ramentum* Borkent, 2008 (immatures undescribed), which shares other synapomorphies with this clade.

The **chaetotaxy** of pupae (Fig. 22H) is quite variable, even between closely related species, and is very informative and useful for distinguishing species. Members of the *peruviana* group, as already discussed by Borkent (2008: 219, 2012), share the synapomorphic condition of lacking metathoracic and supraalar 2 campaniform sensilla. These are also absent in *Corethrella edwardsi*, *C. quadrivittata*, and *C. whartoni*, although, unlike the *peruviana* group, these species possess a metathorax 1 seta. Borkent (2008: 219) mentioned the spherical structure on the metathorax of *C. quadrivittata* and suggested that it may be homologous to the campaniform sensillum, which disagrees with Belkin & McDonald (1955), who described this structure as a rudimentary spiracle. In this study, we endorse the interpretation of Belkin & McDonald, since we have observed this structure in all species examined, including those with a campaniform sensillum, and it indeed appears to be connected to the tracheal system (Fig. 44).

Some species have elongate lateral abdominal setae, either inserted at the apex of a narrow expansion (as in Fig. 16H) or arising from the lateral side of the segment (as in Fig. 22H). The first case occurs in examined species of the *peruviana* group, such as *Corethrella blanda*, *C. bifida* sp. nov., *C. davisi*, and *C. peruviana*. These species exhibit different degrees of lateral expansion and development of the lateral setae, but in all of them the L-4 is the elongate seta. Alternatively, in *C. ananacola*, *C. borkenti*, *C. fulva*, and *C. infuscata* the L-2 is the elongate seta. In *C. edwardsi* and *C. longituba* (Belkin *et al.* 1970), L-2 and L-3 are more developed. Without further information about the development of these setae in other lineages, it is not possible to interpret this variation phylogenetically.

The terminal process is informative in taxonomic terms, although it is difficult to precisely determine the differences in shape. In *Corethrella bifida* sp. nov. and *C. davisii* (Figs 7F, 21H), the paddles are short and distinctively narrow, which contrasts with other species in the *peruviana* group, such as *C. alticola*, *C. blanda*, and *C. peruviana*, which have elongate, stouter paddles (as in Figs 16H, 18H). Some exclusive features of the *peruviana* group (already discussed by Borkent 2008, 2012) are the D-4-IX unsocketed apical spine and the absent V-1-IX ventroapical seta. *Corethrella edwardsii*, *C. quadrivittata*, and *C. whatoni* have uniquely shaped terminal processes that are strongly narrowed and elongate, with a stout D-1-IX seta (as in Fig. 34I). This distinctive terminal process is not present in *C. belkini*, which was also placed in the *quadrivittata* group by Borkent (2008). *Corethrella fulva* (Fig. 31H), *C. infuscata* (Fig. 30H), *C. tarsata* (Borkent 2008: 414), and *C. unisetosa* (Borkent 2008: 414) have identical paddles, which are short with a broad base and deeply tapering distally. Other species that belong to the sister clade of the *peruviana* group (as in Borkent's phylogeny) have terminal processes similar to this. The patterns of variation in the shape of the terminal process would be better appreciated if methods of geometric morphometrics were used, although this would require larger samples than were available in this study.

All these findings give us new perspectives on the systematics of Corethrellidae. The *peruviana* species group, which has been considered a distinct genus in the past, reveals even more unique features in immatures and adults, such as the pattern of setae on the thorax, mandible of the larva, shape of the pupal respiratory organ, and chaetotaxy of the pupa. Surprisingly, species of the *quadrivittata* group showed peculiar similarities with the *peruviana* group, especially in immatures. These are the shape of the head and the larval postmentum, the presence of large denticles on the antennal groove, the position of seta 16-C, the pigmentation of setae on the siphon, and the absence of metathoracic 2 and supraalar 2 sensilla on the pupa. However, it is hard to assume that the two groups are closely related, since the phylogenies proposed place them as distant lineages and many characters of the adults, especially of



**Fig. 44.** Detail of pupal metathorax of *Corethrella* sp. showing spherical structure, presumably a rudimentary spiracle.

male genitalia, suggest they are more distantly related. The similarities might be due to plesiomorphy and a new phylogenetic analysis is deeply needed.

### **Biology and distribution patterns of Corethrellidae from Brazil**

We report 15 new distribution records for Bahia, which is now the Brazilian state with most recorded species (Appendix 1) and still the only state in the Northeast region with species of *Corethrella* recorded. Two of these records for Bahia, *C. aurita* and *C. curta*, are also new for the country; they were previously recorded only in Panama and Costa Rica, respectively (Borkent 2008). So far, *Corethrella flavitibia* and *C. infuscata* have only been recorded in the South and Southeast regions of Brazil (Borkent 2008) and are widely distributed in the Atlantic forest. The remaining species were previously found throughout Brazil in the South, Southeast, Central-West or North regions. The new records, with large geographical gaps in their distributions, show how little we know about the actual distribution of species of *Corethrella*.

Of the 56 species recorded in Brazil (including the nomina dubia) (Appendix 1), 26 valid species (plus one nomen dubium) have a broader Neotropical distribution, with reported occurrences also in Central America and/or the Caribbean. The other 25 valid species (plus three nomina dubia) are endemic to Brazil, of which 15 (and two nomina dubia) are restricted to the Atlantic forest. Six valid species (and one nomen dubium) have been reported only for the Amazonian region.

As previously discussed by Borkent (2008: 324), even though many species are currently found only in the Atlantic forest or the Amazon and sister group relationships between endemic species within these biomes are revealed in many groups of dipterans and primates (Amorim 2012), it is difficult to affirm the endemism of Corethrellidae in these areas. One reason for this is that there are large sampling gaps in the Neotropical region. For example, Amaral *et al.* (2019) recorded four species in the Atlantic forest of Brazil that were previously known to occur only in Central America and the Caribbean. Furthermore, the species restricted to the Atlantic forest are scattered in the proposed phylogenies (i.e., they do not form a distinct clade) and, although nine of them belong to the *fulva* group, all have closer relatives that occur elsewhere. Three of the seven species seemingly endemic to the Amazon are from the *peruviana* group and *C. shannoni* Lane, 1939 (nomen dubium) also occurs in Peru.

Considering their occurrence on many Caribbean islands, the large distributions of some species throughout the Neotropics, and the scarce evidence of endemism in Corethrellidae, it is likely that some species have a great dispersal capacity. Another possibility is that we may be overlooking numerous cryptic species. A recent paper by Virgo *et al.* (2021) sheds new light on the topic. By analyzing the nuclear ITS2 and mitochondrial COI genes, they found divergent lineages in morphological species that even show distinct preferences in relation to attraction to frogs.

Of the 38 species examined in this study, five are known to typically inhabit phytotelmata (*Corethrella ananacola*, *C. appendiculata*, *C. flavitibia*, *C. fulva*, *C. infuscata*) and *Corethrella longituba* has one record of a larva found in a treehole (Borkent 2008: 172). We also report the first record of a bromeliad as a larval habitat of *C. davisii*, otherwise a ground-dwelling species. In our studies, in over ten years of frog-biting midge sampling, we have found only one record of a phytotelmata species captured with a frog-call trap (*C. infuscata*, recorded in Ambrozio-Assis *et al.* 2018).

The literature is in accordance with these findings, with no other bromeliad-dwelling species reported in frog-call traps and just a few records of species that breed in other types of phytotelmata. *Corethrella appendiculata* is probably the most notable exception, with numerous collections of larvae and pupae especially from treeholes (but also a few specimens from bromeliads) and of adults collected with frog-call traps (Borkent 2008: 139); however, the specimen we examined was collected via a light trap. This is a tentative case, as Borkent (2008: 141) argued that *C. appendiculata* most likely includes more than



one species. *Corethrella calathicola* Edwards, 1930, a species from the Oriental and Oceanian regions that is exclusive to *Nepenthes* pitchers, has also been captured using frog-call traps (Borkent & Grafe 2012).

De Silva *et al.* (2014) recorded 25 individuals of *Corethrella bicolor* Borkent, 2008 in frog-call traps. This species was previously known from several specimens reared from larvae collected in leaf axils of *Ischnosiphon* Körn (Borkent 2008: 107). Bernal & de Silva (2015) reported several specimens of *Corethrella squamifemora* Borkent, 2008 captured by frog-call traps at the Smithsonian Tropical Research Institute in Gamboa, Panama in what seems to be the most relevant report of a bromeliculous species captured via sound.

*Corethrella melanica* was described by Lane & Aitken (1956) from individuals reared from bamboo holes and Lane & Cerqueira (1958) recorded one specimen reared from a Bromeliaceae. Borkent (2008: 148) reported one individual collected via a frog-call trap, among 442 other specimens. *Corethrella douglasi* was described by Borkent (2008: 110), noting that the species was captured with sweep net, light and Malaise traps, and by rearing it from leaf axils of *Dieffenbachia longispatha* Engl. & K.Krause and the tank of a *Pitcairnia valeroi* Standley bromeliad. He also noted that a frog-call trap was running near the light trap where three females were found but did not attract any individuals of the species. De Silva *et al.* (2014) also captured one specimen of *C. douglasi* with a frog-call trap, among a sample of over 500 individuals. *Corethrella belkini* was described by Borkent (2008: 150) from specimens collected in bromeliads. Legget *et al.* (2018) collected over 14000 specimens and recorded 4 individuals of *C. belkini* among them.

There are many particularities to be considered in these findings. First is the already mentioned rarity of these collections. Aside from *C. bicolor* and *C. squamifemora*, it is reasonable to conjecture that these captures could have been accidental, as often happens with many other insects that are by-catches in frog-call traps, possibly due to being pushed by the airflow into the trap while inadvertently flying by or being attracted to an LED light in the sound equipment or the headlamp of the collector. It is possible that, due to the restricted space of their habitats, these species could be significantly less abundant than the ones breeding in large bodies of water on the ground. However, in our field work we frequently find larvae of *Corethrella* inside bromeliad tanks (mainly *C. fulva*, *C. infusca* and *C. borkenti*) and have run frog-call traps near these areas without any success of capturing the adults.

One could speculate that phytotelmata species might not feed on frog blood and for this reason are not attracted to frog-call traps, but this does not seem to be the case. de Silva *et al.* (2014) collected two specimens each of *Corethrella bicolor* and *C. douglasi* directly feeding on *Engystomops pustulosus* (Cope, 1864) and *Dendropsophus ebraccatus* (Cope, 1874) and one *C. flavitibia* feeding on *E. pustulosus*. Moreover, female individuals of these species have biting mouthparts identical to those of other species in the family. Another possibility is that these species might be attracted to frogs of which vocalizations have not yet been explored in frog-call traps, even though the calls of many species, which inhabit a large variety of habitats, have been tried so far.

Another aspect to consider is that for most species, including some of those captured by frog-call traps, breeding habitats are still unknown, so it is not entirely clear how strong this pattern is.

As such, we do not understand why species of frog-biting midges breeding in phytotelmata are scarcely or not at all attracted to frog-call traps, since the studies conducted to date (cited above) used the vocalizations of various species of frogs and trapped at different heights, localities, and seasons. These midges are probably using sensory cues other than sound to find their hosts. This was suggested by Borkent (2008: 243) and tested by Bernal & de Silva (2015), who did not find a significant effect of CO<sub>2</sub> or temperature in the long-range attraction of female Corethrellidae. Conversely, Virgo *et al.* (2021)

found stronger host specificity in corethrellids when considering only the midges directly collected from frogs compared to specimens collected via sound traps. Selection of the feeding sites by the adult females also indicates the use of other cues which enable them to partition the host and select the optimal biting spot (de Silva *et al.* 2014; Virgo & Eltz 2022, preprint). In fact, the presence of several types of sensilla on the antennae and palpi of adult frog-biting midges, as well as well-developed eyes, strongly suggest that they can detect CO<sub>2</sub>, odours, and heat sources, and use vision to locate hosts and breeding sites, similarly to other blood-feeding insects, including the closely related Culicidae (Montell & Zwiebel 2016).

In the past years, we have been sampling various aquatic habitats to look for immature corethrellids in Brazil. From several types of ground bodies of water and phytotelmata, we collected no more than a dozen species. In the two regions more thoroughly surveyed (i.e., the states of Santa Catarina and Bahia), we regularly found roughly the same species or closely related ones. For example, *C. fulva* and *C. infusata* are frequent bromeliad dwellers, as well as *C. borkenti* (although a little less often). *Corethrella alticola* is easily found in flowing water and *C. davisii* is found in ponds and marshes. It is intriguing that when we set traps in the same locations where we collected immatures of these species, the most abundant species are often different. *Corethrella lopesii* is a common species in frog-call and Malaise traps in Santa Catarina, but we have never found its immatures. Many species in the *fulva* group (which *C. lopesii* belongs to) are known to inhabit phytotelmata. The well-supported New World *rotunda* group currently has eleven assigned species, but only recently has the first description of immature stages (Dorff *et al.* 2022), collected from the hyporheic zone of a river in Arizona, in the USA, been published. Earlier, Boulton *et al.* (1992) reported larvae of Corethrellidae collected from the hyporheic zone of small streams which probably belonged to *C. kerrvillensis* (Stone, 1965) (Borkent 2008). Hence, the hyporheic habitats are potential places to look for corethrellids, especially those of the *rotunda* group and other early lineages, but they are certainly not the only ones.

Habitat segregation in corethrellid larvae has been little investigated. Borkent (2008: 251) discussed the habitat diversification of immatures, noting the two types of habitats to which species seem to be restricted: ground-dwelling and phytotelmata. The present study mostly supports this idea, with only two exceptions, one specimen each of *C. davisii* and *C. fulva* (previously mentioned). Borkent also discussed some data which indicated the rarity of different species coexisting in the same bromeliad, which is also mostly congruent with this study, although the first author of the present study has reared larvae of *C. fulva* and *C. infusata* collected from the same bromeliad on a few occasions (unpublished data). Studies with culicids have shown that some species preferably oviposit at distinct heights, from ground-level to the forest canopy (Fitzgerald & Livdahl 2019). Therefore, we may be missing some species by neglecting the highest vertical strata in forests, not reachable without proper equipment. Finding further larval habitats will also help us better understand the ecology of species of Corethrellidae and how they interact with other groups of organisms.

## Conclusions

With our study, we increase the number of valid species of Corethrellidae in Brazil to 52. Bahia State has 24 species and becomes the state with most recorded species. Worldwide, we now have 126 valid extant species. The increase in species records for Brazil and especially Bahia State suggests a vast richness that is still unknown, as well as the need for more studies.

This paper increases what is known about frog-biting midges in the Northeast Region of Brazil (focusing on the largest state, Bahia) and the immatures of these insects, and proposes diagnoses and detailed descriptions, including characters not previously described. However, this task is not finished. It is necessary to further investigate and describe these novel characters for the other known species in order to understand how they vary and relate to the evolutionary history of the family.

Although thoroughly analyzed and discussed by Borkent (2008) and Baranov *et al.* (2016), many phylogenetic relationships in Corethrellidae are not sufficiently resolved, and these new perspectives on immature and adult morphology should help interpret them. With more detailed descriptions, the inclusion of characters from immatures in the matrices, and the aid of different techniques, such as geometric morphometrics and molecular analyses, we will obtain a more complete understanding of the phylogeny of Corethrellidae, including the position of the many currently unplaced species.

Important biological aspects of frog-biting midges remain largely obscured. The more we discover about these insects, the more questions are raised. Some that especially arose from this study are the following: What is the actual distribution of species of *Corethrella*? Are we missing cryptic species? What are the immature habitats and the morphological variations of the 80 species of Corethrellidae for which they remain unknown? Why do phytotelmata species appear not to be attracted to frog-call traps?

We hope to answer these and other questions soon and encourage researchers to collaborate in order to learn more about these wonderful frog-biting midges and their interactions with the natural world.

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## Appendix 1

### List of species recorded from Brazil

List of species of Corethrellidae recorded from Brazil. <sup>1</sup> stage only briefly described; <sup>2</sup> stage with description uncertain. Asterisks denote new records reported in this paper. L = larva(e); P = pupa(e). C. = *Corethrella* throughout. Continued on next 3 pages.

| Species  | Synonyms   | Type locality                 | Type material           | Brazilian districts     | Stages               | References  |
|--|--|-------------------------------|-------------------------|-------------------------|----------------------|---|
| <i>C. alticola</i> Lane, 1939                              | <i>Lutzoniops lutzii</i> Lane, 1942  | Campos do Jordão, SP          | DEFS                    | BA*, GO, RJ, RS, SC, SP | ♂, ♀, L, P           | Lane 1939a:110, 1939b:386, 1942:128, 1953:96; Borkent 2008:71; Amaral & Pinho 2015:281; Caldwell <i>et al.</i> 2016:534   |
| <i>C. amabilis</i> Borkent, 2008                           |  | Costa Rica                    | CNC                     | SC                      | ♀                    | Borkent 2008:115; Ambrozio-Assis <i>et al.</i> 2018:3   |
| <i>C. amazonica</i> Lane, 1939                             | <i>C. coutinhoi</i> Lane, 1942   | Porto Velho, RO               | DEFS                    | BA*, ES, PA, RO, SC, SP | ♂, ♀                 | Lane 1939a:110, 1942:131, 1953:99; Borkent 2008:86; Amaral <i>et al.</i> 2019:105   |
| <i>C. ananacola</i> Dyar, 1926                             | <i>C. bromelicola</i> Lane, 1939a;<br><i>C. downsi</i> Lane, 1943                | Panama                        | USNM, DEFS              | ES, SC, SP              | ♂, ♀, L, P           | Dyar 1926:150; Lane 1939a:108, 1939b:390, 1942:107,112, 1943:164, 1953:76; Lane & Aitken 1956:530; Borkent 2008:98; Amaral & Pinho 2015:277; Amaral <i>et al.</i> 2019:105  |
| <i>C. appendiculata</i> Grabham, 1906                      | <i>C. arborealis</i> Shannon & Del Ponte, 1928;<br><i>C. confusa</i> Lane, 1939a | Jamaica                       | USNM, INMA, DEFS        | AM, BA, GO, SP, SC      | ♂, ♀, E, L, P        | Grabham 1906:343; Dyar & Shannon 1924:216; Shannon & Del Ponte 1928:102; Edwards 1930:532; Lane 1939a:109, 1942:113, 1951:333; Matheson 1944: 92; Cook 1956: 60; Lane & Cerqueira 1958:561; Stone 1968:185; Belkin <i>et al.</i> 1970:242; McKeever 1985a, 1985b, 1986; Borkent & McKeever 1990; McKeever & French 1991b:525; Amaral <i>et al.</i> 2019:105 |
| <i>C. atricornis</i> Borkent, 2008                         |  | Salesópolis (Casa Grande), SP | USNM                    | RS, SP                  | ♀                    | Borkent 2008:188; Caldwell <i>et al.</i> 2016:534   |
| <i>C. aurita</i> Borkent, 2008                             |  | Panama                        | CNC, USNM               | BA*                     | ♀                    | Borkent 2008:122  |
| <i>C. bicolor</i> Borkent, 2008                            |  | Belém, PA                     | USNM                    | PA                      | ♂, ♀, P <sup>1</sup> | Borkent 2008:106  |
| <i>C. blanda</i> Dyar, 1928                                | <i>C. iridescens</i> Lane, 1939b;<br><i>Lutzoniops iridescens</i> Lane, 1953     | Panama                        | USNM, DEFS              | AM, PA, SC, SP          | ♂, ♀, L, P           | Dyar 1928:79; Lane 1939b:389, 1953:81,97; Lane & Cerqueira 1958:564; Borkent 2008:81; Amaral & Pinho 2015:283; Ambrozio-Assis <i>et al.</i> 2018:3  |
| <i>C. borkentii</i> Amaral & Pinho, 2015                   |  | Florianópolis, SC             | MZUSP                   | BA, SC                  | ♂, ♀, L, P           | Amaral & Pinho 2015:275; Amaral <i>et al.</i> 2019:105  |
| <i>C. cabocla</i> Feijó, Belchior, Marialva & Pessoa, 2021 |  | Manaus, AM                    | ILMD, INPA, CEIOC, ZCPB | AM                      | ♀                    | Almeida <i>et al.</i> 2021:151  |
| <i>C. cambirela</i> Amaral, Mariano & Pinho, 2019          |  | S.A. da Imperatriz, SC        | MZUSP, MHS              | SC                      | ♂, ♀                 | Amaral <i>et al.</i> 2019:113   |
| <i>C. carariensis</i> Borkent, 2008                        |  | Costa Rica                    | MNCR                    | SC                      | ♂, ♀                 | Borkent 2008; Ambrozio-Assis <i>et al.</i> 2018   |



**Appendix 1** (continued). List of species of Corethrellidae recorded from Brazil. <sup>1</sup> stage only briefly described; <sup>2</sup> stage with description uncertain. Asterisks denote new records reported in this paper: L = larva(e); P = pupa(e). C. = *Corethrella* throughout.

| Species  | Synonyms  | Type locality                 | Type material           | Brazilian districts        | Stages  | References  |
|--|---|-------------------------------|-------------------------|----------------------------|---|---|
| <i>C. cardosoi</i> Lane, 1942                          |   | Salesópolis (Casa Grande), SP | DEFS                    | RJ, SC, SP                 | ♂, ♀  | Lane 1942:118, 1953:86; Lane & Aitken 1956:530; Borkent 2008:113; Amaral <i>et al.</i> 2019:106                                   |
| <i>C. curta</i> Borkent, 2008                          |   | Costa Rica                    | CNC, MNCR, USNM         | BA*                        | ♀   | Borkent 2008:163  |
| <i>C. davisi</i> Shannon & Del Ponte, 1928             | <i>Lutzomiops davisi</i> Lane, 1953;<br><i>C. nigra</i> Lane, 1939*;<br><i>C. nigrescens</i> Lane, 1942;<br><i>Lutzomiops nigrescens</i> Lane, 1953 | Argentina                     | INMA, DEFS              | BA, MG, MS, PA, RJ, SC, SP | ♂, ♀, L, P  | Shannon & Del Ponte 1928:102; Lane 1939a:105, 1939b:388, 1942:127,129, 1953:94,96; Borkent 2008:88; Amaral <i>et al.</i> 2019:106 |
| <i>C. dicosimoeae</i> Borkent, 2008                    |   | Bahamas                       | USNM                    | SP                         | ♂, ♀, P <sup>1</sup>                                | Borkent 2008:195; Amaral <i>et al.</i> 2019:104   |
| <i>C. edwardsi</i> Lane, 1942                          |   | Miranda (Salobra), MS         | DEFS                    | BA*, ES, MG, MS            | ♂, ♀, L, P  | Lane 1942:126, 1953:91; Borkent 2008:153  |
| <i>C. flavitibia</i> Lane, 1939                        |   | Juquiá, SP                    | DEFS                    | BA*, SP                    | ♂ <sup>2</sup> , ♀, L <sup>2</sup> , P <sup>2</sup> | Lane 1939b:392, 1953:85; Lane & Aitken 1956:531; <sup>2</sup> Borkent 2008:101  |
| <i>C. fulva</i> Lane, 1939                             |   | Cajamar (Água Fria), SP       | DEFS                    | BA, RJ, SC, SP             | ♂, ♀, L, P  | Lane 1939a:107, 1939b:388, 1942:101, 1953:69; Borkent 2008:133; Amaral <i>et al.</i> 2019:106                                     |
| <i>C. fuscipalpis</i> Borkent, 2008                    |   | Belém, PA                     | USNM                    | PA                         | ♂, ♀  | Borkent 2008:97   |
| <i>C. ielemdei</i> Feijó, Ramires, Lima & Pessoa, 2021 |   | Manaus, AM                    | ILMD, INPA, CEIOC, ZCPB | AM                         | ♀   | Almeida <i>et al.</i> 2021:155  |
| <i>C. inca</i> Lane, 1939                              |   | Peru                          | DEFS                    | SC                         | ♀   | Lane 1939a:103; Borkent 2008:187; Ambrozio-Assis <i>et al.</i> 2018:3   |
| <i>C. incompta</i> Borkent, 2008                       |   | Costa Rica                    | MNCR                    | BA*, PA                    | ♂, ♀  | Borkent 2008:182  |
| <i>C. infuscata</i> Lane, 1939                         |   | Juquiá, SP                    | DEFS                    | RJ, SC, SP                 | ♂, ♀, L, P  | Lane 1939b:389; Borkent 2008:130; Ambrozio-Assis <i>et al.</i> 2018:3   |
| <i>C. lepida</i> Borkent, 2008                         |   | Costa Rica                    | MNCR                    | AM, BA*                    | ♂, ♀  | Borkent 2008:123; Amaral <i>et al.</i> 2019:104   |
| <i>C. longituba</i> Belkin, Heinemann & Page, 1970     |   | Jamaica                       | USNM                    | SP                         | ♂, ♀, L, P  | Belkin <i>et al.</i> 1970:245; Borkent 2008:172; Amaral <i>et al.</i> 2019:104  |
| <i>C. lopesti</i> Lane, 1942                           |   | Angra dos Reis, RJ            | DEFS                    | BA, RJ, RS, SC, SP         | ♂, ♀  | Borkent 2008:188; Caldart <i>et al.</i> 2016:534; Ambrozio-Assis <i>et al.</i> 2018:3   |
| <i>C. manaosensis</i> (Lane & Cerqueira, 1958)         | <i>Lutzomiops manaosensis</i> Lane & Cerqueira, 1958  | Manaus, AM                    | DEFS                    | AM                         | ♂, ♀, P <sup>1</sup>                                | Lane & Cerqueira 1958:565; Borkent 2008:69  |

**Appendix 1** (continued). List of species of Corethrellidae recorded from Brazil. <sup>1</sup> stage only briefly described; <sup>2</sup> stage with description uncertain. Asterisks denote new records reported in this paper. L = larva(e); P = pupa(e). C. = *Corethrella* throughout.

| Species  | Synonyms   | Type locality         | Type material           | Brazilian districts    | Stages                                | References  |
|--|--|-----------------------|-------------------------|------------------------|---------------------------------------|---|
| <i>C. menini</i> Feijó, Picelli, Ríos-Velásquez & Pessoa, 2021 |  | Manaus, AM            | ILMD, INPA, CEIOC, ZCPB | AM                     | ♀                                     | Almeida <i>et al.</i> 2021:158  |
| <i>C. munteantaroku</i> Amaral, Mariano & Pinho, 2019          |  | Manaus, AM            | INPA                    | AM                     | ♂                                     | Amaral <i>et al.</i> 2019:107   |
| <i>C. orthicola</i> Borkent, 2008                              |  | Costa Rica            | MNCR                    | SC                     | ♀                                     | Borkent 2008:112; Amaral <i>et al.</i> 2019:105   |
| <i>C. peruviana</i> Lane, 1939                                 | <i>Lutzomiotops peruviana</i> Lane, 1939; <i>C. juquiána</i> Lane, 1939; <i>Lutzomiotops juquiána</i> Lane, 1953; <i>C. similans</i> Lane & Aitken, 1956 | Peru                  | DEFS                    | BA*, PA, SC, SP        | ♂, ♀, L, P                            | Lane 1939a:109–110, 1939b:388, 1942:130–131, 1953:98–99; Lane & Aitken 1956:537,539; Borkent 2008:72; Amaral <i>et al.</i> 2019:106   |
| <i>C. pillosa</i> Lane, 1939                                   |  | Juquiá, SP            | DEFS                    | SC, SP                 | ♂ <sup>1</sup> , ♀                    | Lane 1939a:108, 1942:106, 1953:75; Borkent 2008:121; Ambrozio-Assis <i>et al.</i> 2018:3  |
| <i>C. puella</i> Shannon & Del Ponte, 1928                     | <i>C. laneana</i> Vargas, 1946; <i>C. mecalfi</i> McKeever, 1988   | Argentina             | INMA, USNM              | BA                     | ♂, ♀, P <sup>1</sup>                  | Shannon & Del Ponte 1928:101 (mistyped as <i>C. arborealis</i> ); Vargas 1946:64; Lane 1953:88; McKeever 1988:400; Borkent 2008:166   |
| <i>C. quadrivittata</i> Shannon & Del Ponte, 1928              | <i>C. kammii</i> Lane, 1942; <i>C. dyari</i> Lane, 1942; <i>C. izquierdoi</i> Vargas, 1952   | Argentina             | INMA, BMNH, USNM, InDRE | AM, BA, ES, MS, SC     | ♂, ♀, E <sup>1</sup> , L, P           | Shannon & Del Ponte 1928:101; Lane 1942:121–122,125, 1953:90–91; Vargas 1952:59; Lane & Cerqueira 1958:561; Balseiro & Spinelli 1984:193; Borkent 2008:155; Amaral <i>et al.</i> 2019:106 |
| <i>C. ranapungens</i> Borkent, 2008                            |  | Costa Rica            | CNC                     | BA*, PA                | ♂, ♀, E <sup>1</sup> , P <sup>1</sup> | Borkent 2008:160  |
| <i>C. redacta</i> Borkent, 2008                                |  | Belém, PA             | USNM                    | BA*, PA                | ♀                                     | Borkent 2008:85   |
| <i>C. rotunda</i> Borkent, 2008                                |  | Costa Rica            | MNCR                    | SC                     | ♂, ♀                                  | Borkent 2008:60; Amaral <i>et al.</i> 2019:105  |
| <i>C. selvicola</i> Lane, 1939                                 |  | Juquiá, SP            | DEFS                    | AM, BA, ES, PA, RJ, SP | ♂, ♀, P <sup>1</sup>                  | Lane 1939b:391, 1942:119, 1953:87; Lane & Cerqueira 1958:562; Borkent 2008:178  |
| <i>C. tarsata</i> Lane, 1942                                   |  | Camaçari, BA          | BMNH                    | BA                     | ♂, ♀, L, P                            | Lane 1942:102, 1953:71; Lane & Aitken 1956:537; Borkent 2008:129  |
| <i>C. travassosi</i> Lane, 1942                                |  | Miranda (Salobra), MS | DEFS                    | GO, MS                 | ♂, ♀, P <sup>1</sup>                  | Lane 1942:105, 1953:74; Borkent 2008:194  |
| <i>C. truncata</i> Borkent, 2008                               | <i>C. nigrescens</i> Lane, 1942 (in part); <i>Lutzomiotops nigrescens</i> Lane, 1953 (in part)   | Juquiá, SP            | DEFS                    | SP                     | ♀                                     | Borkent 2008:84   |
| <i>C. vittata</i> Lane, 1939                                   | <i>C. tripunctata</i> Lane, 1942   | Juquiá, SP            | DEFS, USNM              | ES, SC, SP             | ♂, ♀                                  | Lane 1939b:390, 1942:120,124, 1953:89,92; Lane & Aitken 1956:538; Borkent 2008:151; Amaral & Pinho 2015:283   |

**Appendix 1** (continued). List of species of Corethrellidae recorded from Brazil. <sup>1</sup> stage only briefly described; <sup>2</sup> stage with description uncertain. Asterisks denote new records reported in this paper. L = larva(e); P = pupa(e). C. = *Corethrella* throughout.

| Species  | Synonyms | Type locality                           | Type material       | Brazilian districts | Stages                   | References   |
|--|----------|---|---------------------|---------------------|--------------------------|--|
| <i>C. xokleng</i> Amaral, Mariano & Pinho, 2019  |          | Grão Pará, SC                           | MZUSP, CE-MHS       | SC                  | ♂, ♀                     | Amaral <i>et al.</i> 2019:110                                      |
| <i>C. yanomami</i> Amaral, Mariano & Pinho, 2019 |          | Barcelos, AM                            | INPA                | AM                  | ♀                        | Amaral <i>et al.</i> 2019:117                                      |
| <i>C. yucuman</i> Caldart & Pinho, 2016          |          | Derrubadas, RS                          | MZUSP, CE-MHS, INPA | RS                  | ♂, ♀                     | Caldart <i>et al.</i> 2016:530                                     |
| <i>C. barretto</i> Lane, 1942 nomen dubium       |          | Salesópolis (Casa Grande), SP           | DEFS                | SP                  | ♂                        | Lane 1942:132; Borkent 2008:27                                     |
| <i>C. shannoni</i> Lane, 1939 nomen dubium       |          | Peru                                    | USNM (missing)      | AM                  | ♂, ♀, L <sup>1</sup> , P | Lane 1939a:104, 1953:97; Borkent 2008:26                           |
| <i>C. striata</i> Lane, 1942 nomen dubium        |          | Santa Cruz das Palmeiras (Palmeira), SP | DEFS                | ES, RJ, SP          | ♀                        | Lane 1942:110, 1953:80; Borkent 2008:26                            |
| <i>C. whitmani</i> Lane, 1942 nomen dubium       |          | Vitória, ES                             | DEFS                | AM, ES, SP          | ♀, L, P                  | Lane 1942:108, 1953:79; Lane & Cerqueira 1958:562; Borkent 2008:27 |
| <i>C. bifida</i> Amaral & Pinho sp. nov.         |          | Palhoça, SC                             | MZUSP, CE-MHS       | BA*, SC*            | ♂, ♀, L, P               |  |
| <i>C. fuscifimbria</i> Amaral & Pinho sp. nov.   |          | Rio de Contas, BA                       | MZUSP, CE-MHS       | BA*                 | ♀                        |  |
| <i>C. patasho</i> Amaral & Pinho sp. nov.        |          | Porto Seguro, BA                        | MZUSP               | BA*                 | ♀                        |  |
| <i>C. pindorama</i> Amaral & Pinho sp. nov.      |          | Lençóis, BA                             | MZUSP, CE-MHS       | BA*, SC*            | ♀                        |  |
| <i>C. unifasciata</i> Amaral & Pinho sp. nov.    |          | Porto Seguro, BA                        | MZUSP, CE-MHS       | BA*                 | ♀                        |  |

## Appendix 2

### Key to New World Species of *Corethrella* Coquillett, 1902 (modified from Borkent 2008)

Males of the following species are unknown: *C. amabilis* Borkent, 2008, *C. anniae* Borkent, 2008, *C. atricornis* Borkent, 2008, *C. aurita* Borkent, 2008, *C. cabocla* Feijó, Belchior, Marialva & Pessoa, 2021, *C. colombiana* Borkent, 2008, *C. flavitibia* Lane, 1939, *C. fuscifimbria* Amaral & Pinho sp. nov., *C. fusciradialis* Borkent, 2008, *C. globosa* Borkent, 2008, *C. gloma* Borkent, 2008, *C. grandipalpis* Borkent, 2008, *C. hirta* Borkent, 2008, *C. ielemdei* Feijó, Ramires, Lima & Pessoa, 2021, *C. inca* Lane, 1939, *C. jenningsi* Lane, 1942, *C. kerrvillensis* (Stone, 1965), *C. kipferi* Dorff, Borkent & Curler, 2022, *C. menini* Feijó, Picelli, Ríos-Velásquez & Pessoa, 2021, *C. orthicola* Borkent, 2008, *C. patasho* Amaral & Pinho sp. nov., *C. pillosa* Lane, 1939, *C. pindorama* Amaral & Pinho sp. nov., *C. procera* Borkent, 2008, *C. redacta* Borkent, 2008, *C. truncata* Borkent, 2008, *C. unifasciata* Amaral & Pinho sp. nov., *C. unisetosa* Borkent, 2008, and *C. yanomami* Amaral, Mariano & Pinho, 2019. The females of *C. munteantaroku* Amaral, Mariano & Pinho, 2019, *C. remiantennalis* Borkent, 2008 and *C. stenostyla* Amaral, Bello-González & Pinho, 2021 are also unknown. Figures marked with an asterisk (\*) refer to Borkent (2008).

1. Wing with discrete subapical band (\*fig. 71a), with no dark scales of this band extending to wing apex (or, at most, with dark scales on  $R_{4+5}$  reaching wing apex) .....2
  - Wing either completely plain or with banding but if with darkened scales beyond midlength band, these extend along veins  $R_3$ ,  $R_{4+5}$ , and  $M_1$  to the wing apex (\*fig. 71f) .....6
2. Hind tibia mostly pale, with dark pigmentation restricted to apex (\*fig. 54a) .....*C. vittata* Lane, 1939 (in part)
  - Hind tibia with dark pigmentation at base and apex (\*fig. 54b) .....3
3. Wing with basal band of pigmented scales and membrane (\*fig. 70n) .....4
  - Wing without basal band (subbasal band present) (\*fig. 71b) .....5
4. Halter yellow or very light brown (\*fig. 54b); base of  $R_1$  without patch of dark scales (so that  $R_1$  has one group of dark scales on its apical portion) (\*fig. 70n); length of male fore  $Ta_3/Ta_4 = 0.55–0.64$ ; male gonocoxite long and slender (\*fig. 95a); tarsomeres uniformly pigmented (\*fig. 54b) .....*C. edwardsi* Lane, 1942
  - Halter dark brown (\*fig. 54c);  $R_1$  of female wing with patch of dark scales at about  $\frac{1}{4}$  of its length from base (so that  $R_1$  has a patch of dark scales between the midlength and subbasal band); in a few specimens these dark scales appear continuous with those on  $R_1$  of the midlength band (\*fig. 71a); male with length of fore  $Ta_3/Ta_4 = 0.76–0.80$ ; male gonocoxite shorter and tapering (\*fig. 95b); tarsomeres 2–4 of at least hind leg banded (as in \*fig. 55c) .....*C. quadrivittata* Shannon & Del Ponte, 1928
5. Clypeus with 1 seta (\*fig. 18y); hind femur uniformly dark brown or dark brown and with apex even more darkly pigmented (\*fig. 54d) .....*C. whartoni* Vargas, 1952
  - Clypeus with 18–28 setae (\*fig. 18u); hind femur apically pale, with at most a small, discrete dark spot near its apex (\*fig. 53d) .....*C. belkini* Borkent, 2008 (in part)
6. Wing either completely plain and without any differentiated markings of any sort or, if with some darkening or pattern, the scales along the entire anterior margin more or less uniformly pigmented (\*fig. 67n) (some adults with slight differentiation but in these it is not very discrete (\*figs 69i, 72i); male of *C. munteantaroku* with somewhat discrete band); male gonocoxite

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