

## *Paraskusella* Cranston, 2018 and *Kribiodosis* Kieffer, 1921 (Diptera: Chironomidae: Chironomini): two new species from Borneo described, allowing incorporation into a multi-gene molecular phylogeny

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**Abstract.** Based on Chironomidae (Diptera) specimens collected from Gunung Mulu National Park, Sarawak, East Malaysia, an additional two genera are recognised, belonging to the cosmopolitan tribe Chironomini. Two new species, each represented by adult males, are described and illustrated as *Paraskusella sarawak*, new species and *Kribiodosis mulu*, new species. The larva of *Kribiodosis* Kieffer, 1921 is described for the first time based on its barcode identity to a male of *Kribiodosis cantonensis* Tang, 2021. New insights into phylogenetic relationships are provided for *Paraskusella* Cranston, 2018 and *Kribiodosis* Kieffer, 1921 based on multi-gene analyses that include these taxa. Each is located independently within a broad informal ‘Microtendipes–group’. Biogeographic implications of these ‘tropical Gondwanan’ distributions are discussed briefly.

**Key words.** new records, new species, Borneo, phylogeny, distribution

### INTRODUCTION

Studies of the Diptera family Chironomidae have long been central to our understanding of the tempo and locations of insect evolutionary diversification (Brundin, 1966). However, in assessing patterns of biodiversity, our conclusions are only as good as the existing data. Insights often are limited by the fragmentary nature of distributional data, and prevailing records of endemic or restricted distribution taxa may be unreliable, requiring re-evaluation and frequent updating. This is especially so for species-poor genera in Southeast Asia, including some with distinctive Africa– (Australia) –Oriental distributions. This applies amongst others to *Conochironomus* Freeman, 1961 (Cranston, 2016), *Skusella* Freeman, 1961 (Cranston & Tang, 2018), *Paraskusella* Cranston, 2018 (Cranston, 2018) and *Kribiodosis* Kieffer, 1921 (Han et al., 2021). *Paraskusella*, recently distinguished from the more diverse and widespread austral *Skusella*, was reported from central Africa and Australia (Cranston, 2018). *Kribiodosis* Kieffer, 1921, established originally for a West African species, *Kribiodosis clavigera* Kieffer, 1921, was found also in oriental China (Han et al., 2021), revealing a major disjunction in the distribution of the genus.

During the preparation of a regional guide to larvae of Southeast Asian Chironomidae (Cranston & Tang, 2024), new collections and existing regional collections were examined. To our surprise, in East Malaysia (Sarawak, Borneo), we found adult males of both *Paraskusella* and *Kribiodosis*. Here we report the presence of one new species of each, collected by the first author during an aquatic insect workshop held in the Gunung [= mountain] Mulu National Park, Sarawak, Malaysia in June 2023, supplemented in July 2024. Upon closer examination of slide-mounted material, we found a species that conforms to *Kribiodosis* Kieffer, 1921, notably in the extremely long legs and banded abdomen, although it lacks the pale ‘knee’ in legs exhibited typically by congeners. The other interesting species found matches the description of *Paraskusella*, with characteristic straight comb spurs and well-developed median volsella. Here we describe and illustrate these two taxa as new, based on adult males. Further, we assess the phylogenetic positions of *Kribiodosis* and *Paraskusella* based on enhanced molecular-based results (Han et al., 2021). Our discoveries extend the distribution ranges of both *Paraskusella* and *Kribiodosis*, suggesting a broader distribution and thus a more complex biogeographical history than was understood previously.

In addition, the previously unknown larva of *Kribiodosis* has been discovered recently in oriental China by a ‘barcode’ shared with the male of *Kribiodosis*. We take this opportunity to describe this larva, and make comparisons with putative relatives in a ‘Microtendipes–group’.

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## MATERIAL AND METHODS

Adults from light traps were preserved directly into 85% ethanol in the field. Specimens were dissected under a stereoscope, the dissected thorax was retained, and the remainder mounted on a slide with Euparal. The thorax went to the molecular laboratory for DNA extraction and the thoracic exoskeleton was mounted subsequently on the same slide as its corresponding parts. Morphological terminology and abbreviations for many structures follow Sæther (1980) and larval head morphology follows Cranston (2012). Measurements are given as ranges, with the number of observed specimens in parentheses. In descriptions, units of length are in  $\mu\text{m}$ , unless stated to be mm.

The holotypes are deposited in the Department of Ecology, Life Science and Technology College, Jinan University, Guangzhou, China (EJNU), and paratypes in the Australian National Insect Collection, CSIRO, Canberra, Australia (ANIC) and Sarawak Forestry Corporation (SFC).

Photographs were taken with an Olympus BX53 compound microscope with Mshot™ (MSX2) camera mounted to allow automated retention of focused parts of exposures at different depths. Ink drawings were made subsequently by hand, aided by use of a drawing attachment (U-DA). Image manipulations and assembly were made in Adobe® Photoshop™.

Molecular materials were prepared according to Han et al. (2021), with subsequent extraction, sequencing, alignment and analyses as described in Cranston et al. (2011), Krosch et al. (2011), and Han et al. (2021). In total 3 males and 1 larva of *Kribiodosis*, 1 male of *Kribiodorum* and 2 males of *Paraskusella* were used for DNA extraction, and 35 new sequences were generated for the first time in this study.

## TAXONOMY

### *Paraskusella sarawak*, new species

(Figs. 1A, C, E, F; 2A–C, G–I).

**Material examined.** Holotype male, slide mounted in Euparal, MALAYSIA: Sarawak, Gunung Mulu National Park, Lupar tributary of Melinau River, 75 m a.s.l., 04°1'48.8"N 114°49'4.4"E, 12 June 2023, light trap, coll. H.Q. Tang (EJNU). Paratype male, as holotype (ANIC), teneral male in alcohol, as holotype except 11 July 2024 (SFC)

**Etymology.** From the type locality, Sarawak, the largest state of Malaysia on the island of Borneo. To be treated as a noun in apposition.

**Description.** Adult male (n = 2). Colour (Fig. 1A). Generally yellow green, thorax without distinct vittae, postnotum brown. Foreleg with darker proximal band on femur, and stronger darkening on distal femur and all of tibia and tarsus. Middle and hind leg with distal darker band on femora, tibiae yellow, all tarsomeres browner apically.

Total length 2.8–3.1 mm, wing length 1.35–1.45 mm.

Head. Frontal tubercles absent. Flagellomeres 1–12, 370–390; flagellomere 13, 575–590; AR 1.51–1.55. Palpomeres 1–5: 25–30; 20–25; 87–100; 90–105; 140–148, Pm3 and Pm4 slightly thickened. Temporals 6–8, uniserial. Clypeus with 9–10 setae.

Thorax with rounded scutum with weak median hump or smoothly rounded. Anteprenotals 2–3; acrostichals 0; dorsocentrals comprising 4 anterior and 3–4 more posterior; prealars 2–3. Scutellum with 4 setae.

Wing (Fig. 1C) appears 'smoky' with some darkening alongside veins, anal lobe weak. VR 1.17–1.25, Setation: R 0, R<sub>1</sub> 0, R<sub>4+5</sub> 0, squama bare.

Legs (Fig. 1A, 2A–C). Fore tibia with round scale occupying half circumference. Spurs on mid and hind combs straight, 25–40 long. LR<sub>1</sub> 2.04–2.08, LR<sub>2</sub> 0.60–0.62, LR<sub>3</sub> 0.77–0.82; BV<sub>1</sub> 1.39–1.41, BV<sub>2</sub> 4.19–4.20, BV<sub>3</sub> 2.88–2.89; SV<sub>1</sub> 1.37–1.39, SV<sub>2</sub> 3.65–3.78, SV<sub>3</sub> 2.74–2.80.

Hypopygium (Figs. 1E, F; 2G–I). Anal tergite bands separated medially to form incomplete V-shape, with two median anal tergite setae; 6–8 basal-lateral setae submarginal on tergite IX. Anal point (Fig. 1F, lateral view) spatulate, narrower in mid-section, 30–40 long from sclerotised base. Transverse sternapodeme broad, shallowly rounded anteriorly, with relatively strong oro-lateral projections. Phallapodeme indistinct. Gonocoxite c. 60 long, gonostylus c. 100 long, slender, inwardly curved, tapering to rounded point. Superior volsella apically crescent shaped, 35–40 long, without microtrichia, 2 medially-directed setae arising from distinct tubercle bases close to basal inner margin, with only 1 seta on outer margin. Median volsella (Fig. 2H) c. 40 long, with strong stem, medio-distally with simple setae, medially broadened and apically recurved and tapered distally, mostly not extending beyond distal apex of superior volsella. Inferior volsella globular apically and extending beyond gonocoxite apex, microtrichiose apicoventrally, apically with medially and dorsomedially-directed, simple setae, without differentiated posteriorly directed strong seta.

Female, pupa and larva unknown.

**Remarks.** *Paraskusella sarawak*, new species, conforms substantially to the morphological generic diagnosis for males of *Paraskusella* Cranston (2018). The thorax with only slight medio-dorsal bulge at most, is consistent with previously described species excepting *Paraskusella hawkei* Cranston, 2018 in which a protuberance is distinct (Cranston, 2018). The male of *P. sarawak* is separated from congeners by all the wing veins being bare.

### *Kribiodosis mulu*, new species

(Figs. 1B, D, G; 2D–F, J–L)

**Material examined.** Holotype male, slide mounted in Euparal, MALAYSIA: Sarawak, Gunung Mulu National Park, Melinau Paku tributary stream, 75 m a.s.l., 04°1'48.8"N

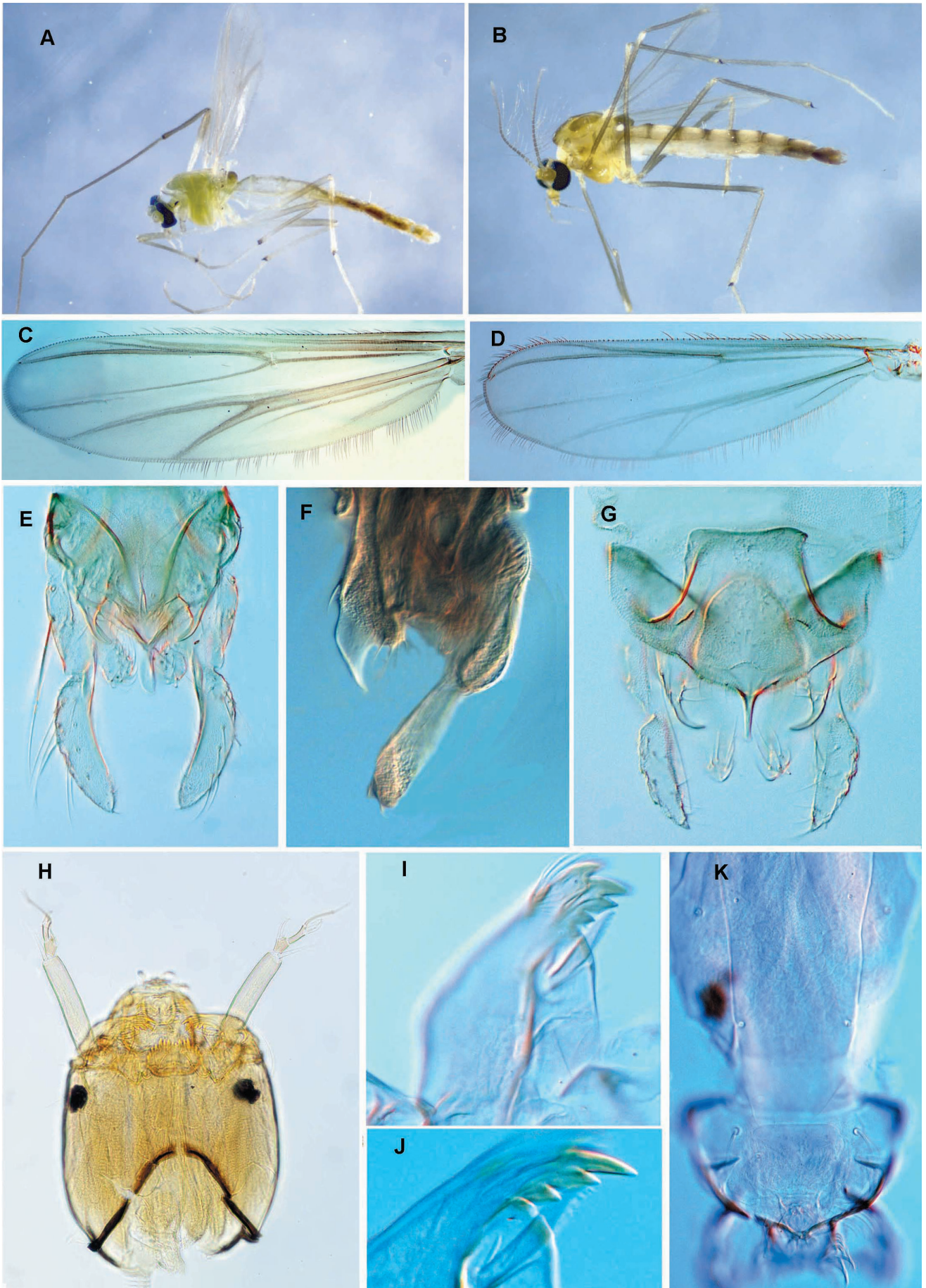


Fig. 1. Colour images. *Paraskusella sarawak*, new species, male; A, habitus; C, wing; E, hypopygium, dorsal; F, hypopygium, lateral. *Kribiodosis mulu*, new species, male; B, habitus; D, wing; G, hypopygium, dorsal. *K. cantonensis* Tang, 2021, larva; H, ventral head; I, mandible; J, seta subdentalis, detail; K, dorsal head.

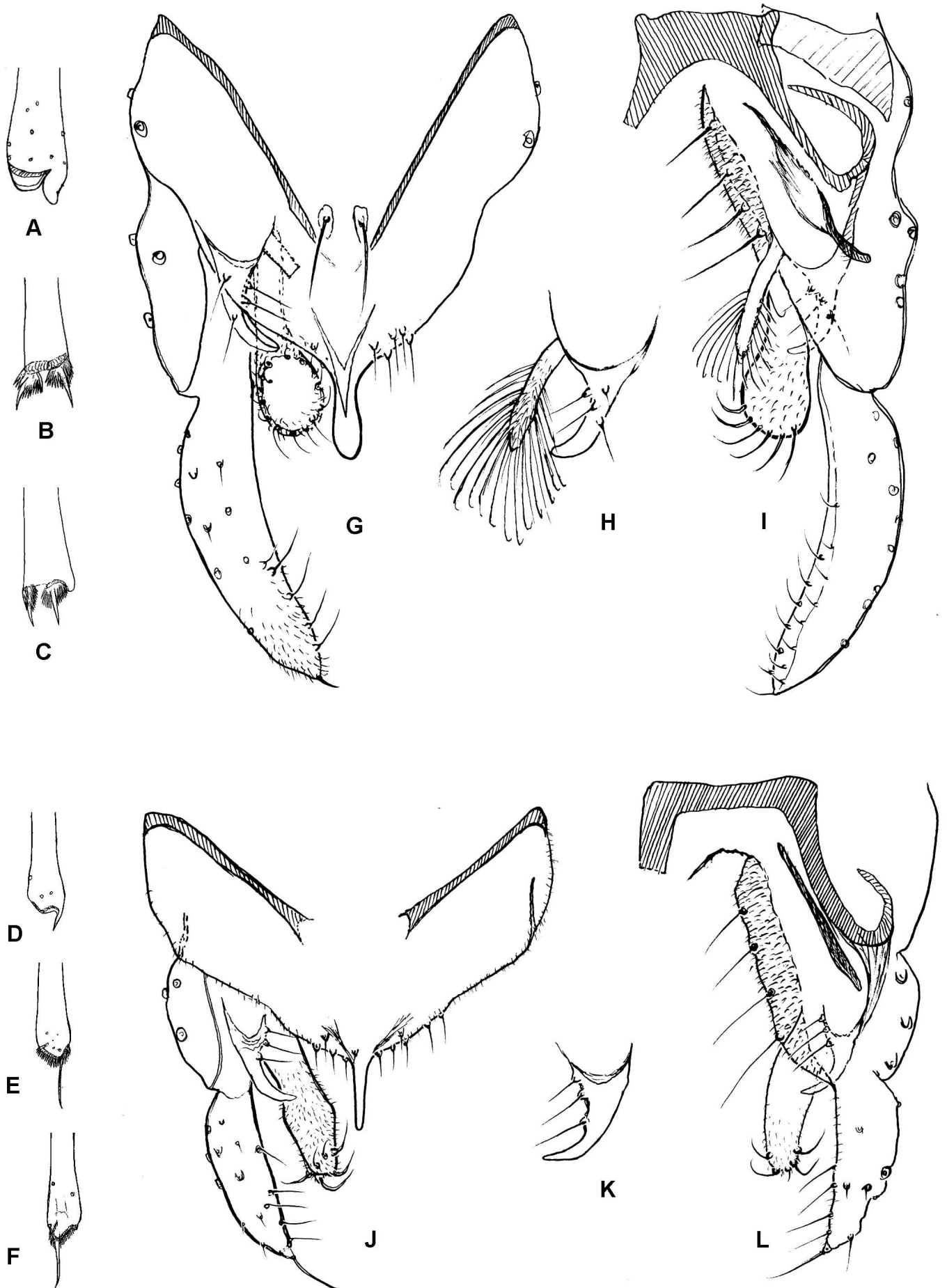


Fig. 2. Males: *Paraskusella sarawak*, new species; A–C: apices of tibiae P<sub>1</sub>, P<sub>2</sub>, P<sub>3</sub>; Hypopygium: G, dorsal; H, median and superior volsellae; I, ventral. *Kribiodosis mulu*, new species; D–F: apices of tibiae P<sub>1</sub>, P<sub>2</sub>, P<sub>3</sub>; Hypopygium: J, dorsal; K, superior volsella; L, ventral.

114°49'4.4"E, 12 June 2023, light trap, coll. H.Q. Tang (EJNU). Paratypes 2 males, one on slide under 7 coverslips; hypopygium, wing and legs of partial additional DNA voucher specimen under 8<sup>th</sup> coverslip; as holotype (ANIC); 2 males, as holotype, except 10 July 2024 (SFC).

**Etymology.** From the type locality, Gunung Mulu National Park. To be treated as a noun in apposition.

**Description.** Adult males (n = 2–3). Colour (Fig. 1B) generally brown, thorax with darker brown vittae, scutellum yellow. All legs brown, with pale knee limited to articulated area. Abdomen with distinct dark brown posterior bands in segment I–VIII. Hypopygium brown in basal section and slightly pale in distal part.

Total length 2.3–2.8 mm, wing length 1.1–1.3 mm.

Head. Frontal tubercles absent. Flagellomere 1–12, 490–500 (n = 2); flagellomere 13, 370–380 m (n = 2). AR 0.74–0.78 (n = 2). Lengths (µm) of palpomeres (Pm) 1–5: 25–30; 30–35; 90–95; 80–90; 150–165, respectively (n = 2). Temporals 5–6, uniserial. Clypeus with 10–12 setae.

Thorax with distinct scutal tubercle at 1/3 from antepnotum to scutellum. Antepnotals 0; acrostichals 0; dorsocentrals 4–6, sparsely distributed, with 1–2 humerals; tiny humeral pit present. Prealars 0. Scutellum with 2 setae.

Wing (Fig. 1D). Plain, wedge-shaped, anal lobe very reduced. VR 1.29–1.31. Setation: R 0, R<sub>1</sub> 0, R<sub>4+5</sub> 2–4, squama bare.

Legs (Figs 1B, 2D–F). Length of fore-leg 4.0–4.3 mm, c. 7× thoracic height. Fore tibia scale pointed, 30–35 long, subapex of tarsomere IV of fore-leg with 3 aligned stiff setae, 30–35 long. Long spurs of mid and hind combs 55–63 long, curved. LR<sub>1</sub> 2.50–2.58, LR<sub>2</sub> 0.95–0.98, LR<sub>3</sub> 1.22–1.24; BV<sub>1</sub> 2.10–2.24, BV<sub>2</sub> 2.90–2.96, BV<sub>3</sub> 2.46–2.48; SV<sub>1</sub> 1.15–1.17, SV<sub>2</sub> 2.44–2.52, SV<sub>3</sub> 1.82–1.85.

Hypopygium (Fig. 1G, 2J–L). Anal tergite bands separated medially, with 0 (?) median seta, 4–6 baso-lateral setae submarginal on tergite IX. Anal point narrow (4 wide at base) parallel-sided to slightly tapering to towards apex, c. 25 long from sclerotised base. Superior volsella (Fig. 2K) curved medially, 25–30 long, with 3 medially-directed setae arising from basal-mid inner margin. Inferior volsella cylindrical, 70 long (inner margin) extending to mid-section of gonostylus, microtrichiose apicoventrally, apically with medially and dorsomedially-directed, simple setae, with 4–6 differentiated posteriorly directed strong seta. Gonostylus c. 50 long, slender, tapering to blunt point. Transverse sternapodeme broadly plate-shaped, bluntly rounded anteriorly, without oral projections. Phallapodeme simple, distinct. Female, pupa and larva unknown.

**Remarks.** *K. mulu* conforms substantially to the male generic diagnosis for *Kribiodosis* (Han et al., 2021) but is distinguished from congeners by the legs showing a limited pale ‘knee’, and wing veins R and R<sub>1</sub> totally lacking setae

(R<sub>4+5</sub> has few setae). The three stiff setae (‘pseudospurs’) on Ta<sub>4</sub> in the fore-legs (Han et al., 2021: fig. 4b), are unusual, possibly assisting in copulation. Similar structures in *Chironomus claggi* Tokunaga, 1964 are located on the mid- and hind leg tarsomeres (Yamamoto & Yamamoto, 2018), rather than on the fore leg as in *Kribiodosis*.

### *Kribiodosis cantonensis* Tang, 2021

(Figs. 1H–K, 3A, C, E–I)

*Kribiodosis cantonensis* Tang in Han et al., 2021: 564.

**Larva.** Body length 3.2–5.1 mm. Body colour unreported. Head capsule (Fig. 1H) length 340–350, ventral head length 195–245, pale yellow with golden teeth of mentum, apical mandible and premandible (Fig. 1H). Dorsal surface of head (Figs. 1K, 3H) with frontoclypeus lacking fenestra, flared distally; labral sclerites weakly demarcated. Antenna (Figs. 1H, 3C) 6-segmented, with short wedge-shaped segment 2, and longer segment 3 bearing large Lauterborn organs on apex and subapex of 3rd segment, lengths 140–145: 20–22: 29–35: 38–42: 18–20: 6–8; Antennal ratio 1.12–1.25. Basal segment with weak ring organ in proximal third, seta absent. Blade 90–100 long, extending beyond apex of 4th segment.

Labrum (Figs. 3F) with SI on conjoined bases, seemingly shaped as smooth-edged fan, with minor setal fringe, and SII placed on a distinct pedestal, blade-like, apical ¼ with inner fringe, 30–35 long; SIII simple, 30 long; SIVa, b weak. 6–7 plumose chaetae. Seta premandibularis simple. Labral lamellae lie largely beneath SI, fringed. Pecten eipharyngis comprising three separated plates, each with 5–8 teeth; 7–8 apically finely plumose chaetulae laterales, 2 apically branched chaetulae basales. Premandible (Fig. 3G) 70–80 long, with 4 sharply pointed teeth and modest brush. Mandible (Figs. 1I, J, 3E) 100–110, with dorsal tooth, pointed apical tooth and 3 pointed inner teeth. Pecten mandibularis comprising a 25–32 spine-like lamella, protruding to mandibular margin, other branches few, short, simple. Seta subdentalis (Fig. 3E, inset) 30–35 long, arising from ventral surface, sickle-shaped, distally with comb, extending to notch delimiting apical mandibular tooth. Mola and inner margin smooth. Seta interna 4–5 branched, densely plumose, but short.

Mentum (Figs. 1H, 3A) 60–75 wide, with 16 continuous pale gold teeth without a delimited ventromental component; central 2 teeth recessed, the 2nd and 3rd elevated thereafter evenly declining. Ventromental plate 80–85 wide, 40–45 deep, fan-shaped, with smoothly curved anterior margin, medially tapered to medially-directed (not upcurved) point, inter-plate distance subequal to two recessed median teeth; striae very fine, seemingly restricted to median, lateral / posterior plate, lappets/ hooklets indistinct. Setae submenti simple.

Abdomen (Fig. 3I) without lateral or ventral tubules nor dorsal hump. Anterior parapod claws pale, dense, fine, simple; posterior parapods claws golden, simple. Procercus pale yellow, 2× as high as wide (45–55 × 25–30), bearing 5 anal

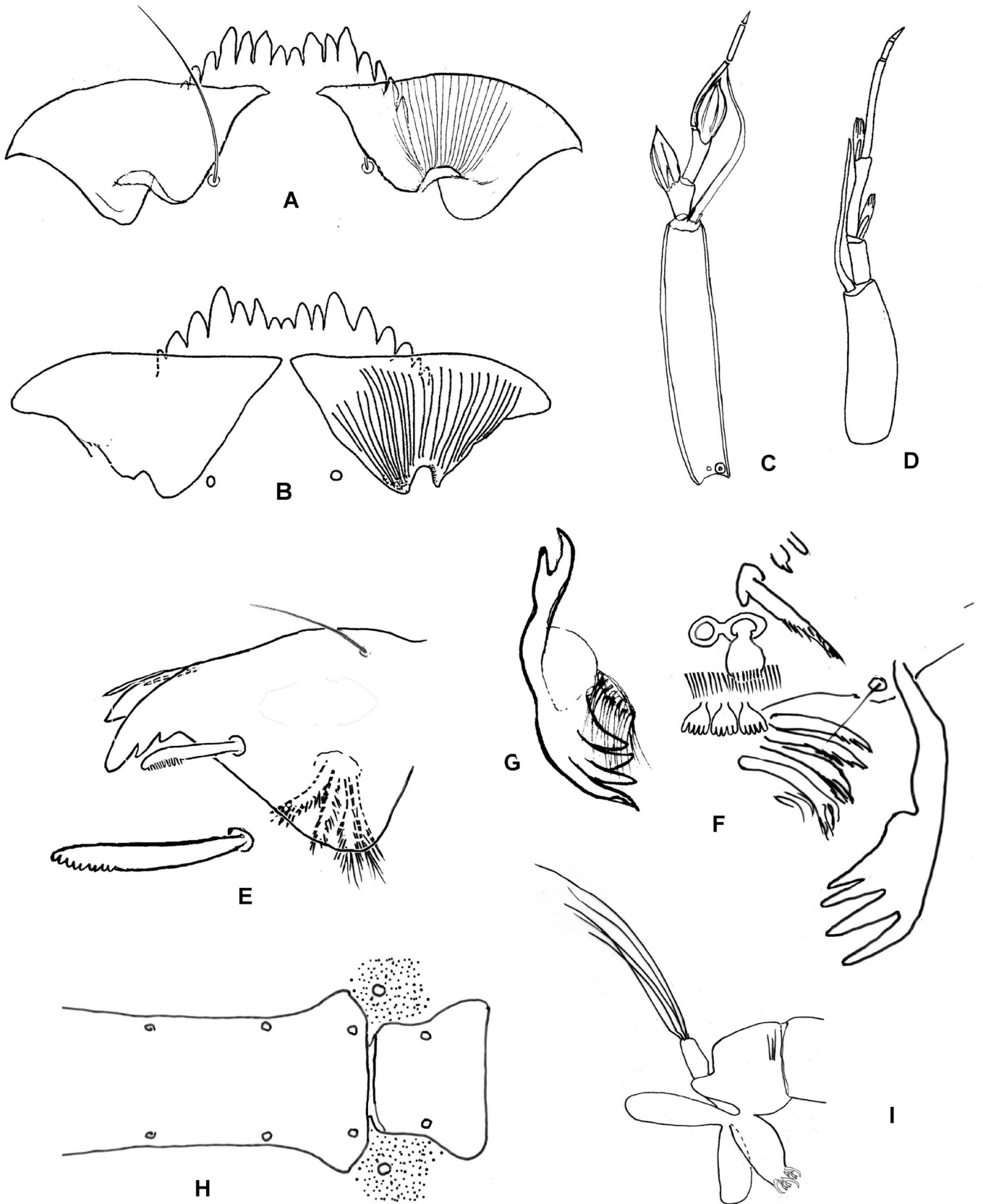


Fig. 3. Larva: *Kribiodosis cantonensis* Tang, 2021, A, C, E-I; ?*K.* sp. Australia 'SO1', B, D. A, B, mentum, ventral view; C, D, antenna; E, mandible ventral, insert seta subdentalis; F, labrum; G, premandible with 'beard'; H, dorsal head; I, posterior abdomen.

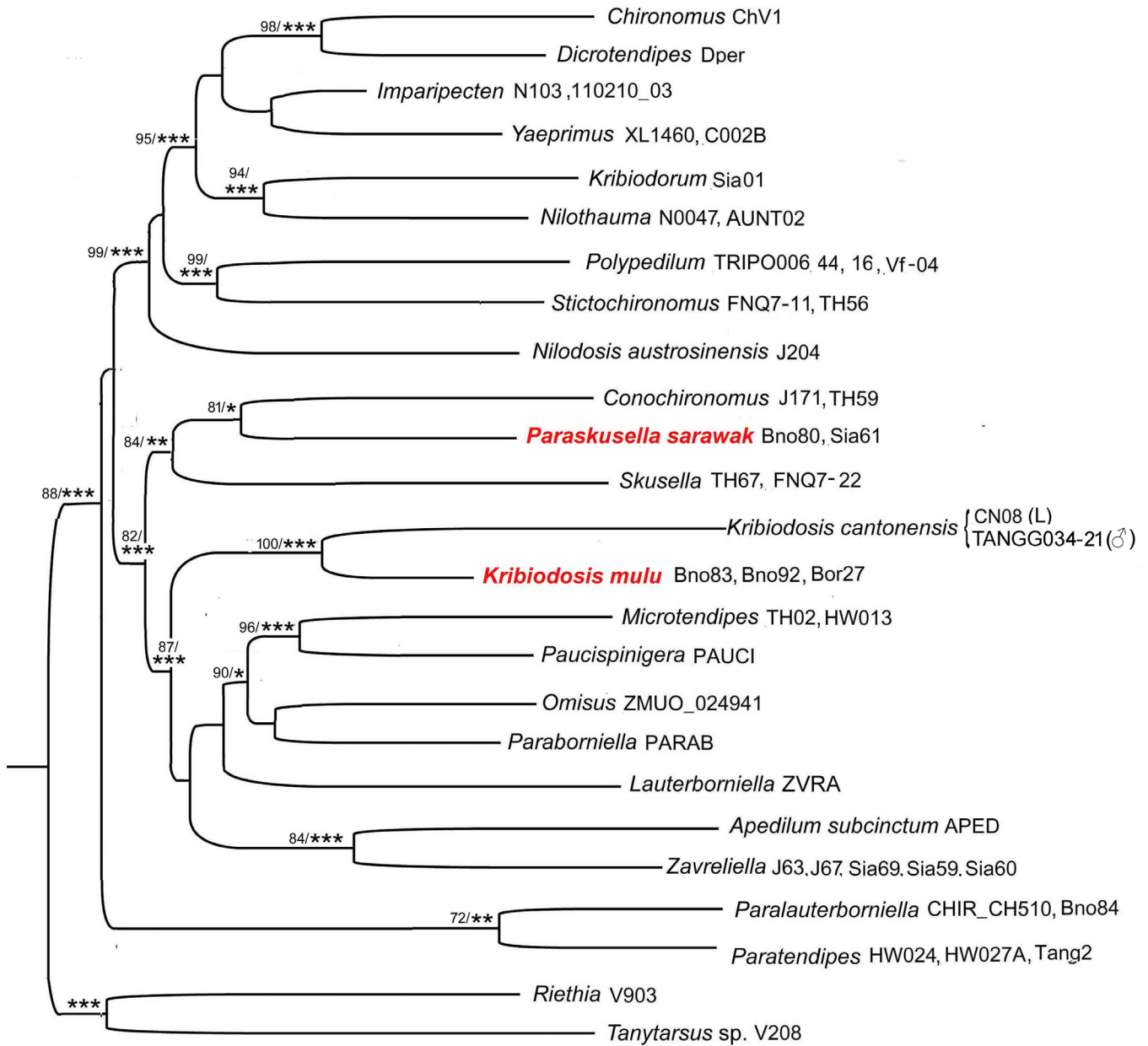


Fig. 4. Phylogenetic tree. Codes following multispecies generic names refer to identification in current and previous published analyses, accessible from databases. Posterior probability values at nodes: \*\*\* = 1, \*\* 96–99, \* 93–96. Unlabelled nodes unsupported. All supported nodes have bootstrap values labelled prior to PP.

setae 400–750 long. Anal tubules elongate-ovoid (150–200 × 50–80), dorsal slightly shorter than ventral, subequal or slightly shorter than posterior parapsods.

**Comments.** The larva of *Kribiodosis* does not key beyond the cluster with 6-segmented antenna and alternating distinctive Lauterborn organs on the apices of antennal segments 2 and 3 in Epler et al., 2013. The ‘wedge-shaped’ (triangular) ventromental plate directs to couplet *Zavreliella* Kieffer, 1920 vs *Lauterborniella* Thienemann & Bause, 1913, both of which have case-bearing larvae and considered as sister-taxa on morphological grounds by Andersen et al. (2017). Of these, *Kribiodosis* resembles *Zavreliella* in having simple setae submenti (vs. plumose) and the dorsal head including a frontoclypeus (vs frons and isolated clypeus).

A broad seta subdentalis with comb-like distal margin (Fig. 1J) occurs in *Kribiodosis* and *Lauterborniella*, and in a different form in the distant *Goeldichironomus* Fittkau, 1965, *Kiefferulus* Goetghebuer, 1922 and *Axarus* Roback, 1980. *Kribiodosis* will not key to any Holarctic taxon even if restricted to those in which a ventromentum is not delimited (*Apedilum*). Southern hemisphere genera belonging to a ‘*Microtendipes*–group’ show permutations of larval features. Included are *Oukuriella* Epler, 1986, *Claudiotendipes* Andersen, Mendes & Pinho, 2017, *Conochironomus* Freeman, 1961, *Skusella* Freeman, 1961, *Paraskusella* Cranston, 2018, *Paraborniella* Freeman, 1961 and *Paucispinigera* Freeman, 1959 (Cranston, 2020). In the Neotropics, *Kribiodosis* keys unequivocally to *Zavreliella* /*Lauterborniella* based on the sub-triangular ventromental plates in near contact medially

(Silva et al., 2018). *Claudiotendipes* is excluded on these features. In the guide to Australian and New Zealand larvae (Cranston, 2019) despite the increased diversity, a similar conclusion is reached for identical reasons. Since the larva of *Kribiodosis* is unlikely to be case-bearing, judging by morphology, it can be excluded from *Zavreliella* or *Lauterborniella*. Larval keys indicate resemblance to several other taxa, amongst which is *Beardius* Reiss & Sublette, 1985, a diverse New World genus that includes species with the diagnostic antenna of the ‘Microtendipes–group’.

In both *Zavreliella* and *Lauterborniella* the basal antennal segment has a distinct ‘antennal’ seta located subapically but this seta is lacking in *Kribiodosis*. In the plate of line drawings of Australian larval ‘*Zavreliella*’ (Cranston, 1996), the mentum and antenna of taxon ‘K1’ (K = Kakadu, northern Australia) and S1 (S = Sydney) (Fig. 3B, D), closely resemble those of *Kribiodosis* described here, in contrast to Australian *Zavreliella marmorata* (Wulp, 1859) on the previous page that conforms to the (‘true’) *Zavreliella* larva (and pupa). Access to these specimens is currently unavailable due to databasing, reorganisation and relocation of slide collections at ANIC. These could confirm differences between genera as reported above. It is likely that *Kribiodosis* is to be found in tropical Australian waters. Unfortunately, as the associated pupae of both *Kribiodosis* species are unavailable to us, the presumed pupal type described in Cao & Tang (2017) is an unreliable individual association.

**Molecular results and discussion.** Our molecular multi-gene analysis uses a set derived from exemplars of the ‘Microtendipes–group’ of genera for which DNA data are available, including *Conochironomus* and *Skusella*, presumed relatives of *Paraskusella*. This is anchored with *Riethia* and *Tanytarsus* as outgroups which consistently have formed the sister group to tribe Chironomini (e.g., Cranston et al., 2011; Han et al., 2021). New sequences for *Paraskusella* and a second species of *Kribiodosis* from this report have been incorporated into an ongoing expanded study. Most genera represented by multiple species have been pruned to a single terminal, recognisable in Fig. 4 by the published codes that follow the genus name (e.g., *Microtendipes* TH02, HW013). Bayesian inference analysis revealed several strongly supported nodes identified by PP (posterior probability) = 0.99–1, indicated on Fig. 4 by \*\*\*, fewer weaker supported nodes (\*\* PP = 0.95–0.98, \* PP = 0.90–0.95) and with critical nodes lacking Bayesian support (PP < 0.90 (unlabelled). Bootstrap values (72–100) are indicated only for nodes with Bayesian support > 0.90.

*Kribiodosis mulu*, new species, is sister to *K. cantonensis* Tang, 2021 from oriental China with maximal Bayesian support, confirming their morphological assignment as congeners. The species are well separated on long branches usually associated with substantial difference. The *Kribiodosis* species pair are sister to a core ‘Microtendipes–group’, with maximal support (Bayes 1, BS 87), in keeping with Han et al. (2021). The internal structure within the ‘Microtendipes–group’ finds variable support at many nodes in both analyses,

but resembles relationships from previous analyses lacking *Kribiodosis*. Ongoing study incorporating more species and genera in this important and diverse clade should produce resolution with enhanced support. The relationships proposed here from molecular data are compatible with the discussion above on larval morphology, as previously on the male (Han et al., 2021). Our molecular results support Freeman’s hypothesis that (African) *Kribiodosis* is very close to *Lauterborniella* and also supports his argument for considering these as two independent genera (Freeman, 1958). Minimally, we provide a hypothesis testable by expanded sampling.

The relationships of *Paraskusella* are clarified by our molecular analysis. As argued based on morphology of combined life stages, the genus is placed in a clade with *Conochironomus* and *Skusella* with high Bayesian support. This clade forms the sister group to all included ‘Microtendipes–group’ taxa. Morphological evidence suggested *Paraskusella* was allied with *Skusella* (as the ‘para’ indicates) but with features in each semaphoront precluding consideration as congeners (Cranston, 2018). Previous molecular analyses including *Conochironomus* and *Skusella* showed these to be sister taxa (e.g., Cranston et al., 2011, Han et al., 2021) so it is unsurprising that *Paraskusella* belongs in a clade with *Skusella* and *Conochironomus*, although internal relationships are weakly supported. Morphological features including the pupal abdominal lateral setal fringe, comb teeth on T VIII, and the larval antenna structure needs to be reconciled with this conditional molecular result.

**Biogeography.** The revelation of ever-increasing taxa in the subfamily Chironominae, notably in the tribe Chironomini, showing African – (Australian) – Oriental distributions has been reported in Han et al. (2021) with regard to *Kribiodosis*. To the examples discussed there, we add *Paraskusella*, previously known from Africa and Australia, now reported from Borneo in the Oriental region. The closest relatives *Conochironomus* and *Skusella* each show the same distribution pattern, referred to as the tropical Gondwana track by Matile (1990) and discussed by Cranston (2005). Whether this remains a valid descriptor given recent discoveries of these taxa in (non-Gondwanan) oriental China is unclear at present. A robust and dated phylogeny that includes these taxa at species-level will be necessary to further explore this pattern.

## ACKNOWLEDGEMENTS

We are grateful to Dr. Gregory Curler (Smithsonian Institution, USA), Dr. Wu Han (The University of Hong Kong) and Ms Tsz-Ying Chan (The University of Hong Kong) for their help in the fieldwork. The authors are grateful to Hazijah binti Yusup (Department of the Premier of Sarawak, Malaysia), for help with the permit and report submission. All specimens were collected from Gunung Mulu National Park under the research permit issued by Sarawak Forestry Corporation (SFC.810-4/6/1(2023)–106).



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