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RESEARCH ARTICLE

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Purealus beckelorum, a new genus and species of cleonine weevil from western Texas and eastern New Mexico (Coleoptera, Curculionidae, Lixinae, Cleonini)

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Abstract

The new genus *Purealus* Anderson (type species, *Purealus beckelorum* **gen n. et sp. n.**, type locality: McKenzie Lake, Gaines County, Texas) is described to accommodate a new species of cleonine weevil from western Texas and eastern New Mexico. Habitus images and images of taxonomically significant structures are presented. *Purealus* appears to be unique within Cleonini in the distinctly tumescent and asperate base of elytral interval 3, and widely separated procoxae, two characters apparently not shared with any other world Cleonini. The species cannot be placed in either *Apleurus* or *Scaphomorphus* due to a combination of characters in part shared by each genus and the lack of characters used to define the monophyly of each genus. Coding of the character states and addition to the analysis presented in a recent comprehensive analysis of world Cleonini did not provide any significant information on phylogenetic affinities. No information on plant associations is available; most specimens have been collected walking on the ground in winter months in arid habitats.

Keywords

Biodiversity, endemism, new species, species discovery

Introduction

During a visit to the weevil collection of retired colleague Charles W. O'Brien in Green Valley, Arizona in May of 2016 I found 5 specimens of an odd cleonine weevil collected in western Texas in October of 2004 that I was unable to identify. Further examination and comparison with other described species of North American Cleonini verified that the species was new and furthermore, questioned the generic placement of the new species which was not accommodated in any of the present North American genera *Stephanocleonus*, *Apleurus* or *Scaphomorphus*. This discovery led to a short trip to western Texas in October of 2016 during which time two additional specimens were acquired, one collected in the field at McKenzie Lake, the second collected in March of 2016 by Darren and George Pollock in Quay County, New Mexico. Since then, three additional specimens have turned up based on the collecting efforts of Darren and George Pollock, and Boris Kondratieff.

The present paper describes this new genus and species and discusses the placement of the genus with respect to *Apleurus* and *Scaphomorphus* and considering the recent overview and phylogenetic analysis of world Cleonini (Arzanov and Grebennikov 2017).

Materials and methods

Generic and species description follows Anderson (1988). Specimens are deposited in the following collections:

CMNC Canadian Museum of Nature, Ottawa, Ontario, Canada; F. Génier;
CWOB Charles W. O'Brien collection, Green Valley, Arizona; C. W. O'Brien;
ENMU Eastern New Mexico University, Portales, New Mexico; D. A. Pollock.

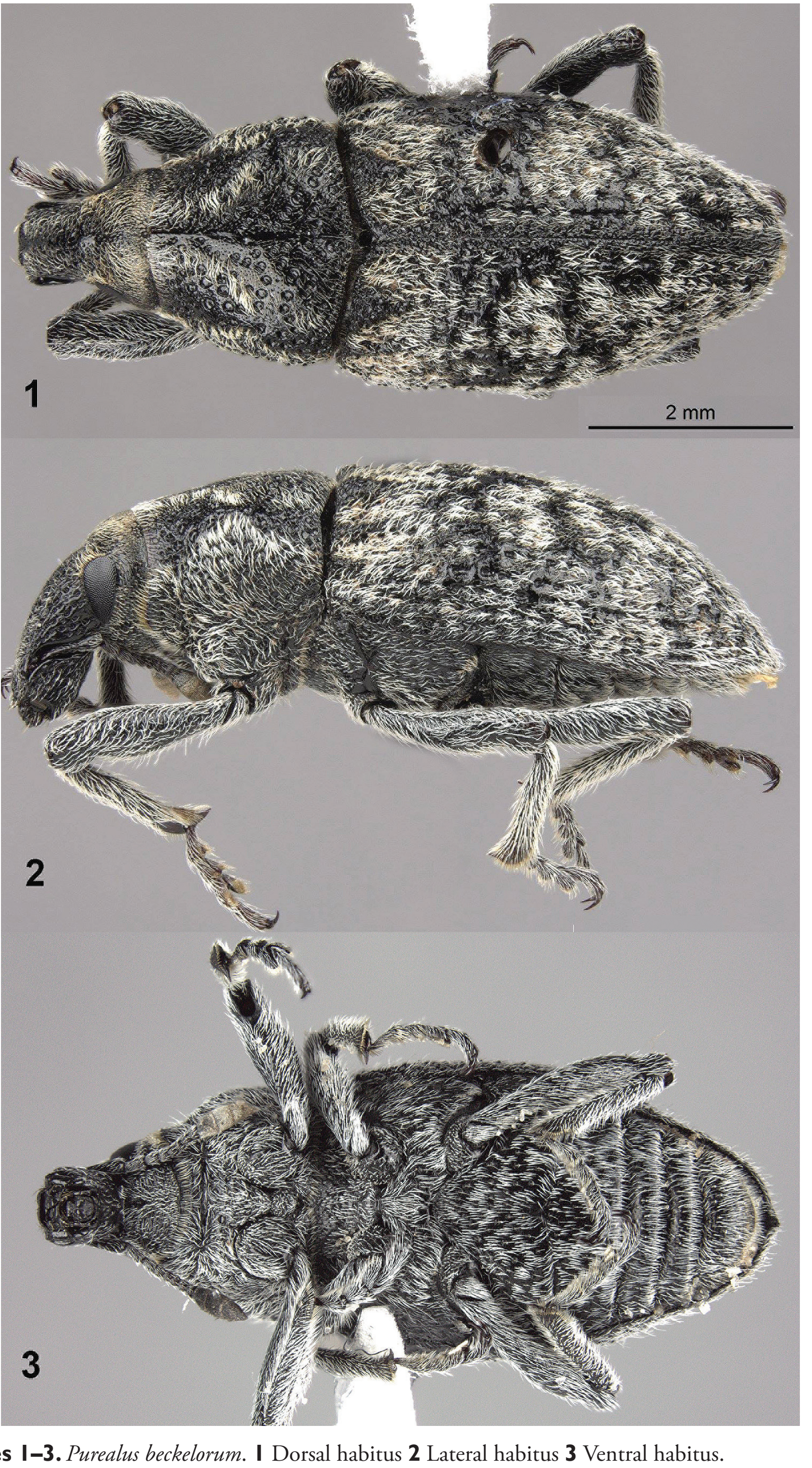
Taxonomic treatment

***Purealus* gen. n.**
http://zoobank.org/8512E7F9-5537-4D53-942E-7A7BE835DBB8
Figures 1–8

Type species. *Purealus beckelorum* sp. n. by present designation.

Diagnosis. Cleonini with body form moderately robust, rostrum medially longitudinally tumescent with dorsal contour in lateral view evenly rounded, procoxae widely separated, base of elytral interval 3 distinctly tumescent and asperate.

Description. *Size.* Moderately large, body length 7.8–9.4 mm (exclusive of head and rostrum), moderately robust in body form. *Mouthparts.* Prementum rugose, concave medially, carinate laterally, with 2–3 large and 2–3 smaller setae on each side, a pair of long setae towards middle at apical margin. Maxillary and labial palpi not externally



Figures 1–3. *Purealus beckelorum*. **1** Dorsal habitus **2** Lateral habitus **3** Ventral habitus.

visible. *Rostrum.* Robust, longitudinally medially tumescent, dorsal contour in lateral view distinctly arched, rounded. Median tumescence low, not evident as distinct carina. Epistoma slightly swollen, produced anteriorly, with apical margin very slightly, very broadly, apically emarginate. Antenna with funiculus with article I subequal in length to, to slightly longer than, article II; club of four articles, apical three articles of club with placoid sensillae. *Head.* Eye elongate teardrop shaped, slightly prominent, not convex dorsally. Area behind eye with shallow irregular punctures. Upper margin of eye rounded, frons convex especially at base of median rostral tumescence. *Vestiture.* Dorsum with suberect or erect vestiture short and sparse; with simple very elongate-narrow recumbent white hair-like scales of variable size and density. *Prothorax.* Dorsal surface of pronotum coarsely punctate. Pronotum with median basal area deeply impressed towards basal margin; anterolateral margin, behind eyes, with moderately developed rounded postocular lobe; postocular vibrissae short, of equal length; disk with elongate white larger moderately dense scales present in lateral sinuate stripe, variously larger and denser along lateral margins; median area largely black in color, underlying black cuticle not obscured by any scales, subglabrous. Prosternum with very slight impression anterolaterad of each procoxal cavity; without any swelling immediately anterior to each prosternal impression; procoxae widely separated by about one-half width of coxa by globular posterior process of prosternum. *Legs.* Foretarsus moderately broad, articles II and III more or less subequal in length, at most only slightly longer than broad; article I longer than articles II or III; article III deeply bilobed. Meso- and metatarsus very slightly more elongate-narrow, article II slightly to distinctly longer than article III; article I distinctly longer than articles II or III; article III deeply bilobed. Ventral tarsal pilosity reduced to some extent (not covering entire ventral surface of a tarsal article) to almost lacking entirely from at least more basal tarsal articles (especially of metatarsus). Claws connate from near base to through basal one-third, slightly to markedly divergent. Foretibia with inner margin lacking denticles; near apex with second spur not developed. Tibia with corbel ridge rounded. *Hind wings.* Absent. *Elytra.* Intervals, except humerus and bases of intervals 3, 5, 7, and 9 flat, bases of intervals 3, 5, 7, and 9 slightly to markedly swollen, asperate (especially that of interval 3 which is tumescent). Striae confused, punctate. Humeri rounded. Scales variously condensed in patches of larger, denser white scales. *Abdomen.* Ventral surface almost uniformly covered with fine dense white hair-like scales. Abdominal sternum VII in males with apical margin at middle simple, without small dorsally directed median tooth. *Genitalia.* Female. Abdominal sternum VIII lacking basal arm (spiculum gastrale). Gonocoxite II elongate triangular in form, apex not prolonged into lobe; stylus present, moderately large in size; apical. Spermathecal gland oval. Symbiont pouches elongate-oval lying adjacent to vagina, composed of 10–12 rings, joined to vagina near apex. Male. Abdominal sternum VIII with interior angle of each sclerite lacking basal projection. Aedeagus moderately robust, in lateral view more or less evenly arcuate throughout length; apex not spatulate, somewhat acuminate. Internal sac not everted. Apical sclerite complex not evident.

Derivation of generic name. The generic name *Purealus* is derived as an anagram of *Apleurus*. Gender masculine.

Natural history. Five specimens of this species were collected in October 2004 at McKenzie Lake, Gaines County, Texas by tiger beetle enthusiast Dave Brzoska while hunting tiger beetles. The exact circumstances of capture are not known but the specimens were likely walking around on the ground in areas inhabited by tiger beetles. One specimen was collected dead by me in fine debris and other insects washed up along the northern shore of McKenzie Lake in October 2016. Another three specimens were collected in Lea and Quay Counties, New Mexico, walking on the ground. During my trip to McKenzie Lake numerous species of shrubs and herbs were searched for this species without success. Searches of tiger beetle habitats such as open sandy flats, open alkaline areas around the lake, and dirt roadways also yielded no specimens.

Comments. The robust form, robust, medially longitudinally tumescent rostrum with dorsal contour in lateral view evenly rounded (Fig. 2), but especially the widely separated procoxae (Fig. 3) and the distinctly tumescent and asperate base of elytral interval 3 (Figs 1–2), will readily distinguish this genus among all Cleonini. Such widely separated procoxae are apparently not known in any other world Cleonini, all of which have the procoxae contiguous. The genus combines characters of the North American genera *Apleurus* Chevrolat and *Scaphomorphus* Motschulsky with the rounded tibial flange and rounded postocular lobes of *Scaphomorphus* but the robust rostrum, reduced ventral tarsal vestiture and more robust form of an *Apleurus*. Characters used to recognize the monophyly of *Scaphomorphus* (shiny glabrous median tubercle at base of abdominal sternum VII in female) and various groups of *Apleurus* (blunt tooth at apical margin of abdominal sternum VII in male, swellings anterior to front coxae, apically rounded epistoma) are not present in *Purealus*.

Purealus beckelorum sp. n.

http://zoobank.org/04568E7E-09BB-4EB4-9115-61B760974C93

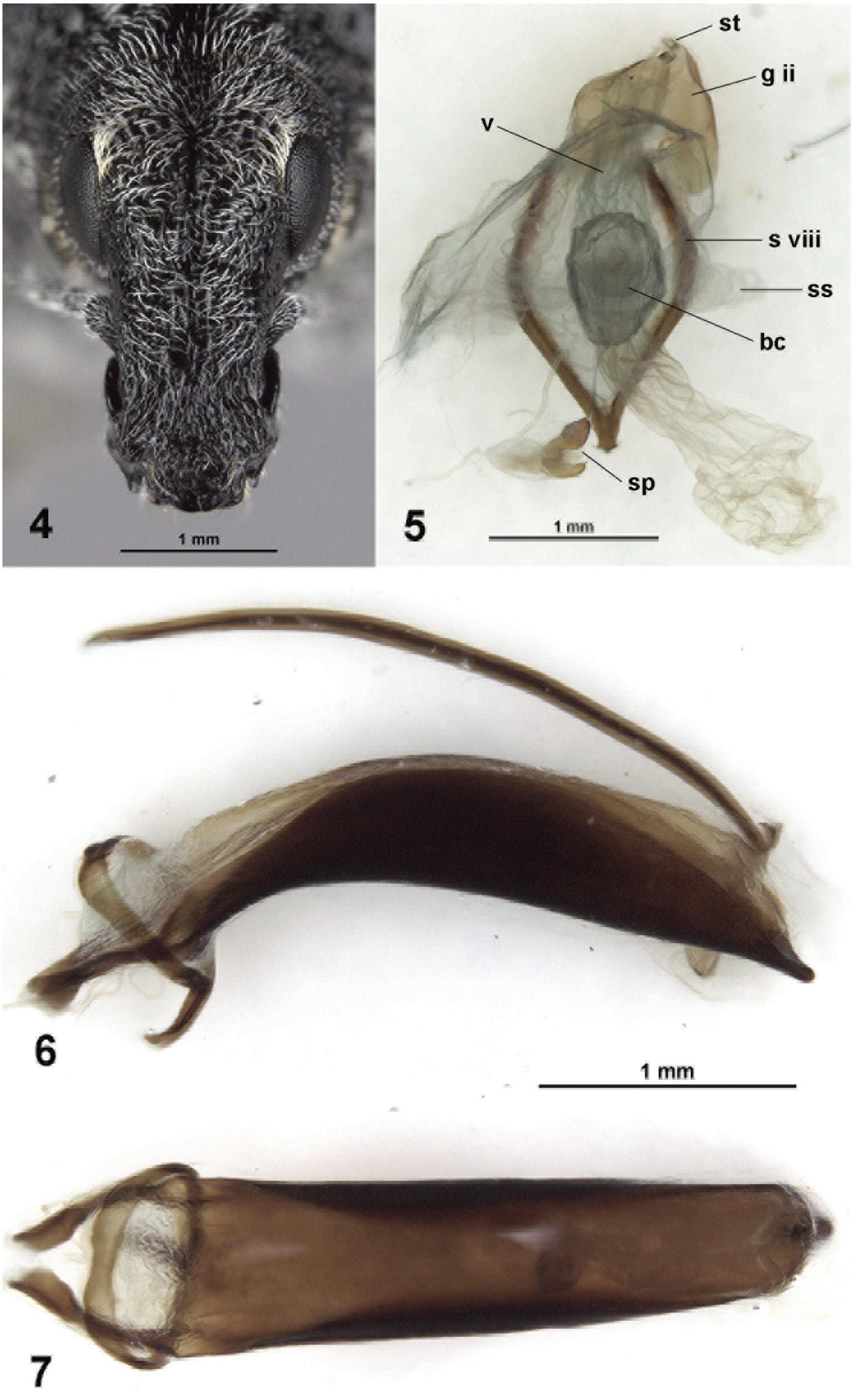
Figures 1–8

Diagnosis. Rostrum dorsally medially longitudinally tumescent, not distinctly carinate; elytra with humerus rounded, bases of intervals 3, 5, 7, and 9 elevated and variously convex, especially base of interval 3 which is markedly tumescent and distinctly asperate.

Description. *Size.* Length, male, 7.8–9.4 mm; female, 8.5–9.0 mm. Width, male, 3.5–4.2 mm; female, 3.5–4.2 mm. *Head.* Eye very slightly prominent and very slightly convex in dorsal view. Frons and vertex with moderately dense, moderately large, deep punctures. Frons also with sparse, short suberect golden or white hair-like scales densest immediately above eyes. Area immediately behind posterior margin of eye with small shallow indistinct punctures. Area above eyes not elevated above rest of frons (eyes not browed in anterior view). Width of frons subequal to width at apex of rostrum. Rostrum robust (width at apex 0.76–0.82 times length). Median longitudinal tumescence present, broad, low, not carinate. Dorsal and lateral punctation moderately dense, moderately deep. Dorsally, excluding epistoma, with moderately dense, short to long, recumbent elongate white hair-like scales. In lateral view with apical portion flat to very slightly declivous from point of antennal insertion to apex. Epistoma with apical margin very slightly, very broadly emarginate at middle. *Pronotum*. In dorsal view with lateral margins subparallel to slightly convergent from base to apical one-quarter; constricted at oblique angle anterior to apical one-quarter; apical one-quarter and base subequal in width; without distinct lateral tubercles. Dorsal and lateral punctation large, moderately dense, deep; punctures less distinct, sparser and smaller on flanks. Scales white, elongate-narrow, appressed, lacking medially from disk and dorsally from flanks, dense laterally in sinuate line and at lateral margins. Median carina slightly developed in anterior one-half or lacking. Dorsally with dense very short fine suberect white hair-like scales each situated within large puncture. Anterolateral margin with postocular rounded lobe distinct. *Elytra*. Very robust in general form (width at midlength 0.65–0.69 times length. In dorsal view with lateral margins arcuate throughout length. Humerus rounded, indistinct. Dorsally with bases of intervals 3, 5, 7, and 9 elevated and variously convex, especially base of interval 3 which is markedly tumescent and distinctly asperate, otherwise remainder of all intervals flat. Scales white, various in density and size; elongate-narrow, hair-like, pattern various but with larger and denser scales condensed in variously arranged patches. Wings absent. Legs. Ventral pilose vestiture of foretarsus present as fine elongate lines on apical one-half of articles I and II, and as oval pads covering apical one-half of article III; of mesotarsus present as minute apical tufts on article I, as apical small fine line on article II, and as very small oval apical pads on article III; of metatarsus present as minute apical tufts on articles I and II, and as very small oval apical tuft on article III. *Abdomen*. Ventral surface with uniformly moderately dense, elongate-fine recumbent white hair-like scales. *Genitalia. Female*. Abdominal sternum VIII with lateral arms narrow, divergent basally, markedly inwardly arcuate at about midlength then strongly convergent to apex. Gonocoxite II with stylus moderately large, apical in position. *Male*. Abdominal sternum VIII with paired sclerite with inner apices lacking ventral projections. Aedeagus elongate-narrow, in lateral view thickest near base; in ventral view with lateral margins slightly convergent to near apex, then strongly convergent subapically to acuminate tip. Internal sac not everted.

Specimens examined. Holotype male, labelled Texas: Gaines County, McKenzie Lake, N.E. shore, 32.72536 -102.32003, 929m, 19.x.2016, R.S. Anderson, beach washup, 2016-205 (CMNC). Paratypes, Texas: Gaines County, Highway 380, McKenzie Draw (Lake), 920m, 32 41.5'N 102 18.4'W, 19.x.2004, D. Brzoska (1 male, 4 females, CMNC, CWOB). Pecos County, Coyanosa Draw, [31.2882 -103.1216], Rte. 285, 11.iii.1990, B. Kondratieff & F. Welch (1 male, CMNC). New Mexico: Lea County, County Road 164 (Ranger Lake Road), 1.3 mi. E. Highway 206, 4007', 33.358278 -103.295226, 25.xi.2016, D. & G. Pollock (1 female, CMNC). Quay County, Highway 278, ca. 13.8 mi. S.W. San Jon, Apache Canyon, 4600', 34.934684 -103.460314, 27.iii.2016, D. & G. Pollock (1 female, ENMU); same except 11.xii.2016 (1 female, CMNC).

Derivation of species name. The species is named after the Beckel family of Vancouver, Canada. William Edwin and Dorothy (née Brown) Beckel, parents of Cana-



Figures 4–7. *Purealus beckelorum*. **4** Head, dorsal view **5** Female genitalia, dorsal view **6** Aedeagus, lateral view **7** Aedeagus, dorsal view. Abbreviations: bc, bursa copulatrix; g ii, gonocoxite ii; s viii, sternite viii; sp, spermatheca; ss, symbiont sac; st, stylus; v, vagina.

dian Museum of Nature President, Margaret Beckel, graciously funded the field work in October of 2016 in an attempt to collect additional specimens of the species and to discover aspects of its biology and host plants. William Beckel was president of Carleton University (Ottawa, Ontario) for the years 1979–1989 and before that President of the University of Lethbridge (Lethbridge, Alberta). Previously William Beckel was the Head of the Entomology Lab and Dorothy Beckel was the Head of the Botany Lab at the Northern Defense Research Laboratory at Fort Churchill, Manitoba in the early 1950s.

Natural history. Specimens were collected in the months of October, November, December, and March. It is possible that the species is winter active and as such has not been discovered previously. One specimen was collected dead in beach wash-up and three other specimens were collected walking on the ground. There are no plant associations known.

Comments. This species bears a superficial resemblance to *Scaphomorphus canescens* (LeConte), a species found in the same general area. The large, asperate swellings at the base of elytral interval 3 and widely separated procoxae are distinctive and apparently not known in other world Cleonini. Despite examination of thousands of specimens from almost all major museums, no specimens of this species were seen by Anderson (1988).

This addition prior to couplet 1 in the key to North American Lixinae (Anderson 2002) or North American Cleonini (Anderson 1988) will accommodate *Purealus* (references are to figures in this paper):

1'	Procoxae widely separated by about one-half width of procoxa by globular posterior prosternal process (fig. 3). Elytra with base of interval 3 tumescent and asperate (figs 1–2), humeri absent (rounded) (fig. 1) ....***Purealus* Anderson**
–	Procoxae contiguous. Elytra with base of interval 3 variously swollen or not, not asperate, humeri absent or present **1**

Phylogenetic considerations

As noted, this genus is characterized by the distinctly tumescent and asperate base of elytral interval 3 and the widely separated procoxae, two characters apparently not shared with any other world Cleonini. These are both significant characters, particularly the widely separated procoxae, a character used in many beetle groups as of higher taxonomic significance. With regard to the North American fauna, *Purealus beckelorum* cannot be accommodated in the genera *Apleurus* or *Scaphomorphus* due to a combination of characters in part shared by each genus and by the lack of characters used to define the monophyly of each genus (or major part thereof). For *Scaphomorphus*, this is the presence of a shiny glabrous median tubercle at the base of abdominal sternum VII in the female, and for various groups of *Apleurus*, the presence of a blunt tooth at the apical margin of abdominal sternum VII in the male, prosternal swellings anterior to the front coxae, and an apically rounded epistoma. *Purealus* has reduced ventral

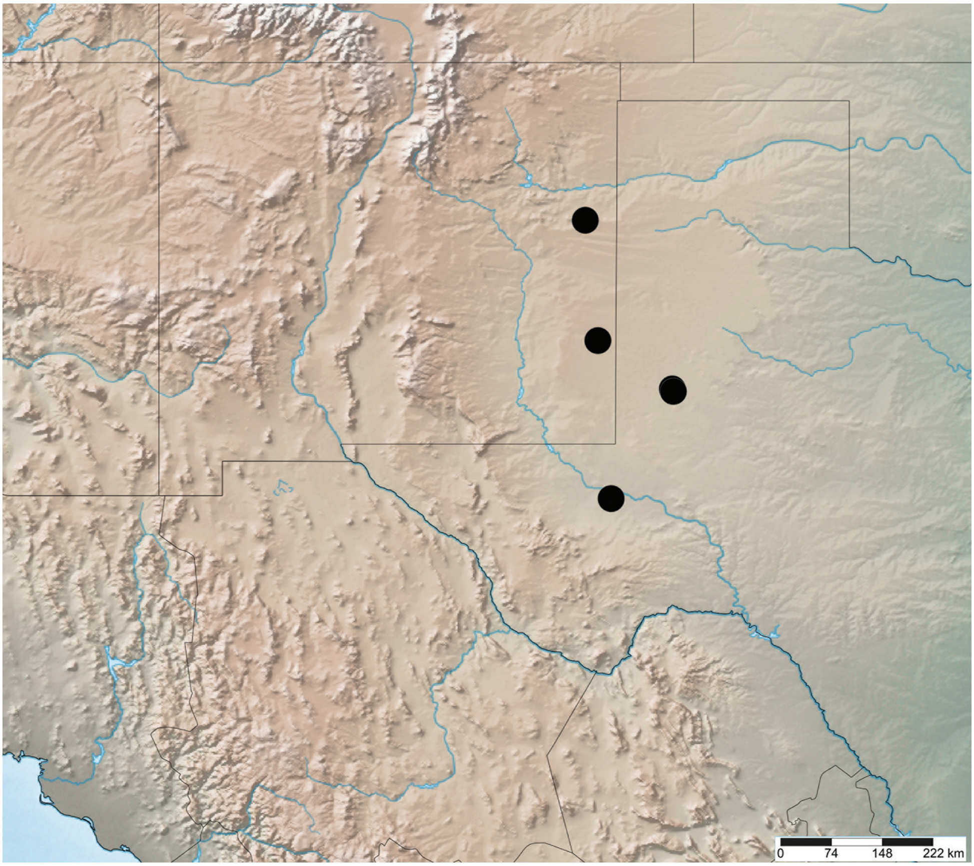


Figure 8. *Purealus beckelorum*, distribution.

tarsal vestiture on the middle and hind legs, and rounded humeri, character states each shared with some *Apleurus* and *Scaphomorphus,* and has distinct postocular lobes and an apical stylus on gonocoxite II of the female, character states shared with all or most *Scaphomorphus* but not *Apleurus*.

The possible phylogenetic relationship of the genus with respect to the world fauna was investigated following the character analysis of world Cleonini presented by Arzanov and Grebennikov (2017). They scored adult morphological characters for 79 of a total of 96 extant genus-group Cleonini taxa considered valid to date. Their resulting matrix contained 121 parsimoniously informative characters scored for 145 ingroup (Cleonini) and 29 outgroup terminals. Neither the extent of procoxal separation or the condition of the base of elytral interval 3 are coded as distinct characters likely because states of these two characters in *Purealus* appear to be unique. Here, I code the 121 characters listed in Arzanov and Grebennikov (2017) (not relisted here) for *Purealus beckelorum*. The string of 121 character scores is as follows:

11101100100010001011000000??????100001100010100110101000000000000001
010110101011110?????????????????001000000000010000000.

No attempt was made to inflate the lobes of the internal sac of the aedeagus as done by Anderson (1988) and Arzanov and Grebennikov (2017) and mouthparts were not dissected (hence the "?" in the string above).

The results of the new analysis places *Purealus beckelorum* as sister to *Glebius confluens* (Fahraeus) with negligibly small statistical support of 8% (see Arzanov and Grebennikov [2017], figs. 8–9 for placement of *Glebius confluens*). However, as discussed by Arzanov and Grebennikov (2017) their results showed that relationships within the Cleonini remain largely unresolved with either 47 (Bayesian inference) or 37 (maximum parsimony) branches radiating from the tribe's most recent common ancestor so this putative sister-group relationship of *Purealus* is almost meaningless. Specimens of *Glebius confluens* (CMNC) were examined but show no shared significant character states with *Purealus beckelorum*. Phylogenetic relationships of the new genus are thus best considered unknown and the genus another member of the unresolved basal comb of Arzanov and Grebennikov (2017).

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François Génier (Canadian Museum of Nature, Ottawa) took the excellent images and arranged the plates. Vasily Grebennikov (Canadian Food Inspection Agency, Ottawa) assisted with phylogenetic analysis of the placement of *Purealus beckelorum* and advised with interpretation of results. Dave Brzonska (Naples, Florida), who collected the original series, provided information about the possible circumstances of capture and about the McKenzie Lake location. Darren Pollock (Eastern New Mexico University, Portales, New Mexico) generously donated New Mexico specimens and provided information about, and arranged for a trip to, Apache Canyon. Darren and George Pollock are thanked for companionship in the field. Funding for field work in 2016 was provided by the William Beckel family.

References

Anderson RS (1988) Systematics, phylogeny and biogeography of New World weevils of the tribe Cleonini (Coleoptera: Curculionidae). Quaestiones Entomologicae 23: 431–709.

Anderson RS (2002) Chapter 131. Curculionidae. In: Arnett Jr RH, Thomas MC, Skelley P (Eds) American Beetles Volume 2. CRC Press, Gainesville, 722–815.

Arzanov YG, Grebennikov VV (2017) Cleonini (Coleoptera: Curculionidae: Lixinae) are monophyletic and flightless: tribe overview, rampant adult homoplasy and illustrated global diversity. Zootaxa 4329: 1–63. https://doi.org/10.11646/zootaxa.4329.1.1

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RESEARCH ARTICLE

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Two new species of *Lithobius* on Qinghai-Tibetan plateau identified from morphology and COI sequences (Lithobiomorpha: Lithobiidae)

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Abstract

Lithobius (*Ezembius*) *longibasitarsus* **sp. n.** and *Lithobius* (*Ezembius*) *datongensis* **sp. n.** (Lithobiomorpha: Lithobiidae), recently discovered from Qinghai-Tibet Plateau, China, are described. A key to the species of the subgenus *Ezembius* in China is presented. The partial mitochondrial cytochrome *c* oxidase subunit I barcoding gene was amplified and sequenced for eight individuals of the two new species and the dataset was used for molecular phylogenetic analysis and genetic distance determination. Both morphology and molecular data show that the specimens examined should be referred to *Lithobius* (*Ezembius*).

Keywords

China, COI, *Ezembius*, Lithobiidae, Qinghai-Tibet Plateau, taxonomy

Introduction

The myriapod fauna of China has been poorly investigated and this is especially the case with centipedes of the order Lithobiomorpha, with only approximately 80 species/subspecies of lithobiomorphs are known from the country. Qinghai-Tibet Plateau is among the very poorly studied regions of China (Ma et al. 2014a, b, 2015, 2018, Pei et al. 2014, 2015, 2016, 2018, Qiao et al. 2018, Qin et al. 2014, 2017). Altogether, 20 species of *Lithobius* (*Ezembius*) have been recorded from China, but none of them have been reported from Qinghai Province (Pei et al. 2018). Herein *Lithobius* (*Ezembius*) *longibasitarsus* sp. n. and *Lithobius* (*Ezembius*) *datongensis* sp. n. are described and illustrated, both from Qinghai Province.

The centipede subgenus *Ezembius* was erected by Chamberlin (1919) as a monotypic genus to receive *Lithobius stejnegeri* Bollman, 1893 from Bering Island and was then formally proposed as new and described by Chamberlin (1923). It accommodates a group of 58 species/subspecies known mostly from Asia, but also western North America and spans a wide range of habitats from the arctic and sub-arctic to tropical and sub-tropical forests, to steppe and overgrazed stony areas of central Asia, and Himalayan montane forests, from the sea shore up to 5500 m (Himalayas) (Zapparoli and Edgecombe 2011). *Ezembius* is characterized by antennae with ca. 20 articles, ocelli 1+4–1+20, forcipular coxosternal teeth usually 2+2, porodonts generally setiform but sometimes stout, tergites generally without posterior triangular projections, tarsal articulation of legs 1–13 distinct, female gonopods with uni-, bi- or tridentate claw, 2+2–3+3, rarely 4+4 spurs (Zapparoli and Edgecombe 2011).

Material and methods

Specimen collection and preparation: the specimens were all collected by hand, preserved in 95% ethanol, and deposited in the collections of Northwest Institute of Plateau Biology (**NWIPB**), Chinese Academy of Sciences. Characters were examined using an Olympus SZ61 stereoscope. Terminology for external anatomy follows Bonato et al. (2010). Specimens are numbered from 1 to 12 according to collection quantity and prefixed with the abbreviation of the locality. Abbreviations used in the text are as follows:

a anterior;
C coxa;
D dorsal;
DT Datong.
F femur;
GH Gonghe,
m median;
P prefemur;
p posterior;
T, TT tergite, tergites;
S, SS sternite, sternites;
Ti tibia;
To Tömösváry's organ;
Tr trochanter;
Ts I tarsus I;
Ts II tarsus II;
V ventral.

DNA extraction and sequencing protocols: standard DNA extraction and amplification methods were performed. Total DNA was extracted from a single leg removed from each specimen sample using MicroElute Genomic DNA kit (OMEGA), after overnight incubation at 65°C. Polymerase chain reactions (PCRs) were conducted using Mastercycler pros PCR (Eppendorff) in total reaction volumes of 39μL volumes containing 5–60 ng template DNA, 1μL; ddH2O 28μL; 10×Buffer 5μL (Takara, Dalian, China); 0.5mm/L dNTPs 2.5μL (Takara, Dalian, China); 5U/μL Taq polymerase 0.5μL (Takara, Dalian, China); Forward Primer 1μL; Reverse Primer 1μL (synthesized by Sangon Biotech from Shanghai). A 686 bp fragment of COI was amplified using the primers LCO1490/LCO2198 (Edgecombe et al. 2002). PCR was performed as follows: initial denaturing at 95°C for 10 min; followed by 35 cycles of 95°C for 30 s, 44°C for 30 s, and 72°C for 90 s and a final extension at 72°C for 10 min. The PCR products were purified using a purification kit (DC28106 250 Preps, QIAGEN, Germany). Sequencing reactions were implemented using ABI Prism BigdyeTM Terminator Cycle Sequencing Ready Reaction Kit on ABI 3730XL sequencer, with the PCR primers.

The GenBank accession numbers of all eight new sequences were MH05602–MH045609 (*Ezembius* COI). Sequence identities were confirmed with BLAST searches (Altschul et al. 1997). In order to eliminate indicators of nuclear mitochondrial pseudogenes (numts), such as indels, stop codons and double peaks in sequence chromatograms, the whole dataset was translated into amino acids using the 'invertebrate' code in MEGA6 (Tamura et al. 2013); internal stop codons were absent in our dataset; gaps were absent.

Phylogenetic analyses: the sequences were aligned with Clustal X2.0 (Chenna et al. 2003). The aligned sequences were edited using the program BioEdit 7.0.9.0 (Hall 1999) by hand. The substitution model selection was implemented in jModelTest 2.1.4 (Darriba et al. 2012), the TIM3+I+G model was selected by likelihood ratio tests under the Akaike Information Criterion (AIC 11833.1212) and the Trn+I+G model under the Bayesian Information Criterion (BIC 12085.5234). Topology was reconstructed under the Trn+I+G model of nucleotide evolution in MrBayes. Bayesian inference (BI) was used to generate a phylogenetic hypothesis of the DNA haplotypes. BI was performed in MrBayes version 3.1.2 (Ronquist and Huelsenbeck 2003) with 3,000,000 generations, sampling trees every 300 generations. Two independent runs each with four simultaneous Monte Carlo Markov chains (MCMC) were carried out. The first 25% of generations were discarded as 'burn-in'. The convergence of chains was confirmed until average standard deviation of split frequency is below 0.01 (0.002825) and the potential scale reduction factor (PSRF) is close to 1.0 for all parameters. In phylogenetic analysis *Anopsobius neozelanicus* Silvestri, 1909 was used as outgroup.

Distance analysis: the analysis involved 26 nucleotide sequences (App. 1). Codon positions included were $1^{st}+2^{nd}+3^{rd}$. All ambiguous positions were removed for each sequence pair. There were a total of 613 positions in the final dataset. Evolutionary analyses were conducted in MEGA6 (Tamura et al. 2013). All pair-wise intra- and inter-specific distances were produced to evaluate species divergence in *Ezembius*.

Taxonomic accounts

Class Chilopoda Latreille, 1817
Order Lithobiomorpha Pocock, 1895
Family Lithobiidae Newport, 1844
Subfamily Lithobiinae Newport, 1844
Genus *Lithobius* Leach, 1814
Subgenus *Ezembius* Chamberlin, 1919

***Lithobius* (*Ezembius*) *longibasitarsus* sp. n.**

Type material. Holotype: female labelled GH3 (Figure 1 A, D–E, H–G), body length 17.0 mm, from Gonghe County, Qinghai province, China, 36.64508° N 100.80747° E, 14 July 2011, 3287 meters above sea level, collected by Gonghua Lin. Paratypes: one female, one male, same data as holotype.

Habitat. Specimens were collected under stones on steppes covered with legume shrubs and grass composed mainly of Poaceae. The sampling point belongs to the Gonghe Basin region of the Tibet plateau severely affected by desertification.

Etymology. The specific name refers to the new species with a long tarsus I of leg XV, tarsus I approx. 1.7 times longer than tarsus II.

Diagnosis. Body length 17.0–18.0 mm; head slightly widened; antennae of 20 articles; 10–14 ocelli arranged in three irregular rows; To oval to round, slightly smaller in size to neighbouring ocelli; lateral margins of forcipular coxosternite slanting; anterior margin with 2+2, 3+2 or 2+3 blunt teeth and with strong setiform porodonts; tergites without triangular posterolateral process; legs XIV and XV thicker and longer than anterior ones in both sexes; coxal pores 4–6, round to ovate arranged in one row; female gonopods with two moderately long, bullet-shaped spurs; terminal claw of the third article simple, with a small triangular protuberance on basal ventral side; male gonopods short and small.

Description. Holotype (♀), body 17.0 mm long, cephalic plate width 2.1 mm, length 2.0 mm.

Colour: antennae light yellow; tergites pale yellow-brown; cephalic plate and terminal tergite yellow-brown; pleural region and sternites pale yellow; distal part of forcipules dark brown, maxillipede coxosternum and SXV yellow; legs pale yellow with grey hue, pretarsal claw brown.

Antennae composed of 20+20 articles (Figure 1 A), length 3.31 mm, basal article slightly wider than long, second article with equal length and width, the following articles longer than wide, distal article 2.6 times as long as wide; abundant setae on antennal surface.

Ocelli area translucent with dark pigment, 1+5, 3, 2 ocelli on each side of cephalic plate, arranged in three irregular rows. The posterior ocellus is the biggest. To oval, smaller than the adjacent ocelli, situated ventrally on anterolateral margin of cephalic plate.

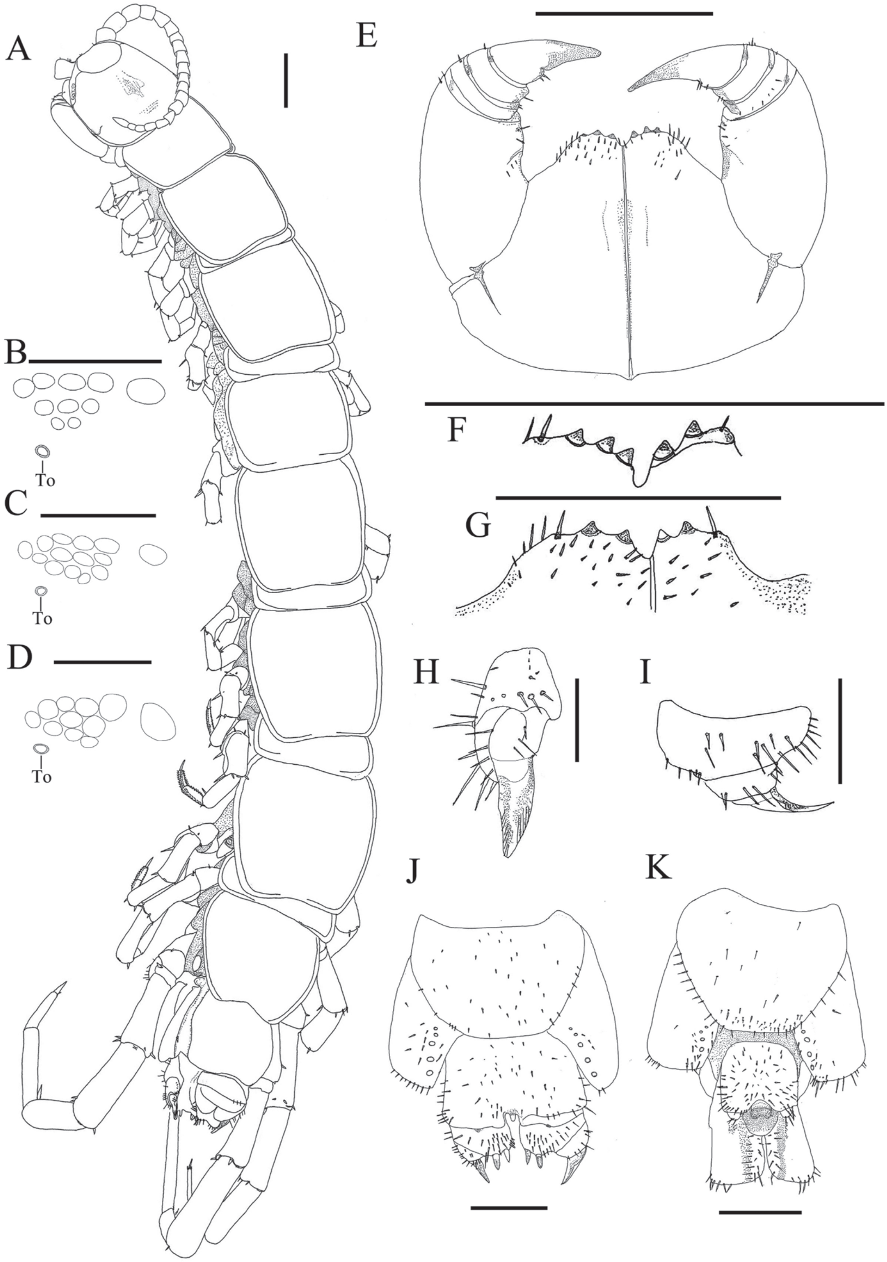

Figure 1. *Lithobius* (*Ezembius*) *longibasitarsus* sp. n., **A, D, E, H–J** holotype, female: **A** dorsal view **D** ocelli and To, lateral view **E** forcipular coxosternite, ventral view **H** posterior segments and gonopods, dorsal view **I** claw of female gonopod, inboard view **J** female posterior segments and gonopods, ventral view **B, F** paratype, female, labelled GH4: **B** ocelli and To, lateral view **F** forcipular coxosternite, ventral view **C, G, K** paratype, male, labelled GH8: **C** ocelli and To, lateral view **G** forcipular coxosternite, ventral view **K** posterior segments and gonopods, ventral view. Scale bars 1 mm **A, E, F, G;** 300 μm **B, C, D, H, I;** 500 μm **J**.

Cephalic plate smooth, slightly broader than long; as broad as TIII or slightly broader. Frontal marginal of head with clear transverse suture. Posterior margin slightly concave; projection of lateral marginal conspicuously discontinuous; posterior marginal ridge slightly concave with median thickening.

Coxosternite subtrapezoidal, anterior margin narrow, lateral margins of the coxosternite slightly longer than medial margins. Median diastema shallow, U-shaped; anterior margin with 3+2 blunt nipple-like teeth (Figure 1E). Porodonts thick and strong separated from the lateral tooth ventrolaterally. Scattered short setae on the ventral side of coxosternite, longer setae near the dental margin and the porodonts.

Tergites all smooth, without wrinkles, TI narrower posterolaterally than anterolaterally, generally trapezoidal, narrower than the cephalic plate and TIII, the cephalic plate almost the same width as TIII. Posterior marginal ridge of TI straight; of TT III, V shallow concave; of TT VIII, X, XII slightly concave; of TXIV deeply concave; TT VI– XIV bordered laterally only (Figure 1A). Posterior angles of all tergites rounded without triangular projections. Only one or two pairs of setae on anterior angles of each tergite.

Sternites: posterior part of sternites narrower than anterior, generally trapezoidal, smooth; 2–8 setae on anterior angle, anterior lateral side, posterior angle and posterior lateral side; some minute setae on SS XIV and XV, most of which distributed on posterior lateral margins and posterior borders.

Legs: tarsal articulation well defined on legs I-XV. All legs with fairly long curved claws. Legs I–XIV with anterior and posterior accessory spurs, anterior accessory spur moderately long and slender ca. 33%-50% the length of principle claw, the posterior one stouter forming slightly larger angles with tarsal claws, ca. 0.25 the length of principal claw. Legs XV lacking anterior and posterior accessory spurs. Dense glandular pores on the surface of prefemur, femur, tibia, and tarsi of legs XIV and XV. Short to long setae sparsely scattered over the surface of prefemur, femur, tibia, and tarsi of legs I-XIII, more setae on the tarsal surface, with two rows of comb-like setae along ventral side, fewer setae on legs XIV and XV. Legs XIV and XV moderately thicker and longer than anterior legs, tarsus I ca. 6.6 times as long as wide, tarsus II ca. 37% length of the whole tarsus on leg XV. Leg plectrotaxy as presented in Table 1.

Coxal pores circular on legs XII–XV, separated by a distance 1–2 times larger than diameter of pore; inner pores smaller; formula 6, 5, 5, 5. Coxal pores set in a shallow groove arranged in a row with short to long setae scattered over the surface of apophysis (Figure 1J).

Female posterior segment: S XV generally trapeziform, straight posteromedially; sternite of genital segment wider than long with posterior margin moderately concave between condyles of gonopods, except for a small, median bulge; distal part lightly sclerotised; short to long setae scattered over the surface of genital segment and lateral margins. The first article of gonopod moderately broad bearing 22–24 short to moderately long setae arranged in three rows with 2+2 moderately long, bullet-shaped spurs, inner spur slightly smaller and more anterior than the outer (Figure 1J), four short setae, and three long setae on dorsolateral ridge (Figure 1H). The second article

Table 1. *Lithobius* (*Ezembius*) *longibasitarsus* sp. n.: leg plectrotaxy; letters in brackets indicate variable spines.

legs	ventral					dorsal				
	C	Tr	P	F	Ti	C	Tr	P	F	Ti
1			(a)mp	amp	am			ap	ap	ap
2–3			amp	amp	am			ap	ap	ap
4–7			amp	amp	am			a(m)p	ap	ap
8–11			amp	amp	am			amp	ap	ap
12			amp	amp	am	(a)		amp	ap	ap
13			amp	amp	am	a		amp	p	ap
14		m	amp	amp	am	a		amp	p	p
15		m	amp	am	a	a		amp	p	(p)

of gonopod with 8–10 setae, three long setae along the dorsolateral ridge (Figure 1H). Third article of gonopod with six moderately long setae. Terminal claw simple, slender and sharp, having small triangular protuberance on ventral side (Figure 1I).

Male posterior segment: S XV subtrapeziform, long setae scattered sparsely over its surface and posterior margins. Male genital sternite slightly wider than long; posterior margin quite deeply concave between the gonopods, no bulge medially; ca. 69 short to medium setae scattered sparsely over its surface and at lateral margins; gonopods of a single small semicircular article with 3-5 seta on its surface (Figure 1K). Male leg XV not modified.

Variations. Body length 17.0–18.0 mm; ocelli 1+5, 4, 4 or 1+5, 3, 2 or 1+4, 3, 2 (Figure 1 B–D); coxal pores 5544, 5554 or 6555; coxosternal teeth 2+2, 3+2 or 2+3 (Figure 1 E–G).

Remarks. *Lithobius* (*E.*) *longibasitarsus* sp. n. can be distinguished from all the other known Chinese species of subgenus *Ezembius* Chamberlin, 1919 by 2+2, 2+3 or 3+2 moderately blunt teeth on the forcipular coxosternite and the terminal claw of the female gonopod simple, slender and sharp, having a small triangular protuberance on its ventral side. It has a larger body (17.7–18.0 mm), more ocelli (10–14), more coxal pores (5544, 5554 or 6555), and DaC spine on legs XII and XV.

Morphologically it resembles *L.* (*E.*) *tetraspinus* but can be readily distinguished by the following characters: more ocelli (10–14 vs. 9–10), more coxosternal teeth (2+3, 3+2 vs. 2+2), more coxal pores (4–6 vs. 2–5), and less spurs on female gonopods (2+2 contrary to 2+3 or 3+2).

Lithobius (*Ezembius*) *datongensis* sp. n.

http://zoobank.org/05A00271-9A67-4226-87DD-2BDB240AE1FF

Type material. Holotype: female labelled DT5 (Figure 2), body length 14.2 mm, from Datong County, Qinghai province, China, 37.12494° N 101.811611° E, 21 October 2010, 2950 meters above sea level, collected by Gonghua Lin. Paratypes: one female, one male, same data as holotype.

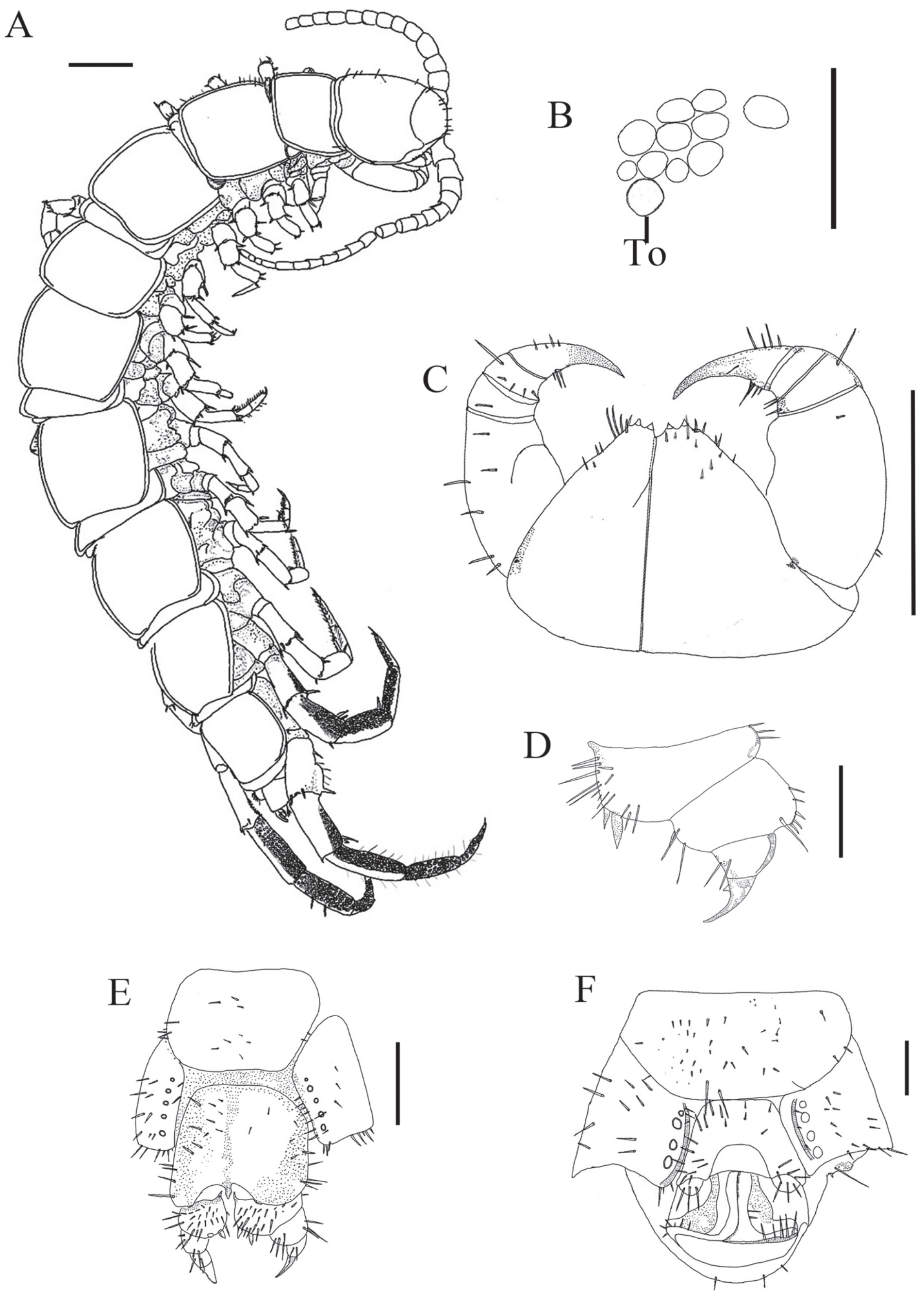

Figure 2. *Lithobius* (*Ezembius*) *datongensis* sp. n., **A, C–E** holotype, female: **A** habitus, dorsal view; **C** forcipular coxosternite, ventral view **D** female gonopods, dorsal lateral view **E** female posterior segments and gonopods **B, F** paratuype, male: **B** ocelli and Tömösváry's organ (To), lateral view **F** posterior segments and gonopods, ventral view. Scale bars 1 mm **A, C;** 300 μm **B, D;** 500 μm **E, F.**

Habitat. Specimens were collected under stones of slope-lands covered with grass mainly of *Pedicularis chinensis* and shrub mainly of *Potentilla fruticosa* along the riverside in coniferous forest composed mainly of *Picea crassifolia*.

Etymology. The name is derived from the locality Datong County where the new species was discovered.

Diagnosis. Body length 12.3–14.2 mm; antennae composed of 20+20 articles; 10 ocelli on each side arranged in 3 irregular rows, terminal one ocellus comparatively large; To larger than the adjoining ocelli; 2+2 coxosternite teeth and setiform porodonts posterolateral to the lateralmost tooth; posterior angles of all tergites without triangular projections; tarsal articulation well-defined on all legs; legs XII–XV with DaC, leg XV with posterior accessory claw; coxal pores 4–7, round, arranged in one row; female gonopods with 2+2 moderately large, coniform spurs; claw of the third article simple, with a small triangular protuberance on basal ventral side; male gonopods short and small.

Description. Holotype (♀), body 14.2 mm long, cephalic plate width 1.54 mm, length 1.54 mm.

Colour red-brown, with a distinct, darker, axial stripe on cephalic plate and tergites. Legs pale yellow-brown. Sternite yellow-brown with distal part brown with reddish hue.

Antennae tapering, ca. 4.3 mm long, reaching the anterior part of T V, composed of 20 elongate articles (Figure 1A). Basal article to the seventh article wider than long, following articles elongate, distal article markedly longer than wide, up to 2.2 times as long as wide. Abundant setae on the antennal surface.

Ocelli area: ten on each side, dark, arranged in three broken rows; posterior ocellus slightly larger than posterosuperior ocellus and other seriated ocelli. To slightly larger than nearest ocellus, rounded.

Cephalic plate: breath/length ratio 1.0 (1.54 mm); smooth, longer setae scattered along the entire surface sparsely and the marginal ridge of the cephalic plate. Transverse suture distinct, lateral marginal ridge discontinuous, posterior margin continuous, slightly concave (Figure 2 A).

Coxosternite: dental margin slightly concave, with 2+2 slightly acute teeth and setiform porodonts separated from the lateral tooth laterally, median diastema U-shaped; shoulders of coxosternite strongly sloping, as in Figure 2C. Scattered short setae on the anterior ventral side of coxosternite, longer and stronger setae near the porodonts.

Tergites almost smooth. The anterior part of T I is approx. the same width as cephalic plate and T III; T I and T III approximately the same width. Posterior angles of all tergites rounded without triangular projections. Posterior margin of TI straight; posterior margin of TT III, V, VIII, X, XII, and XIV concave; posterior margin of TVII convex; posterior margin of intermediate T straight; TT VI–XIV bordered laterally only (Figure 2A). Short to long setae along the lateral margin and anterior and posterior angles of each tergite.

Sternites: posterior side of sternites narrower than anterior, generally trapezoidal, smooth; SS XIII–XV with miniscule setae scattered sparsely over the surface; genital sternite more densely setose, as in Figure 2E; four to five pairs of short to long fine setae along anterior lateral borders and posterior borders of sternites; several fine setae along posterior margins of SS I– XII.

Legs: tarsal articulation of all legs distinct. Legs XIV and XV incrassate, without visible modification. Length of legs XV: F = 0.85 mm, Ti = 1.00 mm, Ts I = 0.77 mm, Ts II = 0.54 mm. Legs XII– XV with DaC. All legs with fairly long curved claws; legs I– XIV with anterior and posterior accessory spurs, anterior accessory spur moderately long and slender, posterior accessory spur slightly more robust; the anterior accessory spines form relatively small angles with the main claw, the posterior accessory spines form relatively large angles with the main claw; posterior accessory spines on legs XIV. Numerous glandular pores scattered on the surface of prefemur, femur, tibia, tarsus of legs XIV and XIV; short to long comparatively long setae scattered very sparsely over the surface of all segments of legs I– XIII, more setae scattered on the whole surface of tarsus, slightly thick setae arranged in two rows on the ventral side of tarsus. Plectrotaxy as presented in Table 2.

Coxal pores present on legs XII–XV, rounded and separated by distance 0.2–2.5 times greater than their own diameter; inner pores smaller than neighbouring ones; formula 4655 and 5575. Coxal pores 4654 and 4554 in male. Coxal pore field set in a relatively shallow groove, the coxal pore-field fringe with prominence. Prominence with short to moderately long setae sparsely scattered over the surface.

Female posterior segment S XV generally trapeziform, straight posteromedially; sternite of genital segment wider than long with posterior margin moderately concave between condyles of gonopods, except for a small, median bulge; distal part lightly sclerotised; short to long setae scattered over the surface of genital segment and lateral margins. Basal article of gonopod bearing 22–25 setae, with two blunt spurs of approximately equal size at distal end of slender, elongate process and three long spines on dorsolateral side; second article of gonopod with 5-6 setae and five long curved spines on dorsolateral side; third article with two setae (Figure 2E). Claw undivided, bearing a small triangular protuberance on ventral side (Figure 2D).

Male posterior segment (Figure 2F) S XV subtrapeziform, long setae scattered sparsely over its surface. Sternite of genital segment obviously smaller than the female, well sclerotized; posterior margin quite deeply concave between the gonopods, no bulge medially; gonopods short, appearing as a hemispherical bulge, one segmented, with three setae. Male leg XV not modified.

Variations. Body length 12.3–14.2 mm; 9–10 ocelli; coxal pores 4655, 5575, or 5544 in female, 4654 and 4554 in male.

Remarks. The new species can be easily distinguished from the other species of the subgenus of *Ezembius* of China except *Ezembius anabilineatus* by the apical claw of female gonopods simple with a small subtriangular protuberance on the ventral side. It differs from *E. anabilineatus* in many aspects, such as a larger body, fewer antennal articles (20+20, vs. 23+23 in *E. anabilineatus*), more ocelli, a DaC spine on legs XII–XV (only on legs XIV and XV in *E. anabilineatus*), and a posterior accessory spur present on legs XV present. It differs from *Lithobius* (*Ezembius*) *longibasitarsus* sp. n. by having posterior accessory spur on XV legs, fewer ocelli (10 versus up to 14 in *E. longibarsitarsus*) and different plectrotaxy (VmTr absent on legs XII and XIII vs. present).

Table 2. *Lithobius* (*Ezembius*) *datongensis* sp. n.: leg plectrotaxy; letters in brackets indicate variable spines.

legs	ventral					dorsal				
	C	**Tr**	**P**	**F**	**Ti**	**C**	**Tr**	**P**	**F**	**Ti**
1			mp	(a)mp	am			ap	a(p)	ap
2–9			amp	amp	am			ap	ap	ap
10			amp	amp	am			ap	ap	ap
11			amp	amp	am			a(m)p	ap	ap
12–14		m	amp	amp	am	a		amp	p	p
15		m	amp	am	a	a		amp	p	

Key to species of the subgenus *Ezembius* in China

1 Posterior angles of tergites with triangular projections **2**

– Posterior angles of tergites rounded, without projections **3**

2 Posterior angles of TT VII, IX, XI, XIII with triangular projections ....**L. (E.) *kiayiensis* Wang, 1959**

– Posterior angles of TT XIV with slightly triangular projections ....**L. (E.) *sulcipes* Attems, 1927**

3 At most four ocelli on each side of cephalic plate ....**L. (E.) *parvicornis* (Porat, 1893)**

– At least five ocelli on each side of cephalic plate **4**

4 Cephalic plate with scattered, rough punctae and tergites with distinct punctae..**L. (E.) *rhysus* Attems, 1934**

– Cephalic plate and tergites without any punctae **5**

5 All ocelli subequal in size **6**

– All ocelli not subequal in size **7**

6 Six ocelli on each side of cephalic plate ....**L. (E.) *sulcifemoralis* Takakuwa & Takashima, 1949**

– Eight to twelve ocelli on each side of cephalic plate...................................... ....**L. (E.) *sibiricus* Gerstfeldt, 1858**

7 Posterior ocellus small.............................**L. (E.) *lineatus* Takakuwa, 1939**

– Posterior ocellus large...**8**

8 The terminal two ocelli comparatively large **9**

– The terminal one ocellus comparatively large **12**

9 Ocelli arranged in two rows ....**L. (E.) *laevidentata* Pei, Ma, Hou, Zhu & Gai, 2015**

– Ocelli arranged in three rows **10**

10 3+3 coxosternal teeth ....**L. (E.) *multispinipes* Pei, Lu, Liu, Hou, Ma & Zapparoli, 2016**

– 2+2 coxosternal teeth **11**

11 Tömösváry's organ larger than the adjoining ocellus..................................... ....**L. (E.) *bilineatus* Pei, Ma, Zhu & Gai, 2014**

– Tömösváry's organ smaller than the adjoining ocellus ....**L. (E.) *anabilineatus* Ma, Pei, Hou, Zhu & Gai, 2015**

12 Only five ocelli on each side of cephalic plate... ....***L.* (*E.*) *chekianus* Chamberlin & Wang, 1952**
– At least six ocelli on each side of cephalic plate **13**
13 Tömösváry's organ smaller than the adjoining ocellus. **14**
– Tömösváry's organ larger than the adjoining ocellus.................................**16**
14 Ocelli arranged in three rows .... ***L.* (*E.*) *longibasitarsus* sp. n.**
– Ocelli arranged in two rows **15**
15 First article of female gonopods with 3+3 spurs ....***L.* (*E.*) *insolitus* Eason, 1993**
– First article of female gonopods with 2+2 or 2+3 spurs ....***L.* (*E.*) *irregularis* Takakuwa & Takashima, 1949**
16 First article of female gonopods with 1 + 1 spurs .... ***L.* (*E.*) *gantoensis* Takakuwa & Takashima, 1949**
– First article of female gonopods with more than 1+1 spurs **17**
17 First article of female gonopods with 3+3 or 4+4 spurs **18**
– First article of female gonopods with 2+2 or 2+3 spurs **19**
18 Terminal claw of female gonopods simple without a small subtriangular tooth on inner margin......................... ***L.* (*E.*) *mandschreiensis* Takakuwa, 1939**
– Terminal claw of female gonopods simple with a small subtriangular tooth on inner margin..***L.* (*E.*) *bidens* Takakuwa, 1939**
19 Terminal claw of female gonopods bipartite.. ....***L.* (*E.*) *anasulcifemoralis* Ma, Pei, Wu & Gai, 2013**
– Terminal claw of female gonopods not bipartite.......................................**19**
20 Terminal claw of female gonopods tridentate.. ....***L.* (*E.*) *zhui* Pei, Ma, Shi, Wu & Gai, 2011**
– Terminal claw of female gonopods simple...**20**
21 Terminal claw of female gonopods simple without a small subtriangular teeth on inner margin..................................***L.* (*E.*) *giganteus* Sseliwanoff, 1881**
– Terminal claw of female gonopods simple with a small subtriangular teeth on inner margin...***L.* (*E.*) *datongensis* sp. n.**

Molecular analysis

Sequence characterisation. Alignment of the PCR fragment sequences from COI showed that in the 613 bp there were 271 variable sites and 258 parsimony informative characters. The base composition of the fragments showed a strong bias of A + T (29.0+32.3). The results of the substitution saturation test showed that the index of substitution saturation 0.2562 (*Iss*) is significantly lower than the critical value of the index of substitution saturation 0.7345 (*Iss.c*).

Genetic distance. Calculation of the distances (Table 3) between different species showed that they ranged from 16.97% (*Lithobius* (*Ezembius*) *giganteus*/*Lithobius holsti*) to 26.26% (*Lithobius* (*L.*) *forficatus*/*Lamyctes inermipes*) with an average genetic

Table 3. Estimates of evolutionary divergence between sequences.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1. DT4																									
2. DT6	0.0016																								
3. DT5	0.0016	0.0000																							
4. GH04	0.1794	0.1794	0.1794																						
5. GH05	0.1794	0.1794	0.1794	0.0000																					
6. GH03	0.1794	0.1794	0.1794	0.0000	0.0000																				
7. GH011	0.1794	0.1794	0.1794	0.0000	0.0000	0.0000																			
8. GH06	0.1794	0.1794	0.1794	0.0000	0.0000	0.0000	0.0000																		
9. MF123702.1	0.1990	0.1974	0.1974	0.2055	0.2055	0.2055	0.2055	0.2055																	
10. HM453305.1	0.1876	0.1876	0.1876	0.1811	0.1811	0.1811	0.1811	0.1811	0.2039																
11. MF123710.1	0.1876	0.1892	0.1892	0.2202	0.2202	0.2202	0.2202	0.2202	0.2153	0.1811															
12. HM453306.1	0.1958	0.1941	0.1941	0.1794	0.1794	0.1794	0.1794	0.1794	0.2088	0.1794	0.1941														
13. HM453307.1	0.2104	0.2104	0.2104	0.2055	0.2055	0.2055	0.2055	0.2055	0.2235	0.1713	0.1974	0.1697													
14. AF334311.1	0.2072	0.2072	0.2072	0.1925	0.1925	0.1925	0.1925	0.1925	0.2055	0.2007	0.2202	0.1794	0.1909												
15. JN269950.1	0.1974	0.1974	0.1974	0.1990	0.1990	0.1990	0.1990	0.1990	0.1990	0.1697	0.1843	0.1582	0.1860	0.1778											
16. HM453308.1	0.2219	0.2202	0.2202	0.2039	0.2039	0.2039	0.2039	0.2039	0.2153	0.1925	0.1958	0.1990	0.2023	0.2007	0.1827										
17. AY214425.1	0.2545	0.2561	0.2561	0.2496	0.2496	0.2496	0.2496	0.2496	0.2626	0.2235	0.2333	0.2202	0.2333	0.2577	0.2251	0.2365									
18. AF334316.1	0.2284	0.2268	0.2268	0.2300	0.2300	0.2300	0.2300	0.2300	0.2398	0.2088	0.2251	0.2251	0.2480	0.2545	0.2202	0.2349	0.1599								
19. AY214428.1	0.2512	0.2512	0.2512	0.2349	0.2349	0.2349	0.2349	0.2349	0.2365	0.2170	0.2153	0.2300	0.2186	0.2349	0.2072	0.2251	0.1746	0.1713							
20.AF334315.1	0.2121	0.2137	0.2137	0.2365	0.2365	0.2365	0.2365	0.2365	0.2284	0.2088	0.2039	0.2055	0.2235	0.2414	0.2121	0.2268	0.1794	0.1697	0.1729						
21. KX442654.1	0.2382	0.2398	0.2398	0.2300	0.2300	0.2300	0.2300	0.2300	0.2316	0.2219	0.2039	0.2316	0.2398	0.2414	0.2186	0.2349	0.1909	0.1843	0.1876	0.1876					
22. AF334330.1	0.2398	0.2414	0.2414	0.2398	0.2398	0.2398	0.2398	0.2398	0.2219	0.2382	0.2186	0.2496	0.2414	0.2463	0.2170	0.2594	0.2202	0.2023	0.1925	0.1958	0.1892				
23. AF334332.1	0.2529	0.2512	0.2512	0.2431	0.2431	0.2431	0.2431	0.2431	0.2431	0.2349	0.2251	0.2186	0.2349	0.2349	0.1925	0.2072	0.2055	0.1778	0.1876	0.1990	0.2072	0.1925			
24. AF334313.1	0.2284	0.2284	0.2284	0.2170	0.2170	0.2170	0.2170	0.2170	0.2121	0.1892	0.2039	0.2170	0.1892	0.2219	0.1762	0.2121	0.2055	0.1958	0.1664	0.1827	0.1925	0.1941	0.1860		
25. AF334320.1	0.2316	0.2316	0.2316	0.2219	0.2219	0.2219	0.2219	0.2219	0.2235	0.2104	0.2480	0.2251	0.2284	0.2300	0.2251	0.2300	0.2219	0.1974	0.1941	0.2153	0.2072	0.1990	0.2039	0.1794	
26. DQ201428.1	0.2202	0.2186	0.2186	0.2235	0.2235	0.2235	0.2235	0.2235	0.2186	0.1958	0.1974	0.1974	0.2202	0.2007	0.1860	0.2055	0.1876	0.1925	0.1860	0.1974	0.1925	0.2153	0.1860	0.1876	0.1892

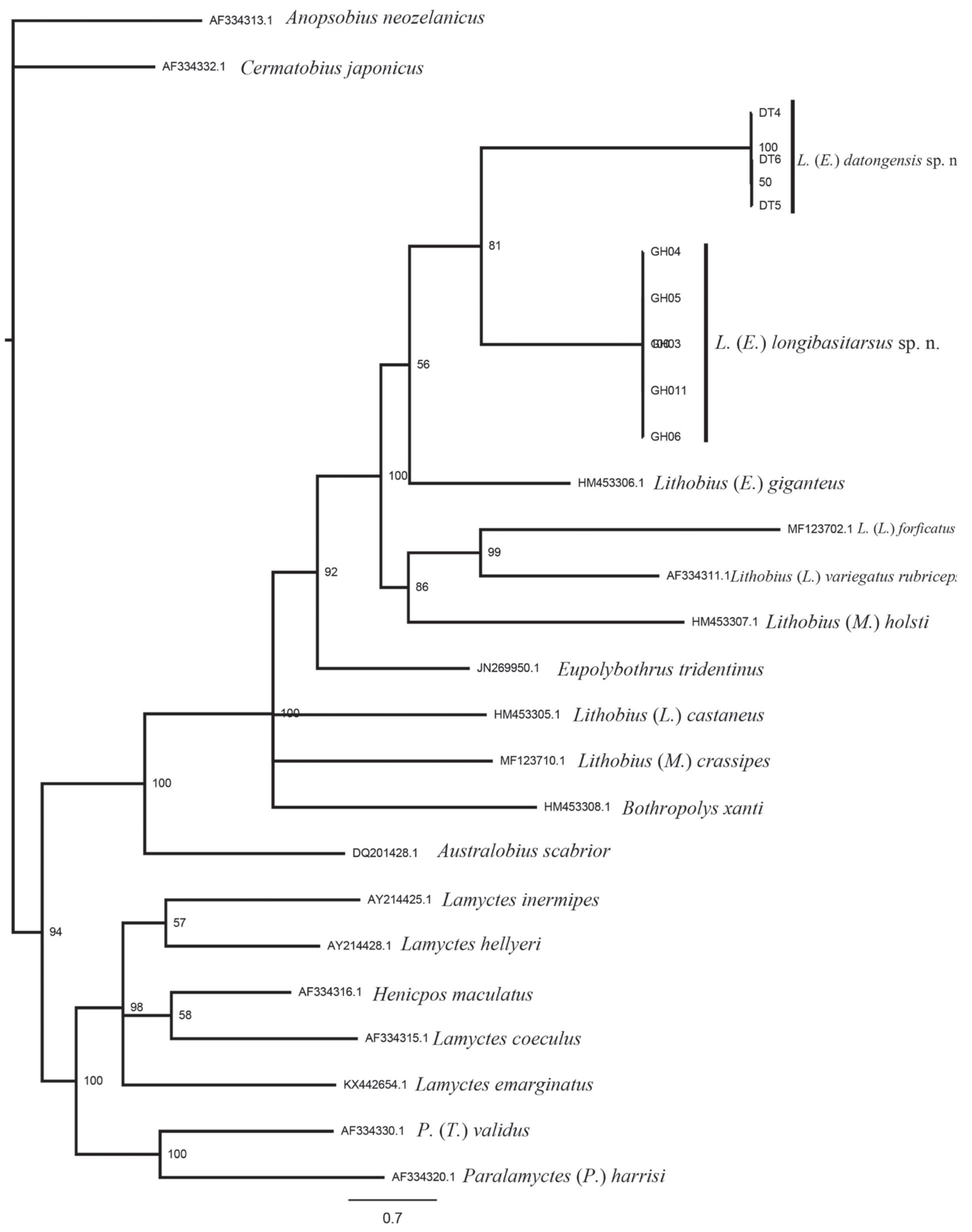

Figure 3. Bayesian tree for the 26 sequences of Lithobiomorpha based on COI sequences. The Bayesian posterior probabilities from Bayesian analyses are presented above the main branches. The scale bar represents substitutions per site.

distance of 20.32%. The five sequences of *Lithobius* (*Ezembius*) *longibasitarsus* sp. n. are identical. There is only one nucleotide change in *Lithobius* (*Ezembius*) *datongensis* sp. n. Uncorrected p-distances to the outgroup ranges from 16.64% to 21.70%.

Phylogenetic relationship. Bayesian inference (BI) analysis (Figure 3) reveal that Lithobiomorpha shows a split between Lithobiidae and Henicopidae with posterior probabilities 94%. The monophyly of *Ezembius* is supported with bootstrap values of 56%. The monophyly of *Paralamyctes* is supported by the COI data, with posterior probabilities of 100%. The genus *Australobius* was placed in the basal position as the sister to the rest of Lithobiidae, which includes the two subfamilies Lithobiinae and Ethopolyinae.

Discussion

Both molecular analysis (Figure 3) and morphology support that the two new species belong to the subgenus *Ezembius*. The subgenus *Ezembius* (sensu Eason 1986, 1992) has an Asiatic distribution which extends from the Urals across Siberia and central Asia to China, Japan, and Alaska, southwards into the northern Indian subcontinent and the northern part of the oriental region, and the southwest extremity to Israel and neighbouring areas (Eason 1992, Negrea 2005).

The intraspecific distance (less than 1%), is significantly less than interspecific distance (more than 10%), so the COI can be used for species identification. The intraspecific genetic polymorphism of *Lithobius* (*E.*) *longibasitarsus* sp. n. and *Lithobius* (*E.*) *datongensis* sp. n.) is very low and could indicate weak migration and diffusion capacity with strong natural selection. Assuring the monophyly and interrelationships of the many genera and subgenera belong to Lithobiidae needs further intensive study including more diverse sampling and molecular evidence, the direction of our future effects.

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References

Altschul SF, Madden TL, Schäffer AA, Zhang J, Zhang Z, Miller W, Lipman DJ (1997) Gapped BLAST and PSI-BLAST: a new generation of protein database search programs. Nucleic acids research 25: 3389–3402. https://doi.org/10.1093/nar/25.17.3389

Bollman CH (1893) The Myriapoda of North America. Bulletin of the United States national Museum. 46: 1–210.

Bonato L, Edgecombe GD, Lewis JGE, Minelli A, Pereira LA, Shelley RM, Zapparoli M (2010) A common terminology for the external anatomy of centipedes (Chilopoda). ZooKeys 69: 17–51. https://doi.org/10.3897/zookeys.69.737

Chamberlin RV (1919) The Chilopoda collected by the Canadian Arctic Expedition, 1913–1918. In: Report of the Canadian Arctic Expedition, 1913–1918. Volume III: Insects. Part H: Spiders, Mites and Myriapods, 15–22.

Chamberlin RV (1923) Chilopods of the Pribilof Islands. North American Fauna 46: 240–244.

Chenna R, Sugawara H, Koike T, Lopez R, Gibson TJ, Higgins DG, Thompson JD (2003) Multiple sequence alignment with the Clustal series of programs. Nucleic acids research 31: 3497–3500. https://doi.org/10.1093/nar/gkg500

Darriba D, Taboada GL, Doallo R, Posada D (2012) jModelTest 2: more models, new heuristics and parallel computing. Nature methods 9: 772–772. https://doi.org/10.1038/nmeth.2109

Eason EH (1986) On the synonymy of *Lithobius giganteus* Sseliwanoff, 1881 and the taxonomic status of *Porobius* Attems, 1926 (Chilopoda). Annalen des Naturhistorischen Museums, Wien 87(B): 181–192.

Eason EH (1992) On the taxonomy and geographical distribution of the Lithobiomorpha. Berichte des Naturwissenschaftlich Medizinischen Vereins in Innsbruck Supplement 10: 1–9.

Edgecombe GD, Giribet G (2003) A new blind *Lamyctes* (Chilopoda: Lithobiomorpha) from Tasmania with an analysis of molecular sequence data for the *Lamyctes-Henicops* Group. Zootaxa 152: 1–23. http://dx.doi.org/10.11646/zootaxa.152.1.1

Edgecombe GD, Giribet G, Wheeler WC (2002) Phylogeny of Henicopidae (Chilopoda: Lithobiomorpha): a combined analysis of morphology and five molecular loci. Systematic Entomology 27: 31–64. https://doi.org/10.1046/j.0307-6970.2001.00163.x

Giribet G, Edgecombe GD (2006) Conflict between Datasets and Phylogeny of Centipedes: An Analysis Based on Seven Genes and Morphology. Proceedings Biological Sciences 273: 531–538. https://doi.org/10.1098/rspb.2005.3365

Hall TA (1999) BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. In: Nucleic acids symposium series. Information Retrieval Ltd., c1979-c2000, London, 95–98.

Murienne J, Edgecombe GD, Giribet G (2010) Including secondary structure, fossils and molecular dating in the centipede tree of life. Molecular Phylogenetics & Evolution 57: 301–313. https://doi.org/10.1016/j.ympev.2010.06.022

Ma H, Lu Y, Liu H, Hou X, Pei S (2018) *Hessebius luculentus*, a new species of the genus *Hessebius* Verhoeff, 1941 from China (Lithobiomorpha, Lithobiidae). In: Stoev P, Edgecombe GD (Eds) Proceedings of the 17th International Congress of Myriapodology, Krabi, Thailand. ZooKeys 741: 193–202. https://doi.org/10.3897/zookeys.741.20061

Ma H, Pei S, Hou X, Zhu T (2014a) *Lithobius* (*Monotarsobius*) *zhangi* sp. n., a new species from Eastern China (Chilopoda, Lithobiomorpha, Lithobiidae). ZooKeys 459: 1–10. http://dx.doi.org/10.3897/zookeys.459.8169Ma H, Pei S, Hou X, Zhu T, Gai Y (2015) *Lithobius* (*Ezembius*) *anabilineatus* sp. nov., a new species (Lithobiomorpha: Lithobiidae) from Eastern China. Oriental Insects 49(3–4): 256–263. http://dx.doi.org/10.1080/00305316.2015.1081647

Ma H, Pei S, Hou X, Zhu T, Wu D, Gai Y (2014b) An annotated checklist of Lithobiomorpha of China. Zootaxa 3847(3): 333–358. http://dx.doi.org/10.11646/zootaxa.3847.3.2

Negrea S (2005) On the *Lithobius* species (Chilopoda: Lithobiomorpha) from Israel and adjoining areas. Israel Journal of Zoology 51(1): 27–38. https://doi.org/10.1560/QTQY-YKM8-FPB2-FK9U

Pei S, Lu Y, Liu H, Hou X, Ma H, Zapparoli M (2016) *Lithobius* (*Ezembius*) *multispinipes* n. sp., a new .species of centipede from Northwest China (Lithobiomorpha: Lithobiidae), Zootaxa 4169 (2): 390–400. https://doi.org/10.11646/zootaxa.4169.2.12

Pei S, Lu Y, Liu H, Hou X, Ma H (2018) *Lithobius* (*Ezembius*) *tetraspinus*, a new species of centipede from northwest China (Lithobiomorpha, Lithobiidae). In: Stoev P, Edgecombe GD (Eds) Proceedings of the 17th International Congress of Myriapodology, Krabi, Thailand. ZooKeys 741: 203–217. https://doi.org/10.3897/zookeys.741.19980

Pei S, Ma H, Hou X, Zhu T, Gai Y (2015) *Lithobius* (*Ezembius*) *laevidentata* sp. n., a new species (Chilopoda: Lithobiomorpha: Lithobiidae) from the Northwest region of China. Biologia 70(8): 1113–1117. https://doi.org/10.1515/biolog-2015-0124

Pei S, Ma H, Zhu T, Gai Y (2014) A new species of *Lithobius* (*Ezembius*) Chamberlin (Lithobiomorpha: Lithobiidae) from China, Oriental Insects 48(1–2): 102–107. http://dx.doi.org/10.1080/00305316.2014.959787

Qiao P, Qin W, Ma H, Su J, Zhang T (2018) Two new species of the genus *Hessebius* Verhoeff, 1941 from China (Lithobiomorpha, Lithobiidae). ZooKeys 735(2631): 65–82. https://doi.org/10.3897/zookeys.735.22237

Qin W, Lin GH, Zhao XX, Li B, Xie JX, Ma HQ, Su JP, Zhang TZ (2014) A new species of *Australobius* (Lithobiomorpha: Lithobiidae) from the Qinghai-Tibet Plateau, China. Biologia 69(11): 1601–1605. https://doi.org/10.2478/s11756-014-0459-4

Qin W, Qiao P, Huang YG, Lin G, Su J, Zhang T (2017) A new species of *Bothropolys* and a new record of *Lithobius magnitergiferous* (Lithobiidae) from the Qinghai-Tibet plateau, China. Biologia 72(11): 1314–1319. https://doi.org/10.1515/biolog-2017-0151

Ronquist F, Huelsenbeck JP (2003) MrBayes 3: Bayesian phylogenetic inference under mixed models. Bioinformatics 19: 1572–1574. https://doi.org/10.1093/bioinformatics/btg180

Stoev P, Komerički A, Akkari N, Liu S, Zhou X, Weigand A, Hostens J, Hunter C, Edmunds S, Porco D, Zapparoli M, Georgiev T, Mietchen D, Roberts D, Faulwetter S, Smith V, Penev L (2013) *Eupolybothrus cavernicolus* Komerički & Stoev sp. n. (Chilopoda: Lithobiomorpha: Lithobiidae): the first eukaryotic species description combining transcriptomic, DNA barcoding and micro-CT imaging data. Biodiversity Data Journal 1: e1013. https://doi.org/10.3897/BDJ.1.e1013

Tamura K, Stecher G, Peterson D, Filipski A, Kumar S (2013) MEGA6: molecular evolutionary genetics analysis version 6.0. Molecular biology and evolution 30: 2725–2729. https://doi.org/10.1093/molbev/mst197. Epub 2013 Oct 16 https://doi.org/10.1093/molbev/mst197

Voigtländer K, Iorio E, Decker P, Spelda J (2017) The subgenus *Monotarsobius* in the Iberian Peninsula with a description of a new pseudo-cryptic species from Northern Spain revealed by an integrative revision of *Lithobius crassipes* L. Koch, 1862 (Chilopoda, Lithobiomorpha, Lithobiidae). ZooKeys 681: 1–38. https://doi.org/10.3897/zookeys.681.12942

Zapparoli M, Edgecombe GD (2011) Lithobiomorpha. In: Minelli A (Ed.) Treatise on Zoology. Anatomy, Taxonomy, Biology. The Myriapoda, Volume 1. Jordaan Luchtmans, Brill, 538 pp.

Appendix 1

Table 4. Species used for CO1 sequence analysis, sequence references, GenBank accession numbers, voucher, and locality. ZSM = Zoologische Staatssammlung München, Germany; AM KS = Australian Museum; MCZ = Museum of Comparative Zoology, Harvard University; SMNG= Senckenberg Museum of Natural History.

Taxa	Sequence reference	GenBank No.	Voucher	Locality
Lithobiidae				
Lithobiinae				
Lithobius (*Monotarsobius*) *crassipes*	Voigtländer et al. 2017	MF123710.1	SMNG VNR 17281-1	France,
Lithobius (*L.*) *forficatus*	Voigtländer et al. 2017	MF123702	SMNG VNR 17150-2	Germany
Lithobius (*L.*) *variegatus rubriceps*	Murienne et al. 2010	AF334311	MCZ DNA100283	Spain
Lithobius (*L.*) *castaneus*	Murienne et al. 2010	HM453305	MCZ DNA103939	Italy
Lithobius (*Ezembius*) *giganteus*	Murienne et al. 2010	HM453306	MCZ DNA101089	Kazakhstan
Lithobius (*E.*) *longibasitarsus* sp. n.	this paper	MH05602	GH04	China
Lithobius (*E.*) *longibasitarsus* sp. n.	this paper	MH05603	GH05	China
Lithobius (*E.*) *longibasitarsus* sp. n.	this paper	MH05604	GH03	China
Lithobius (*E.*) *longibasitarsus* sp. n.	this paper	MH05605	GH011	China
Lithobius (*E.*) *longibasitarsus* sp. n.	this paper	MH05606	GH06	China
Lithobius (*E.*) *datongensis* sp. n.	this paper	MH05607	DT4	China
Lithobius (*E.*) *datongensis* sp. n.	this paper	MH05608	DT6	China
Lithobius (*E.*) *datongensis* sp. n.	this paper	MH05609	DT5	China
Lithobius (*M.*) *holsti*	Murienne et al. 2010	HM453307	MCZ DNA102106	Japan
Australobius scabrior	Giribet and Edgecombe 2006	DQ201428		Australia
Ethopolyinae				
Eupolybothrus tridentinus	Stoev et al. 2013	JN269950.1	BC ZSM MYR 00430	Croatia
Bothropolys xanti	Murienne et al. 2010	HM453308	Bmultide	USA
Henicopidae				
Anopsobiinae				
Anopsobius neozelanicus	Edgecombe et al. 2002	AF334313.1	AM KS 57958	New Zealand
Henicopinae				
Henicopini				
Henicops maculatus	Edgecombe and Giribet 2003	AF334316.1	AM KS 57962	Australia
Lamyctes coeculus	Edgecombe and Giribet 2003	AF334315.1	MCZ DNA100288	Australia
Lamyctes emarginatus	Voigtländer et al. 2017	KX442654.1	ZSM-JSP120527-016	Germany
Lamyctes inermipes	Edgecombe and Giribet 2003	AY214425.1	MCZ DNA100478	Argentina
Lamyctes hellyeri	Edgecombe and Giribet 2003	AY214428.1	MCZ DNA100639	Australia
Paralamyctes (*P.*) *harrisi*	Edgecombe et al. 2002	AF334320	AM KS 57971	New Zealand
P. (*Thingathinga*) *validus*	Edgecombe et al. 2002	AF334330	AM KS 57969	New Zealand
Zygethobiini				
Cermatobius japonicus	Edgecombe et al. 2002	AF334332	MCZ 28612	Japan

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RESEARCH ARTICLE

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Rediscovery of *Lobonychium palpiplus* Roewer, 1938 (Opiliones, Laniatores, Epedanidae) in Sabah, Malaysia

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Abstract

Lobonychium palpiplus Roewer, 1938, originally reported from Indonesian Borneo, is redescribed based on the specimens from Malaysia. The genitalia of this species are described for the first time and a new genital terminology is proposed. The rediscovery expands the known distribution of the species to Malaysian Borneo.

Keywords

Arachnida, harvestmen, genitalia, functional morphology, taxonomy, Indonesia

Introduction

The monotypic epedanid genus *Lobonychium* Roewer, 1938 was previously known from three specimens of the nominate species *L. palpiplus* Roewer, 1938, collected in the area of Pontianak (Kalimantan Barat, Indonesia, island of Borneo). The species is peculiar in having seven ventral and medial setiferous tubercles on the femur of the pedipalp and basal lobes on the claw of tarsi III and IV. The types are deposited in the Naturmuseum Senckenberg, Sektion Arachnologie, Frankfurt am Main, Germany. Except for the original description, the genus and species have not been mentioned in the literature during the past eighty years.

In February 2017, the senior author was able to re-examine the type specimens. Moreover, Malaysian Borneo, to the north of the type locality, was visited in October 2015 and May 2017 and several specimens (male and female) of *L. palpiplus* were collected. The newly discovered *Lobonychium* specimens are redescribed and illustrated.

The functional morphology of the male genitalia has been elaborated in some Laniatores families, e.g., Assamiidae Sørensen, 1884; Biantidae Thorell, 1889; Fissiphalliidae Martens, 1988; Phalangodidae Simon, 1879; Podoctidae Roewer, 1912; Stygnommatidae Roewer, 1923; Zalmoxidae Sørensen, 1886, etc. (Martens 1986, 1988; Ubick and Briggs 1992; Kury and Pérez-González 2002; Schwendinger 2006; Pérez-González 2007). In order to improve the morphological knowledge of Epedanidae Sørensen, 1886 we describe for the first time the expanded and unexpanded male genitalia.

Materials and methods

Taxonomic methods follow the outline proposed by Acosta et al. (2007). The type material of *Lobonychium* is preserved in 70% denatured ethanol, and the specimens were examined under a Leica MZ16 at the Senckenberg Museum, Frankfurt, Germany (SMF). Non-type specimens were preserved in 75% ethanol, examined and drawn under a Leica M205A stereomicroscope. Photographs were taken using a Leica M205A stereomicroscope equipped with a DFC450 CCD. The male genitalia were placed first in hot lactic acid, then transferred to distilled water to expand the movable parts for observation (Schwendinger and Martens 2002). The terminology of genital structures follows Macías-Ordóñez et al. (2010), and the macrosetae terminology follows Kury and Villarreal (2015). Non-type material is deposited in the Museum of Hebei University, Baoding, China (MHBU). All measurements are given in mm.

Taxonomy

Epedanidae Sørensen, 1886
Epedaninae Sørensen, 1886

***Lobonychium* Roewer, 1938**

Lobonychium Roewer, 1938: 125.

Type species: *Lobonychium palpiplus* Roewer, 1938, by monotypy.

Etymology. The name *Lobonychium* is derived from the Greek *λοβός*, meaning lobe of the ear, and the Latinized Greek *onyx* (genitive *onychos*), meaning claw.

Diagnosis. Body, including ocularium, unarmed. Basichelicerite and tibia II elongate. Basichelicerite dorsally with conspicuous granules. Femur of pedipalp ventrally with a row of seven setiferous tubercles. Distitarsus I with two tarsomeres, distitarsus II with three. Double claws of tarsi III–IV with basal lobes, untoothed; no scopula. Ventral plate of penis forming a heart-shaped stereoscopic structure (ventral view, Fig. 28). Glans partially sunken into dorsally depressed portion of pars distalis (Fig. 26). Stylus with capsula interna sunken into capsula externa (Fig. 27).

Sexual dimorphism. Tibia II in male distended at distal portion, but normal in female.

Remarks. Within the subfamily Epedaninae, *Lobonychium* is morphologically similar to *Epedanidus* Roewer, 1943, *Metepedanulus* Roewer, 1913, and *Zepedanulus* Roewer, 1927 in having an unarmed body. Besides, *Lobonychium* and *Caletorellus* Roewer, 1938 have characteristic basal lobes or medial branches on double claws of tarsi III–IV (Roewer 1938: 125, 129, fig. 4 b–d). However, *Lobonychium* is noticeably distinct from these epedanids by the pedipalp femur, medially with a row of seven setiferous tubercles.

Distribution. The type locality is at or near the city of Pontianak (Fig. 36 A), Indonesia. The new records are from Malaysia, at Trus Madi Mountain (Fig. 36 B) and Kalabakan (Fig. 36 C).

Lobonychium palpiplus **Roewer, 1938**

Figs 1–34, 36

Lobonychium palpiplus Roewer, 1938: 125, fig. 44.

Type specimens. Male lectotype (SMF-5376-1201), here designated, labeled: "*Lobonychium palpiplus*, male lectotype (SMF-5376-1201), designated by Chao Zhang [handwritten]".

All types (lectotype and two paralectotypes) from Pontianak [00°01'S, 109°20'E], Borneo (West Kalimantan, Indonesia), deposited in the Senckenberg Museum Frankfurt, Germany, labeled: "Arachn. Coll. Roewer – Lfd. No. 5376, Opil: Epedaninae No. 16, *Lobonychium palpiplus* Rwr [abbreviation for Roewer], 2♂1♀, Borneo: Pontianak, Typus, Roewer det. 1935" (Fig. 35) (examined).

Additional material examined. 1♂ (MHBU-Opi-20151208m) and 2♀, (MHBU-Opi-20151208f, MHBU-Opi-2015120801f), Malaysia: Sabah, Trus Madi Mountain, about 1103 m alt. 05°25.637'N, 116°25.984'E, October 9, 2015, Z. Z. Gao leg.; 1♀, Malaysia: Sabah, Trus Madi Mountain, about 1081 m alt. 05°26.111'N, 116°27.237'E, October 10, 2015, Z. Z. Gao leg.; 1♀, Malaysia: Sabah, Trus Madi Mountain, about 760 m alt. 05°27.598'N, 116°26.936'E, October 12, 2015, Z. Z. Gao leg.; 1♀, Malaysia: Sabah, Kalabakan, about 330 m alt. 04°32.522'N, 117°10.020'E, October 18, 2015, Z. Z. Gao leg.; 2♀, Malaysia: Sabah, Trus Madi Mountain, about 1121 m alt. 05°26.529'N, 116°27.309'E, May 1, 2017, C. Jin leg.; 1♂1♀, Malaysia: Sabah, Trus Madi Mountain, about 1081 m alt. 05°26.111'N, 116°27.237'E, May 3, 2017, C. Jin leg.

Redescription. Male (MHBU-Opi-20151208m) habitus as in Figs 1, 8–9, 31. Coloration (Fig. 31): entire body rusty yellow, with somewhat dark brown to blackish brown patches on dorsum; median area of carapace with dark brown reticulations; both lateral ridges of scutum with blackish brown stripes; opisthosomal region of scutum banded with a dark brown outline; a dark brown band across posterior margin of scutum; free tergites I–III each with a dark brown band; coxa with dark brown reticulations; free sternites with transverse dark brown band; chelicerae and pedipalp reticulated; trochanters of all legs pale yellow, femur, patella, tibia and metatarsus with black reticulations, tarsus lighter.

Dorsum (Figs 8, 31). Scutum elongate in appearance, both sides straight, nearly parallel, widest portion of body at scutal area IV, abdomen bluntly pointed posteriorly. Carapace unarmed on lateral portion of anterior margin. Surface of dorsum smooth. Ocularium low and oval, unarmed, removed from anterior border of scutum by 0.16 mm. Borders of opisthosomal scutum parallel to each other. Free tergites and anal operculum unarmed.

Venter (Fig. 9). Surface of coxa I tuberculated, antero-dorsally with a coarse tubercle, and a row of five tubercles on ventral surface. Coxa II with a row of small granules on ventral surface. Coxae III and IV nearly smooth aside from a row of small teeth on front and rear margins of coxa III. Genital operculum and free sternites with seta-tipped granules. Spiracles clearly visible.

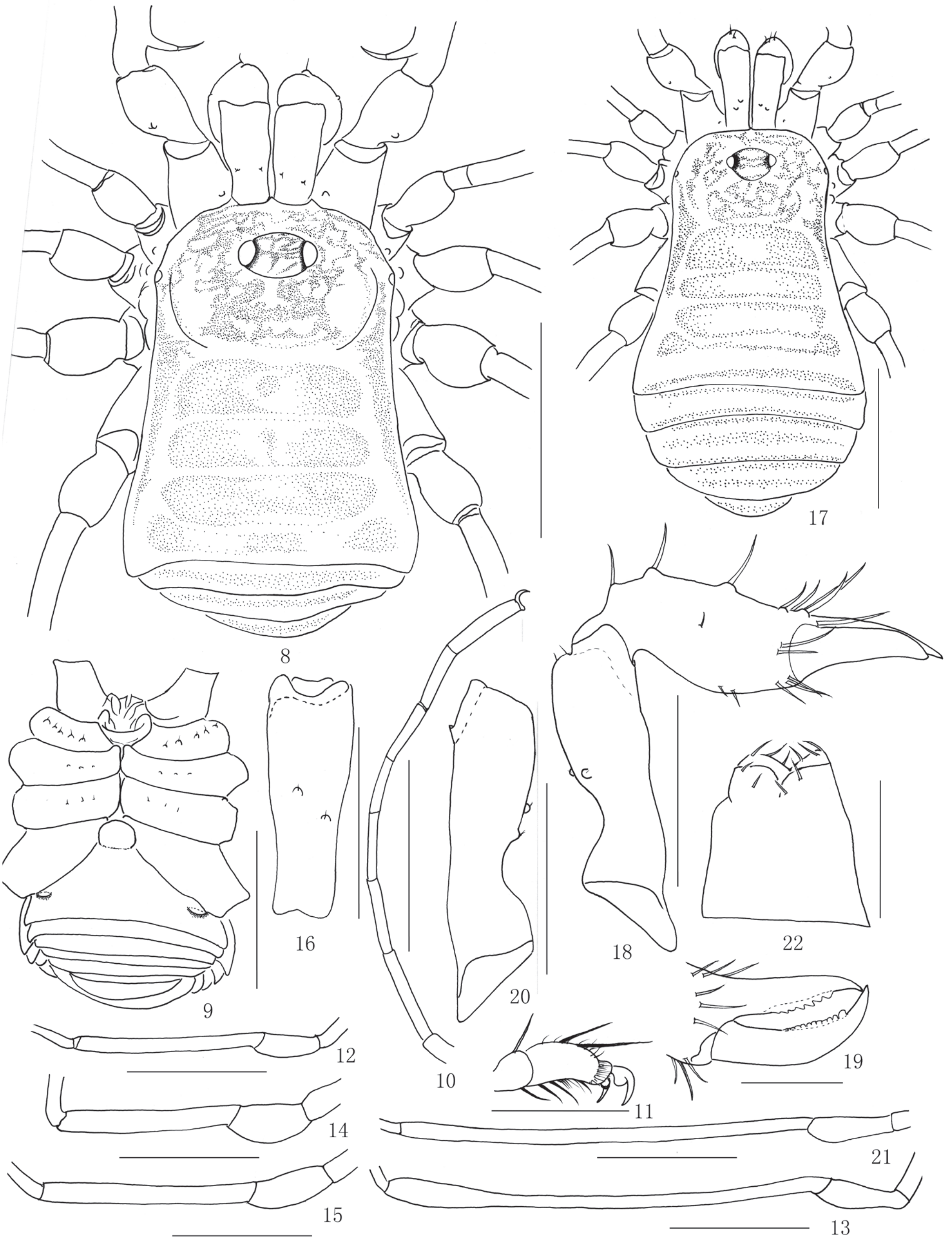
Chelicerae (Figs 2–5, 16). Basichelicerite elongate, with a slight bulla and armed with two conspicuous granules at base of bulla, medial surface with a basal protuberance (Figs 2, 3, 5). Cheliceral hand with some greater seta-tipped tubercles. Fingers relatively short, inner edges toothed (Fig. 4): moveable finger and fixed finger with eight crested teeth, respectively.

Pedipalpi (Fig. 6). Coxa dorsally with one small tubercle near distal margin. Trochanter ventrally with one setiferous tubercle and dorsally with one small tubercle. Femur ventrally with a row of seven setiferous tubercles of even size and spirally arranged from base to distal end on medial side; dorsally with many low conical tubercles along entire length. Patella ventro-mesally with two long and one short setiferous tubercles, and ventro-ectally with one long and one short setiferous tubercles. Tibia ventro-mesally with three setiferous tubercles, and ventro-ectally with four setiferous tubercles. Tarsus with three setiferous tubercles on each side of ventral surface. Tarsal claw curved, approximately same length as tarsus.

Legs (Figs 10–15). Slender and long. All segments unarmed, nearly smooth. Femora I–IV not curved, almost straight. Tibia II distended at distal portion, conspicuously longer than tibiae I, III and IV (Figs 12–15). Distitarsus I with two (Fig. 10), distitarsus II with three tarsomeres. Distitarsi III–IV without scopula. Each claw of tarsi III–IV with one basal lobe nearly circular in shape (Fig. 11). Tarsal formula (I–IV): 7/19/7/7.

Penis (Figs 23–30). Shaft slender, nearly parallel-sided, then distended towards apical portion (pars distalis). Ventral plate inflated, hollow on inner side, forming a heart-shaped stereoscopic ventral frame (ventral view, Fig. 28) (Figs 27, 30). Glans partially sunken into dorsal depressed portion of pars distalis (Fig. 26). Prior to inflation

Figures 1–7. *Lobonychium palpiplus* Roewer, 1938, male (MHBU-Opi-20151208m) (**1–6**), female (MHBU-Opi-20151208f) (**7**) **1** Body, lateral view **2** Left chelicera, medial view **3** Same, ectal view **4** Cheliceral fingers, frontal view **5** Basal segment of left chelicera, dorsal view **6** Left pedipalp, medial view **7** Right pedipalp, medial view. Scale bars: 1mm (**1, 6–7**); 0.5 mm (**2–3, 5**); 0.25 mm (**4**).



Figures 8–22. *Lobonychium palpiplus* Roewer, 1938, male (MHBU-Opi-20151208m) (**8–16**), female (MHBU-Opi-20151208f) (**17–22**) **8** Body, dorsal view **9** Same, ventral view **10** Right tarsus I, retrolateral view **11** Distal segment of right tarsus III, retrolateral view **12–15** Patellae and tibiae of left legs, prolateral view **12** Leg I **13** Leg II **14** Leg III **15** Leg IV **16** Basal segment of right chelicera, dorsal view **17** Body, dorsal view **18** Right chelicera, ectal view **19** Cheliceral fingers, frontal view **20** Basal segment of left chelicera, ectal view **21** Patella and tibia of left leg II, prolateral view **22** Ovipositor, ventral view. Scale bars: 1 mm (**8–9, 12–15, 17, 21**); 0.5 mm (**10, 16, 18, 20**); 0.25 mm (**11, 19, 22**).

Table 1. Pedipalp and leg measurements (mm) of *Lobonychium palpiplus* Roewer, 1938, male, length/width.

	Trochanter	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Pedipalp	0.32/0.28	1.47/0.20	0.97/0.19	0.77/0.18		0.71/0.14	4.24
Leg I	0.35/0.18	1.72/0.14	0.46/0.18	1.38/0.11	2.21/0.05	1.33/0.03	7.45
Leg II	0.36/0.18	3.34/0.10	0.66/0.18	2.99/0.17	3.75/0.05	2.80/0.04	13.90
Leg III	0.37/0.24	2.20/0.15	0.64/0.25	1.23/0.17	2.63/0.10	1.24/0.07	8.31
Leg IV	0.37/0.24	2.90/0.15	0.61/0.25	1.52/0.17	3.56/0.10	1.44/0.07	10.40

Table 2. Pedipalp and leg measurements (mm) of *Lobonychium palpiplus* Roewer, 1938, female, length/width.

	Trochanter	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Pedipalp	0.45/0.31	1.49/0.18	1.10/0.22	0.91/0.19		0.89/0.12	4.84
Leg I	0.37/0.19	1.62/0.10	0.48/0.18	1.36/0.10	2.20/0.06	1.34/0.04	7.37
Leg II	0.39/0.20	3.18/0.10	0.62/0.18	3.01/0.10	3.72/0.06	2.73/0.04	13.65
Leg III	0.42/0.26	2.13/0.12	0.54/0.26	1.28/0.16	2.54/0.09	1.10/0.06	8.01
Leg IV	0.42/0.26	2.88/0.12	0.54/0.26	1.61/0.16	3.41/0.09	1.43/0.06	10.29

Table 3. Numbers of tarsomeres of on legs of *Lobonychium palpiplus* Roewer, 1938. L left, R right tarsus. Only one number is given when the specimen is symmetrical.

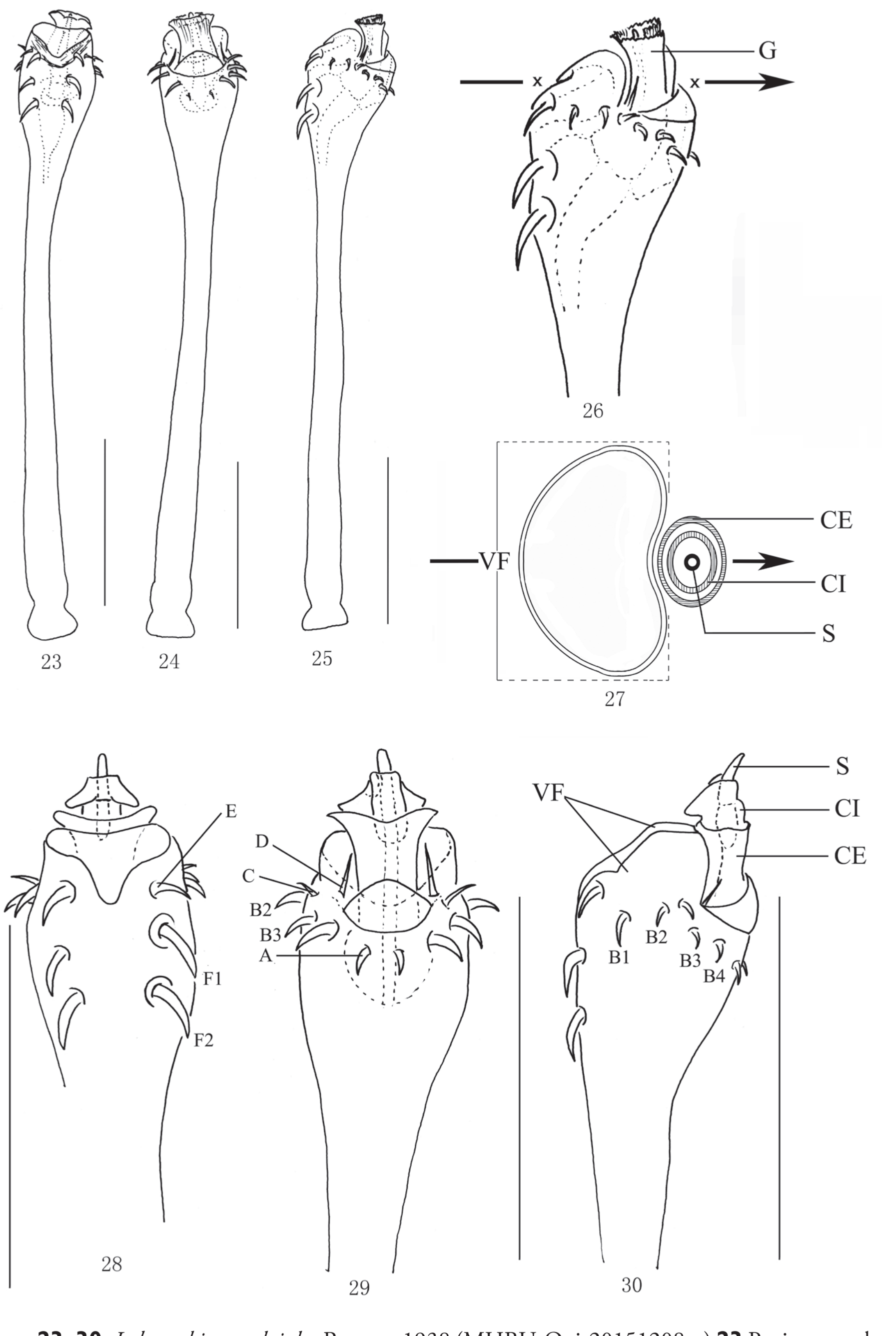
Specimen number (n=10)	Sex	Leg I	Leg II	Leg III	Leg IV
1	male	7	L19, R 21	7	7
2	female	7	L19, R 20	7	7
3, 4	male and female	7	19	7	7
5, 6	females	7	22	7	7
7, 8	females	7	18	7	7
9	female	7	L18, R 21	6	7
10	female	7	21	7	7

of capsula externa (follis) (Fig. 30), stylus with capsula interna sunken into capsula externa (Fig. 27). Capsula externa dorsally and ventrally extended at distal end. Everted capsula interna with a bifurcate ventral lobe distally. Stylus finger-shaped. Spination symmetrical. One pair of setae A, C, D, and E. Two pairs of setae F. Four pairs of setae B (Figs 28–30).

Female (MHBU-Opi-20151208f) (Figs 7, 17–22, 32–34). Generally similar to male except abdomen slightly wider than in male (Figs 17, 32). Tibia II conspicuously longer than tibiae I, III and IV, but inconspicuously distended distally (Fig. 21). Inner edges of finger of chelicera toothed (Fig. 19): moveable finger with 12 teeth; fixed finger with seven teeth. Tarsal formula (I–IV): 7/22/7/7.

Ovipositor (Fig. 22). Ventral surface with four setae and dorsal surface with six setae.

Measurements. Male (female): body 1.89 (2.74) long, 1.36 (1.64) wide at widest portion, scutum 1.69 (1.76) long. Ocularium 0.19 (0.20) long, 0.37 (0.35) wide. Proximal article of chelicera 0.69 (0.62) long, 0.24 (0.23) wide; second 0.89 (0.98)



Figures 23–30. *Lobonychium palpiplus* Roewer, 1938 (MHBU-Opi-20151208m) **23** Penis, ventral view **24** Same, dorsal view **25** Same, lateral view **26** Distal part of penis, lateral view **27** cross-section through glans and truncus at the marked point **28** Distal part of penis (expanded), ventral view **29** Same, dorsal view **30** Same, lateral view. Abbreviations: **CE** capsula externa (follis) **CI** capsula interna **G** glans **S** stylus **VF** ventral frame. Scale bars: 0.25 mm.

Figures 31–34. *Lobonychium palpiplus* Roewer, 1938 Photographs of male (MHBU-Opi-20151208m) and female (MHBU-Opi-20151208f) **31** Male body and parts of appendages, dorsal view **32** Female body and parts of appendages, dorsal view **33** Same, lateral view **34** Same, ventral view. Scale bars: 1 mm (Fig. 33); 0.5 mm (Figs 31–32, 34).

long, 0.26 (0.26) wide; distal 0.40 (0.44) long, 0.09 (0.08) wide. Pedipalp claw 0.64 (0.63) long. Penis 0.88 long. Measurements of pedipalp and legs as in Tables 1, 2.

Habitat. The specimens were collected by leaf litter sieving in dark moist places under dense forest canopy.

Variation. The collection examined contains ten specimens, two males and eight females. The male (MHBU-Opi-20151208m) and the female (MHBU-Opi-20151208f) described here are asymmetrical in the position of granules on the left (Figs 5, 20) and right (Figs 16, 18) basichelicerites of chelicerae. Another male body 1.96 long, 1.21 wide at the widest portion, scutum 1.68 long. Size range of other females (n=7) as follows minimum (maximum in parentheses): body 2.20 (2.70) long, 1.59 (1.76) wide at the widest portion, scutum 1.72 (1.89) long. The variations in the number of segments in the tarsus are shown in Table 3.

Distribution. Indonesia (Pontianak), Malaysia (Trus Madi Mountain, Kalabakan).

Remarks. The three type specimens have not been dissected and are in good condition, with all appendages attached. The original description of the types by Roewer (1938) corresponds more-or-less to the morphology of the type specimens except for few minor characters, e.g., the male tibia II is distended at its distal portion, the

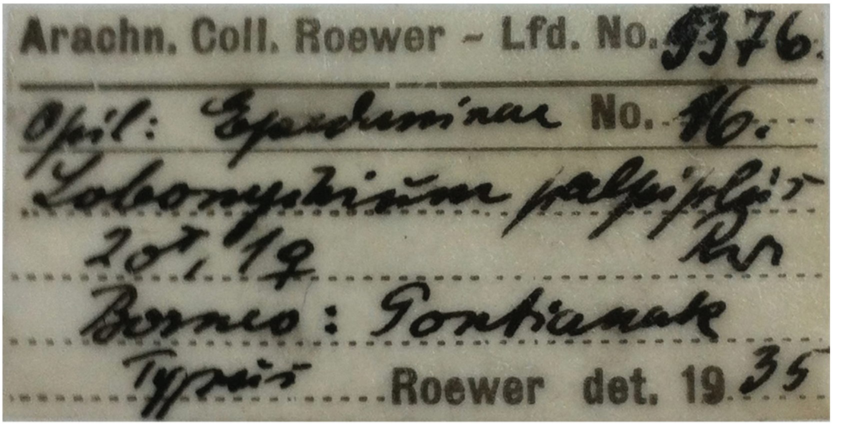


Figure 35. Original label with Roewer's handwriting of the type series of *Lobonychium palpiplus* Roewer, 1938.

Figure 36. Distribution of *Lobonychium palpiplus* Roewer, 1938 in Borneo. **A** type locality **B** Trus Madi Mountain **C** Kalabakan.

presence of one short setiferous tubercle ventro-mesally on the pedipalpal patella, the minimum numbers of the tarsomeres II and III are 18 and 6, respectively, and the smaller male body (1.89–1.96).

Additionally, the localities of the new records from Malaysia are at most about 120 km apart. The distance between the recorded type locality (Indonesian part of Borneo) and the new localities (Malaysian part) is nearly 1000 km (Fig. 36).

According to the drawings presented by Suzuki (1969: 30, fig. 19 E; 1977: 19, fig. 6 F–G; 1981: 268, fig. 1B–C) the male genital morphology of Epedanidae seems to be quite homogeneous and little functional variation has been documented to date.

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References

Acosta LE, Pérez-González A, Tourinho AL (2007) Methods for taxonomic study. In: Pinto-da-Rocha R, Machado G, Giribet G (Eds) Harvestmen: The biology of Opiliones. Harvard University Press, Cambridge and London, 494–510.

Kury AB, Pérez-González A (2002) A new family of Laniatores from northwestern South America (Arachnida, Opiliones). Revista Ibérica de Aracnología 6: 3–11.

Kury AB, Villarreal MO (2015) The prickly blade mapped: establishing homologies and a chaetotaxy for macrosetae of penis ventral plate in Gonyleptoidea (Arachnida, Opiliones, Laniatores). Zoological Journal of the Linnean Society 174: 1–46. https://doi.org/10.1111/zoj.12225

Macías-Ordóñez R, Machado G, Pérez-González A, Shultz J (2010) Genitalic Evolution in Opiliones. In: Leonard J, Córdoba-Aguilar A (Eds) The Evolution of Primary Sexual Characters in Animals. Oxford University Press, New York, 285–306.

Martens J (1986) Die Grossgliederung der Opiliones und die Evolution der Ordnung (Arachnida). In: Barrientos JA (Ed.) Actas del X Congreso Internacional de Aracnología. Editorial Juvenil, Barcelona, 289–310.

Martens J (1988) Fissiphalliidae, a new family of South American laniatorean harvestmen (Arachnida: Opiliones). Zeitschrift für zoologische Systematik und Evolutionsforschung 26: 114–127. https://doi.org/10.1111/j.1439-0469.1988.tb00303.x

Pérez-González A (2007) Stygnommatidae Roewer, 1923. In: Pinto-da-Rocha R, Machado G, Giribet G (Eds) Harvestmen: The biology of Opiliones. Harvard University Press, Cambridge and London, 229–232.

Roewer CF (1912) Die Familien der Assamiiden und Phalangodiden der Opiliones-Laniatores. (= Assamiden, Dampetriden, Phalangodiden, Epedaniden, Biantiden, Zalmoxiden, Samoiden, Palpipediden anderer Autoren). Archiv für Naturgeschichte 78: 1–242.

Roewer CF (1913) Die Familie der Gonyleptiden der Opiliones-Laniatores. Archiv für Naturgeschichte 79: 1–256.

Roewer CF (1923) Die Weberknechte der Erde. Systematische Bearbeitung der bisher bekannten Opiliones. Gustav Fischer, Jena, 1116 pp.

Roewer CF (1927) Brasilianische Opilioniden, gesammelt von Herrn Prof. Bresslau im Jahre 1914. Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft 40: 331–352.

Roewer CF (1938) Über Acrobuninae, Epedaninae und Sarasinicinae. Weitere Weberknechte IX. Veröffentlichungen aus dem Deutschen Kolonial- und Übersee-Museum in Bremen 2: 81–169.

Roewer CF (1943) Über Gonyleptiden. Weitere Webernechte (Arachn., Opil.) XI. Senckenbergiana, Frankfurt 26: 12–68.

Schwendinger PJ (2006) A taxonomic revision of the family Oncopodidae VI. *Martensiellus*, a new genus from Borneo, and the discovery of a tarsal pore organ in Oncopodidae (Opiliones: Laniatores). Zootaxa 1325: 255–266.

Schwendinger PJ, Martens J (2002) A taxonomic revision of the family Oncopodidae III: Further new species of *Gnomulus* Thorell (Opiliones, Laniatores). Revue suisse de zoologie 109: 47–113. https://doi.org/10.5962/bhl.part.79580

Simon E (1879) Les Arachnides de France. Tome 7. Contenant les ordres des Chernetes, Scorpiones et Opiliones. Librairie Encyclopédique de Roret, Paris, 1–332.

Sørensen WE (1884) Opiliones Laniatores (Gonyleptides W. S. Olim) Musei Hauniensis. Naturhistorisk Tidsskrift, Kjøbenhavn 14: 555–646.

Sørensen WE (1886) Opiliones. In: Koch L, Keyserling E (Eds) Die Arachniden Australiens nach der Natur beschrieben und abgebildet. Bauer & Raspe, Nürnberg, 53–86.

Suzuki S (1969) On a collection of opilionids from Southeast Asia. Journal of Science of the Hiroshima University 22: 11–77.

Suzuki S (1977) Report on a collection of opilionids from the Philippines. Journal of Science of the Hiroshima University 27: 1–120.

Suzuki S (1981) Three opilionids from Thailand. Annotationes Zoologicae Japonenses 54: 267–272.

Thorell TTT (1889) Aracnidi Artrogastri Birmani raccolti da L. Fea nel 1885–1887. Annali del Museo Civico di Storia Naturale di Genova 7: 521–729.

Ubick D, Briggs TS (1992) The harvestman family Phalangodidae. 3. Revision of *Texella* Goodnight and Goodnight (Opiliones: Laniatores). Texas Memorial Museum, Speleological Monographs 3: 155–240.

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Redescription of the dasydytid gastrotrich *Haltidytes ooëides* (Brunson, 1950) based on type material

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Abstract

The semi-pelagic gastrotrich species *Haltidytes ooëides* (Brunson, 1950) is redescribed based on original type material deposited at the Smithsonian National Museum of Natural History. Herein we present a new diagnosis and figures of the species, detailing the insertion position of the lateral spines, misinterpreted in the original description. Furthermore, we reassess the taxonomic key for the genus *Haltidytes* Remane, 1936 based on our new findings.

Keywords

Chaetonotida, Dasydytidae, Gastrotricha, *Haltidytes*, USA

Introduction

While most gastrotrichs are epibenthic, periphytic, or interstitial, some species belonging to the family Dasydytidae Daday, 1905 present a semi-pelagic lifestyle (Kieneke et al. 2008, Balsamo et al. 2014, Kånneby and Todaro 2015). Seven genera are currently assigned to Dasydytidae, including the genus *Haltidytes* Remane, 1936 recently found as monophyletic (Minowa and Garraffoni 2017). *Haltidytes* was originally established as a subgenus of *Dasydytes* Gosse, 1851 by Remane (1936), who then elevated it to a genus rank (Remane, 1967). Currently, the genus *Haltidytes* contains six valid species (Minowa and Garraffoni 2017): *H. festinans* (Voigt, 1909) (type species), *H. crassus* (Greuter, 1917), *H. ooëides* (Brunson, 1950), *H. saltitans* (Stokes, 1887), *H. squamosus* Kisielewski, 1991, and *H. pseudosquamosus* Minowa & Garraffoni, 2017.

While preparing a forthcoming study incorporating phylogenetic analyses of all valid Dasydytidae species based on morphology (Minowa and Garraffoni, in preparation), we came across the possible type specimen of *Haltidytes ooëides* (Brunson, 1950), originally described as *Dasydytes ooëides* (USNM W 26869S). Although Brunson (1950) had not designated any type specimen, the locality and sampling date (Michigan State, Washtenaw County, Half-Moon Lake; May, 30, 1944) registered in the Smithsonian Data Base are the same as those reported in the Brunson's study. It came as a surprise to us that after more than 75 years the specimen is still preserved. Due to small size and fragile bodies, fixed specimens of gastrotrichs usually have their diagnostic morphological characters deteriorated after fixation (e.g. Balsamo et al. 2014, Kånneby 2016, Garraffoni and Freitas 2017). It is interesting to highlight that we also found the possible type specimen of *Stylochaeta scirtetica* Brunson, 1950 (USNM W 26870), but in this case, the material is in a poor condition and could not be used for a reanalysis.

Materials and methods

Herein we redescribe *Haltidytes ooëides* based upon a single type material deposited at the Smithsonian National Museum of Natural History. External morphology was observed using an Olympus BX63F compound fluorescence microscope with a digital DP80 camera and cellSens software (Olympus, Philadelphia, USA). Videos were prepared using the open-source platform Fiji (Schindelin et al. 2012). The necessity for a re-examination was caused by the shallow description by Brunson (1950), who only briefly reported and illustrated a few morphological features of the new species. This need was further noted by Balsamo et al. (2014), suggesting a misinterpretation of the insertion positions of the lateral spines. In the redescription of the species, the groups of spines are coded according to Kisielewski (1991).

Taxonomic account

Phylum Gastrotricha Metschnikoff, 1865
Order Chaetonotida Remane, 1925 [Rao & Clausen, 1970]
Family Dasydytidae Daday, 1905
Genus *Haltidytes* Remane, 1936

***Haltidytes ooëides* (Brunson, 1950)**
Figs 1, 2

Redescription. The observed specimen has a compact, bowling pin-shaped body, measuring 88 µm in total body length, 184 µm with spines included. Conical head with convex sides (24 µm wide), pentalobate, dorsally with a middle furrow (Figure 1D). Cephalic ciliature consists of two lateral tufts, one adjacent to mouth and another slightly posterior, and a transverse band interrupted medially in the ventral

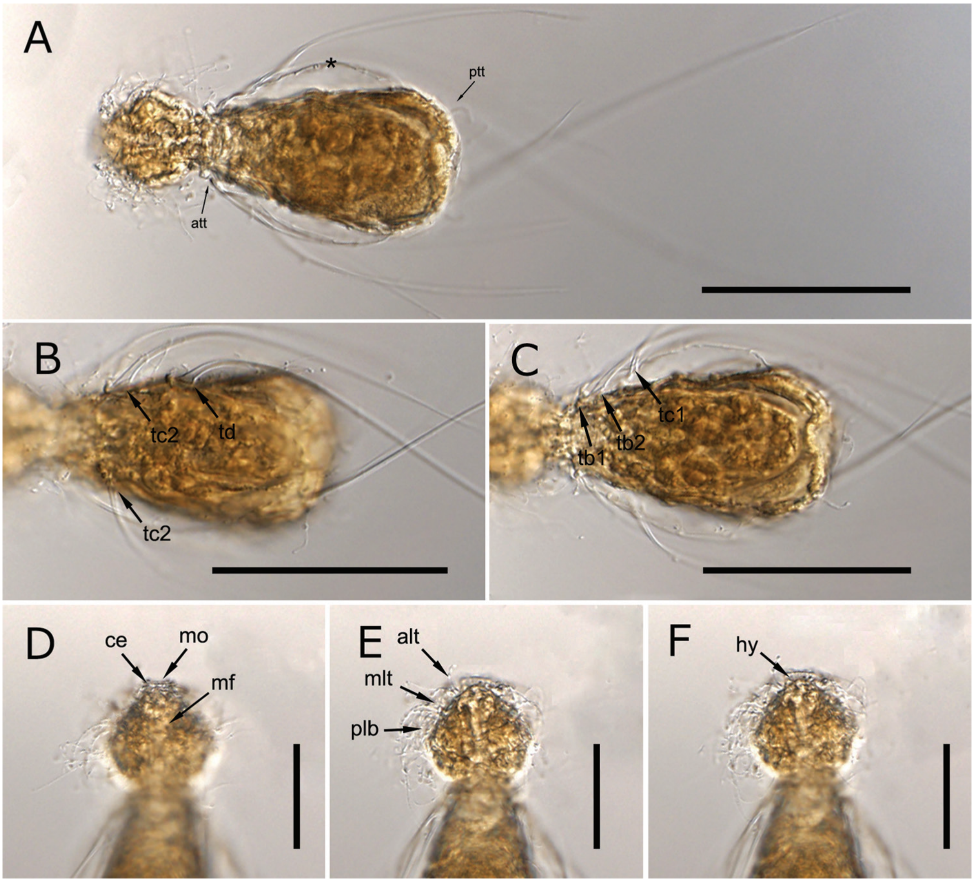

Figure 1. Light micrographs (DIC) of *Haltidytes ooëides* (Brunson, 1950). **A** dorsal view, **B–C** ventral view showing the insertion of trunk spines **D** dorsal view of the head **E–F** ventral view of the head. Asterisks (*) indicate the body cuticle. Scales bars: **A–C** 50 µm, **D–F** 25 µm. Abbreviations: **alt** anterior lateral ciliary tuft **att** anterior locomotory ciliation tuft **ce** cephalion, **hy**: hypostomion **mf** middle furrow **mlt** mediolateral ciliary tuft **mo** mouth **plb** posterior lateral ciliary band **ptt** posterior locomotory ciliation tuft **tb1-2** trunk spines **tc1-2** trunk spines **td** trunk spines.

and dorsal portion on middle head region (Figures 1E, 2C, D). Kephalion, trapezoidal in shape (9 µm length, 13 µm wide) (Figures 1D, 2C), hypostomion, triangular in shape (5 µm length, 8 µm wide) located around the ventral portion of the mouth ring (Figures 1F, 2D). Distinct neck constriction (17 µm wide), much narrower than the head and trunk. Trunk ovoidal in shape (42 µm in maximum width) with a rounded posterior end (Figure 1A).

Cephalic spines or rear spines not observed. On the anterior half of the trunk four paired groups of 2-2-2-1 curved simple spines (ta1-2, tb1-2, tc1-2, td) respectively, inserted directly on the cuticle without scales (Figs 1B, C, 2A–D). The first group (ta1 at U32; ta2 at U35) inserted ventrolaterally at the neck base strongly bends dorsally at the neck level showing a slightly (almost straight) concave curvature extending all over the trunk (Figure 2B). The other three groups (tb, tc and td) are inserted ventrally at

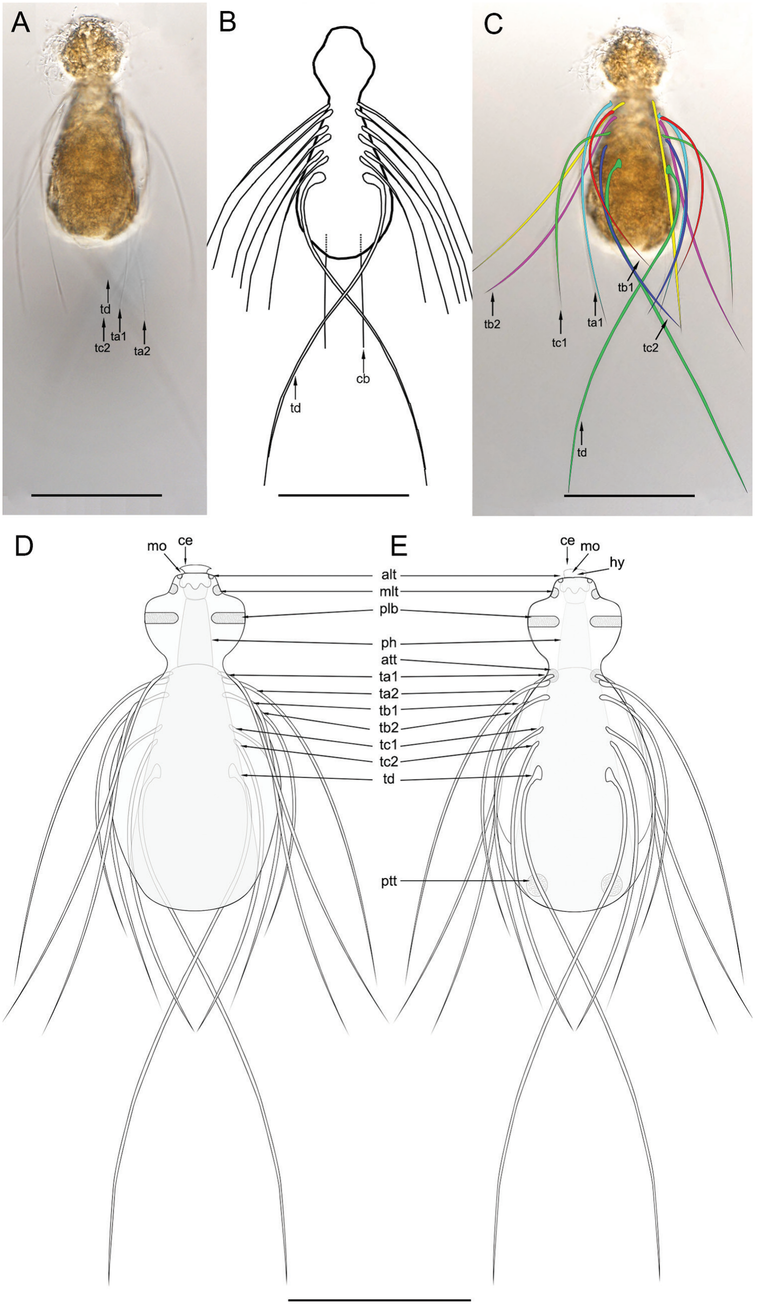

Figure 2. Light micrographs (DIC) and redrawing of the schematic drawing of *Haltidytes ooëides* (Brunson, 1950). **A** whole animal view **B** redrawing of the schematic drawing of the original description **C** the same image of **A** in which the arrangement of the trunk spines is highlighted **D** schematic drawing of the dorsal view **E** schematic drawing of the ventral view. Scales bars: 50 µm. Abbreviations: **alt** anterior lateral ciliary tuft **att** anterior locomotory ciliation tuft **cd** caudal bristle **ce** cephalion **hy**: hypostomion **mlt** mediolateral ciliary tuft **mo** mouth **ph** pharynx **plb** posterior lateral ciliary band **ptt**: posterior locomotory ciliation tuft **ta1-2** trunk spines **tb1-2** trunk spines **tc1-2** trunk spines **td** trunk spines.

U32, U35, U38, U40, U46, U50, and U60, respectively (Figure 1 B–C, 2 B). Spines tb2 turn dorsally like spines ta. Spines tb1, tc1-2, and td show a slight convex curvature and extend ventrally along the trunk, (Figure 2B). Spines of ta to tc group measure 100, 90, 75, 90, 82, 80 µm respectively. Group td is composed of one pair of very long saltatorial spines, 140 µm in length.

Trunk locomotory ciliation divided into 2-paired ventral tufts at 15U and 93U on the ventral side of at the neck and posterior trunk, respectively (Figure 2C, D). No dorsal sensory bristles were observed.

Mouth ring is terminal (3 µm in diameter). Pharynx (33 µm in length) increases in width uniformly from 9 µm anteriorly to 11 µm at the posterior end) (Figure 1A, D, F).

Remarks. Usually, the trunk width is given as the maximum trunk widthwhich is at the midgut level. In this case, the type specimen *H. ooëides* is 42 µm wide. However, Brunson (1950) measured the trunk width posterior to the midgut level (close to the posterior end of the body) and found it to be 36 µm wide.

Differences in spines length between the original description and the present one (Table 1) are due to different measurement methods. We chose to measure each spine length outlining its curvature (100, 90, 75, 90, 82, 80 µm respectively) instead of

Table 1. Morphometric features of *Haltidytes ooëides* (Brunson, 1950): measures are expressed in µm; the relative positions of morphological structures along the body are expressed in percentage unities (U) in relation to the total body length.

Feature type	Measure (µm)
Total body length, spines excluded	88
Total body length, spines included	184
Maximum head width) (U17)	24
Minimum neck width (µm) (U30)	17
Maximum trunk width (µm) (U65)	42
Trunk length (µm)	60
Pharynx length (µm)	33
Anterior pharynx width (µm)	9
Posterior pharynx width (µm)	11
Diameter of mouth ring (µm)	3
Kephalion length (µm)	9
Kephalion width (µm)	13
Hypostomion length (µm)	5
Hypostomion width (µm)	8
Spine ta1-2 length (µm)	100, 90
Spine tb1-2 length (µm)	75, 90
Spine tc1-2 length (µm)	82, 80
Spine td length (µm)	140
Ventral spine ta1-2 insertion	U32, U35
Ventral spine tb1-2 insertion	U38, U40
Ventral spine tc1-2 insertion	U46, U50
Ventral spine td insertion (U)	U60
Cephalic ciliary tufts insertion (U)	U1, U4, U8
Ventral trunk ciliary tufts insertion (U)	U15, U93

measuring the distance between the spine base insertion and apex as a straight line, as Brunson (1950) did (86, 86, 67, 82, 82 and 58 µm, respectively).

Additionally, the original description mentions a pair of caudal bristles (Figure 2C) that originate 10 µm from the posterior end of the trunk. After reexamination of the type specimen (Figure 2A, B–D) we conclude that Brunson (1950) may have misinterpreted these structures. In fact, our observations revealed that the caudal bristles described by Brunson (1950) actually are the ta1 spines, due to their similar position relative to the posterior trunk, size and shape (Figure 2A, B).

As previously mentioned, the description of some morphological characters of *H. ooëides* were misinterpreted by Brunson (1950) and incorrectly replicated by Balsamo et al. (2014) and Minowa and Garraffoni (2017). We address this issue by correcting the taxonomic key *Haltidytes* in order to correct previous misinterpretations.

Taxonomic key to genus *Haltydytes*

1	Seven pairs of spines with ventral insertion besides td (saltatorial spines)	**2**
–	Six or fewer pairs of spines with ventral insertion besides td (saltatorial spines)	**4**
2	Dorsal trunk totally or partially covered with rhombic scales arranged sparsely or aggregate	**3**
–	Dorsal trunk without scales	***H. festinans***
3	Dorsal scales arranged sparsely; dorsal trunk covered with rhombic scales with a short median keel or smooth; ventral trunk covered with small smooth scales	***H. squamosus***
–	Dorsal scales aggregate; median and rear dorsal trunk covered with smooth, rhombic scales; ventral trunk without scales	***H. pseudosquamosus***
4	Anterior spines (ta) cross each other above dorsal trunk	***H. saltitans***
–	Anterior spines (ta) do not cross each other above dorsal portion of the trunk	**5**
5	Ventral ciliature consisting of 2 tufts; 3 pairs of spines arrive to the dorsum while 3 other spines remain ventral besides td group	***H. oöeides***
–	Ventral ciliature consisting of 2 longitudinal bands; all 5 pairs of spines arrive to the dorsum; only td group remain on venter	***H. crassus***

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References

Balsamo M, Grilli P, Guidi L, d'Hondt JL (2014) Gastrotricha: biology, ecology and systematics. Families Dasydytidae, Dichaeturidae, Neogosseidae, Proichthydiidae. Backhuys Publishers, Margraf Publishers, Weikersheim, 187 pp.

Brunson RB (1950) An introduction to the taxonomy of the Gastrotricha with a study of eighteen species from Michigan. Transactions of the American Microscopical Society 69: 325–352. https://doi.org/10.2307/3223127

Daday E von (1905) Untersuchungen über die Süsswasser Mikrofauna Paraguays. Zoologica 44: 1–374.

Garraffoni ARS, Freitas AVL (2017) Photos belong in the taxonomic Code. Science 355: 805. https://doi.org/10.1126/science.aam7686

Gosse PH (1851) XVIII A catalogue of Rotifera found in Britain; with descriptions of five new genera and thirty-two new species. Journal of Natural History 8: 197–203. https://doi.org/10.1080/03745486109496205

Greuter A (1917) Beiträge zur Systematik der Gastrotrichen in der Schweiz. Revue Suisse de Zoologie 25: 35–76. https://doi.org/10.5962/bhl.part.31929

Kånneby T (2016) Phylum Gastrotricha. In: Thorp JH, Rogers DC (Eds) Key to Nearctic Fauna: Thorp and Covich's Freshwater Invertebrates. Elsevier, Amsterdam, 115–130. https://doi.org/10.1016/B978-0-12-385028-7.00007-X

Kånneby T, Todaro MA (2015) The phylogenetic position of Neogosseidae (Gastrotricha: Chaetonotida) and the origin of planktonic Gastrotricha. Organisms Diversity & Evolution 15: 459–469. https://doi.org/10.1007/s13127-015-0223-9

Kieneke A, Riemann O, Ahlrichs WH (2008) Novel implications for the basal internal relationships of Gastrotricha revealed by an analysis of morphological characters. Zoologica Scripta 37: 429–460. https://doi.org/10.1111/j.1463-6409.2008.00334.x

Kisielewski J (1991) Inland-water Gastrotricha from Brazil. Annales Zoologici 43: 1–168.

Metschnikoff E (1865) Über einige wenig bekannte niedere Thierformen. Zeitschrift für Wissenschaftliche Zoologie 15: 450–463.

Minowa AK, Garraffoni ARS (2017) A new species of *Haltidytes* Remane, 1936 (Gastrotricha: Chaetonotida: Dasydytidae) from an urban lagoon in Brazil with a phylogenetic reconstruction of the genus based on morphological data. Zoologischer Anzeiger 269: 100–109. https://doi.org/10.1016/j.jcz.2017.08.003

Rao GC, Clausen C (1970) *Planodasys marginalis* gen. et sp. nov. and Planodasyidae fam. nov. (Gastrotricha Macrodasyoidea). Sarsia 42: 73–82. https://doi.org/10.1080/00364827.1970.10411164

Remane A (1925) Organisation und systematische Stellung der aberranten Gastrotrichen. Verhandlungen der deutschen zoologischen Gesellschaft 30: 121–128.

Remane A (1936) Gastrotricha. In: Bronn HG (Ed.) Klassen Und Ordnungen Des Tierreichs. Liefr. IV, Abt. 2, Buch 1, Teil 2. Akademische Verlagsgesellschaft, Leipzig, 142 pp.

Remane A (1967) Gastrotricha. In: Illies J (Ed.) Limnofauna Europaea, Gustav Fischer Stuttgart, 69–72.

Schindelin J, Arganda-Carreras I, Frise E, Kaynig V, Longair M, Pietzsch T, Preibisch S, Rueden C, Saalfeld S, Schmid B, Tinevez JY, White D, Hartenstein V, Eliceiri K, Tomancak P, Cardona A (2012) Fiji: an open-source platform for biological-image analysis. Nature Methods 9: 676. https://doi.org/10.1038/nmeth.2019

Stokes AC (1887) Observations on *Chaetonotus*. Microscope 7: 33–43.

Voigt M (1909) Nachtrag zur gastrotrichen-fauna Plöns. Zoologischer Anzeiger 39: 717–722.

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Trichopolydesmidae from Cameroon, 1: The genus *Hemisphaeroparia* Schubart, 1955. With a genus-level reclassification of Afrotropical genera of the family (Diplopoda, Polydesmida)

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Abstract

In addition to one of the two species of Trichopolydesmidae hitherto recorded from Cameroon, *Polydesmus integratus* Porat, 1894, which is revised based on type material and shown to represent the genus *Hemisphaeroparia* Schubart, 1955, **comb. n.**, 12 new species from the same genus are described from that country: *H. zamakoe* **sp. n.**, *H. bangoulap* **sp. n.**, *H. spiniger* **sp. n.**, *H. ongot* **sp. n.**, *H. digitifer* **sp. n.**, *H. parva* **sp. n.**, *H. fusca* **sp. n.**, *H. bonakanda* **sp. n.**, *H. bamboutos* **sp. n.**, *H. subfalcata* **sp. n.**, *H. falcata* **sp. n.** and *H. mouanko* **sp. n.** A key to all 13 species (of *Hemisphaeroparia*) known to occur in Cameroon is presented, and their distributions are mapped. All ten recognizable (but excluding two dubious) Afrotropical genera or subgenera of Trichopolydesmidae are rediagnosed and reclassified, based both on their type species and a presumed scenario of gonopodal evolution. As a result, the number of accepted genera is reduced to five: *Sphaeroparia* Attems, 1909 (= *Megaloparia* Brolemann, 1920), *Physetoparia* Brolemann, 1920 (= *Elgonicola* Attems, 1939, **syn. n.**, = *Mabocus* Chamberlin, 1951, **syn. n.**, = *Heterosphaeroparia* Schubart, 1955, **syn. n.**}, *Eburodesmus* Schubart, 1955, *Mecistoparia* Brolemann, 1926 (= *Dendrobrachypus* Verhoeff, 1941, **syn. n.**), and *Hemisphaeroparia*.

Keywords
Afrotropical, Cameroon, millipede, new combination, new species, new status. new synonymy, review, taxonomy Trichopolydesmidae

Introduction

The millipede family Trichopolydesmidae, not long ago largely referred to as Fuhrmannodesmidae, a group that mainly included tropical taxa (e.g., Hoffman 1980, Golovatch 1994, Mauriès and Heymer 1996) as opposed to the originally Mediterranean Trichopolydesmidae, presently contains ca. 140 species from ca. 75 genera, mainly across the Northern Hemisphere, both temperate and, especially, tropical (Golovatch 2013, Golovatch and Enghoff 2015). Even after the resurrection of the small and mainly Nearctic family Macrosternodesmidae from synonymy to Trichopolydesmidae, as recently proposed by Shear and Reddell (2017), the diversity of trichopolydesmids in the restricted sense remains impressive.

Apparently because of the small to very small bodies (3–20 mm long), regional tropical faunas of Trichopolydesmidae are particularly poorly known. This fully applies to the Afrotropical realm which, based on the latest review of the mainland fauna (Mauriès and Heymer 1996) and updated here using the available information about adjacent insular faunas (Golovatch and Korsós 1992, Mauriès and Geoffroy 1999, Golovatch and Gerlach 2010), contains only two accepted genera (*Bactrodesmus* Cook, 1896 and *Sphaeroparia* Attems, 1909) and ca. 40 species. Quite a few of these species still remain obscure, e.g., *Sphaeroparia*? sp. from the Seychelles (Golovatch and Korsós 1992, Golovatch and Gerlach 2010) or several *Mauritacantha* spp. from the Reunion (= Mauritius) Island (Mauriès and Geoffroy 1999). The same also concerns *Polydesmus integratus* Porat, 1894 and *P. parvulus* Porat, 1894, both from unknown localities and both representing the only species of Trichopolydesmidae hitherto reported from Cameroon (Porat 1894).

The present paper puts on record most of a rich fresh collection of Trichopolydesmidae from Cameroon, provides the results of a revision of the sole male type of *P. integratus* and thus seriously updates the fauna of this family not only in the country, but in entire Africa. Unfortunately, the type series of *P. parvulus*, which also contained male material (Porat 1894), remains unavailable for restudy, apparently being misplaced in the Stockholm Museum. A new generic classification of the Afrotropical trichopolydesmids is also proposed, a key to and a map of all trichopolydesmids currently known to occur in Cameroon are also given.

Material and methods

Most of the material treated here derives from the collection of the Musée Royal de l'Afrique Centrale (MRAC), Tervuren, Belgium, with only a few duplicates retained for the collections of the University of Yaounde 1 (UY1) and the second author

(ARNF), Cameroon or donated to the Zoological Museum, State University of Moscow (ZMUM), Russia, as indicated below. The samples are stored in 70% ethanol. Specimens for scanning electron microscopy (SEM) were air-dried, mounted on aluminium stubs, coated with gold and studied using a JEOL JSM-6480LV scanning electron microscope. The colour pictures were taken using the focus stacking setup described by Brecko et al. (2014). Canon EOS Utility software was used to control the camera. Zerene Stacker was applied for stacking the individual pictures into one 'stacked image'.

The abbreviations used to denote gonopodal structures are explained directly in the text and figure captions.

A generic reclassification of Afrotropical Trichopolydesmidae

The high number of generic categories (12 genera or subgenera, see below) to adopt some 35 species recorded throughout continental tropical Africa (Mauriès and Heymer 1996) is likely evidence of the poor state of the art. One more genus, *Mauritacantha* Verhoeff, 1939, from Mauritius, remains invalid as no proper typification has ever been done (Verhoeff 1939). The suggestion by Mauriès and Geoffroy (1999) of *Mauritacantha lawrencei* Verhoeff, 1939 as a potential type species of this genus is not a valid act of typification and is thus to be ignored.

The following nomenclaturally available generic or subgeneric names have been suggested to accommodate the Afrotropical Trichopolydesmidae, arranged below in alphabetic order and followed by their brief descriptions and gonopodal characters (Figs 1, 2), as well as provenance, all this derived from the original descriptions of their type species alone.

Bactrodesmus Cook, 1896

Type-species. *Bactrodesmus claviger* Cook, 1896, by subsequent monotypy; Liberia.

The genus was first proposed as a *nomen nudum* (Cook 1896a), but then properly typified (Cook 1896b). The sole useful information contained in the original description of *B. claviger* concerns its small size (7 mm long, 1 mm wide), typically micropolydesmid facies (small paraterga, large and clubbed tergal setae arranged in three transverse rows etc.), strongly enlarged gonocoxae that fully conceal the telopodites and, above all, male legs 2, especially their tibiae, greatly enlarged compared to others (Cook 1896b). No number of body segments has been given.

Dendrobrachypus Verhoeff, 1941

Type-species. *Dendrobrachypus pusillus* Verhoeff, 1941, by monotypy; Fernando Po.

Twenty segments (male, female), body length 5–5.5 mm. Male head without epicranial modifications. Paraterga moderate, tergal setae medium-sized and bacilliform.

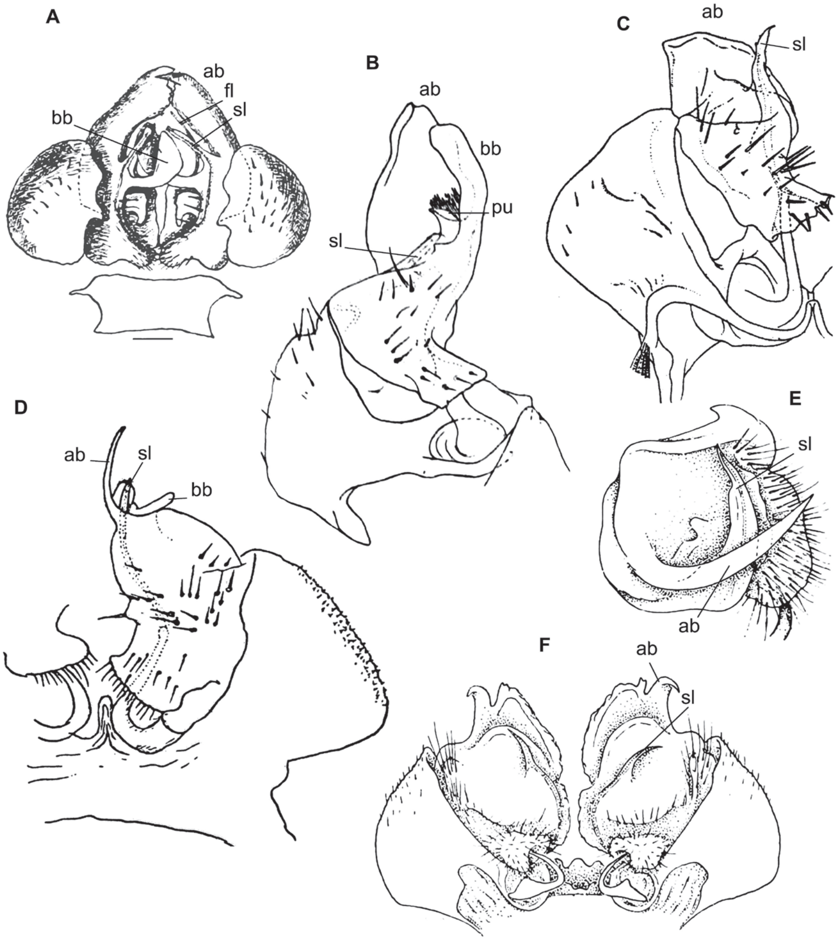

Figure 1. Gonopods of the type species of some African Trichopolydesmidae. **A** *Sphaeroparia minuta* Attems, 1909 (after Attems 1909) **B** *Sphaeroporia* (*Megaloparia*) *lignivora* Brolemann, 1920 (after Brolemann 1920) **C** *Sphaeroparia* (*Physetoparia*) *imbecilla* Brolemann, 1920 (after Brolemann 1920) **D** *Elgonicola jeanneli* Attems, 1939 (after Attems 1939) **E, F** *Mabocus granulifer* Chamberlin, 1951 (after Kraus 1958). Reproduced not to scale. Abbreviations: **ab** apical branch of telopodite, **bb** basal branch of telopodite, **fl** flagellum, **lo** lobe, **sl** solenomere, **pu** pulvillus.

Gonopodal coxa very large, concealing most of telopodite; the latter's apical part with only one branch (ab); seminal groove simple and rather long, ending subapically on a long solenomere (sl) (Figure 2D).

Eburodesmus Schubart, 1955

Type-species. *Eburodesmus erectus* Schubart, 1955, by original designation; Guinea, Côte d'Ivoire.

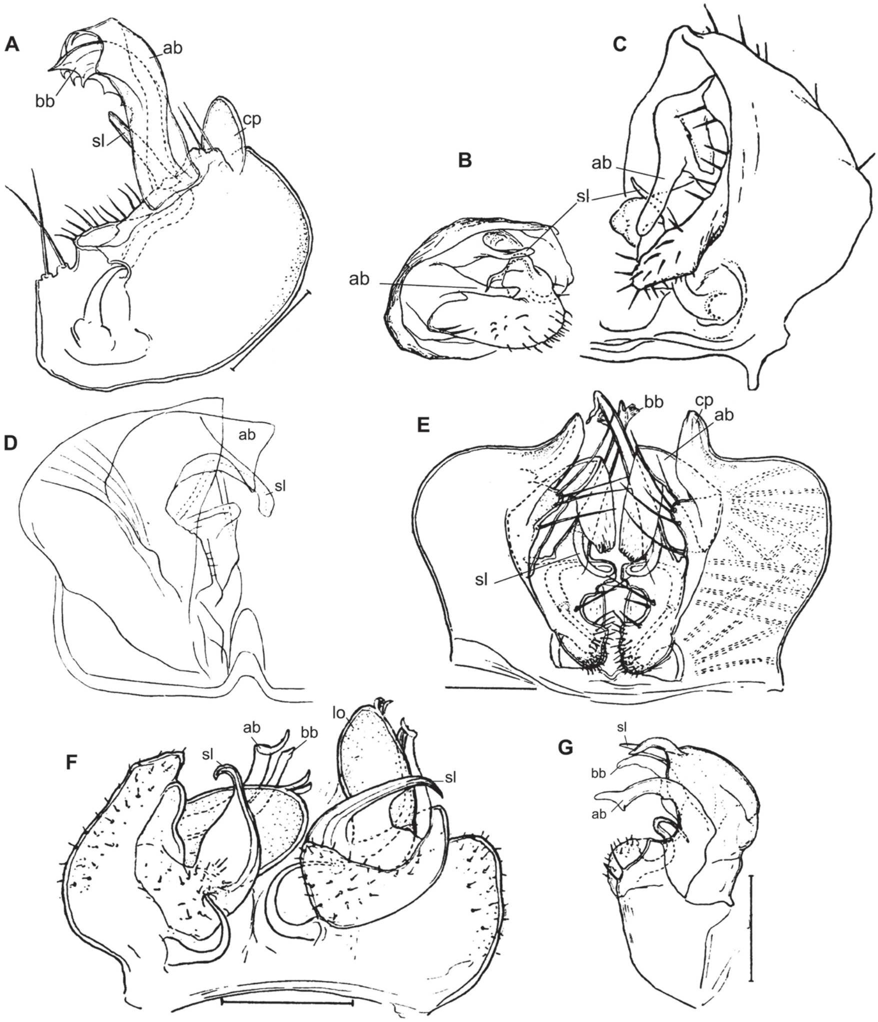

Figure 2. Gonopods of the type species of some African Trichopolydesmidae. **A** *Heterosphaeroparia-villiersi* Schubart, 1955 (after Schubart 1955) **B, C** *Mecistoparia lophotocrania* Brolemann, 1926 (after Brolemann 1926) **D** *Dendrobrachypus pusillus* Verhoeff, 1941 (after Verhoeff 1941) **E** *Eburodesmus erectus* Schubart, 1955 (after Schubart 1955) **F, G** *Hemisphaeroparia cumbula* Schubart, 1955 (after Schubart 1955). Reproduced not to scale. Abbreviations: **ab** apical branch of telopodite, **bb** basal branch of telopodite, **cp** coxal process, **lo** lobe, **sl** solenomere.

Twenty segments (male, female); body length; 5.5–6 mm. Male head without epicranial modifications. Paraterga modest, tergal setae medium-sized and bacilliform. Gonopodal coxae very large; gonocoel very deep, each coxa apically with an evident process (cp) directed mesally; seminal groove forming a very clear loop before running onto a long and simple solenomere (sl); apical branch (ab) of telopodite forming a strong finger directed basad; middle part with a long straight process (bb) directed apicad (Figure 2E).

Elgonicola Attems, 1939

Type-species. *Elgonicola jeanneli* Attems, 1939, by original designation; Uganda.

Twenty segments (male, female); body length 8 mm. Male head without epicranial modifications. Paraterga moderate, tergal setae very long, slender and bacilliform. Gonopodal coxae very large, gonocoel deep, concealing most of telopodite; seminal groove short and straight, ending subapically on a short solenomere (sl); apical part of telopodite with two small branches (ab and bb), one of which (ab) a slender hook (Figure 1D).

Hemisphaeroparia Schubart, 1955

Type-species. *Hemisphaeroparia cumbula* Schubart, 1955, by original designation; Guinea, Côte d'Ivoire.

Twenty segments (male, female); body length 3.5–4 mm. Male head without epicranial modifications. Paraterga moderate, tergal setae medium-sized and bacilliform. Gonopodal coxae very large, gonocoel deep, concealing most of telopodite; seminal groove short, ending on a simple finger-shaped solenomere (sl); telopodite basically tripartite, with a large, central, sac-shaped part and two slightly higher, subflagelliform, adjacent, lateral branches (ab and bb) (Figure 2F, G).

Heterosphaeroparia Schubart, 1955

Type-species. *Heterosphaeroparia villiersi* Schubart, 1955, by original designation; Guinea, Côte d'Ivoire.

Twenty segments (male, female); body length 5–6 mm. Male head without epicranial modifications. Paraterga relatively well developed, tergal setae long and bacilliform. Gonopodal coxae large, each with an evident apical process (cp) laterally, gonocoel shallow, leaving most of telopodite exposed; seminal groove rather short and straight, ending on a simple, long, finger-shaped solenomere (sl); telopodite basically bipartite with two subequal, high, ribbon-shaped processes/branches (ab and bb) distal to solenomere (Figure 2A).

Mabocus Chamberlin, 1951

Type-species. *Mabocus granulifer* Chamberlin, 1951, by original designation; Angola.

Twenty segments (male, female); body width 0.6 mm. Male head with a central, boletiform, epicranial projection. Paraterga relatively well developed, tergal setae medium-sized, bacilliform to slightly clavate. Male coxae moderately large, gonocoel relatively small; telopodite well exposed, distal part with a single apical branch (ab) subdivided into two on top. Both seminal groove and solenomere (sl) short and simple, the latter spiniform (Figure 1E, F). Poorly described originally (Chamberlin 1951), properly redescribed from the holotype by Kraus (1958).

Mecistoparia Brolemann, 1926

Type-species. *Mecistoparia lophotocrania* Brolemann, 1926, by original designation; Dahomey.

Nineteen segments (male, female); body length 3–3.5 mm. Male head without epicranial modifications. Paraterga moderate; setae long and bacilliform. Gonopodal coxae very strongly developed; gonocoel very deep, almost fully concealing telopodite; seminal groove very short and simple, ending on a long simple solenomere (sl); telopodite with a long apical finger-shaped branch (ab) directed basaly and a shorter finger-shaped branch (bb) parabasally; telopodite bipartite (Figure 2B, C).

Megaloparia Brolemann, 1920

Type-species. *Sphaeroparia* (*Megaloparia*) *lignivora* Brolemann, 1920, by subsequent designation by Attems (1940); Kenya.

Twenty segments (male, female); body length 6.5 mm. Male head without epicranial modifications. Paraterga moderate, tergal setae very short. Gonopodal coxae unusually small, leaving telopodite mostly exposed and suberect; telopodite bipartite, seminal groove short and simple, ending on a short solenomere (sl) with a hairy pulvillus squeezed between both branches ab and bb (Figure 1B).

Physetoparia Brolemann, 1920

Type-species. *Sphaeroparia* (*Physetoparia*) *imbecilla* Brolemann, 1920, by monotypy; Kenya.

Body length 7.5 mm; paraterga moderate. Male head without epicranial modifications. Gonopodal coxae very large; gonocoel deep, containing most of telopodite; both solenomere (sl) and seminal groove short, apical branch (ab) very large (Figure 1C).

Sphaeroparia Attems, 1909

Type-species. *Sphaeroparia minuta* Attems, 1909, by monotypy; Tanzania.

Nineteen segments (male, female); body length 6–6.5 mm. Genae of male much larger than those of female. Male head without epicranial modifications. Paraterga moderate; setae medium-sized and bacilliform. Gonopodal telopodite tripartite; both coxae and gonocoel relatively small; telopodite well-exposed; distalmost branch (ab) particularly large and high, with an apical tooth; seminal groove relatively short and simple, ending on a long simple solenomere (sl); parabasal (= prefemoral) part as usual, clearly setose; middle part a large scapuliform lobe (bb) with a long and thin flagellum (fl) near base (Figure 1A).

Trichozonus Carl, 1905

Type-species. *Trichozonus escalerae* Carl, 1905, by monotypy; Equatorial Guinea.

Female. 20 segments, body length 8 mm; paraterga modest, tergal setae long and bacilliform. Like *Bactrodesmus*, this genus remains too poorly documented to consider in our following analysis.

The above brief accounts are given to reiterate the foundations of the previous classification and to offer a new one below. The classification developed by Mauriès and Heymer (1996) in their review of the African Trichopolydesmidae (= Fuhrmannodesmidae) cannot be accepted because it totally lacks any evolutionary perspective. These authors themselves admit their approach as being "bastard" and overly lumping, as they placed all species but one (*Bactrodesmus*, dubious) in the single genus *Sphaeroparia*, within which they accepted six subgenera and suggested several synonymies.

Golovatch (1992, 1994) provided an evolutionary scenario for the genera of Trichopolydesmidae (= Fuhrmannodesmidae) known from South America, accepting as the basalmost those genera showing rather small, narrowly fused[1], subglobose gonopodal coxae that form no significant gonocoel in which to hinge the largely exposed, usually rather complex and elongate telopodites. Amongst the Afrotropical trichopolydesmids such are the genera *Elgonicola*, *Heterosphaeroparia*, *Megaloparia*, and *Sphaeroparia* (Figs 1D, 2A, 1B, and 1A, respectively). At the opposite end which obviously represents the evolutionary summit are such genera as *Dendrobrachypus*, *Eburodesmus*, and *Mecistoparia* (Figs 2D, E and 2B-C, respectively). Their gonopodal coxae are especially voluminous and inflated laterad; the particularly deep gonocoel is capable of concealing entire or nearly entire telopodites. Sometimes the coxa shows a rather conspicuous apicolateral process or lobe, this being suberect (*Heterosphaeroparia*, Figure 2A, cp) or directed more or less mesally (*Eburodesmus*, Figure 2E, cp). Schubart (1955) created his *Eburodesmus*, based on such evident and more or less mesally directed coxal processes (Figure 2E, cp), but we think this may be only a species-level character occasionally present also in distinctly more basal taxa, e.g., *Heterosphaeroparia* (Figure 2A, cp). A series

[1] Shear and Reddell (2017) have recently suggested to consider the polydesmidan gonopodal coxae fused only when the medial fusion is as strong as that observed in the Dalodesmidea. However, the gonocoxae in the Polydesmidea are also fused not only basally to their sternum, but also medially through two small chitinous flaps, each typically supporting two strong setae. However slight, this is also fusion, a condition which may be termed "narrowly fused".

of transitions can be seen between the two extremes, e.g., in *Heterosphaeroparia*, *Elgonicola* or *Hemisphaeroparia*, when 1–3 prominent branches project well beyond the coxal margin, while the telopodite is mainly deeply sunken inside the coxa. Typically there are 2+2 particularly strong setae near the place of central fusion of both coxae, while their lateral surfaces are normally more or less clearly granulate/alveolate and setose.

The cannula in Afrotropical Trichopolydesmidae is invariably medium-sized, tube-shaped, strongly curved, long, and slender, its tip entering the densely setose, funnel-shaped, "prefemoral" part of the telopodite which extends from base to apex. The seminal groove is mostly rather short and straight, usually running on the mesal side to end on a simple, more or less finger- or spine-shaped, sometimes retrorse solenomere (sl). In a few cases, the solenomere ends near a kind of hairy pulvillus or shows a tooth at its base. However, there is a remarkable exception, when the seminal groove makes a distinct loop before proceeding onto a prominent solenomere (e.g., *Eburodesmus*, Figure 2E). Such situations seem to imply telopodite torsion. The length of a solenomere is usually barely more than species-specific, but the course of the seminal groove is definitely a generic-level character, as can be seen in Neotropical or Southeast Asian Trichopolydesmidae (Golovatch 1992, 1994, Golovatch et al. 2014, Golovatch and VandenSpiegel 2016).

The gonopodal telopodite is typically helmet- or boat-shaped. At the apicolateral end which is opposite to the "prefemoral" funnel there is a group of partly especially stiff setae usually extending basad across or over most of the funnel. Variations in the shape of the remaining parts of the telopodite are especially prominent. Among the most common outgrowths or processes of the telopodite we choose to denominate the following. A unipartite telopodite which shows only a single prominent branch, apical in position (ab), is observed in *Dendrobrachypus*, *Mabocus*, *Mecistoparia* and *Physetoparia* (Figs 2D, 1E-F, 2B–C and 1C, respectively). Bi- or tripartite telopodites are more usual, sometimes also supplied with evident central lobes (lo). The branch which is the closest to the apex is denominated an apical branch (ab), while that lying the closest to the basal part is termed a basal branch (bb). If there is another branch located between ab and bb, this is a medial branch (mb). Two of or all three branches are often strongly adjacent to each other. A few species groups may be provisionally outlined based on the general conformation of the gonopodal telopodites.

Two different general trends can be observed in the evolution of the gonopods in Afrotropical Trichopolydesmidae. While the coxa tends to grow and develops an increasingly prominent gonocoel, the originally relatively complex and largely exposed telopodite, at least in some cases, seems to shrink gradually and often becomes simplified. Indeed, the presumably basal taxa with particularly small gonocoxae (e.g., *Sphaeroparia*, *Elgonicola* or *Megaloparia*, Figs 1A, 1D and 1B, respectively) show complex apical structures on telopodites. In cases like *Eburodesmus* (Figure 2E) and *Heterosphaeroparia* (Figure 2), it is the coxal apicolateral process (cp) that takes the protective function to secure the still complex and exposed parts of the telopodite. Usually, when the outgrowths are mostly concealed and little exposed beyond the coxa, they are particularly few and sometimes reduced just to one branch (e.g., *Dendrobrachypus*, Figure

2D or *Mecistoparia*, Figure 2B, C). Interestingly, the single species of *Sphaeroparia*, *S. simplex* Golovatch, 2013, described from the Balkans and several Greek islands (Golovatch 2013), i.e., well beyond the Afrotropical realm, shows voluminous gonopodal coxae and especially simple and small telopodites, these latter being mostly concealed inside the gonocoel. Now that *Sphaeroparia* receives a clear definition (see below) and joins the basal group of genera with still small gonocoxae and complex and well-exposed telopodites, the identity and generic allocation of *S. simplex* must be revised (Vagalinski et al., in preparation).

When a delicate solenomere is left well-exposed (Figs 1C, 2D, F-G), it appears to always be protected by adjacent stronger structures serving as a solenophore. The number and shapes of such accessory outgrowths (processes and lobes) varies between species, but they are always few (1–3) and tend to be little exposed to fully concealed or even absent in more advanced genera.

Such are the main guidelines, all based solely on gonopodal anatomy, to follow in order to obtain new generic delimitations arranged according to an increasing complexity of the coxae, combined with a decreasing complexity of the telopodites. Somatic characters such as the number of body segments (19 in the male or in both sexes, or 20 in both sexes), the pore formula (always normal, but can be a little abbreviated on the last 1–2 segments before the telson: 5, 7, 9, 10, 12, 13, 15–17(18,19)), the degree of development of paraterga (usually moderate, often small, but never really well-developed and strongly flattened dorsally), the position of the ozopores (usually open flush dorsally near the caudal corner of pore-bearing paraterga), the shape of tergal setae (short and clavate to very long and bacilliform), the presence of modifications on male legs 2 (enlarged in *Bactrodesmus*) and on the male head (ranging sporadically from nothing to a strong, central bulge or a mushroom-like or bulbous tubercle), they all are considered here as species-specific. This situation agrees with general wisdom derived from other tropical faunas (Golovatch 1994, Golovatch et al. 2014).

A somatic character that deserves special mention is the unusually strongly developed peri-spiracular structure on segment 2. In all new species described below, the spiracle is located on a high finger with a complex tip placed next to coxa 2 (Figs 11K, 21J-L). Is this a generic feature that characterizes *Hemisphaeroparia*? Could Cook (1896b) have mistaken the spiracle for leg 2 in his *Bactrodesmus*?

The generic reclassification presented below considers only the type species, leaving aside the other component species and their allocations to our next paper on Afrotropical Trichopolydesmidae (Golovatch et al., in preparation). Two nominal genera, *Bactrodesmus* and *Trichozonus*, are dubious and are for the time being to be discarded from further consideration, because their gonopodal characters remain unknown. Whereas *B. claviger* is generally possible to revise or recognize based either on type or topotypic material from Liberia, since male legs 2 of this species are said to be conspicuously enlarged (Cook 1896b), the identity of *T. escalerae* is bound to remain obscure (Carl 1905) until a male topotypic sample from Fernando Po becomes available for study.

Genus *Sphaeroparia* Attems, 1909

Type-species: *Sphaeroparia minuta* Attems, 1909

Synonym: *Megaloparia* Brolemann, 1920, synonymized by Mauriès and Heymer (1996: 167) (type-species: *Sphaeroparia lignivora* Brolemann, 1920)

Diagnosis. Both gonopodal coxae and gonocoel relatively small; telopodite strongly exposed, complex, with at least two strong branches (ab and bb, the latter may be subdivided into two, including fl); seminal groove short and simple, solenomere on caudal face, shorter or longer, spiniform, with or without a pulvillus (pu) near end (Figure 1A).

Remark. This genus is presumably among the basalmost representatives of Afrotropical Trichopolydesmidae.

Genus *Physetoparia* Brolemann, 1920, stat. n.

Type-species. *Sphaeroparia imbecilla* Brolemann, 1920

Synonyms. *Elgonicola* Attems, 1939, syn. n. (type-species: *Elgonicola jeanneli* Attems, 1939); *Mabocus* Chamberlin, 1951, syn. n. (type-species: *Mabocus granulifer* Chamberlin, 1951); *Heterosphaeroparia* Schubart, 1955, syn. n. (type-species: *Heterosphaeroparia villiersi* Schubart, 1955)

Diagnosis. Both gonopodal coxae and gonocoel medium-sized; telopodite usually less strongly exposed and less complex (when strongly exposed, then with a protective coxal apicolateral process), with 1–2 strong branches (ab or ab and bb); seminal groove short and simple, solenomere shorter or longer, sometimes exposed, subspiniform (Figs 1C, D, E–F, 2A).

Remarks. This genus is among the more advanced representatives of Afrotropical Trichopolydesmidae. Mauriès and Heymer (1996: 168) regarded it as a subgenus of *Sphaeroparia*, with *Hemisphaeroparia* and possibly also *Dendrobrachypus* and *Trichozonus* as synonyms of *Physetoparia*.

Genus *Mecistoparia* Brolemann, 1926

Type-species. *Mecistoparia lophotocrania* Brolemann, 1926

Synonym. *Dendrobrachypus* Verhoeff, 1941, syn. n. (Type-species: *Dendrobrachypus pusillus* Verhoeff, 1941

Diagnosis. Both gonopodal coxae and gonocoel medium-sized; telopodite usually less strongly exposed and complex (when strongly exposed, then with a protective coxal apicolateral process), with 1–2 strong branches (ab or ab and bb); seminal groove short and simple, solenomere shorter or longer, sometimes exposed, subspiniform (Figs 1B, 2D).

Remarks. This genus is among the more advanced representatives of Afrotropical Trichopolydesmidae. Mauriès and Heymer (1996: 168) regarded it as a subgenus of *Sphaeroparia*.

Genus *Eburodesmus* Schubart, 1955, stat. revalid.

Type-species. *Eburodesmus erectus* Schubart, 1955

Diagnosis. Both gonopodal coxae and gonocoel very large; telopodite only barely exposed, but complex (this possibly being in correlation that each coxa has a protective apicolateral process), with two strong branches (ab and bb); seminal groove long and forming a conspicuous loop before moving onto a caudally located solenomere (Figure 2E).

Remarks. This genus is among the most advanced representatives of Afrotropical Trichopolydesmidae. Mauriès and Heymer (1996: 168) regarded it as a subgenus of *Sphaeroparia*.

Genus *Hemisphaeroparia* Schubart, 1955, stat. revalid.

Type-species. *Hemisphaeroparia cumbula* Schubart, 1955

Diagnosis. Both gonopodal coxae and gonocoel large to very large; telopodite usually moderately to barely exposed, but complex, with 1–3 strong branches (ab and/or bb, or ab, mb and bb, occasionally also with a lobe more basally), only sometimes with a single particularly strongly exposed branch (ab); seminal groove mostly short, solenomere only sometimes absent, but usually finger-shaped and located caudomesally (Figure 2F, G).

Remarks. This genus is among the most advanced representatives of Afrotropical Trichopolydesmidae. Mauriès and Heymer (1996: 168) regarded it as a synonym of *Physetoparia*. All trichopolydesmid species treated below from Cameroon appear to belong to this genus, albeit forming a few species groups.

Based on the numerous new and one old species from Cameroon treated below, the diagnosis of *Hemisphaeroparia* can be updated as follows.

Updated diagnosis. Body with 19 or 20 segments. Male epicranial modifications present or absent. Spiracle next to coxa 2 conspicuously enlarged, finger- or mushroom-shaped and with a complex tip. Both gonopodal coxae and gonocoel large to very large; telopodite usually moderately to barely exposed, but complex, with 1–3 strong branches (ab and/or bb, or ab, mb and bb, occasionally also with a lobe more basally), only sometimes with a single particularly strongly (ab) or considerably (bb) exposed branch; seminal groove mostly short, solenomere only sometimes absent, but usually transverse (= directed anteriorly), finger-shaped or spiniform, and located caudomesally.

Species descriptions

Hemisphaeroparia zamakoe **sp. n.**

http://zoobank.org/1D9169D7-FF64-46F0-92BC-D69AED8802CF

Figs 3, 4, 28A

Type material. Holotype ♂ (MRAC 22735), Cameroon, Center Region, Zamakoe Forest, 03°33'N, 011°31'E, 815 m a.s.l., forest, 20.IX.2014, leg. A.R. Nzoko Fiemapong and C. Oumarou Ngoute.

Paratypes. 6 ♂♂ (MRAC 22736), 1 ♂ (SEM, MRAC 22737), same locality, 18.IV.2015; 1 ♂ (without gonopods, either lost or mounted on slide) (MRAC 22738), 1 ♂ (ZMUM), same locality, 19.IV.2014; 1 ♂ (ARNF), same locality, 21.III.2015, all leg. A.R. Nzoko Fiemapong and C. Oumarou Ngoute.

Diagnosis. Differs from all other species of the genus by the presence of a boletiform epicranial tubercle (♂), coupled with unusually densely setose gonopodal telopodites which are deeply sunken inside a large gonocoel and show only two, slender, contiguous, little-exposed branches (ab, bb), both followed by a small, round, fully concealed lobe (lo) more basally (Figure 4).

Name. To emphasize the type locality; noun in apposition.

Description. Length of holotype ca. 5 mm (♂), width of midbody pro- and metazonae 0.4 and 0.6 mm (♂), respectively. Length of paratypes 5–7 mm, width of midbody pro- and metazonae 0.4–0.5 and 0.6–0.7 mm (♂), respectively. Coloration in alcohol uniformly pallid (Figure 28A).

Body with 20 segments. Tegument very delicately micro-alveolate, mainly slightly shining. Head very densely micropilose, with a very distinct, mushroom-like, frontal tubercle (♂) (Figure 3D, G, K). Interantennal isthmus almost two times as large as diameter of antennal socket. Antennae long and strongly clavate, reaching back to segment 2 or 3 when stretched dorsally (♂). In length, antennomere 3 = 6 > 2 = 5 > 1 = 4 =7; antennomere 6 the largest, antennomeres 5 and 4 each with a distinct, round, distodorsal field of sensilla. In width, collum < head < segments 2–4 < 5–16; thereafter body gradually tapering towards telson. Collum ellipsoid, transversely oval, like all following metaterga with three transverse, regular rows of setae. Tergal setae medium-sized, each ca. 1/5 as long as metatergum, bacilliform and longitudinally ribbed (Figure 3A-C, G-J, L, M), always 3+3 in each row on postcollum metaterga. An extremely faint transverse sulcus visible behind first row on some metaterga. Dorsum invariably regularly convex. Paraterga medium-sized, set at around upper 1/3 of metazonae (Figure 3A-C, L), visible starting with collum, often slightly upturned caudally, faintly, but regularly rounded and bordered, lateral incisions absent. Caudal corner of paraterga always rounded, drawn increasingly back, but reaching beyond rear tergal margin only on segments 17 and 18 (Figure 3I). Pore formula normal, only slightly abbreviated: 5, 7, 9, 10, 12, 13, 15–18. Ozopores small, round, opening flush dorsally near caudal corner of poriferous paraterga. Stricture between pro- and metazonae wide, shallow. Lim-

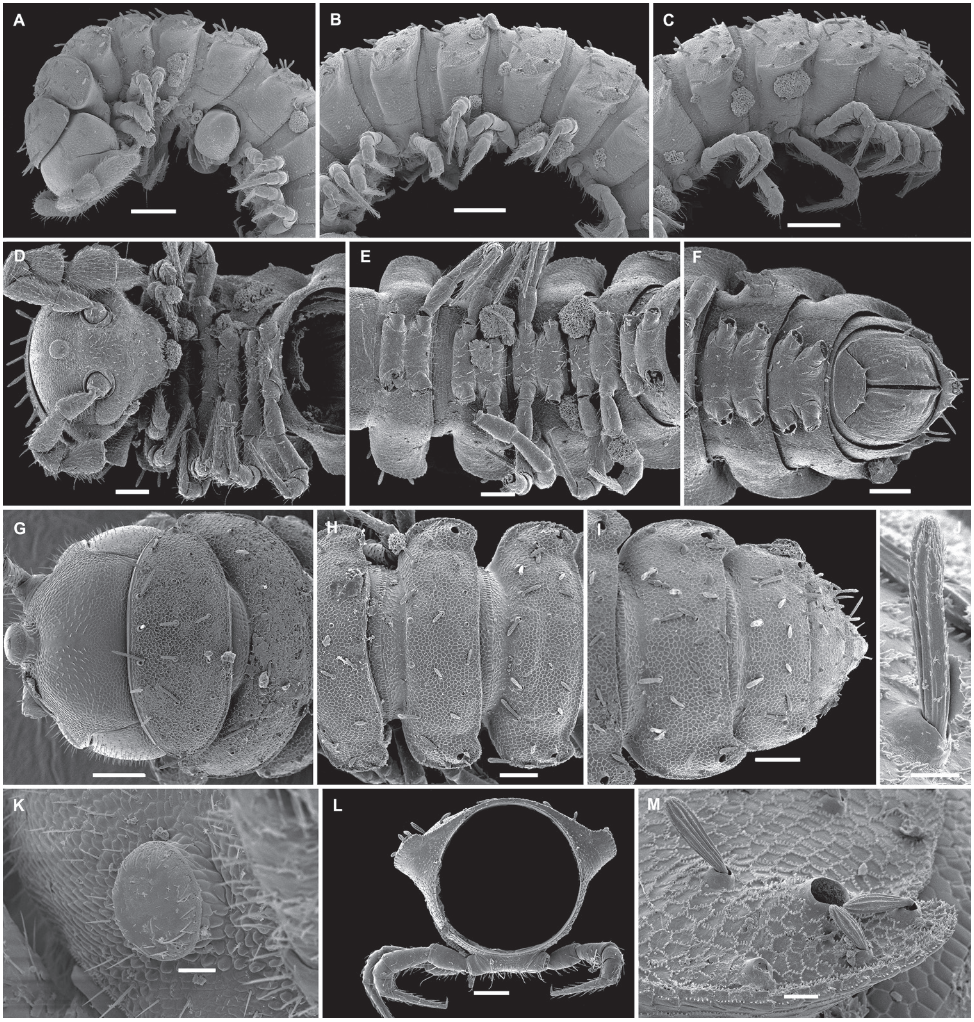

Figure 3. *Hemisphaeroparia zamakoe* sp. n., SEM micrographs of ♂ paratype **A, D, G** anterior part of body, lateral, ventral and dorsal views, respectively **B, E, H** midbody segments, lateral, ventral and dorsal views, respectively **C, F, I** posterior part of body, lateral, ventral and dorsal views, respectively **J** tergal seta, lateral view **K** epicranial tubercle, subdorsal view **L** midbody segment, caudal view **M** midbody paratergum, lateral view. Scale bars: 0.1 mm (**A–I, L**), 0.05 mm (**K, M**), 0.01 mm (**J**).

bus very finely microspiculate. Segment 2 with an unusually prominent, tuberculiform and apically complex spiracle on each side. Pleurosternal carinae traceable as very faint lines on most segments (Figure 3A–C). Epiproct short, conical, flattened dorsoventrally. Hypoproct semi-circular, setae strongly separated and borne on minute knobs.

Sterna wide, unmodified, setose. Legs rather long and slender, ca. 1.1–1.2 times as long as midbody height; in length, tarsus > femur > coxa = prefemur = postfemur = tibia, the latter with a particularly long, tactile seta apicodorsally. Tarsal brushes present (♂).

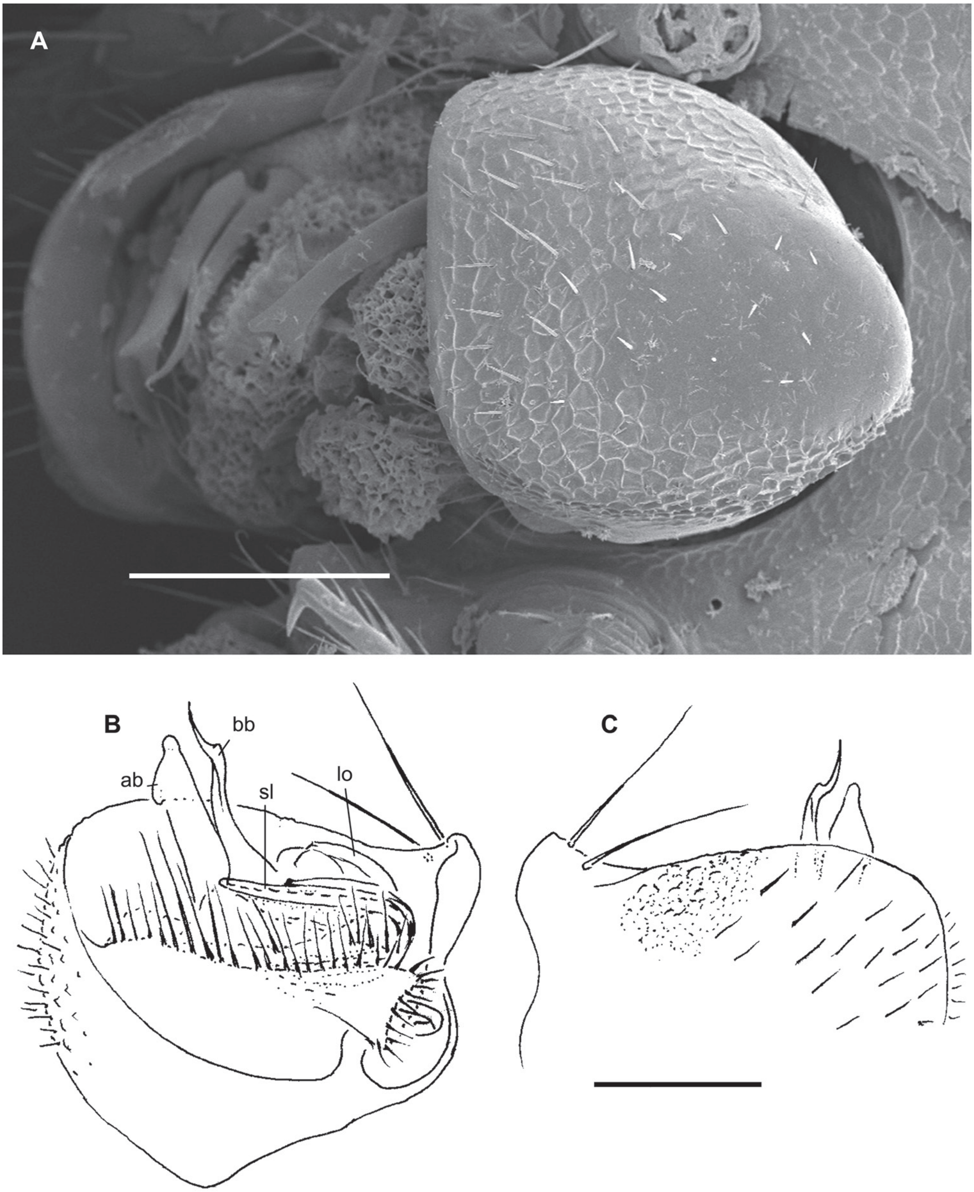

Figure 4. *Hemisphaeroparia zamakoe* sp. n., ♂ paratypes **A** SEM micrograph of both gonopods in situ, ventrolateral view **B, C** right gonopod, mesal and lateral views, respectively. Scale bars: 0.1 mm. Abbreviations: **ab** apical branch of telopodite, **bb** basal branch of telopodite, **lo** lobe, **sl** solenomere.

Gonopods (Figure 4) with large, subglobose, clearly exposed, alveolate coxae, these rather densely setose nearly throughout, fused medially at base, each carrying two very long setae near place of fusion. Telopodites almost fully concealed inside a very large gonocoel, each very densely setose, with only two branches (ab, bb), both contiguous and only slightly exposed beyond coxa, followed by a small round lobe (lo) more basally. Seminal groove short, moving onto a long, subspiniform solenomere (sl), in mesal view the latter subtransverse and directed apicolaterad.

Hemisphaeroparia bangoulap sp. n.

http://zoobank.org/CA5FE0D5-B0A6-4C48-9443-C51A3B69B946
Figs 5, 6, 28B

Type material. Holotype ♂ (MRAC 22739), Cameroon, West Region, Bangoulap, sacred forest (slightly disturbed), 6°00'N, 10°34'E, 13.X.2017, leg. A.R. Nzoko Fiemapong.

Paratypes. 2 ♂ (both without gonopods, either lost or mounted on slide)(MRAC 22740), 1 ♂ (SEM, MRAC 22741), same locality, together with holotype.

Diagnosis. Differs from other species of the genus by the presence of a boletiform epicranial tubercle (♂), coupled with well-exposed gonopodal telopodites that show not only slender branches ab and bb, but each also a well-expressed lobe (lo) with an unusually deep transverse gutter (g) with very strongly thickened walls at the base, as well as a vestigial solenomere (sl) with a remarkable process (t) near its base (Figure 6).

Name. To emphasize the type locality; noun in apposition.

Description. Length of holotype ca. 6 mm (♂), width of midbody pro- and metazonae 0.5 and 0.7mm (♂), respectively. Length of paratypes 5.5–6 mm, width of midbody pro- and metazonae 0.5 and 0.7–0.75 mm (♂), respectively. Coloration in alcohol light pinkish to light pinkish brown, metaterga and antennae marbled red-brown. Prozonae, venter, and legs light yellowish grey (Figure 28B).

All other characters as in *H. zamakoe* sp. n., except as follows.

In width, collum < head < segment 3 < 3 = 4 < 5–16; thereafter, body gradually tapering towards telson.

Gonopodal telopodites more strongly exposed, less strongly setose, both main branches (ab, bb) longer, lobe (lo) also exposed, at base on lateral face with a prominent transverse gutter (g) with unusually strongly chitinized walls; branch bb sometimes subdivided into two flagelliform branchlets (Figure 6F, G). Seminal groove short, solenomere (sl) rudimentary, near its base with a conspicuous process (t).

Hemisphaeroparia spiniger sp. n.

http://zoobank.org/1AEABC29-FB50-4AB6-A625-2E81EAEBE3F3
Figs 7, 8, 28C

Type material. Holotype ♂ (MRAC 22742), Cameroon, Center Region, Yaounde I University campus, palm plantation, 03°53'N, 011°30'E, 860 m a.s.l., 20.III.2018, leg. A.R. Nzoko Fiemapong.

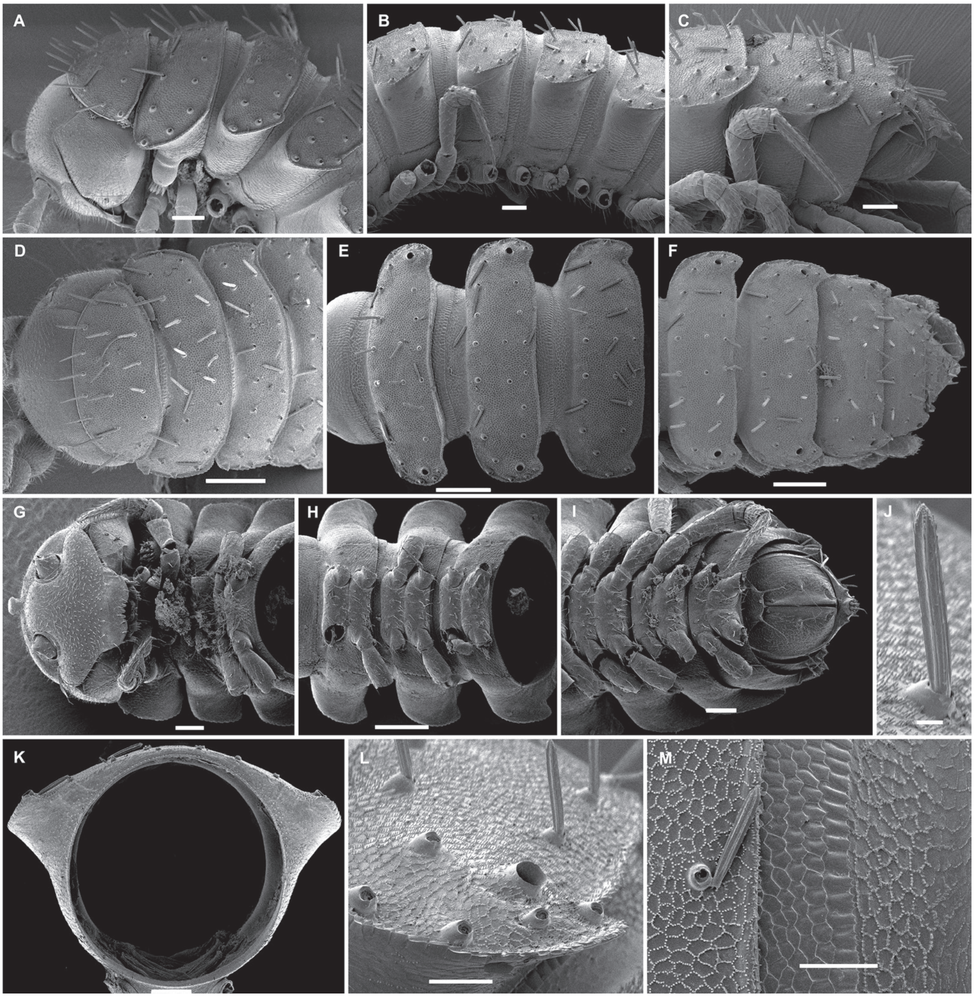

Figure 5. *Hemisphaeroparia bangoulap* sp. n., SEM micrographs of ♂ paratype **A, D, G** anterior part of body, lateral, dorsal and ventral views, respectively **B, E, H** midbody segments, lateral, dorsal and ventral views, respectively **C, F, I** posterior part of body, lateral, dorsal and ventral views, respectively **J** tergal seta, lateral view **K** midbody segment, caudal view **L** midbody paratergum, lateral view **M** tergal fine structure. Scale bars: 0.2 mm (**D–F, H**), 0.1 mm (**A–C, G, I, K**), 0.05 (**L, M**), 0.01 mm (**J**).

Paratypes: 9 ♂♂ (MRAC 22743), 1 ♂ (without gonopods)(MRAC 22744), 4 ♀♀ (MRAC 22745). 1 ♂ (SEM, MRAC 22746), same locality, 18.IV.2015; 12 ♂♂ (MRAC: 22747), 3 ♂♂ (ZMUM), 3 ♂♂ (UY1), same locality, 7.IV.2014, all leg. A.R. Nzoko Fiemapong.

Diagnosis. Differs from other species of the genus by the presence of a boletiform epicranial tubercle (♂), coupled with unusually densely setose gonopodal telopodites which are deeply sunken inside a large gonocoel and show not only two slender, little-

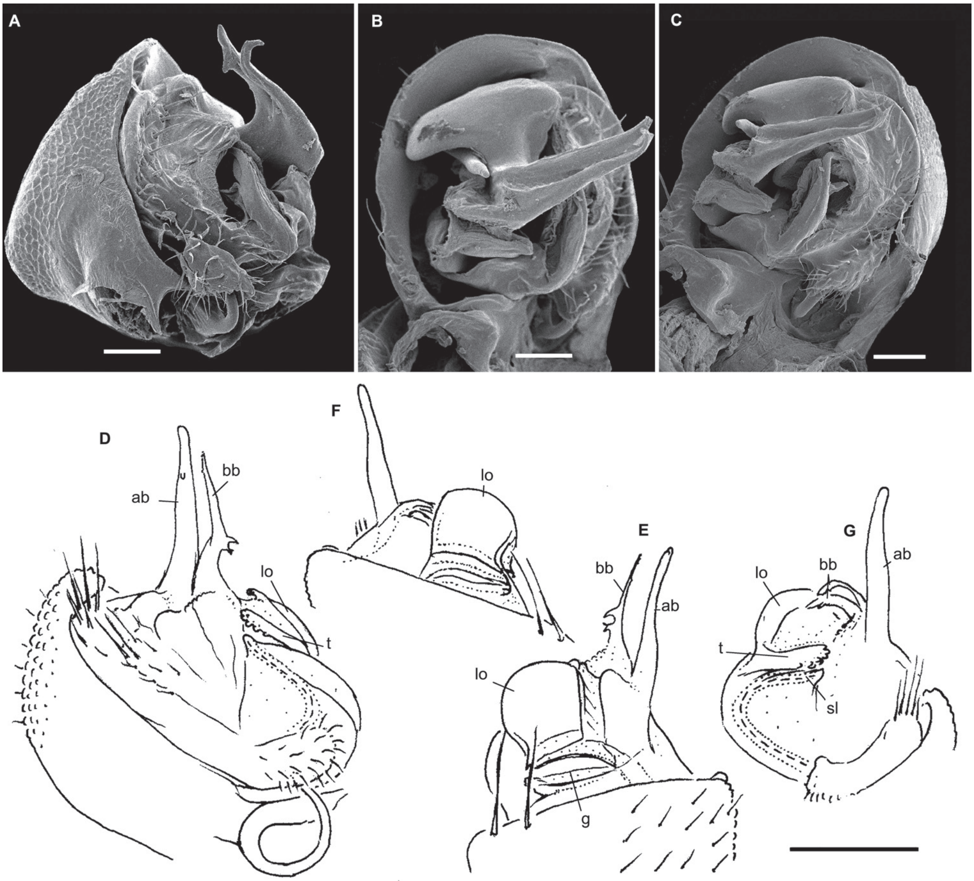

Figure 6. *Hemisphaeroparia bangoulap* sp. n., ♂ paratypes **A–C** SEM micrographs of right gonopod, mesal, ventromesal, subventromesal views, respectively **D–G** right (**D, E**) and left (**F, G**) gonopods, mesal, lateral, mesal and lateral views, respectively. Scale bars: 0.05 (**A–C**), 0.2 mm (**D–G**). Abbreviations: **ab** apical branch of telopodite, **bb** basal branch of telopodite, **g** gutter, **lo** lobe, **sl** solenomere, **t** process.

exposed branches (ab, bb), followed by a small, round, fully concealed lobe (lo) more basally, but also a conspicuous transverse spine arising on the lateral side near the base of ab and bb (Figure 8).

Name. To emphasize the long, transverse spine on the gonopodal telopodite; noun in apposition.

Description. Length of holotype ca. 7 mm (♂), width of midbody pro- and metazonae 0.5 and 0.8 mm (♂), respectively. Length of paratypes 5.5–6 mm (♂, ♀), width of midbody pro- and metazonae 0.4–0.5 and 0.6–0.7 mm (♂) or 0.6 and 0.8 mm (♀), respectively. Coloration of holotype generally marbled red-brown, legs nearly pallid (Figure 28C). Paratypes mostly yellowish to nearly pallid.

All other characters as in *H. zamakoe* sp. n., except as follows.

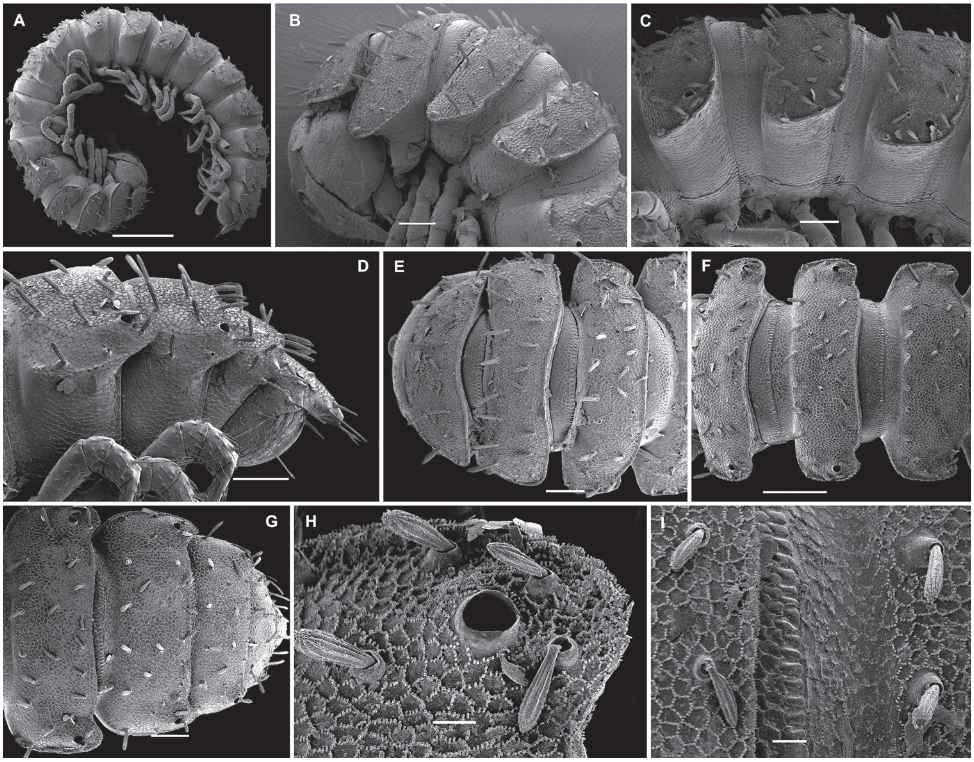

Figure 7. *Hemisphaeroparia spiniger* sp. n., SEM micrographs of ♂ paratype **A** habitus, lateral view **B, E** anterior part of body, lateral and dorsal views, respectively **C, F** midbody segments, lateral and dorsal views, respectively **D, G** posterior part of body, lateral and dorsal views, respectively **H** midbody paratergum, dorsolateral view **I** tergal fine structure. Scale bars: 0.5 mm (**A**), 0.1 mm (**B–G, J**), 0.02 mm (**H, I**).

Both ♂ and ♀ with 20 segments, but ♀ devoid of epicranial modifications. Antennae long and strongly clavate, reaching behind to segment 3 (♂) or 2 (♀) when stretched dorsally. In width, collum < head < segment 3 < 2 = 4 < 5–16; thereafter body gradually tapering towards telson. Tergal setae generally a little longer, ca. 1/3 to 1/4 as long as metatergum, bacilliform and ribbed (Figure 7A–C, G–J, L, M), arranged in two transvers rows on segments 2–7(8), thereafter in three rows (Figure 7A–G).

Gonopods (Figure 8) forming a deep gonocoel, telopodites only slightly exposed through distal halves of their two main branches (ab, bb), both contiguous over most of their length and both subequal in shape and length, followed by a low rounded lobe (lo). Basal part of telopodite densely setose throughout; distobasal part with a conspicuous transverse spine (sp) arising near base of ab and bb on lateral side, but hidden on both sides. Seminal groove short, moving onto a longer or shorter solenomere (sl) on mesal side.

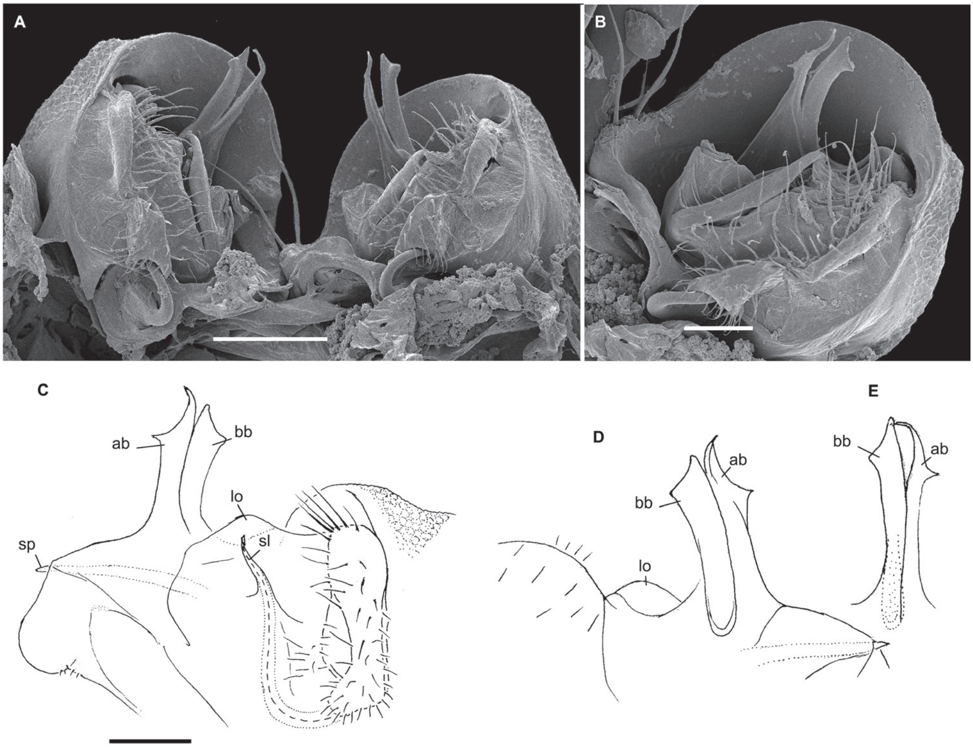

Figure 8. *Hemisphaeroparia spiniger* sp. n., ♂ paratypes **A** SEM micrographs of both gonopods in situ, caudal view **B** SEM micrograph of right gonopod, submesal view **C, D** right gonopod, mesal and lateral views, respectively **E** left gonod, branches ab and bb, mesal view. Scale bars: 0.1 mm (**A, C–E**), 0.5 mm (**B**). Abbreviations: **ab** apical branch of telopodite, **bb** basal branch of telopodite, **lo** lobe, **sl** solenomere, **sp** spiniform process.

Hemisphaeroparia ongot sp. n.

http://zoobank.org/4AF63B91-FAEF-4D7B-8E93-E4A1A32CDE69

Figs 9, 10, 28D

Type material. Holotype ♂ (MRAC 22748), Cameroon, Ongot Forest, 03°51'N, 011°25'E, ca. 810 m a.s.l., 26.III.2014, leg. A.R. Nzoko Fiemapong.

Paratypes: 1 ♂ (SEM, MRAC 22749), same locality, 27.IX.2014, leg. A.R. Nzoko Fiemapong; 1 ♀ (MRAC 22750), same locality, together with holotype.

Diagnosis. Differs from all other species of the genus by the presence of a boletiform epicranial tubercle (♂), coupled with the caudal corner of paraterga becoming increasingly strongly drawn behind the rear tergal margin starting with segment 13 and the gonopodal telopodites that are deeply sunken inside a large gonocoel and show three main branches (ab, mb, bb), all well-exposed and followed

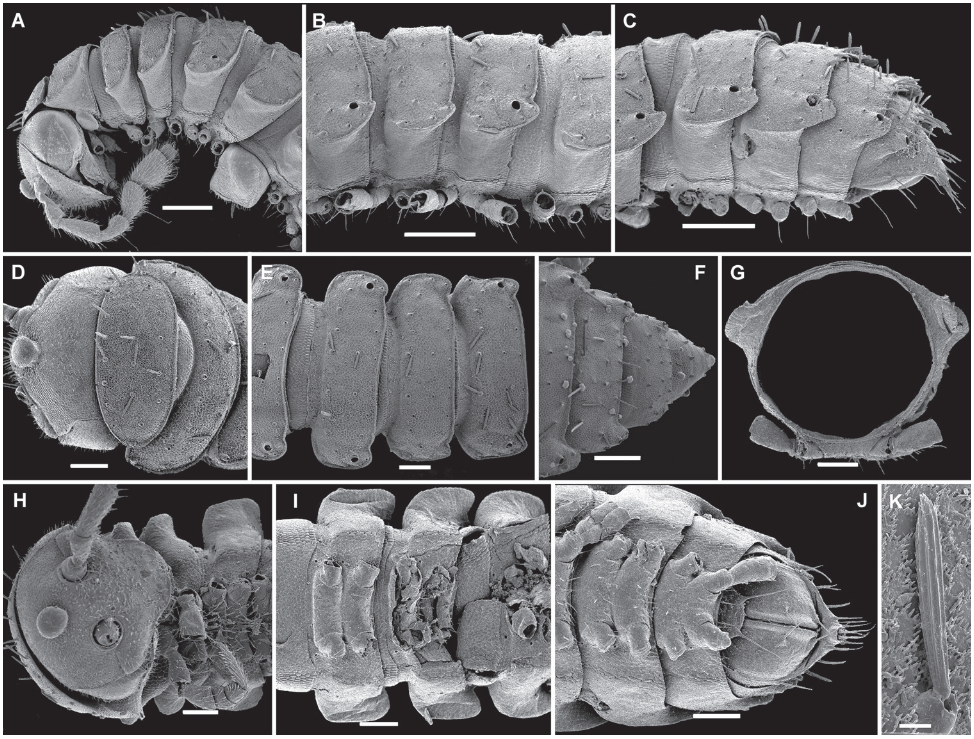

Figure 9. *Hemisphaeroparia ongot* sp. n., SEM micrographs of ♂ paratype **A, D, H** anterior part of body, lateral, dorsal and ventral views, respectively **B, E, I** midbody segments, lateral, dorsal and ventral views, respectively **C, F, J** posterior part of body, lateral, dorsal and ventral views, respectively G midbody segment, caudal view **K** tergal seta, lateral view. Scale bars: 0.2 mm (**A–C**), 0.1 mm (**D–J)**, 0.01 mm (**K**).

by no lobe, as well as a short solenomere with a tooth (t) at base of both sl and ab (Figure 10).

Name. To emphasize the type locality; noun in apposition.

Description. Length of holotype ca. 5.5 mm (♂), width of midbody pro- and metazonae 0.45 and 0.6 mm (♂), respectively. Length of paratypes (♀) 5.5 mm, width of midbody pro- and metazonae 0.55–0.7 mm (♂), respectively. Coloration in alcohol nearly pallid to very light yellow (Figure 28D).

All other characters as in *H. zamakoe* sp. n., except as follows.

Caudal corner of paraterga always rounded, drawn increasingly back, but reaching beyond rear tergal margin on segments 13–18 (Figure 9A–C).

Gonopodal telopodite (Figure 10) deeply sunken inside a deep gonocoel, densely setose at base with three main branches (ab, mb, bb) mostly exposed: bb the shortest and rounded on top, mb slightly curved and subtruncate, and ab the longest and also slightly curved. Seminal groove relatively long, ending on a short solenomere (sl) supplied with an evident tooth (t) at base of sl and ab.

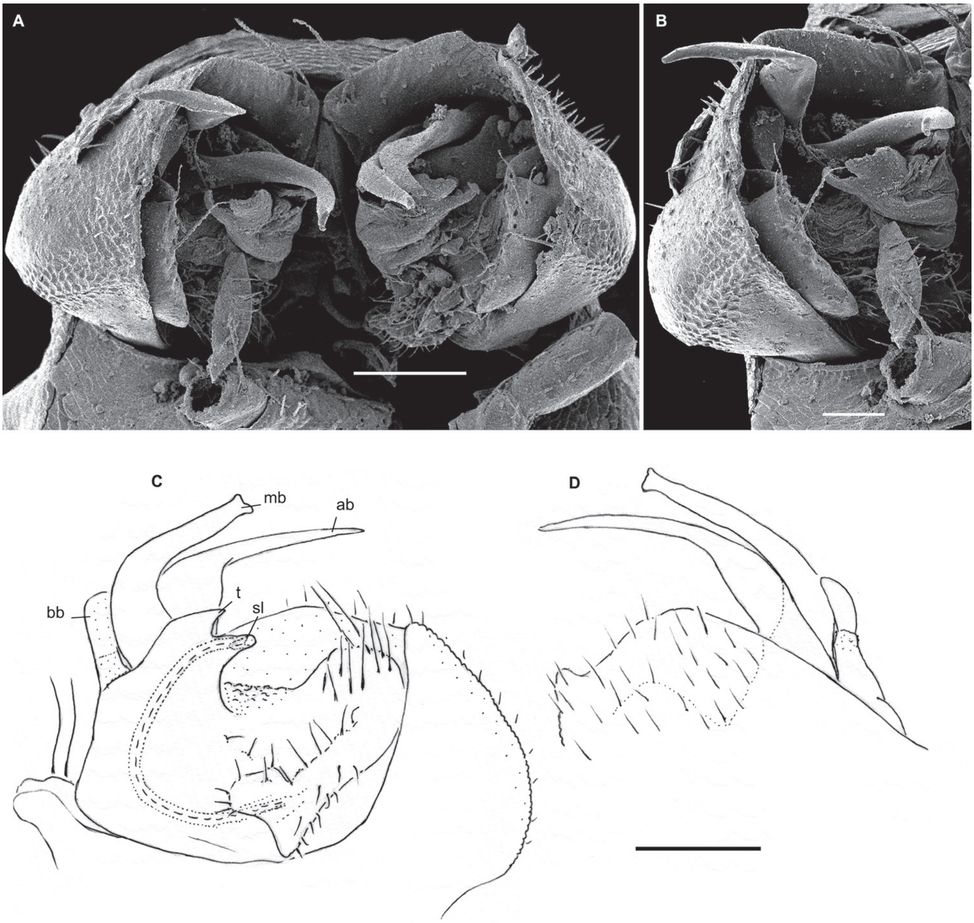

Figure 10. *Hemisphaeroparia ongot* sp. n. **A** ♂ paratype, SEM micrographs of both gonopods in situ, caudoventral view **B** ♂ paratype, SEM micrographs of right gonopod, caudoventral view **C, D** left gonopod of holotype, mesal and lateral views, respectively. Scale bars: 0.1 mm (**A, C, D**), 0.05 mm (**B**). Abbreviations: **ab** apical branch of telopodite, **bb** basal branch of telopodite, **lo** lobe, **mb** medial branch of telopodite, **sl** solenomere, **t** tooth.

Hemisphaeroparia digitifer sp. n.

http://zoobank.org/321E3C2F-1DB7-4A04-9404-A6DF51B47817
Figs 11, 12, 28E

Type material. Holotype ♂ (MRAC 22751), Cameroon, Littoral Region, Nkam Division, Koukoe, forest, 04°08'N, 010°10'E, 28.IX.2017, leg. A.R. Nzoko Fiemapong and J.A. Yetchom Fonjo.

Paratypes: 1 ♂ (SEM, MRAC 22752), 2 ♂♂ (with one gonopod retained in situ) (MRAC 22753), same locality, 28.IX.2017, leg. A.R. Nzoko Fiemapong and J.A. Yetchom Fonjo.

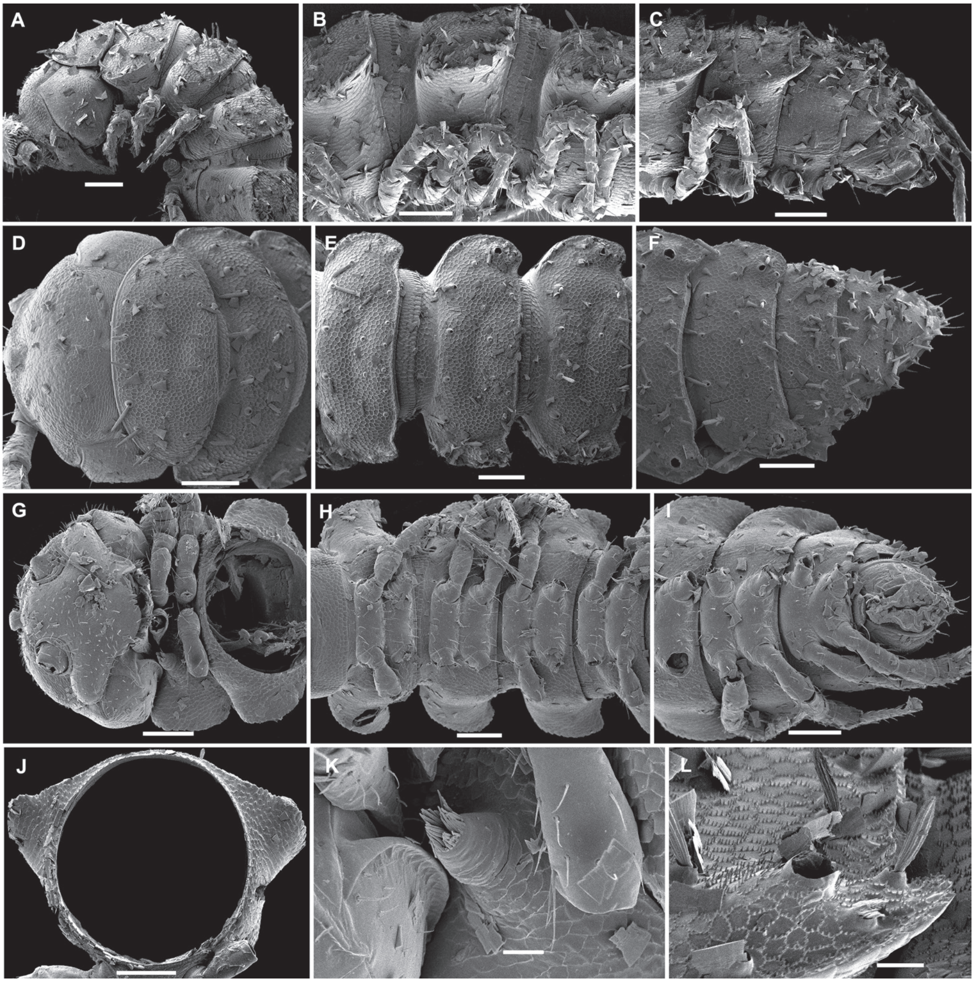

Figure 11. *Hemisphaeroparia digitifer* sp. n., SEM micrographs of ♂ paratype **A, D, G** anterior part of body, lateral, dorsal and ventral views, respectively **B, E, H** midbody segments, lateral, dorsal and ventral views, respectively **C, F, I** posterior part of body, lateral, dorsal and ventral views, respectively **J** midbody segment, caudal view **K** spiracle lateral to coxa 2 **L** midbody paratergum, lateral view. Scale bars: 0.1 mm (**A–J**), 0.02 mm (**K, L**).

Diagnosis. Differs from all other species of the genus by the presence of a boletiform epicranial tubercle (♂), coupled with the gonopodal telopodites that are deeply sunken inside a large gonocoel and show three main branches (ab, mb, bb), all exposed in their distal parts and followed by no lobe, but instead with a conspicuous, setose, fully concealed finger (d) basally in apical part; seminal groove relatively long and straight, ending subapically on ab without any trace of a solenomere (Figure 12).

Name. To emphasize the presence of a conspicuous, setose, fully concealed finger (d) on the gonopodal telopodite; noun in apposition.

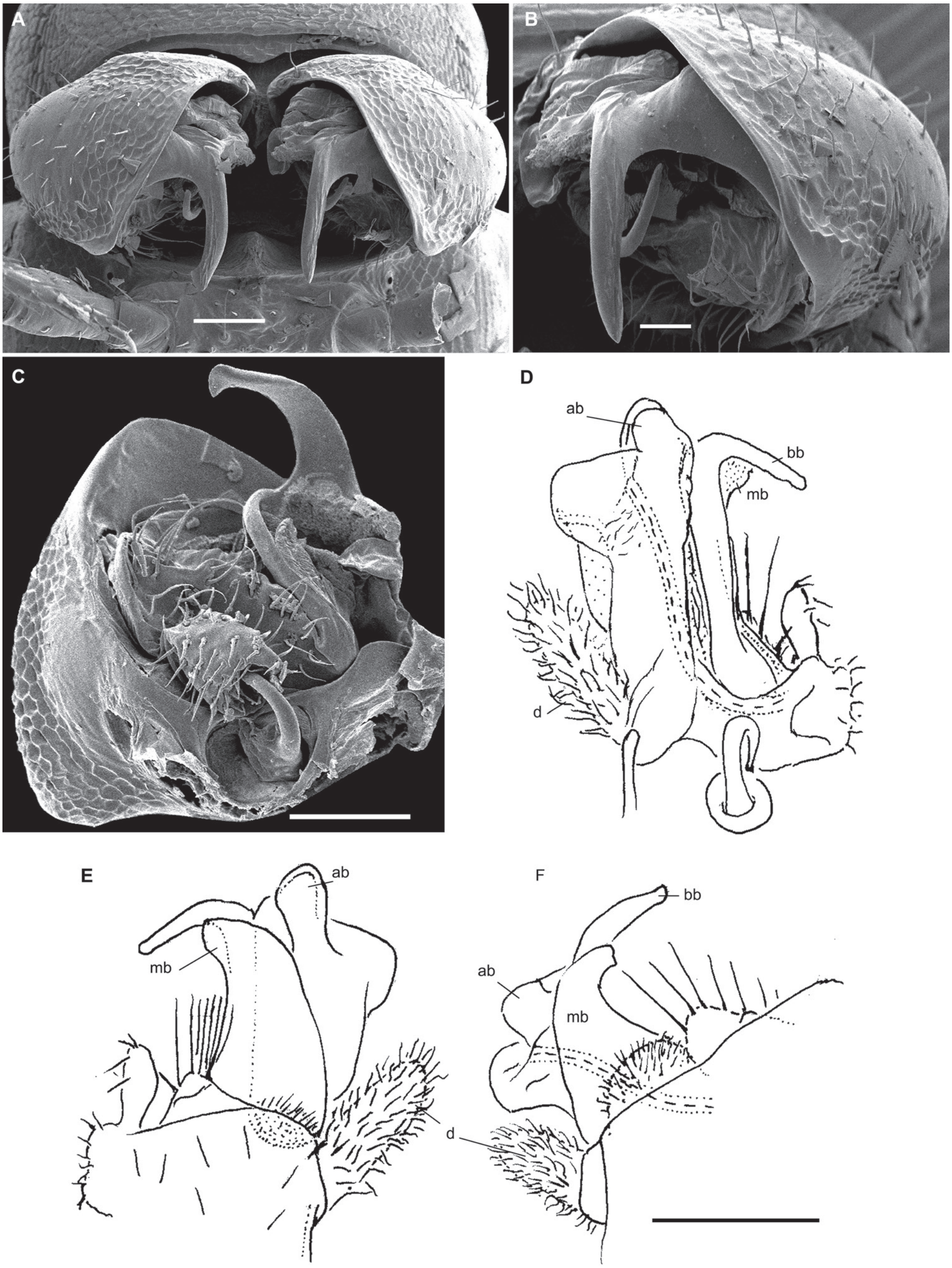

Figure 12. *Hemisphaeroparia digitifer* sp. n., ♂ paratypes **A** SEM micrographs of both gonopods in situ, ventral view **B, C** SEM micrographs of left gonopod, ventral view **D, E** right gonopod, mesal view **F** left gonopod, mesal and lateral views, respectively. Scale bars: 0.05 mm (**A–C**), 0.1 mm (**D–F**). Abbreviations: **ab** apical branch of telopodite, **bb** basal branch of telopodite, **d** setose finger, **mb** medial branch of telopodite.

Description. Length of holotype ca. 4 mm (♂), width of midbody pro- and metazonae 0.3 and 0.45 mm (♂), respectively. Length of paratypes ca. 5 mm, width of midbody pro- and metazonae 0.45–0.6. Coloration in alcohol light yellow (Figure 28E).

All other characters as in *H. zamakoe* sp. n., except as follows.

Body with 20 segments. Antennae long and strongly clavate, reaching back to segment 3 when stretched dorsally (♂). Tergal setae mainly short, each often ca. 1/6–1/7 as long as metatergum, bacilliform, or subclavate (Figure 11A–F, L). A faint transverse sulcus often traceable between rows 1 and 2 of setae on some metaterga. Segment 2 with a prominent and apically complex spiracle on each side (Figure 11K).

Legs rather long and slender, ca. 1.2–1.3 times as long as midbody height (♂).

Gonopods (Figure 12) with a deep gonocoel and complex, only little-exposed telopodites, the latter complex, showing subequally high ab and mb branches, the longest and most curved branch being bb. Apical part of telopodite with a conspicuous, long, and abundantly setose finger (d). Seminal groove long and straight, ending subapically on ab without any trace of a solenomere.

Hemisphaeroparia parva **sp. n.**
http://zoobank.org/9620E447-A2C0-4450-BD4C-9C3A869BBCFB
Figs 13, 14, 28F

Type material. Holotype ♂ (MRAC 22754), Cameroon, Littoral Region, Sanaga Maritine Division, Mouanko, forest, 03°38'N, 009°46'E, leg. A.R. Nzoko Fiemapong and J.A. Yetchom Fonjo.

Paratypes: 4 ♂♂ (MRAC: 22755), 1 ♂ (SEM, MRAC 22756), 1 ♂ (ZMUM), 1 ♂ (UY1), same locality, together with holotype.

Diagnosis. Differs from other species of the genus by having 19 body segments and by the absence of epicranial modifications in the ♂, coupled with the presence of only a single prominent branch (ab) which is exposed beyond the gonopodal coxa only distally; ab at the base with a large, lateral, finger-shaped process (lp); the seminal groove is rather long and moves onto a very short and retrose solenomere (sl) apically (Figure 14).

Name. To emphasize the very small size; adjective in feminine gender.

Description. Length of holotype ca. 3 mm (♂), width of midbody pro- and metazonae 0.25 and 0.3 mm, respectively. Length of paratypes 2.8–3.2 mm, width of midbody pro- and metazonae 0.2–025 and 0.3–0.4 mm, respectively (♂). Coloration in alcohol nearly pallid (Figure 28F), paratypes in places faintly pinkish.

All other characters as in *H. zamakoe* sp. n., except as follows.

Body with 19 (♂) segments. Head very densely micropilose, without epicranial modifications (♂)(Figure 13A, C, F, J). Interantennal isthmus ca. 1.5 times as large as diameter of antennal socket (Figure 13F). Antennae long and strongly clavate, reaching back to segment 3 when stretched dorsally (♂). In width, collum < segment 3 = 4 < 2 < head = 5–16; thereafter body gradually tapering towards telson. Collum and

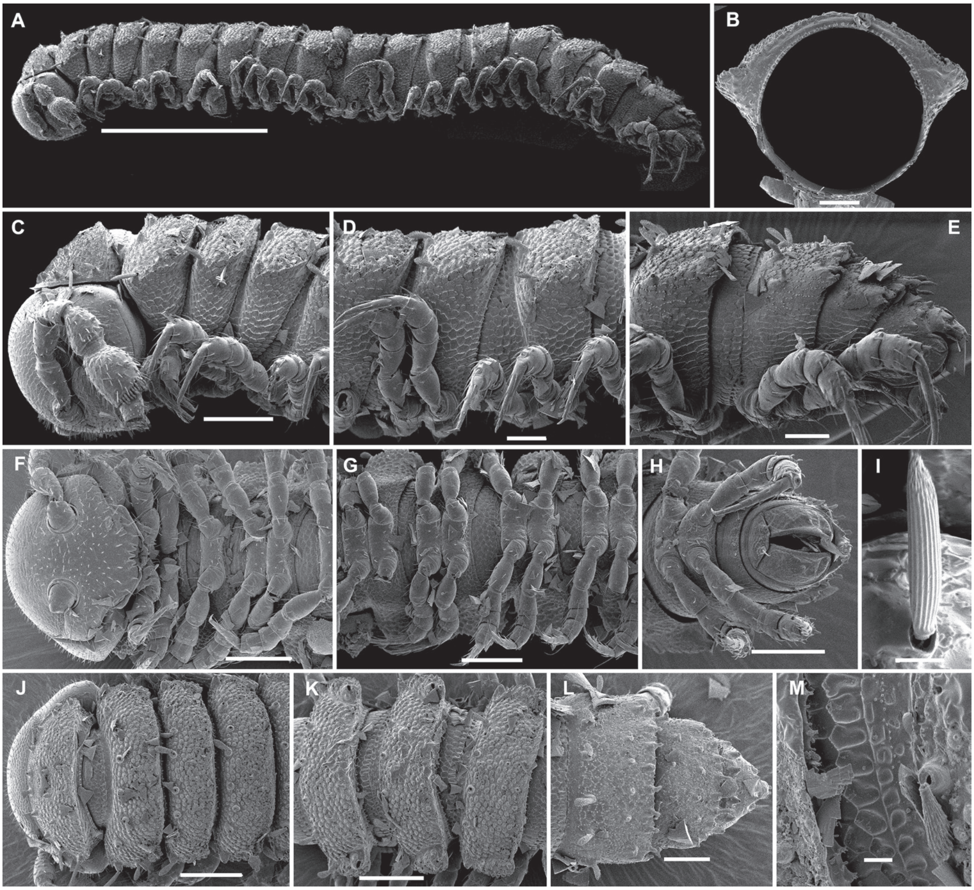

Figure 13. *Hemisphaeroparia parva* sp. n., SEM micrographs of ♂ paratype **A** habitus, lateral view **B** midbody segment, caudal view **C, F, J** anterior part of body, lateral, ventral and dorsal views, respectively **D, G, K** midbody segments, lateral, ventral and dorsal views, respectively **E, H, L** posterior part of body, lateral, ventral and dorsal views, respectively **I** tergal seta, lateral view **M** tergal fine structure. Scale bars: 0.5 mm (**A**), 0.1 mm (**C, F–H, J, K**), 0.05 mm (**B, D, E, L**), 0.01 mm (**I, M**).

most of postcollum metaterga with three transverse regular rows of setae, but some metaterga in anterior body half without middle row (Figure 13C, D, J, K). Tergal setae short, bacilliform to slightly subclavate, longitudinally finely ribbed (Figure 13C–E, I-L). Paraterga always regularly declivous. Caudal corner of paraterga always rounded, never drawn back behind rear tergal margin (Figure 13C–E, J–L).

Legs rather long and slender, ca. 1.2–1.3 times as long as midbody height; in length, tarsus > femur > prefemur> coxa = postfemur = tibia (Figure 13D).

Gonopodal telopodite (Figure 14) almost fully concealed inside a deep gonocoel, with only a single prominent branch (ab), this being exposed beyond coxa only distally; ab at base with a large lateral process (lp). Seminal groove rather long, moving onto a very short and retrose solenomere (sl) apically.

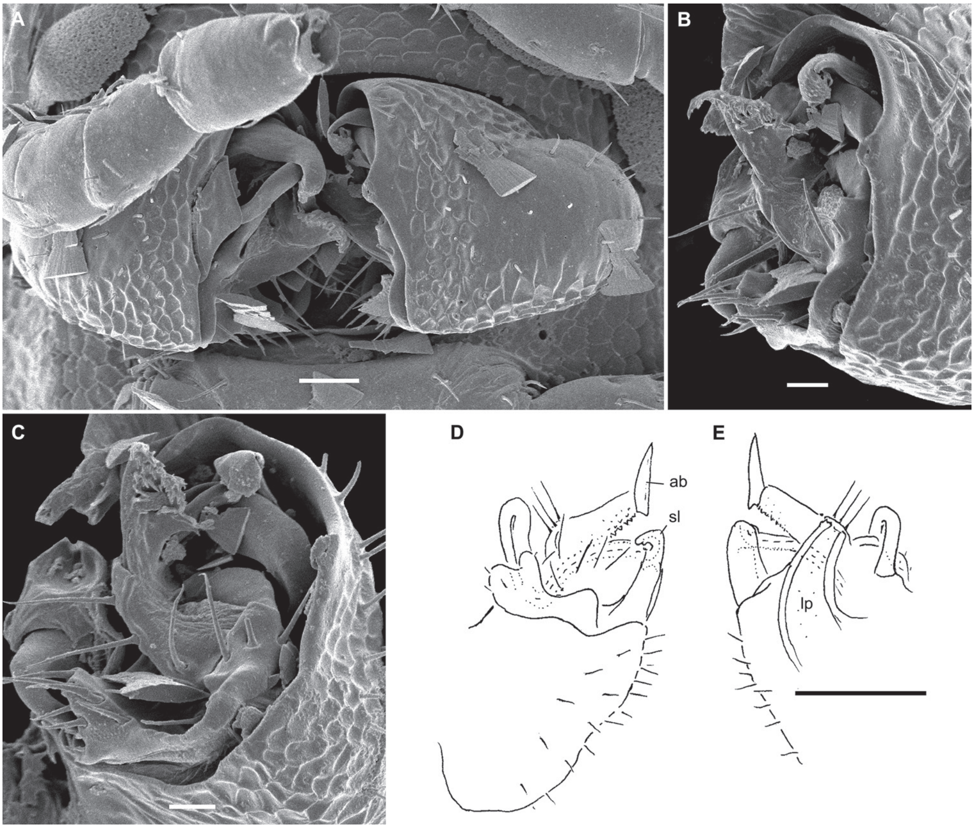

Figure 14. *Hemisphaeroparia parva* sp. n., ♂ paratypes **A** SEM micrographs of both gonopods in situ, ventral view **B, C** SEM micrographs of right gonopod, subcaudal and submesal views, respectively **D, E** right gonopod, mesal and lateral views, respectively. Scale bars: 0.1 mm (**D, E**), 0.02 mm (**A**), 0.01 mm (**B–C**). Abbreviations: **ab** apical branch of telopodite, **lp** lateral process, **sl** solenomere.

***Hemisphaeroparia fusca* sp. n.**
http://zoobank.org/430155E2-B5B3-4DF9-889A-589BABD13839
Figs 15, 16, 29A

Type material. Holotype ♂ (MRAC 22757), Cameroon, Littoral Region, Nkam Division, Koukoe, forest, 04°08'N, 010°10'E, 28.IX.2017, leg. A.R. Nzoko Fiemapong and J.A.Yetchom Fonjo.

Paratypes: 1 ♂ (without gonopods)(MRAC 22758), 1 ♂ (SEM, MRAC 22759), same locality, 19.IV.2014; same locality, 21.III.2015; 1 adult ♀, 1 subadult ♀, 2 fragmented juveniles (MRAC 22760), same locality, together with holotype, all leg. A.R. Nzoko Fiemapong and J.A. Yetchom Fonjo.

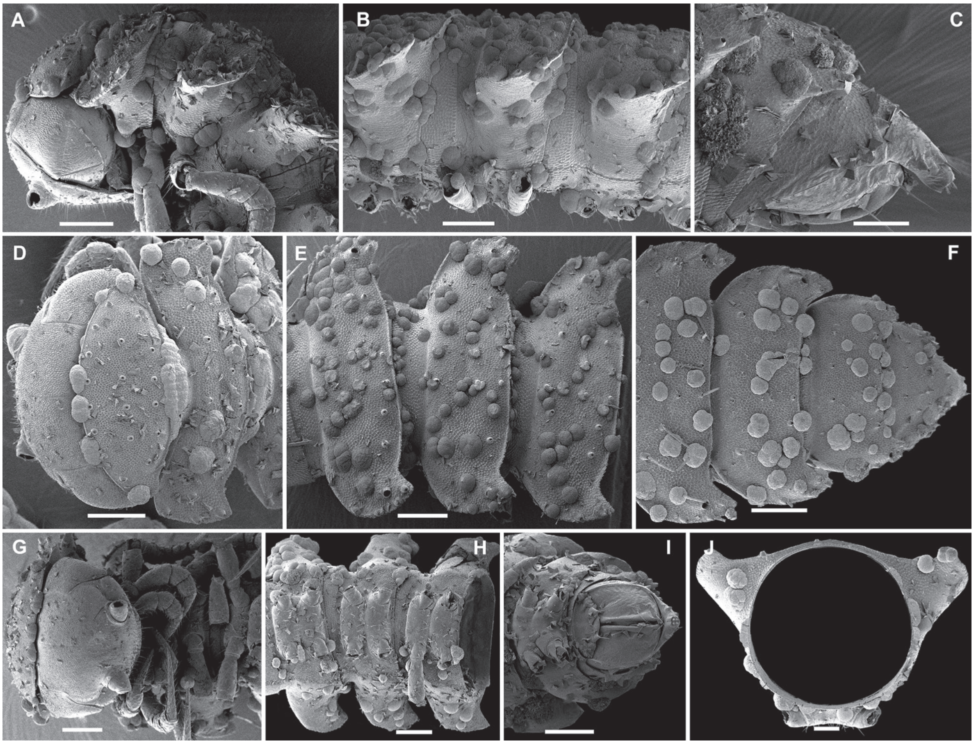

Figure 15. *Hemisphaeroparia fusca* sp. n., SEM micrographs of ♂ paratype **A, D, G** anterior part of body, lateral, dorsal and ventral views, respectively **B, E, H** midbody segments, lateral, dorsal and ventral views, respectively **C, F, I** posterior part of body, lateral, dorsal and ventral views, respectively **J** midbody segment, caudal view. Scale bars: 0.2 mm (**A, B, D–I**), 0.1 mm (**C, J**).

Diagnosis. Differs from all species of the genus by the absence of epicranial modifications (♂), coupled with the clearly more strongly developed and caudally acute paraterga compared to *H. zamakoe* sp. n. and most other congeners, as well as the presence of three prominent branches (ab, mb and bb) and a low lobe (lo) on the gonopodal telopodite and of a conspicuous foramen (fo) in the lateral wall to accommodate the end of the solenomere (sl) in a kind of pulvillus (Figure 16).

Name. To emphasize the mostly dark coloration; adjective in feminine gender.

Description. Length of holotype ca. 8.5 mm (♂), width of midbody pro- and metazonae 0.8 and 1 mm (♂), respectively. Length of paratypes (♀) 9.5 mm, width of midbody pro- and metazonae 0.9 and 1.2 respectively. Coloration in alcohol brown; head, antennae, gonopods, and venter light brown; legs light yellow-brown (Figure 29A). All type material badly overgrown with molds.

All other characters as in *H. zamakoe* sp. n., except as follows.

Head without epicranial modifications (Figure 15A, D, G). Antennae long, slightly clavate, reaching back to segment 3 (♂) or 2 (♀) when stretched dorsally. In length,

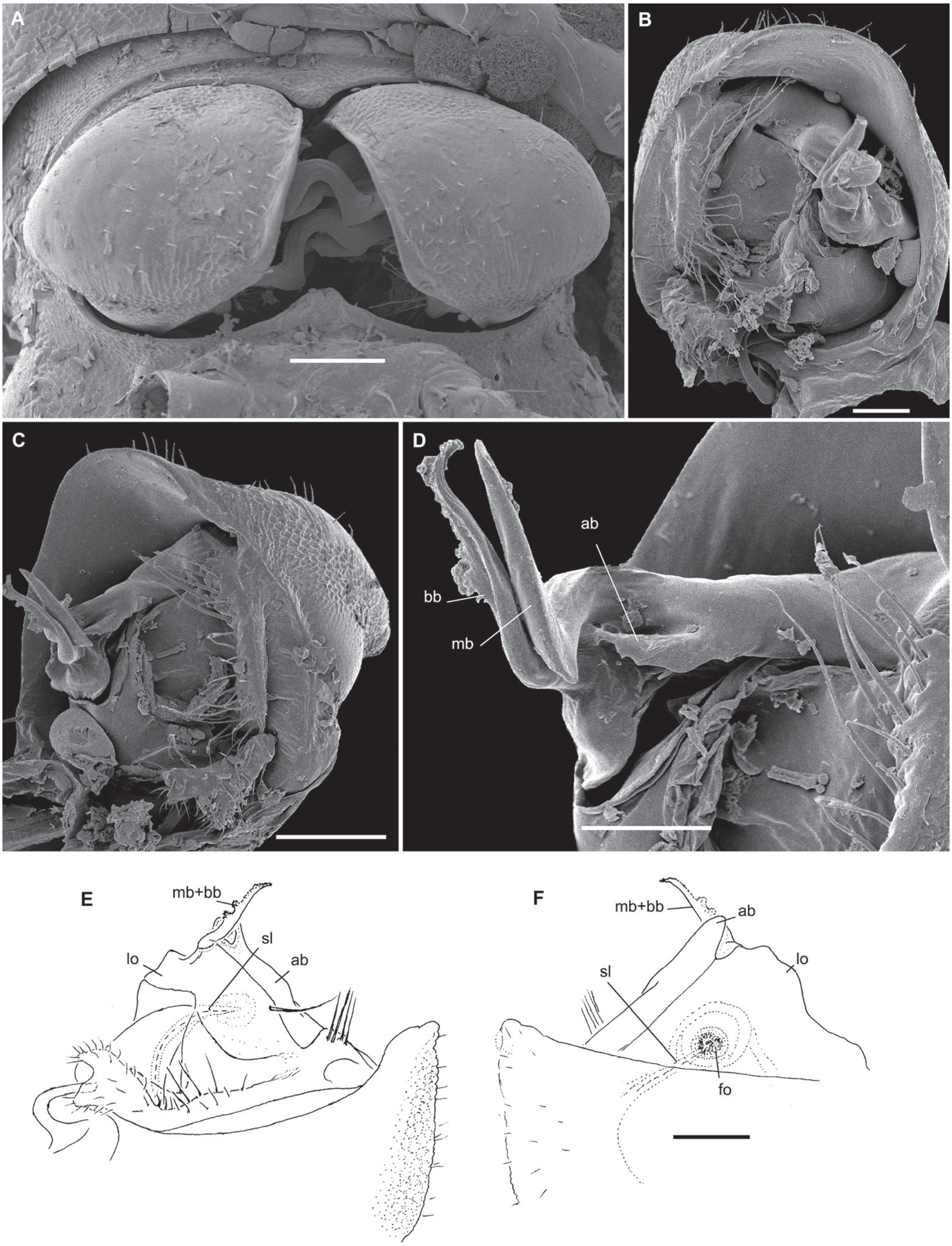

Figure 16. *Hemisphaeroparia fusca* sp. n., ♂ paratype **A** SEM micrographs of both gonopods in situ, ventral view **B–D** SEM micrographs of left gonopod, submesal, ventromesal and enlarged ventromesal views, respectively **E, F** left gonopod of holotype (branch bb fully concealed), mesal and lateral views, respectively. Scale bars: 0.1 mm (**A, C, E, F**), 0.05 mm (**B, D**). Abbreviations: **ab** apical branch of telopodite, **fo** foramen, **lo** lobe, **mb+bb** medial and basal branches, **sl** solenomere.

antennomere 3 > 2 = 5 = 6 > 4 > 7 > 1; antennomeres 5 and 6 the largest. In width, collum < head < segment 2 < 3 = 4 < 5–17. Collum ellipsoid, lateral angles acute and narrowly rounded. Tergal setae relatively long, bacilliform, mainly 1/3 as long as metatergum (Figure 29A). Dorsum nearly flat. Paraterga well-developed, set high, at around upper 1/4 of metazonae, mostly slightly upturned caudad (Figure 15A, F, J). Caudal corner of paraterga increasingly well drawn behind towards telson, narrowly rounded until around midbody segments, thereafter acute and drawn behind rear tergal margin, sharp and subspiniform (♂, ♀)(Figure 15A–F). Pleurosternal carinae traceable as a thin line on all segments.

Legs rather long and slender, ca. 1.3–1.4 (♂) or 1.1–1.2 (♀) times as long as midbody height; in length, tarsus > femur > prefemur> coxa = postfemur = tibia.

Gonopodal telopodites (Figure 16) almost fully concealed inside a large gonocoel, with three branches (ab, mb, bb), all contiguous and moderately only exposed beyond coxa, followed by a small round lateral lobe (lo) more basally. Seminal groove short, moving onto a short subspiniform solenomere (sl), the latter subtransverse and directed laterad, and perforating the lateral wall to form a conspicuous foramen (fo) resembling a pulvillus because of numerous microscopic transparent filaments around.

Hemisphaeroparia bonakanda **sp. n.**

http://zoobank.org/1B374C62-B661-45D0-9007-DA2A8638BD71

Figs 17, 18, 29B

Type material. Holotype ♂ (MRAC 22761) Cameroon, South West Region, Bonakanda, VHF trade, Mt Cameroon National Park, savannah, near edge of mountain forest, 04°13’53”N, 009°15’19”E, by hand, 19.X.2014, leg. K. Maes.

1 ♂ (lost), same locality, together with holotype.

Diagnosis. Differs from other species of the genus by the presence of a boletiform epicranial tubercle (♂), coupled with relatively long tergal setae, line-shaped and microgranulate pleurosternal carinae, as well as deeply sunken gonopodal telopodites, each of which shows a single, moderately exposed, main branch (ab) and a rather short, subtransverse, laterally directed solenomere (sl), with a sharp tooth at its base (Figure 18).

Name. To emphasize the type locality; noun in apposition.

Description. Length of holotype ca. 7 mm (♂), width of midbody pro- and metazonae 0.55 and 0.8 mm (♂), respectively. Coloration light marbled grey-brown; head, antennae, legs, and venter light yellow-brown (Figure 29B).

All other characters as in *H. zamakoe* sp. n., except as follows.

Antennae long and strongly clavate, reaching behind to segment 3 when stretched dorsally (♂). In width, collum < 3 < 2 = 4 < 5–17; thereafter body gradually tapering towards telson. Tergal setae longer, each mostly ca. 1/4 as long as metatergum, bacilliform and ribbed (Figure 17). Caudal corner of paraterga always rounded, drawn in-

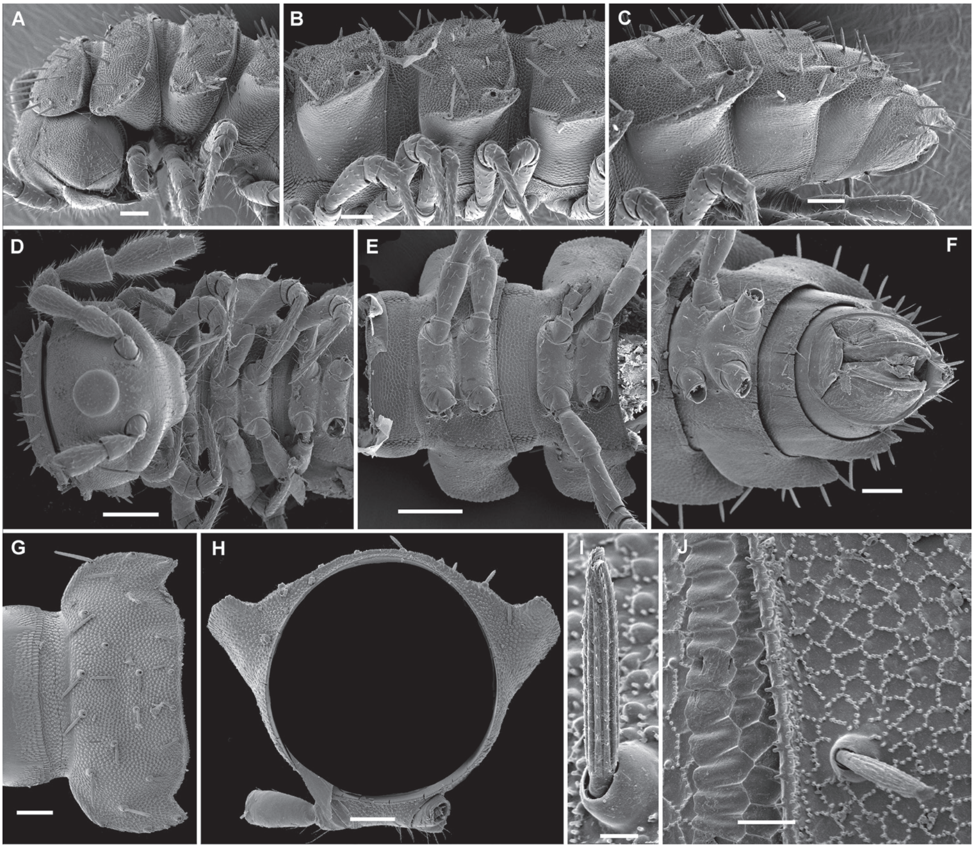

Figure 17. *Hemisphaeroparia bonakanda* sp. n., SEM micrographs of ♂ paratype **A, D** anterior part of body, lateral and dorsal views, respectively **B, E** midbody segments, lateral and dorsal views, respectively **C, F** posterior part of body, lateral and dorsal views, respectively **G, H** midbody segment, dorsal and caudal view, respectively **I** tergal seta, lateral view **J** tergal fine structure, dorsal view. Scale bars: 0.2 mm (**D, E**), 0.1 mm (**A–C, F–H**), 0.02 mm (**J**), 0.01 mm (**I**).

creasingly back, but reaching beyond rear tergal margin only on segments 16–18 (Figs 17A–C, G). Limbus much more sparsely microspiculate (Figure 17J). Pleurosternal carinae visible on all segments as a thin granulated line (Figs 17B, C).

Legs rather long and slender, ca. 1.3–1.4 times as long as midbody height; in length, tarsus > femur > prefemur> coxa = postfemur = tibia.

Gonopodal telopodites (Figure 18) almost fully concealed inside a large gonocoel, with only one unequally bifid branch (ab) moderately strongly exposed beyond coxa. Seminal groove short, moving onto a short, subspiniform solenomere (sl), the latter subtransverse and directed laterally, with a short tooth (t) at base.

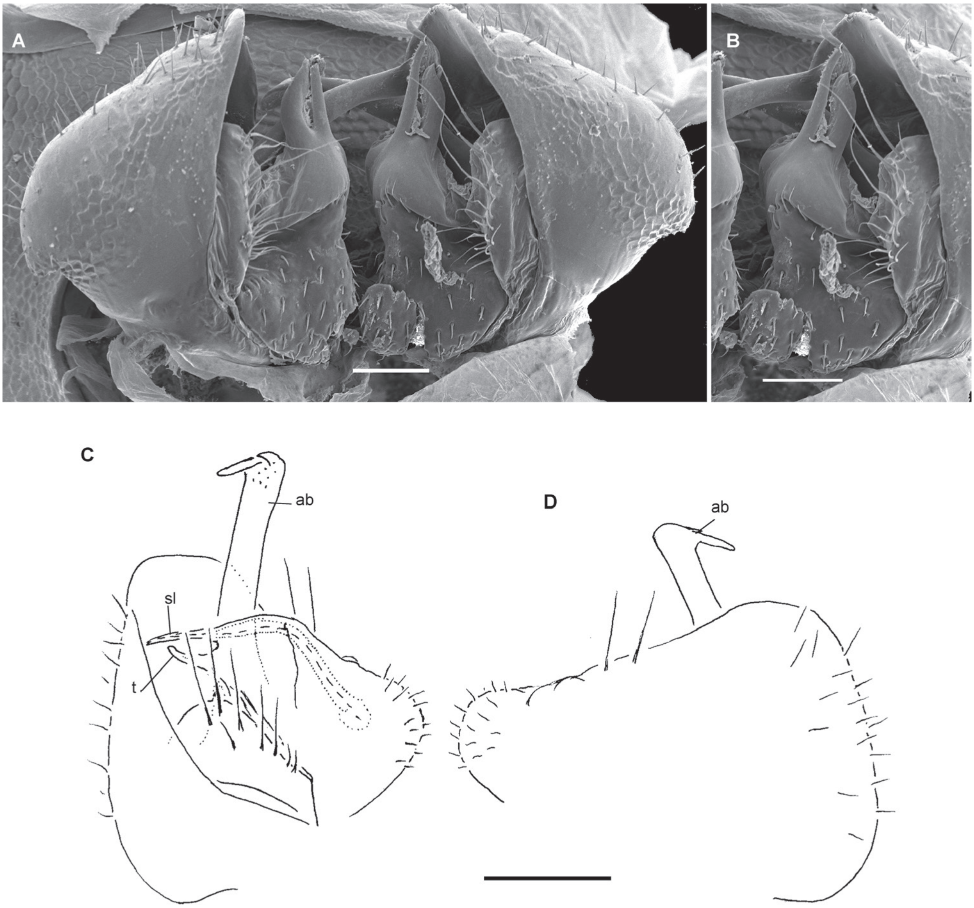

Figure 18. *Hemisphaeroparia bonakanda* sp. n., ♂ paratype **A** SEM micrographs of both gonopods in situ, ventral view **B** SEM micrographs of right gonopod, ventral view **C, D** left gonopod of holotype, mesal and lateral views, respectively. Scale bars: 0.1 mm (**C, D**), 0.05 mm (**A, B**). Abbreviations: **ab** apical branch of telopodite, **sl** solenomere, **t** tooth.

Hemisphaeroparia bamboutos **sp. n.**
http://zoobank.org/23364EA5-AE07-4F2A-B54B-6630EAA81D6C
Figs 19, 20, 29C

Type material. Holotype ♂ (MRAC 22762), Cameroon, West Region, Bamboutos Division, Babajou District, Mt Bamboutos, 5°41'5"N, 10°06'23"E, 2600 m a.s.l., forest, 03.III.2017, leg. A.R. Nzoko Fiemapong.

Paratypes: 1 ♂ (SEM, MRAC 22763), same locality, together with holotype; 4 ♀♀ (MRAC 22764), same locality, 17.X.2017, all leg. A.R. Nzoko Fiemapong.

Diagnosis. Differs from other species of the genus by the presence of a large, round, epicranial bulge (♂), coupled with the gonopodal telopodites being only mod-

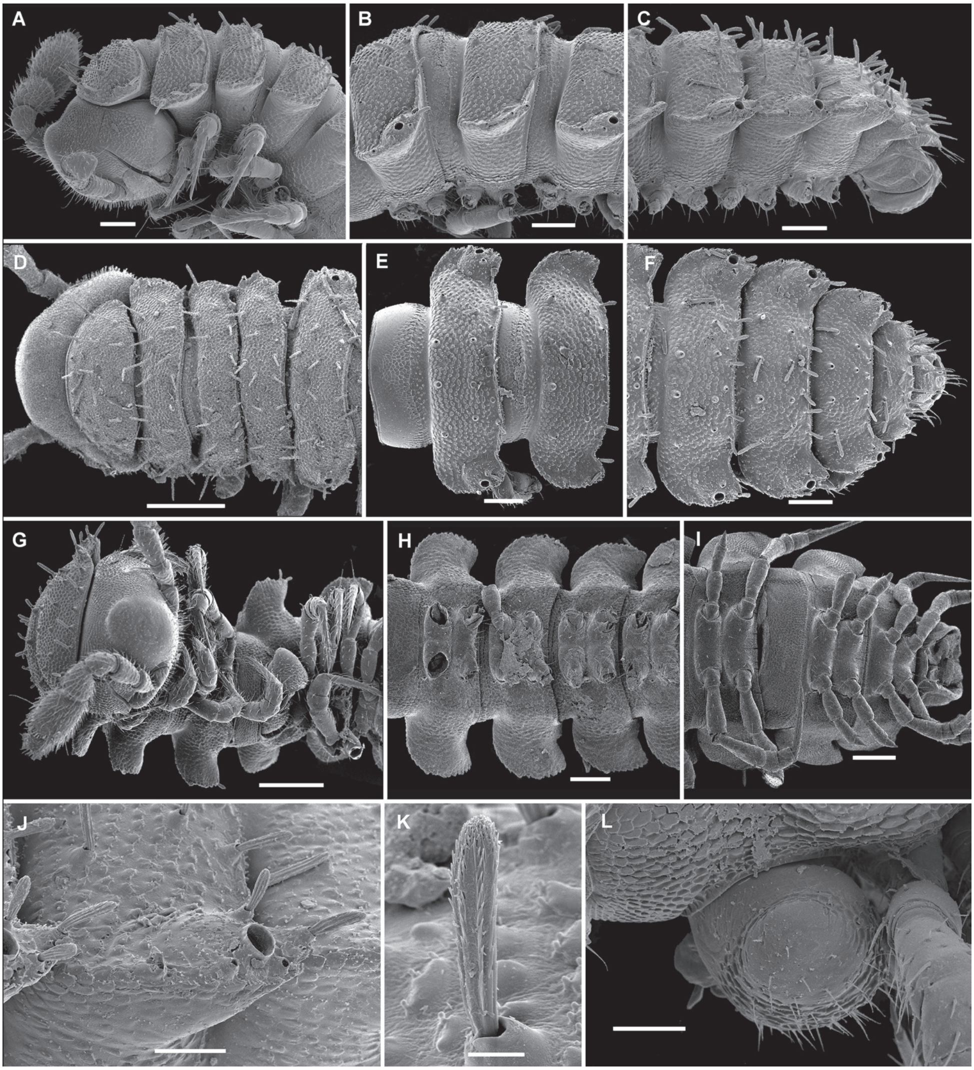

Figure 19. *Hemisphaeroparia bamboutos* sp. n., SEM micrographs of ♂ paratype **A, D, G** anterior part of body, lateral, dorsal and ventral views, respectively **B, E, H** midbody segments, lateral, dorsal and ventral views, respectively **C, F, I** posterior part of body, lateral, dorsal and ventral views, respectively **J** midbody paratergum, lateral view **K** tergal seta, lateral view **J** midbody segment, caudal view **L** gonopods in situ, lateral view. Scale bars: 0.2 mm (**D, G, I**), 0.1 mm (**A–C, E, F, H**), 0.05 mm (**J, L**), 0.01 mm (**K**).

erately exposed above a deep gonocoel, each telopodite with only two branches (ab, bb), contiguous and followed by a small rounded lobe (lo) more basally. Branch bb shorter, with a conspicuous distomesal tooth (t). Seminal groove short, ending on a short retrorse solenomere (sl) nearly level with bb tip.

Name. To emphasize the type locality; noun in apposition.

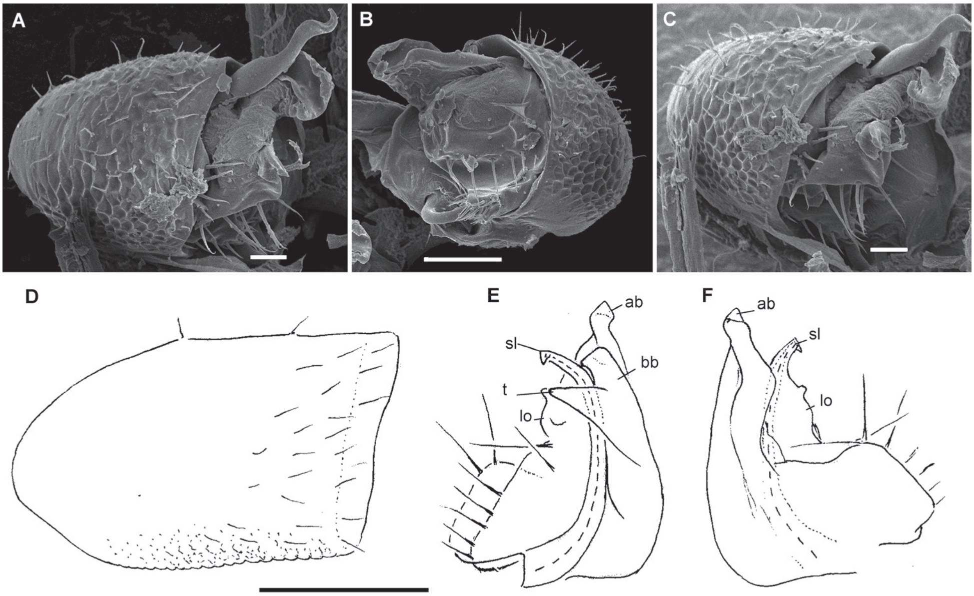

Figure 20. *Hemisphaeroparia bamboutos* sp. n., ♂ paratype **A, C** SEM micrographs of right gonopod, lateral and ventrolateral views, respectively B left gonopod, ventromesal view **D–F** right gonopod of holotype, coxa (**D**) and telopodite (**E, F**), ventral, mesal and lateral views, respectively. Scale bars: 0.1 mm (**D–F**), 0.05 mm (**B**), 0.02 mm (**A, C**). Abbreviations: **ab** apical branch of telopodite, **bb** basal branch of telopodite **lo** lobe, **sl** solenomere, **t** tooth.

Description. Length of holotype ca. 4.5 mm (♂), width of midbody pro- and metazonae 0.5 and 0.7 mm (♂), respectively. Length of ♀ paratypes 4–5 mm, width of midbody pro- and metazonae 0.4 –0.65 and 0.6–0.8 mm, respectively. Coloration in alcohol nearly pallid (♂, ♀)(Figure 29C).

All other characters as in *H. zamakoe* sp. n., except as follows.

Body with 19 segments (♂, ♀). Head with a large, round, densely micropilose, epicranial bulge (♂)(Figs 19A, D, G). Antennae long and clavate, reaching behind to segment 3 when stretched dorsally (♂, ♀). In length, antennomere 3 = 6 < 2 = 5 < 4 = 7 < 1 (♂, ♀). In width, collum < 3 < 2 = 4 < head < 5–15; thereafter body gradually tapering towards telson. Tergal setae slightly longer, each ca. 1/3–1/4 as long as metatergum, slightly clavate and bacilliform, ribbed and extremely delicately serrate (Figure 19K), setation pattern rather irregular per row: 2+2–4+4, 2+2–3+3 and 3+3–4+4 in rows 1–3, respectively. Caudal corner of paraterga always rounded, drawn increasingly back, but reaching beyond rear tergal margin only on segments 14–17 (Figs 19A–F). Pleurosternal carinae a very delicately granulate line visible on all segments (Figure 19A–C).

Legs rather long and slender, ca. 1.3–1.4 (♂) or 1.1–1.2 (♀) times as long as midbody height.

Gonopodal telopodites (Figure 20) only moderately exposed above a deep gonocoel, each with only two branches (ab, bb), both being contiguous and followed by a small rounded lobe (lo) more basally. Branch bb shorter, with a conspicuous distomesal tooth (t). Seminal groove short, ending on a short retrorse solenomere (sl) nearly level with bb tip.

Hemisphaeroparia subfalcata **sp. n.**

http://zoobank.org/D0F4DA21-564C-485D-9D90-756DA0A667ED

Figs 21, 22, 29D

Type material. Holotype ♂ (MRAC 22765), Cameroon, Center Region, Yaounde I University campus, palm plantation, 03°53'N, 011°30'E, 860 m a.s.l., 20.III.2018, leg. A.R. Nzoko Fiemapong.

Paratypes: 1 ♂ (SEM, MRAC 22766), 1 ♂ (without gonopods)(MRAC 22767), same locality, together with holotype; 4 ♂♂, 1 ♀ (MRAC 22768), 1 ♂ (ZMUM), 1 ♂ (UY1), same locality, 7.IV.2014, all leg. A.R. Nzoko Fiemapong.

Diagnosis. Differs from other species of the genus by the presence of a boletiform epicranial tubercle (♂) and 19 segments in both sexes, coupled with the gonopodal telopodites (Figure 22) showing only one, but especially prominent and subfalcate main branch (ab), this being very strongly exposed beyond coxa; a long spiniform solenomere (sl) is subtransverse, directed forward and shows a short truncated tooth (t) at its base.

Name. To emphasize the subfalcate gonopodal branch ab; adjective in feminine gender.

Description. Length of holotype ca. 3.8 mm (♂), width of midbody pro- and metazonae 0.35 and 0.5 mm (♂), respectively. Length of ♂ paratypes 3–3.4 mm, width of midbody pro- and metazonae 0.25–0.35 and 0.5–0.7 mm, respectively; ♀ paratype 3.5 mm long, 0.25 and 0.4 mm wide on midbody pro- and metazonae, respectively. Coloration of holotype in alcohol light marbled brown; legs, head, and venter light brown-yellow. All paratypes lighter, light grey-brown to nearly pallid (Figure 29D).

All other characters as in *H. zamakoe* sp. n., except as follows.

Body with 19 segments (♂, ♀). In width, collum < 3 = 4 < 2 < head < segments 5–17; thereafter body gradually tapering towards telson. Caudolateral corner of collum acute and very norrowly rounded. Tergal setae medium-sized, bacilliform, usually a little longer, each 1/4–1/2 times as long as metatergum (Figs 21D–F), always 3+3 in each row on postcollum metaterga. Paraterga medium-sized, set at ca. 1/3 of upper 1/3 of metazonae (Figs 21A–C), visible starting with collum, mostly slightly declivous to subhorizontal often slightly upturned caudally, faintly, but regularly rounded and bordered, lateral incisions absent. Caudal corner of paraterga always rounded, drawn increasingly back, but reaching beyond rear tergal margin only on segments 16 and 17 (Figs 21C, F). Segment 2 with a very prominent, boletiform and apically complex spiracle on each side (Figs 21A, J, L).

Legs rather long and slender, ca. 1.3–1.4 (♂) or 1.1–1.2 (♀) times as long as midbody height. Sternum behind gonopods with a small central tubercle (Figure 22A).

Gonopodal telopodites (Figure 22) almost fully concealed inside a large gonocoel, each with only one main branch (ab), this being long, subfalcate, and very strongly exposed beyond coxa. Seminal groove short, at around midlength moving onto a long,

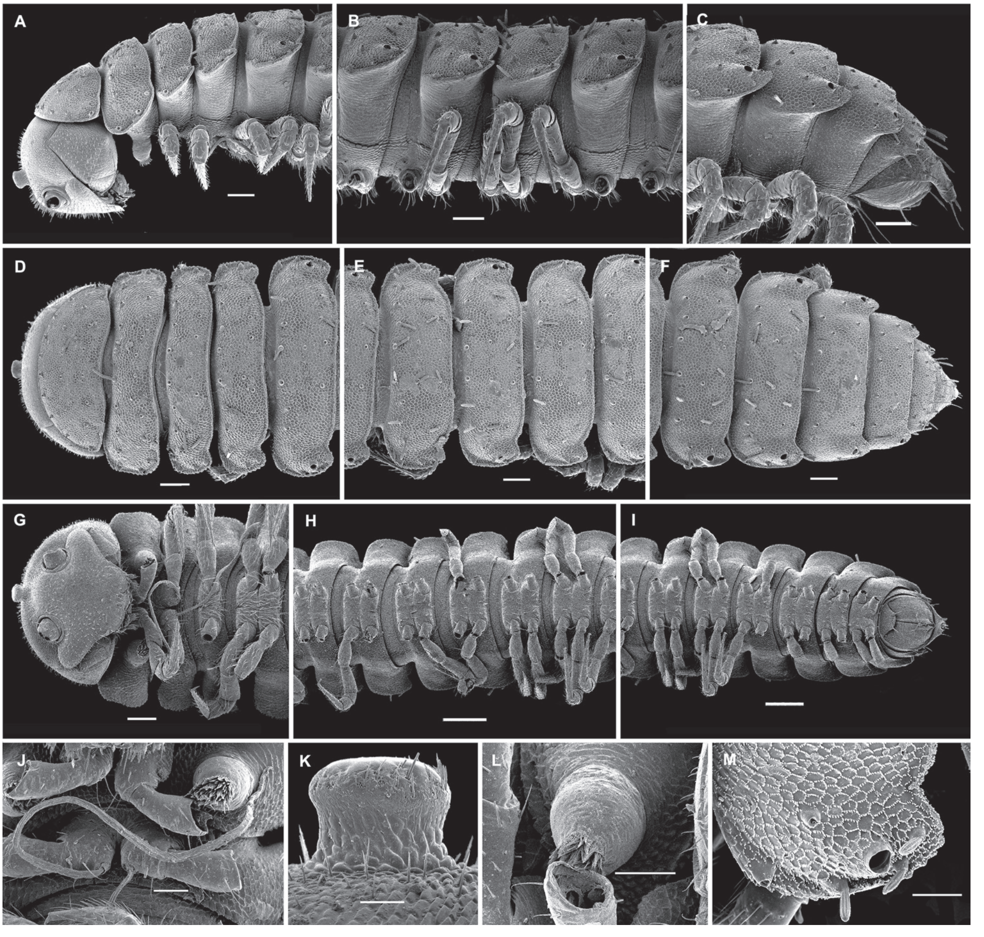

Figure 21. *Hemisphaeroparia subfalcata* sp. n., SEM micrographs of ♂ paratype **A, D, G** anterior part of body, lateral, dorsal and ventral views, respectively **B, E, H** midbody segments, lateral, dorsal and ventral views, respectively **C, F, I** posterior part of body, lateral, dorsal and ventral views, respectively **J, L** spiracle lateral to coxa 2, lateral and sublateral views, respectively **K** epicranial tubercle, dorsal view **M** midbody paratergum, lateral view. Scale bars: 0.2 mm (**H, I**), 0.1 mm (**A–G**), 0.05 mm (**J, M**), 0.02 mm (**K, L**).

spiniform solenomere (sl), the latter subtransverse, directed forward and showing a short truncated tooth (t) at base.

Hemisphaeroparia falcata sp. n.

http://zoobank.org/0D4301A6-F7DC-4D08-BBE6-D12541E96EF0
Figs 23, 24, 29E

Type material. Holotype ♂ (MRAC 22769), Cameroon, Center Region, Awae, secondary forest, 03°06'N, 10°29'E, 27.III.2018, leg. A.R. Nzoko Fiemapong.

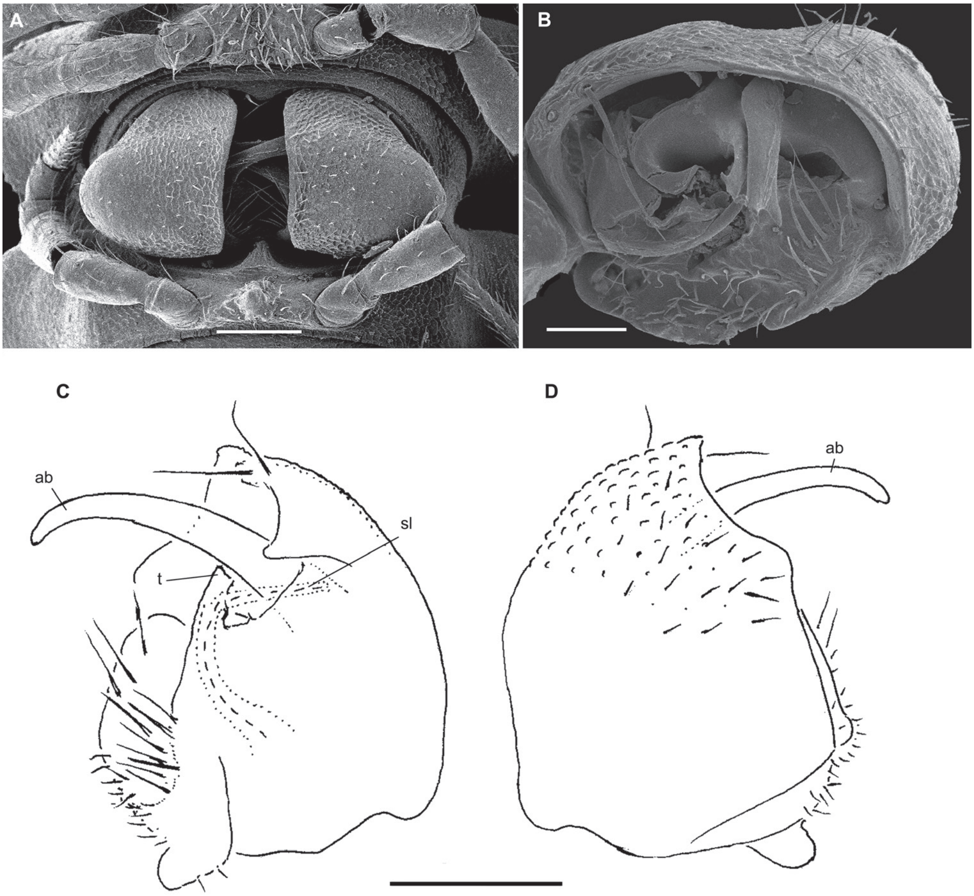

Figure 22. *Hemisphaeroparia subfalcata* sp. n., ♂ paratypes **A** SEM micrographs of both gonopods in situ, ventral view **B** SEM micrographs of left gonopod, submesal view **C, D** right gonopod, mesal and lateral views, respectively. Scale bars: 0.1 mm (**A, C, D**), 0.05 mm (**B)**. Abbreviations: **ab** apical branch of telopodite, **sl** solenomere, **t** tooth.

Paratypes: 1 ♂ (SEM, MRAC: 22770), 1 ♂ (incomplete, badly fragmented and without gonopods)(MRAC 22771), same locality, together with holotype.

Diagnosis. Differs from other species of the genus by the presence of a particular epicranial tubercle with fine filaments on top (♂), of 19 body segments (♂), coupled with only one main branch (ab) on the gonopodal telopodite, this branch being very strongly exposed, very long, falcate and directed laterally, followed by a very small lobe (lo) more basally (Figs 23M, 24). No solenomere.

Name. To emphasize the strongly falcate gonopodal branch ap; adjective in feminine gender.

Description. Length of holotype ca. 3.5 mm (♂), width of midbody pro- and metazonae 0.25 and 0.4 mm (♂), respectively. Width of midbody pro- and metazonae

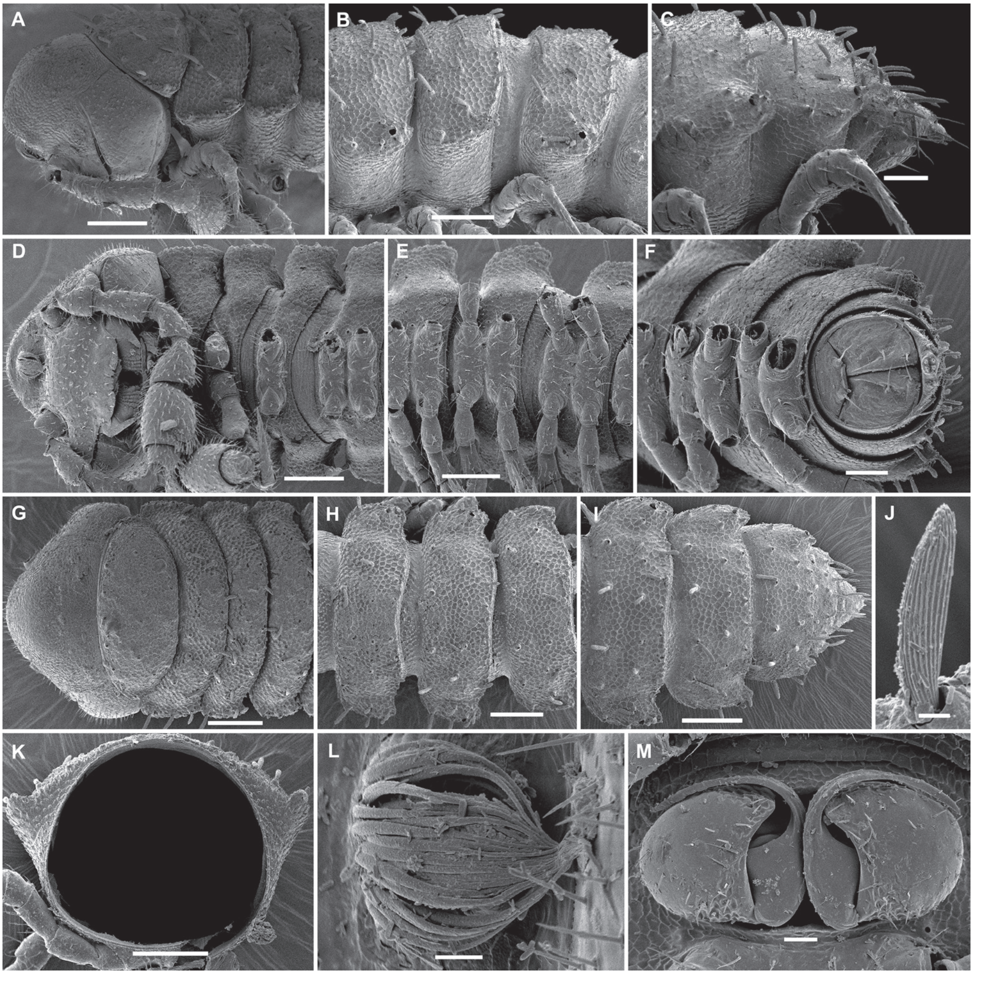

Figure 23. *Hemisphaeroparia falcata* sp. n., SEM micrographs of ♂ paratype **A, D, G** anterior part of body, lateral, ventral and dorsal views, respectively **B, E, H** midbody segments, lateral, ventral and dorsal views, respectively **C, F, I** posterior part of body, lateral, ventral and dorsal views, respectively **J** tergal seta, lateral view **K** midbody segment, caudal view **L** epicranial tubercle with filaments **M** both gonopods in situ, ventral view. Scale bars: 0.1 mm (**A, B, D, E, G–I, K**), 0.05 mm (**C, F**), 0.02 mm (**M**), 0.01 mm (**L**), 0.005 mm (**J**).

of paratype 0.5 amd 0.7 mm, respectively. Coloration in alcohol light marbled red-brown, prozonae, le.g., and venter light grey-yellow (♂)(Figure 29E).

All other characters as in *H. zamakoe* sp. n., except as follows.

Body with 19 segments (♂). Epicranial region concave anteriorly in front of a clear swelling and bearing at bottom a conspicuous round tubercle supporting a tight group of numerous long filaments, these directed anteriorly (Figs 23D, L). Antennae relatively short and clavate, reaching behind to almost segment 3 when

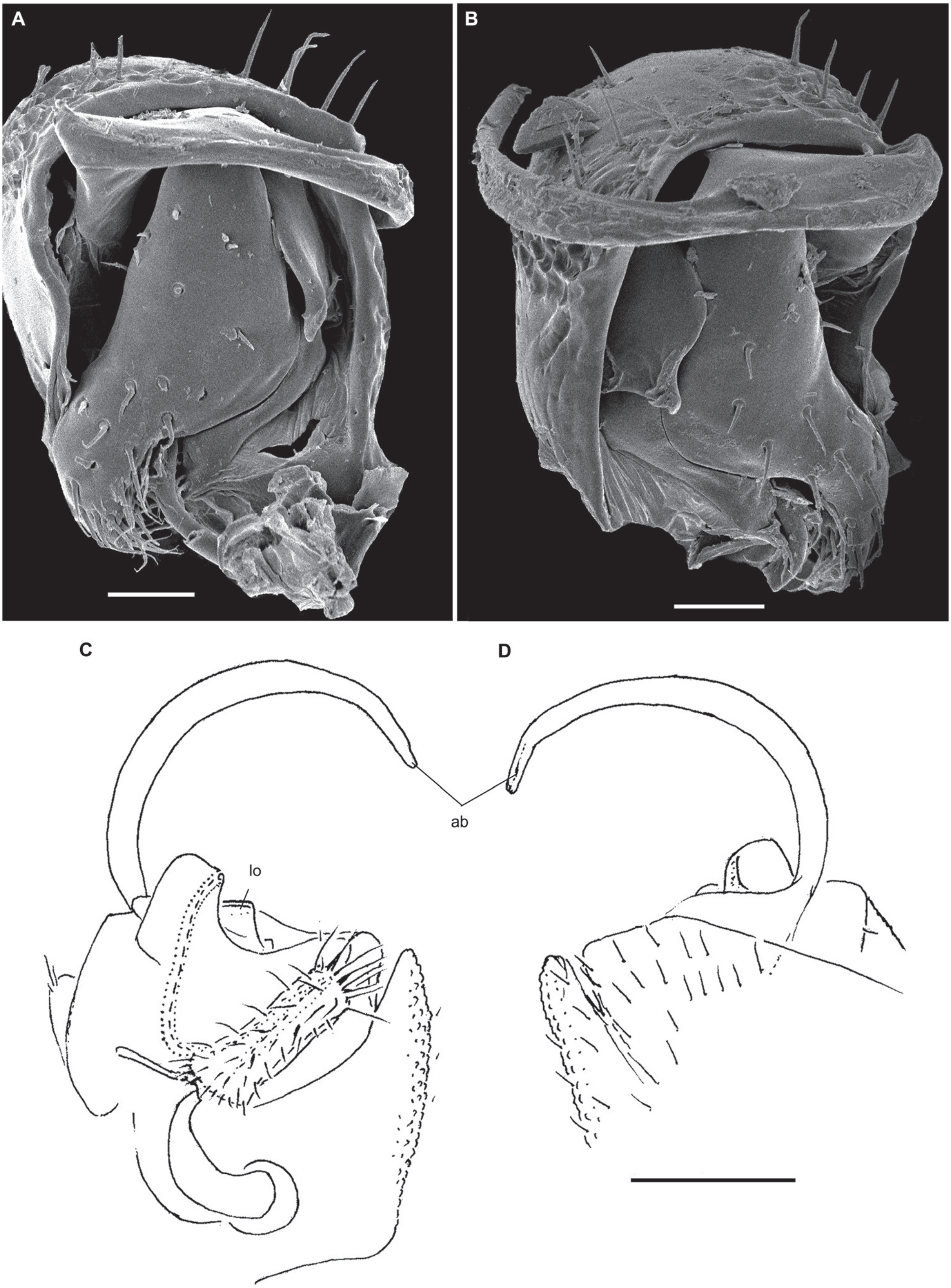

Figure 24. *Hemisphaeroparia falcata* sp. n., ♂ paratypes **A, B** SEM micrographs of left gonopod, ventromesal and submesal views, respectively **C, D** left gonopod, mesal and lateral views, respectively. Scale bars: 0.1 mm (**C, D**), 0.02 mm (**A, B**). Abbreviations: **ab** apical branch of telopodite, **lo** lobe.

stretched dorsally (♂). In length, antennomere 3 = 6 > 5 > 2 = 4 = 7 > 1. In width, collum < segment 3=4 < 2 < head = 5–16; thereafter body gradually tapering towards telson. Tergal setae medium-sized to short, each ca. 1/4–1/3 as long as metatergum, bacilliform or subclavate, ribbed all along (Figs 23A–C, G–K). Paraterga medium-sized, set at around upper 1/3 of metazonae (Figs 23A–C, K), mostly declivous to subhorizontal, often slightly upturned caudally, faintly, but regularly rounded and bordered, lateral incisions absent. Caudal corner of paraterga always rounded, drawn increasingly back, but slightly reaching behind rear tergal margin only on segment 17 (Figs 23C, I).

Legs a little shorter (♂), slender, ca. 1.1–1.2 times as long as midbody height; in length, tarsus > femur > prefemur > coxa = postfemur = tibia.

Gonopodal telopodites (Figs 23M, 24) almost fully concealed inside a very large gonocoel, each with only one main branch (ab) very strongly exposed beyond coxa, being also unusually long, falcate and directed laterally, followed by a very small round lobe (lo) more basally. Seminal groove short, ending on a small squarish lobe without a solenomere.

Hemisphaeroparia mouanko sp. n.

http://zoobank.org/4C367275-8A1B-4AAC-95E9-1A503F1F279E

Figs 25, 26, 29F

Type material. Holotype ♂ (MRAC 22772), Cameroon, Littoral Region, Sanaga Maritine Division, Mouanko, forest, 03°38'N, 009°46'E, 16.VIII.2017, leg. A.R. Nzoko Fiemapong and J.A. Yetchom Fonjo.

Paratypes: 2 ♂♂ (without gonopods)(MRAC 22773), 1 ♂ (SEM, MRAC 22774), same locality, together with holotype.

Diagnosis. Differs from other species of the genus by 19 body segments (♂), the presence of a boletiform epicranial tubercle inside a depression (♂), coupled with each gonopodal coxa supplied with two unusually strong basal setae and the telopodites which are deeply sunken inside a large gonocoel and show only two, contiguous, little-exposed branches (ab, bb). The solenomere (sl) is long and finger-shaped (Figure 26).

Name. To emphasize the type locality; noun in apposition.

Description. Length of holotype and paratype ca. 3.5 mm (♂), width of midbody pro- and metazonae 0.2 and 0.35 mm (♂), respectively. Colouration in alcohol almost uniformly very light yellow brownish (Figure 29F).

All other characters as in *H. zamakoe* sp. n., except as follows.

Body with 19 segments (♂). Epicranial region with a boletiform tubercle at bottom of an excavation in front of an evident swelling (Figs 25B, H). Interantennal isthmus ca. 1.5 times as large as diameter of antennal socket. Antennae long and strongly clavate, reaching behind to segment 3 when stretched dorsally (♂). In length, antennomere 3 = 6 > 5 > 1 = 2 = 4 = 7. In width, collum < 2–4 < head = 5–15; thereafter body gradually tapering towards telson. Tergal setae medium-sized to short, each ca. 1/5–1/3 as long as metatergum, mostly bacilliform, more rarely subclavate, all ribbed

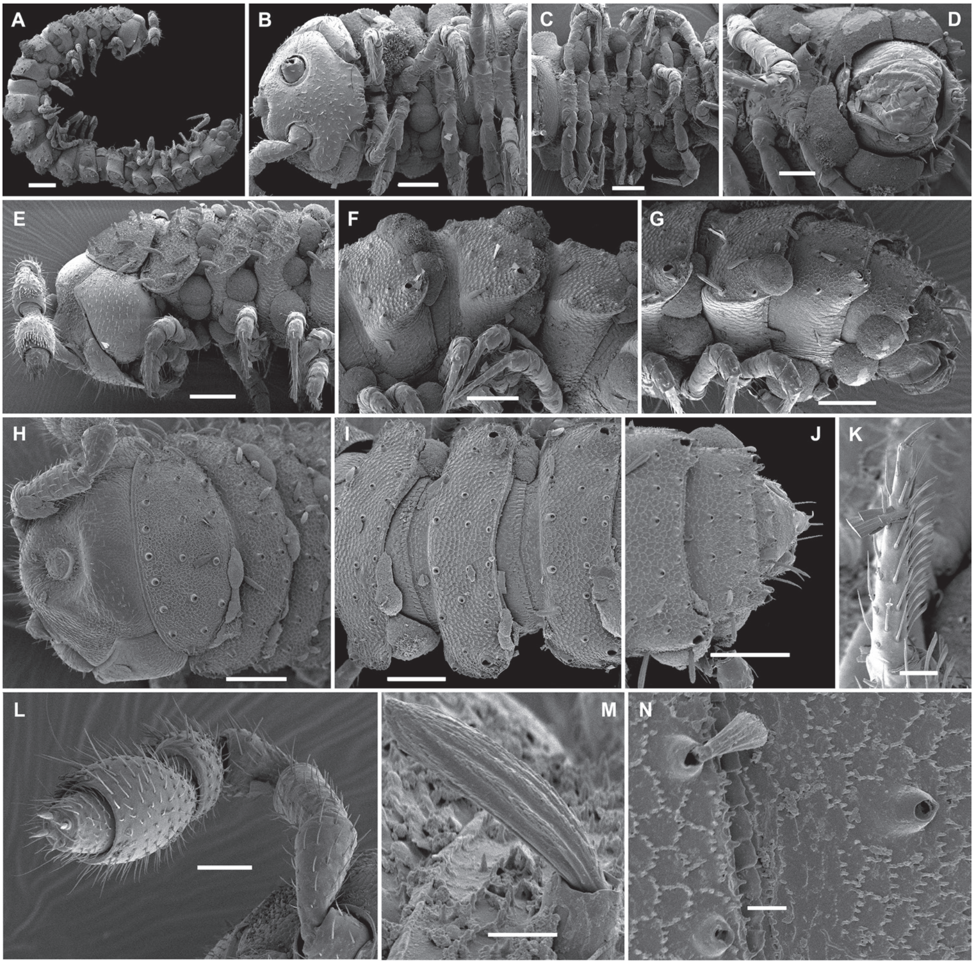

Figure 25. *Hemisphaeroparia mouanko* sp. n., SEM micrographs of ♂ paratype **A** habitus, lateral view **B, E, H** anterior part of body, ventral, lateral and dorsal views, respectively **C, F, I** midbody segments, ventral, lateral and dorsal views, respectively **D, G, J** posterior part of body, ventral, lateral and dorsal views, respectively **K** tarsus from anterior part of body, lateral view **L** antenna, sublateral view **M** bacilliform tergal seta, lateral view **N** tergal fine structure with a subclavate seta, dorsal view. Scale bars: 0.2 mm (**A**), 0.1 mm (**B, C, E–J**), 0.05 mm (**D, L**), 0.02 mm (**K**), 0.01 mm (**M, N**).

(Figs 25M, N). Paraterga medium-sized, set at ca. upper 1/3 of metazonae), mostly regularly declivous (Figs 25A, E–G, I, J). Caudal corner of paraterga always rounded, drawn increasingly back, but reaching beyond rear tergal margin only on segments 16 and 17 (Figs 25J, M).

Legs rather long and slender, ca. 1.3–1.4 times as long as midbody height (♂); tarsi in anterior body half with ventral brushes (Figure 25K).

Gonopodal coxa with two unusually strong setae at base, at fusion site of both coxae (Figs 26C, D). Telopodite (Figure 26) almost fully concealed inside a very large

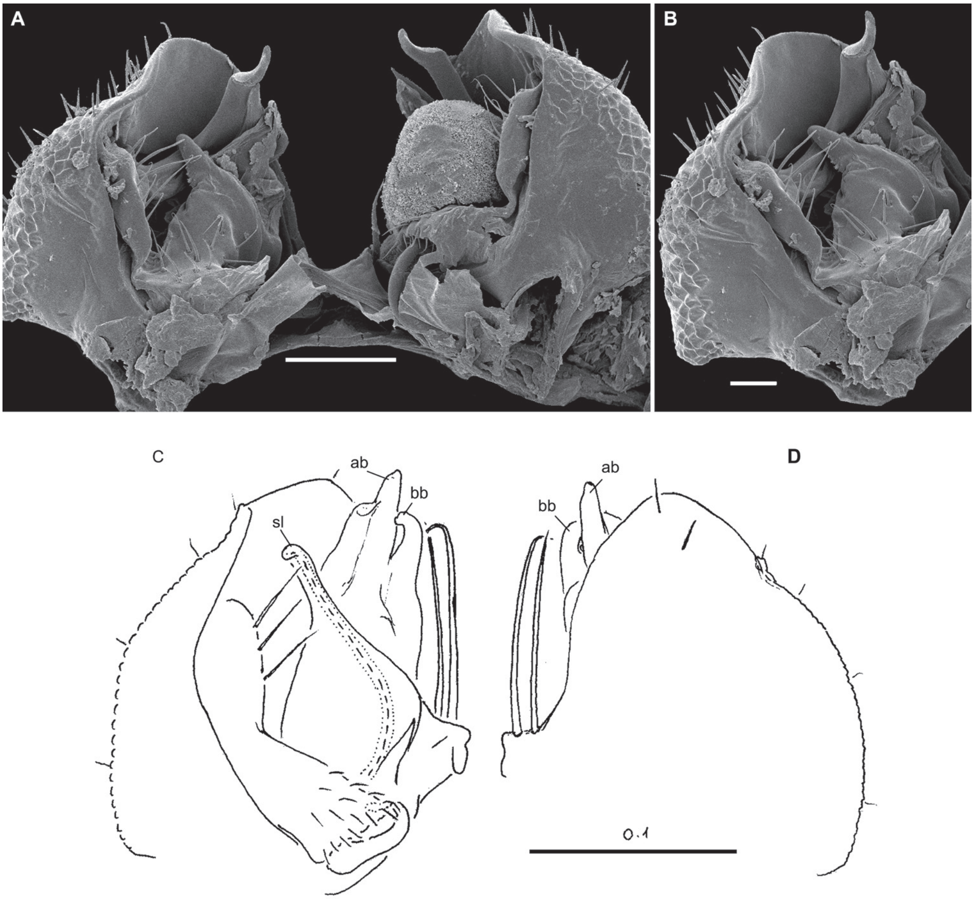

Figure 26. *Hemisphaeroparia mouanko* sp. n., ♂ paratypes **A** SEM micrographs of both gonopods in situ, ventrocaudal view **B** SEM micrographs of right gonopod, ventrocaudal view **C, D** left gonopod, mesal and lateral views, respectively. Scale bars: 0.1 mm (**C, D**), 0.05 mm (**A**), 0.02 mm (**B**). Abbreviations: **ab** apical branch of telopodite, **bb** basal branch of telopodite, **sl** solenomere.

gonocoel, each with only two branches (ab, bb), both contiguous and only slightly exposed beyond coxa, followed by no lobe more basally. Branch ab a little longer and faintly subdivided into two, branch bb shorter and slightly curved at tip. Seminal groove short, moving onto a long finger-shaped solenomere (sl).

Hemisphaeroparia integrata (Porat, 1894), comb. n.

Figure 27

Polydesmus integratus Porat, 1894: 30 (original description).

Type material. Lectotype ♂ (Naturhistoriska riksmuseet, Stockholm), Cameroon, leg. Y. Sjöstedt.

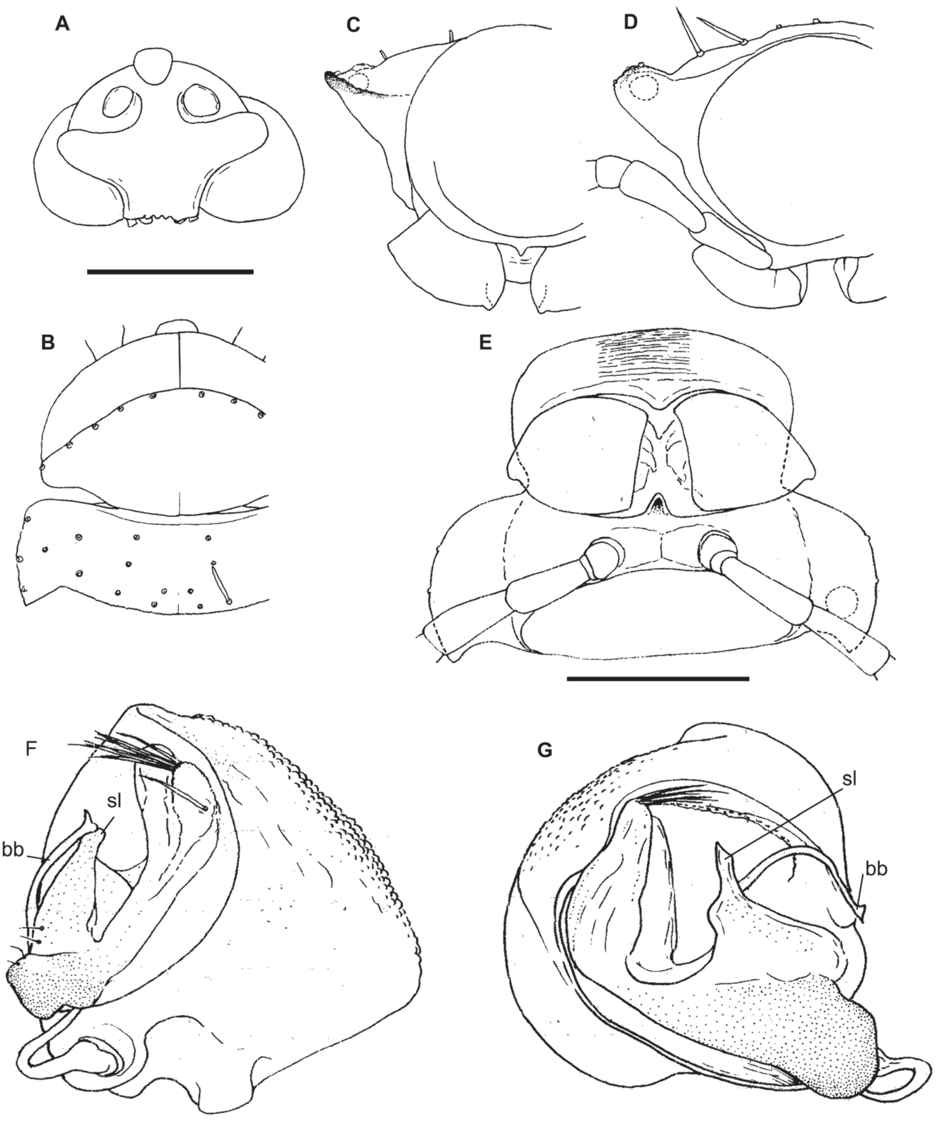

Figure 27. *Hemisphaeroparia integrata* (Porat, 1894), ♂ lectotype **A** head, ventral view **B** anterior part of body, dorsal view **C, D, E** segment 7 with gonopods, oral, caudal and ventral views, respectively **F, G** right gonopod, mesal and ventromesal views, respectively. Scale bars: 0.5 mm (**A–E**), 0.1 mm (**F, G**). Figures by JPM, inked by M. Bertoncini.

Paralectotypes: 2 fragmented ♀♀ (Naturhistoriska riksmuseet, Stockholm), together with lectotype.

One of us (JPM) revised the types and made the present lectotype designation, the latter to ensure that the species is based on male material.

Diagnosis. Differs from other species of the genus by 20 body segments, the presence of a boletiform epicranial tubercle (♂), coupled with the gonopodal telopodites which are

Figure 28. Habitus of *Hemisphaeroparia* species in lateral view, holotypes of *H. zamakoe* sp. n. (**A**), *H. bangoulap* sp. n. (**B**), *H. spiniger* sp. n. (**C**), *H. ongot* sp. n. (**D**), *H. digitifer* sp. n. (**E**) and *H. parva* sp. n. (**F**).

deeply sunken inside a large gonocoel and show only one, flagelliform, basal, main branch (bb) exposed beyond the coxa. The solenomere (sl) is short and finger-shaped (Figs 27F, G).

Descriptive notes. Length of lectotype ca. 8 mm, width of midbody pro- and metazonae 0.6 and 1.1 mm (♂), respectively. Coloration in alcohol red-brown (Porat 1894).

Body with 20 segments. Pore formula normal, but slightly abbreviated: 5, 7, 9, 10, 12, 13, 15–17. Head with a distinct, epicranial, boletiform tubercle (♂)(Figure 27A, B). Interantennal isthmus ca. 1.5 times as broad as diameter of antennal socket (Figure 27A). In width, head = collum < segment 2 (Figure 27B). Paraterga relatively well-developed (Figure 27C–E), mostly slightly upturned caudally. Tarsal brushes present (♂).

Figure 29. Habitus of *Hemisphaeroparia* species in lateral view, holotypes of *H. fusca* sp. n. (**A**), *H. bonakanda* sp. n. (**B**), *H. bamboutos* sp. n. (**C**), *H. subfalcata* sp. n. (**D**), *H. falcata* sp. n. (**E**) and *H. mouanko* sp. n. (**F**).

Gonopodal telopodites deeply sunken inside a large gonocoel and showing only one, flagelliform, basal, main branch (bb) exposed beyond coxa; solenomere (sl) short and finger-shaped (Figs 27F, G).

Key to Trichopolydesmidae from Cameroon

The following key is proposed to separate all 13 adequately known species of the family Trichopolydesmidae recorded from Cameroon (based on male characters):

1(2) Head and collum strictly equal in width (Fig. 27B). Body with 20 segments. Only one, slender, flagelliform, main branch (basal branch, bb) of gonopodal telopodite exposed beyond coxa (Fig. 27F, G) ....***H. integrata* comb. n.**

2(1) Head always at least slightly broader than collum (e.g., Figs 3G, 5D, 9D etc.). Body with 19 or 20 segments. Usually more than one main branch of gonopodal telopodite exposed beyond coxa, but if only a single branch is exposed, then it is apical branch (ab), much stronger and non-flagelliform (e.g., Figs 14, 18, 22, 24).. **3**

3(4) Male head without epicranial modifications.. **5**

4(3) Male head with epicranial modifications (a central bulge or tubercle). **7**

5(6) Body dark, with 20 segments, 8.5–9.5 mm long (Fig. 29A). Gonopodal telopodite with three main branches (ab, mb and bb) and a lobe (lo) well-exposed beyond coxa (Fig. 16). .... ***H. fusca* sp. n.**

6(5) Body light, with 19 segments, 2.8–3.2 mm long (Fig. 28F). Gonopodal telopodite with only a single strong branch (ab) well-exposed beyond coxa (Fig. 14). .... ***H. parva* sp. n.**

7(8) Gonopodal telopodite with only a single main branch (ab), this being strongly exposed beyond coxa (Figs 18, 22, 24). Body with 19 or 20 segments... **9**

8(7) Gonopodal telopodite with 2–3 more or less strong main branches (either ab, mb and bb or ab and bb) clearly exposed beyond coxa (e.g., Figs 6, 8, 25 etc.). Body with 20 segments... **13**

9(10) Body with 20 segments, ca. 7 mm long (Fig. 29B). Main branch (ab) of gonopodal telopodite suberect, bifid and curved only apically (Fig. 18). .... ***H. bonakanda* sp. n.**

10(9) Body with 19 segments, ca. 3–3.8 mm long. Main branch (ab) of gonopodal telopodite especially long, strong and clearly curved all along. **11**

11(12) Male epicranial tubercle with a tight bunch of filaments directed forward (Fig. 23L). Gonopodal telopodite with a particularly long and strongly curved apical branch (ab)(Fig. 24)... ***H. falcata* sp. n.**

12(11) Male epicranial tubercle boletiform, devoid of filaments (Fig. 21A, D, G). Gonopodal telopodite with a shorter and less strongly curved apical branch (ab)(Fig. 22). .... ***H. subfalcata* sp. n.**

13(14) Gonopodal telopodite with three main branches (ab, mb and bb)(Figs 10, 12)... **15**

14(13) Gonopodal telopodite with only two main branches (ab and bb), sometimes followed by a lobe (lo) more basally (e.g., Figs 4, 6, 8 etc.)........................ **17**

15(16) Caudal corner of paraterga always rounded, drawn increasingly back, but reaching beyond rear tergal margin on segments 13–18 (Figs 9A–C). Main branch bb of gonopodal telopodite the shortest, branch ab the longest and spiniform, while a solenomere (sl) present and supplied with a tooth (t) near base (Fig. 10). .... ***H. ongot* sp. n.**

16(15) Caudal corner of paraterga always rounded, drawn increasingly back, but reaching beyond rear tergal margin only on segments 17 and 18 (Figs 9A, C). Main branch bb of gonopodal telopodite the longest and distally curved, branch ab the largest, a solenomere missing, while a prominent setose finger (d) present in apical part (Fig. 12).................................... ***H. digitifer* sp. n.**

17(18) Male head with a large, round, micropilose bulge (Fig. 19G). Main branch ab of gonopodal telopodite the longest, main branch bb shorter, subtruncate, with a large tooth (t) distally (Fig. 20)..........................***H. bamboutos*** **sp. n.**

18(17) Male head with a boletiform epicranial tubercle. Shapes and proportions of ab and bb branches otherwise. 19

19(20) A vestigial solenomere (sl) with a conspicuous rod (t) near base, while a prominent lobe (lo) with a remarkable thick-walled gutter (g) laterally at base (Figure 6)..***H. bangoulap*** **sp. n.**

20(19) Solenomere (sl) evident, neither a process nor a tooth at its base, nor a lateral gutter at base of lobe (lo). **21**

21(22) Two long setae at base of gonopodal coxa particularly strong. Both main branches of gonopodal telopodite different in length, bb being clearly curved at tip and shorter than a larger and more complex ab (Fig. 26). ....***H. mouanko*** **sp. n.**

22(21) Two long setae at base of gonopodal coxa relatively less strong. Both main branches of gonopodal telopodite slender and either subequal in length or bb slightly longer than ab...**23**

23(24) Gonopodal telopodite with a conspicuous, fully concealed, apical spine (sp), both ab and bb branches subequally long (Fig. 8). .... ***H. spiniger*** **sp. n.**

24(23) Gonopodal telopodite without an apical spine, branch ab considerably larger, but shorter than a flagelliform bb (Fig. 4). ....***H. zamakoe*** **sp. n.**

Conclusions

The distribution of the genus *Hemisphaeroparia*, hitherto known to comprise a single, and type, species from Mt Nimba (Côte d'Ivoire and Guinea)(Schubart 1955), appears to presently cover much of western Africa. Furthermore, the whole of Cameroon, at least its better-studied southern half, supports species of this genus alone (Figure 30). Our contribution has enriched the entire fauna of African Trichopolydesmidae by one-third, while the fauna of Cameroon becomes the best studied across the whole continent. There is little doubt that this family is taxonomically one of the most diverse throughout Africa, with numerous further species still awaiting discovery even in Cameroon. We may say that we have just touched the tip of the iceberg.

Sympatry or even syntopy is not too rare among Afrotropical Trichopolydesmidae. Thus, Schubart (1955) described three different species (and genera) from Mt Nimba. Mauriès and Heimer (1996) not only published several species occurring sympatrically from eastern Africa, but they also provided a general map showing the distribution of the family and all of its genera and species then known on the continent. Our material likewise demonstrates a few cases of sympatry or strict syntopy in Cameroon, up to three species per locality (Figure 30).

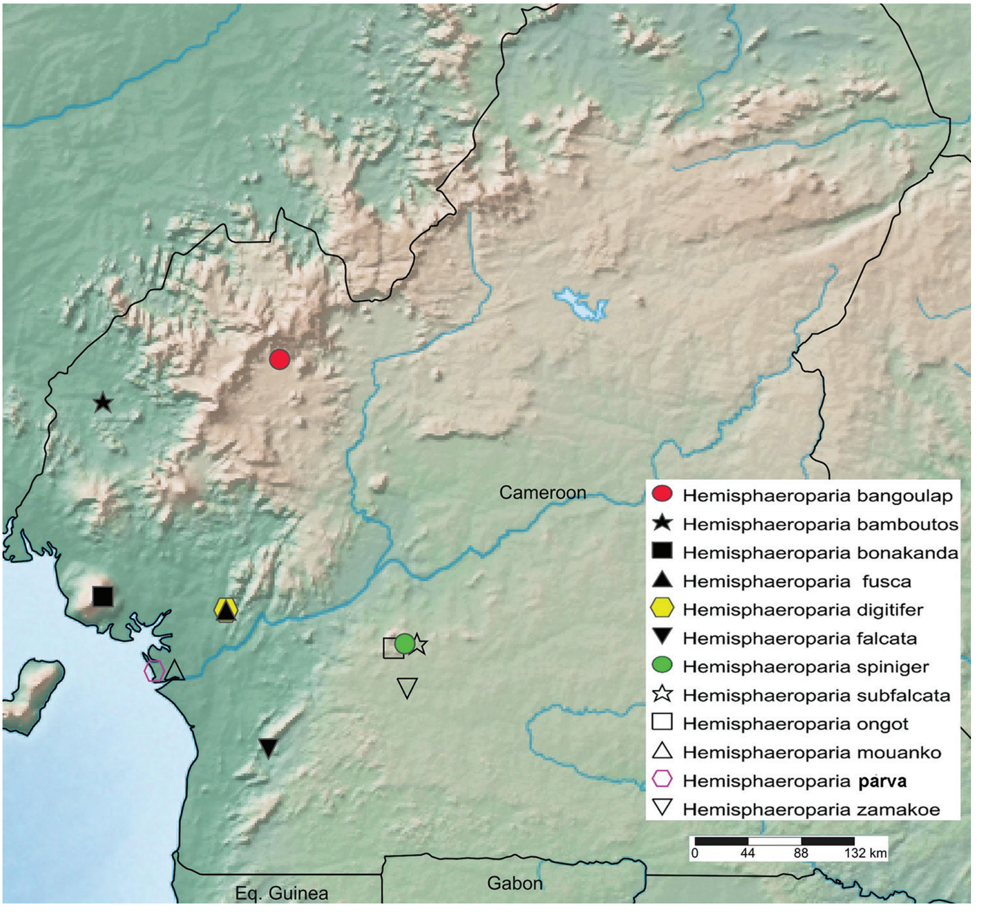

Figure 30. Distribution of the species of Trichopolydesmidae in Cameroon, arranged from north to south: *Hemisphaeroparia bangoulap* sp. n. (**1**), *Hemisphaeroparia bamboutos* sp. n. (**2**), *Hemisphaeroparia bonakanda* sp. n. (**3**), *Hemisphaeroparia fusca* sp. n. (**4**), *Hemisphaeroparia digitifer* sp. n. (**5**), *Hemisphaeroparia falcata* sp. n. (**6**), *Hemisphaeroparia spiniger* sp.n. (**7**), *Hemisphaeroparia subfalcata* sp. n. (**8**), *Hemisphaeroparia ongot* sp. n. (**9**), *Hemisphaeroparia mouanko* sp. n. (**10**), *Hemisphaeroparia parva* sp. n. (**11**), *Hemisphaeroparia zamakoe* sp.n. (**12**), *Hemisphaeroparia integrata* (Porat, 1894)(?) and ?*Hemisphaeroparia parvula* (Porat, 1894)(?).

With a list of already 14 species in *Hemisphaeroparia* alone, some of them may be grouped in a few species groups. Thus, because *H. subfalcata* sp. n. and *H. falcata* sp. n. share not only the very small body with 19 segments and certain epicranial modifications (♂), but also the particularly long branches ab of the gonopods (Figs 22, 24), they seem to belong to the same species group. Perhaps at least some of the species that show only two or all three main branches of the gonopodal telopodite form further 2–3 species groups, but we shall refrain from further outlining and naming them now pending more material becomes described. Some is already available, but remains entirely unstudied yet; further samples may be expected to come in the near future, and all this, as well as a complete species-level reclassification of African Trichopolydesmidae will be treated in the next part of our paper.

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References

Attems CG (1909) 19. Myriopoda. Wissenschafliche Ergebnisse der schwedischen zoologischen Expedition nach dem Kilimandjaro, dem Meru und den umgebenden Massaisteppen Deutsch-Ostafrikas 1905–1906 unter Leitung von Prof. Dr. Yngve Sjöstedt, Stockholm, 64 pp.

Attems C (1939) Myriopoda. Mission scientifique de l'Omo 5(55). Mémoires du Muséum national d'Histoire naturelle, N.S. 9: 303–318.

Attems C (1940) Myriapoda 3. Polydesmoidea III. Fam. Polydesmidae, Vanhoeffeniidae, Cryptodesmidae, Oniscodesmidae, Sphaerotrichopidae, Peridontodesmidae, Rhachidesmidae, Macellolophidae, Pandirodesmidae. Das Tierreich 70: 1–577.

Brecko J, Mathys A, Dekoninck W, Leponce M, VandenSpiegel D, Semal P (2014) Focus stacking: Comparing commercial top-end set-ups with a semi-automatic low budget approach. A possible solution for mass digitization of type specimens. ZooKeys 464: 1–23. https://doi.org/10.3897/zookeys.464.8615

Brolemann HW (1920) Myriapodes III, Diplopoda. Voyage de Ch. Alluaud et R. Jeannel en Afrique orientale (1911–1912). Résultats scientifiques. Paris, L. Lhomme, 49–298.

Brolemann HW (1926) Myriapodes recueillis en Afrique occidentale française par M. l'Administrateur en chef L. Duboscq. Archives de Zoologie expérimentale et générale 65: 1–159.

Carl J (1905) Diplopodes de la Guinée espagnole. Memorias de la Sociedad española de Historia natural 1(15): 261–284.

Chamberlin RV (1951) On Diplopoda of North-East Angola. Museu do Dundo, Estudos Diversos III. Lisboa, Publicações culturais da Companhia de diamantes de Angola (Diamang) 10: 65–93.

Cook OF (1896a) A new diplopod fauna in Liberia. The American Naturalist, Entomology 30: 413–420.

Cook OF (1896b) Summary of new Liberian Polydesmoidea. Proceedings of the Academy of Natural Sciences of Philadelphia 1896: 257–267.

Golovatch SI (1992) Review of the Neotropical fauna of the millipede family Fuhrmannodesmidae, with the description of four new species from near Manaus, Central Amazonia, Brazil (Diplopoda, Polydesmida). Amazoniana 12(2): 207–226.

Golovatch SI (1994) Further new Fuhrmannodesmidae from the environs of Manaus, Central Amazonia, Brazil, with a revision of *Cryptogonodesmus* Silvestri, 1898 (Diplopoda, Polydesmida). Amazoniana 13(1/2): 131–161.

Golovatch SI (2013) A reclassification of the millipede superfamily Trichopolydesmoidea, with descriptions of two new species from the Aegean region (Diplopoda, Polydesmida). ZooKeys 340: 63–78. https://doi.org/10.3897/zookeys.340.6295

Golovatch SI, Enghoff H (2015) Superorder Merochaeta. In: Minelli A (Ed.) Treatise on Zoology, The Myriapoda 2. Brill, Leiden-Boston, 391–407.

Golovatch SI, Gerlach J (2010) Class Diplopoda de Blainville in Gervais, 1844. In: Gerlach J, Marusik Y (Eds) Arachnida and Myriapoda of the Seychelles islands. Siri Scientific Press, Rochdale, UK, 387–402.

Golovatch SI, Korsós Z (1992) Diplopoda collected by the Soviet Zoological Expedition to the Seychelles Island in 1984. Acta Zoologica Hungarica 38(1–2): 1–31.

Golovatch SI, VandenSpiegel D (2016) A new species of the millipede genus *Helicodesmus* Golovatch, Geoffroy et VandenSpiegel, 2014, from southern Vietnam (Diplopoda: Polydesmida: Trichopolydesmidae). Russian Entomological Journal 25(3): 293–297.

Golovatch SI, Geoffroy JJ, VandenSpiegel D (2014) Review of the millipede family Trichopolydesmidae in the Oriental realm (Diplopoda, Polydesmida), with descriptions of new genera and species. ZooKeys 414: 19–65. https://doi.org/10.3897/zookeys.414.7671

Hoffman RL (1980) Classification of the Diplopoda. Muséum d'histoire naturelle, Genève, 238 pp.

Kraus O (1958) Diplopoden aus Angola. Museu do Dundo, Lisboa, Publicações culturais da Companhia de diamantes de Angola (Diamang) 38: 47–84.

Mauriès JP, Heymer A (1996) Nouveaux micropolydesmides d'Afrique centrale: essai de rassemblement pour une révision du genre *Sphaeroparia* (Diplopoda, Polydesmida, Fuhrmannodesmidae). Bulletin du Muséum national d'Histoire naturelle, 4e série, 18 (Section A, Nos 1–2): 165–184.

Mauriès JP, Geoffroy JJ (1999) Les Diplopodes édaphique et souterrains de l'Ile Maurice (Myriapoda: Diplopoda). Revue suisse de Zoologie 106(1): 69–79. https://doi.org/10.5962/bhl.part.80070

Porat O (1894) Zur Myriopodenfauna Kameruns. Bihang till Kungliga Svenska Vetenskaps-Akademie 20(4/5): 1–90.

Schubart O (1955) Proterospermophora oder Polydesmoidea von Französisch West-Afrika (Diplopoda). Bulletin de l'Institut français de l'Afrique noire, sér. A 17(2): 377–443.

Shear WA, Reddell JM (2017) Cave millipedes of the United States. XIV. Revalidation of the genus *Speorthus* Chamberlin, 1952 (Diplopoda, Polydesmida, Macrosternodesmidae), with a description of a new species from Texas and remarks on the families Polydesmidae and Macrosternodesmidae in North America. Insecta Mundi 0529: 1–13.

Verhoeff KW (1939) Diplopoden der Insel Mauritius und ihre zoogeographische Bedeutung. Jenaische Zeitschrift für Naturwissenschaft 73: 37–96.

Verhoeff KW (1941) Myriapoden der Insel Fernando Po. Zoologischer Anzeiger 136(5/6): 89–98.

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A new species of *Aegyptobia* and redescription of *Tenuipalpus szarvasensis* Bozai, 1970 (Acari, Tenuipalpidae)

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Abstract

A new tenuipalpid mite species, *Aegyptobia bozaii* **sp. n.**, is described from Central-Hungary on leaves of the endemic Hungarian statice *Limonium gmelinii* subsp. *hungaricum* (Plumbaginaceae) based on females, nymphs and larva. The previously described endemic flat mite, *Tenuipalpus szarvasensis* Bozai, 1970 is re-described. This species had been treated as a junior synonym of *Tenuipalpus cheladzeae* Gomelauri, 1960, but our new investigation shows that the two species are not the same.

Keywords

tenuipalpids, mites, flat mite, taxonomy, Hungary

Introduction

Tenuipalpid mites are a diverse group of plant-feeding mites found in most regions of the world. Several species are pests, especially within *Brevipalpus*, but pest species are also found in *Dolichotetranychus*, *Raoiella* and *Tenuipalpus*. The family has received considerable attention in some parts of the world, but the majority of the Central

European countries have been scarcely investigated. Hungary is no exception, with only 19 recorded species (Kontschán and Ripka 2017). However, numerous rare and endemic flat mites might remain undiscovered in natural ecosystems in Hungary; and disturbed ecosystems may harbor several unrecorded or possibly new species.

The aim of our paper is to describe a new tenuipalpid species from Hungary and to redescribe the endemic Hungarian flat mite *Tenuipalpus szarvasensis* Bozai, 1970, which we also remove from its synonymy with *Tenuipalpus cheladzeae* Gomelauri, 1960 by Mitrofanov and Strunkova (1979).

Material and methods

Specimens of the new species (*Aegyptobia bozaii* sp. n.) were collected in a pasture close the border of the village Farmos (Central-Hungary) from the leaves of an endemic Hungarian plant (*Limonium gmelinii* subsp. *hungaricum*). The specimens were placed into lactic acid for a week and then slide-mounted in Keifer's F-medium (in 2014) and Hoyer medium (in 2017). The holotype and some paratypes of the new species are stored in the Hungarian Natural History Museum and other paratypes in the Arachnida collection of the Natural History Museum of Geneva (Switzerland).

The type specimens of *Tenuipalpus szarvasensis* Bozai, 1970 were loaned from the Hungarian Natural History Museum.

All specimens were investigated using a Leica 1000 scientific microscope; the illustrations were made with the aid of a drawing tube on this microscope. Pictures were made with a VHX-5000 with 20–200× objective (Keyence Co., Osaka, Japan) digital microscope. All measurements and scales are given in micrometers.

Result

***Aegyptobia bozaii* sp. n.**
http://zoobank.org/CF433BD9-1455-4EE2-84F3-DFF3ABCC858C
Figures 1–26

Material examined. Holotype: female, Hungary, Pest county, Farmos, 47°22'30"N, 19°52'08"E, 10 m a.s.l, from the leaves of the Hungarian statice, *Limonium gmelinii* subsp. *hungaricum*, 2 August 2014, Ripka, G. coll. Paratypes: one female, three deutonymphs, three protonymphs and one larva, locality and date same as for holotype. Other paratypes: four females, Hungary, Farmos, 47°22'30"N, 19°52'08"E, 10 m a.s.l, from the leaves of *Limonium gmelinii* subsp. *hungaricum*, 2 August 2017, Kontschán, J. and Ripka, G. coll.

Diagnosis (based on female). Tarsal claws uncinate. Anterior margin of prodorsal shield with paired projections, prodorsum weakly sculptured, with few irregular lines. Opisthosoma with polygonal reticulation. Propodosomal and opisthosomal setae

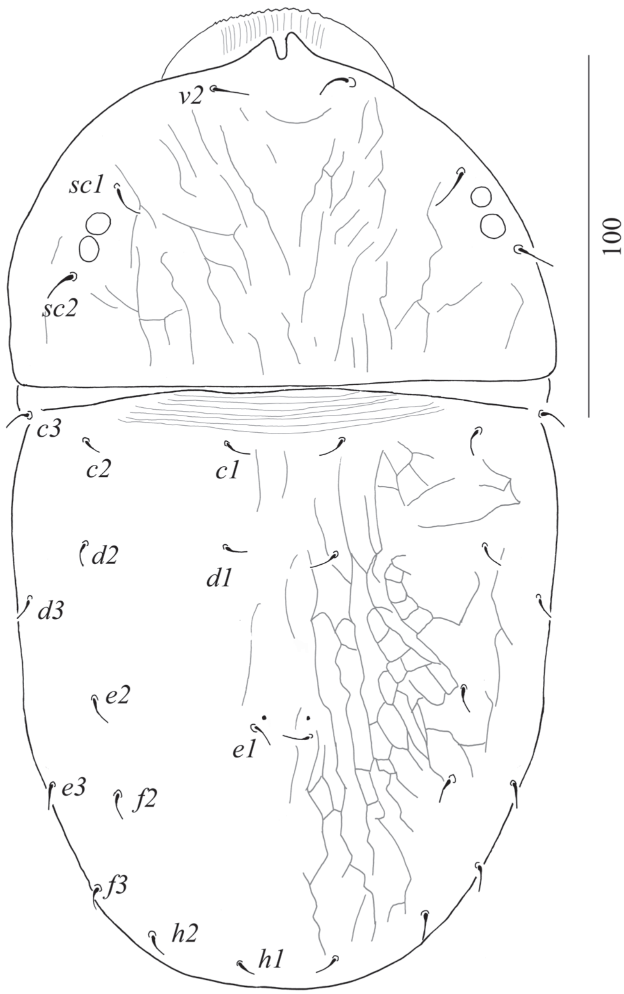


Figure 1. Dorsal view of *Aegyptobia bozaii* sp. n., holotype, female.

smooth and simple; seta *f2* present. Length of dorsal setae 6–14. Dorsal opisthosomal pores close to *e1*. Rostrum extending to middle of tibia I. Genital flap smooth. Intercoxal area between *3a* and *4a* smooth.

Description (females; n = 6). Idiosoma reddish-brown (Figure 27), oval in shape, body measured from *v2* to *h1* 240–245; from tip of rostrum 260–266; width 143–147 near setae *sc2*; distance between setae *sc2* 120–125; length of legs I–IV (without coxa), leg I 105–110, leg II 80–87, leg III 72–78, leg IV 80–88.

Dorsum (Figure 1): Anterior margin of prodorsal shield with paired projections, depth of notch 7–8. Propodosoma finely lineate. Opisthosoma with polygonal reticulations; polygons longitudinally elongate medially, transversally elongate anterolaterally. Propodosomal and opisthosomal setae simple and smooth. Opisthosomal pores present close to *e1*. Prodorsal setae *v2* shorter than half distance between their bases.

Length of dorsal setae: *v2* 11–12, *sc1* 12–14, *sc2* 11–13, *c1* 8–9, *c2* 8–9, *c3* 9–10, *d1* 9–10, *d2* 8–9, *d3* 7–8, *e1* 8–9, *e2* 7–8, *e3* 8–9, *f2* 7–8, *f3* 6–8, *h1* 6–7, *h2* 7–8.

Venter (Figure 2): Surface of ventral idiosoma smooth, except lateral to *ag*, genital and anal plates where longitudinal striations visible. Genital and anal plates smooth. Length of ventral setae, *1a* 53–57, *3a* 11–12, *4a* 8–9, *1b* 7–8, *2b* 8–9, *3b* 8–9, *4b* 9–10, *1c* 11–12, *2c* 10–13, *ag* 8–9, *g1* 9–10, *g2* 7–8. Pseudanal setae, all 6–8. All ventral setae simple and smooth.

Gnathosoma (Figure 3): Rostrum extending to middle of tibia I; palp setal counts: tarsus with one solenidion and two eupathidia, tibia with two setae, genu without seta and femur with one simple dorsal seta. All setae smooth. Subcapitulum with setae *m* (4–5).

Legs (Figures 4–8): Setal formula for leg I-IV (coxae to tarsi): 3-1-4-3-3-9, 2-1-4-3-3-9, 2-2-2-1-3-5, 2-1-1-0-3-5. A supplementary lateral (*l'*) seta present on femora I. Solenidia on tarsi I and II 8–10 long, broad, leaf-like. Tarsal claws uncinate and empodium pad-like.

Deutonymph (n = 3; Figures 9–15). Idiosoma oval in shape, body measured from *v2* to *h1* 190–200; width 130–140 near setae *sc2*.

Dorsum (Figure 9) covered with a few striae, all setae short, simple and needle-like. Length of all setae 5–7.

Venter covered with very few striae with one pair of setae *1a*, *1b*, *2b*, *3a*, *3b*, *3c*, *4a* and *4b*, one pair of aggenital, one pair of genital and three pairs of anal setae, all simple and smooth *1a* 15–16, other setae on venter 5–7 (Figure 10). Palp setal counts: tarsus with one solenidion and two eupathidia, tibia with two setae, genu without seta and femur with one simple dorsal seta (Figure 11). Legs as Figures 12–15 and Table 1.

Protonymph (n = 3; Figures 16–21). Idiosoma oval in shape, body measured from *v2* to *h1* 149–155; width 94–100 near setae *sc2*.

Dorsum (Figure 16). Surface without striae, all setae short, simple and needle-like. All setae 4–6 in length.

Venter covered with very few striae with one pair of setae *1a*, *1b*, *2b*, *3a* and *3b*, one pair of aggenital and three pairs of anal setae, all simple and smooth. *1a* 13–15, other setae on venter 5–6 (Figure 17). Legs as Figures 18–21 and Table 1.

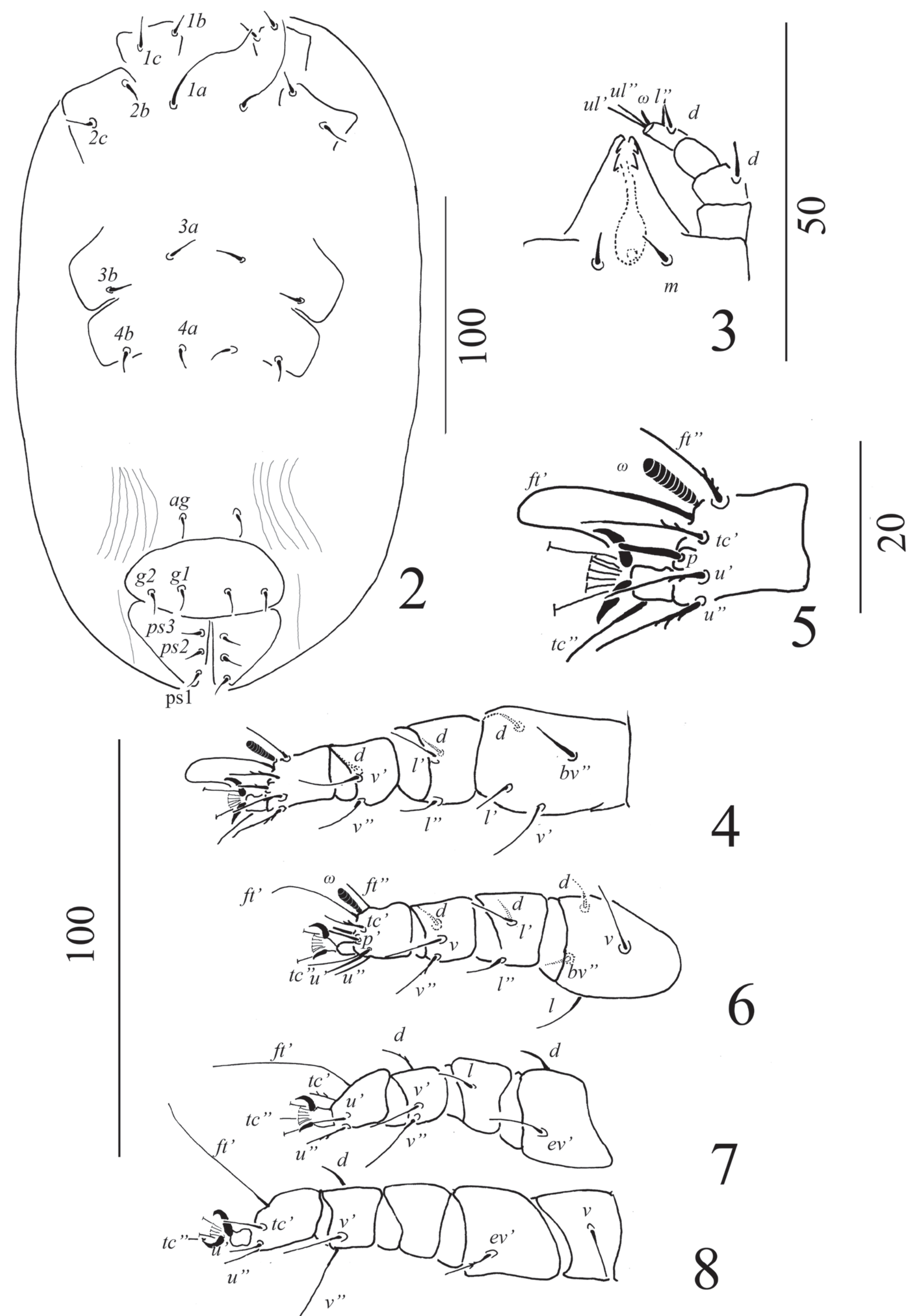
Larva (n = 1; Figures 22–26). Idiosoma oval in shape, body measured from *v2* to *h1* 109; width 82 near setae *sc2*.

Dorsum (Figure 22). Covered with a few striae, all setae short, simple and needle-like. Length of setae: *v2* 30–31; *sc1* 30–37; *sc2* 28–36; *c1* 29–38; *c2* 26–39; *c3* 31–37; *d1* 5; d3 37–43; *e1* 3; *e3* 40–54; *f2* 3–4; *f3* 64–66; *h1* 2–3; *h2* 2–5.

Venter covered with few striae with one pair of setae *1a* and three pairs of anal setae, all simple and smooth (Figure 23). Legs as Figures 24–26 and Table 1.

Etymology. We dedicate the new species to Dr. József Bozai, former Hungarian tenuipalpid specialist.

Notes on the host. The host plant, Hungarian statice (*Limonium gmelinii* subsp. *hungaricum*) (Plumbaginaceae), is an endemic subspecies occurring on salt meadows in Central-Hungary. The mites appeared to prefer leaves of the host plant that were lying close to the surface of the soil. The alkali steppe where the host plant was found



Figures 2–8. *Aegyptobia bozaii* sp. n., holotype, female **2** Ventral view of idiosoma **3** Ventral view of gnathosoma **4** Ventral view of leg I **5** Ventrolateral view of tarsus I **6** Ventral view of leg II **7** Ventral view of leg III **8** Ventral view of leg IV.

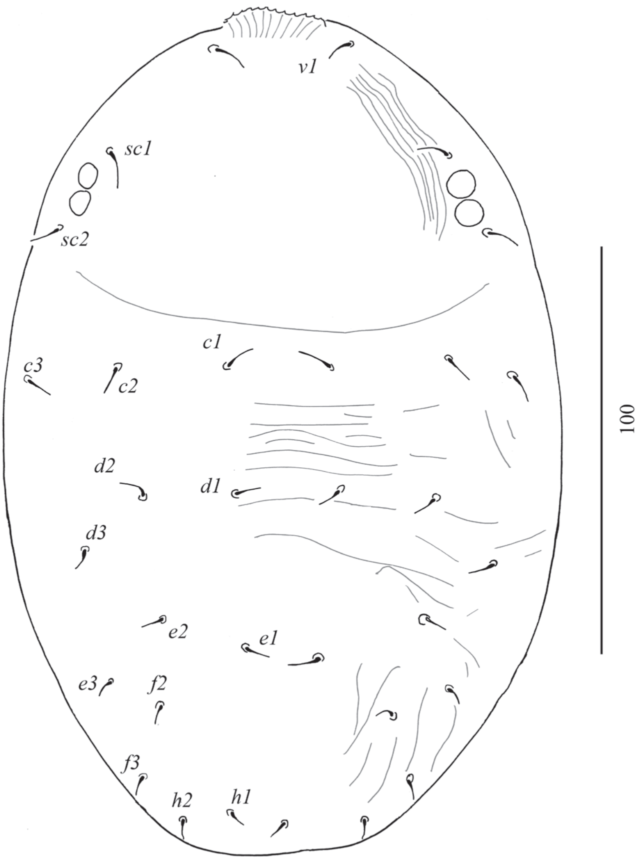
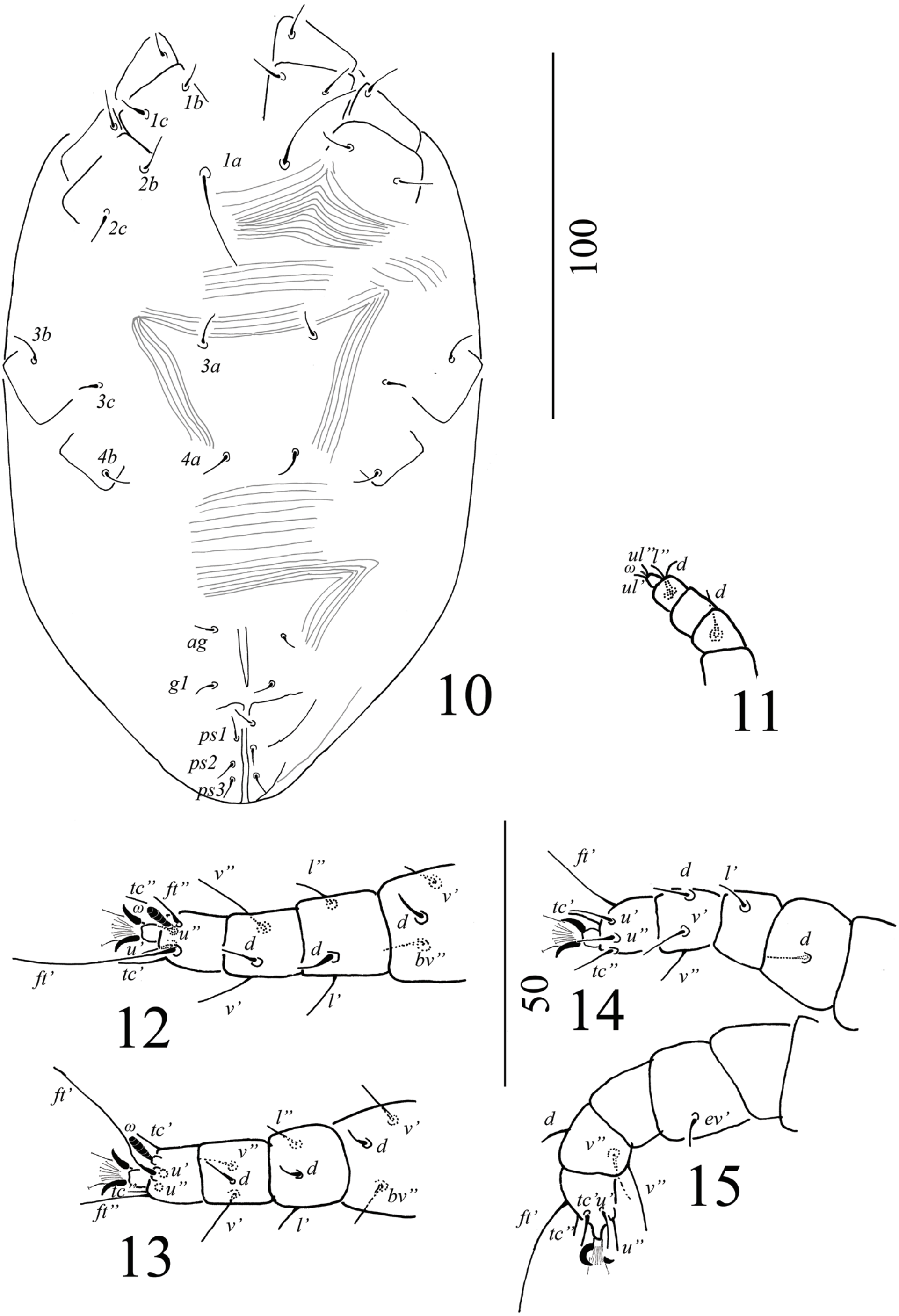


Figure 9. Dorsal view of *Aegyptobia bozaii* sp. n., paratype, deutonymph.

is hot and dry in summer, typical habitat for tenuipalpid species, which prefer warm and dry conditions. Up until now, only one species has been reported from *Limonium* plants: *Capedulia maritima* Gerson & Smith Meyer, 1980 was found on the roots of *Limonium meyeri* in Israel (Ueckermann et al. 2018).

Remarks. The new species has uncinate claws and therefore belongs to the *Aegyptobia tragardhi* species group (Khanjani et al. 2008). It is very similar to *A. iranensis* Khanjani et al., 2008 and *A. wainsteini* Bagdasarian, 1962 based on the claw-like empodium, the slender prodorsal setae, the deeply emarginated notch and the medially smooth prodorsum. The most important differences among three species are summarized in Table 2.

Only one species, *Aegyptobia wainsteini* Bagdasarian, 1962, was previously reported from Hungary from a *Biota orientalis* tree (Cupressaceae) close to the town Kecskemét (Bozai 1969). Other new occurrences have not been given since this first report. The two *Aegyptobia* species reported from Hungary differ in the shape of the dorsal setae, which are short and smooth in *A. bozaii* sp. n. and longer and finely pilose on *Aegyptobia wainsteini*.



Figures 10–15. *Aegyptobia bozaii* sp. n., paratype, deutonymph **10** Ventral view of idiosoma **11** Ventral view of palp **12** Ventral view of leg I **13** Ventral view of leg II **14** Ventral view of leg III **15** Ventral view of leg IV.

Table 1. Development of leg setae (after Seeman and Beard 2011).

	Cx I			Cx II		Cx III		Cx IV		Tr I	Tr II	Tr III		Tr IV	Fe I*			Fe II			Fe III	
	1a	1b	1c	2b	2c	3a	3b	4a	4b	v’	v’	l’	v’	v’	d	v’	bv”	d	v’	bv”	d	ev’
Larva	+	+				+									+	+	+	+	+	+	+	+
PN	+	+	+	+		+	+					+			+	+	+	+	+	+	+	+
DN	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+
Adult	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Fe IV	Ge I			Ge II			Ge III	Ti I**				Ti II				Ti III			Ti IV		
	ev’	l’	d	l”	l’	d	l”	l’	d	l’	v’	v”	d	l’	v’	v”	d	v’	v”	d	v’	v”
Larva		+			+				+	+	+	+					+	+	+	+	+	+
PN	+	+			+			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
DN	+	+	+	+	+	+	+	+	+	?	+	+	+	?	+	+	+	+	+	+	+	+
Adult	+	+	+	+	+	+	+	+	+	?	+	+	+	?	+	+	+	+	+	+	+	+
	Ta I-II									Ta III							Ta IV					
	u’	u”	p’	p”	tc’	tc”	ft’	ft”	ω	u’	u”	p’	p”	tc’	tc”	ft’	u’	u”	tc’	tc”	ft’	
Larva	+	+	+	+			+	+	+	+	+					+						
PN	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+			+	
DN	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Adult	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	

* The new species has a supplementary lateral (*l’*) seta on femora I.

** The setae *l’* on tibiae I and II in adult female and deutonymphs are not visible.

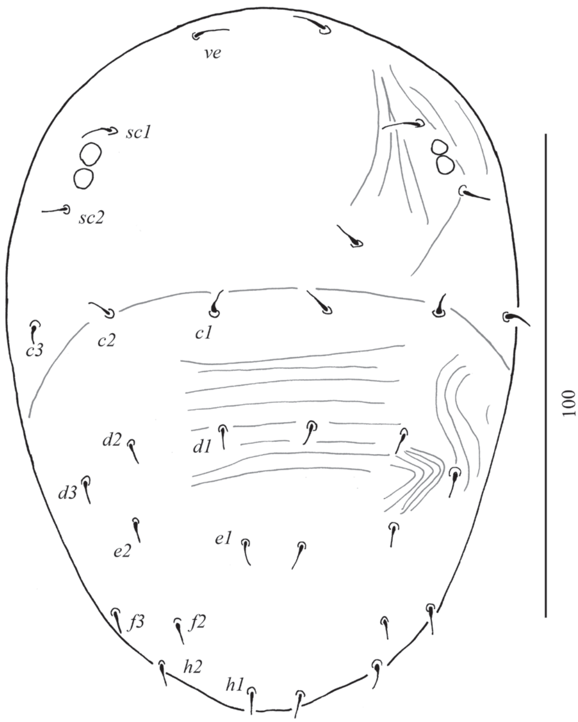
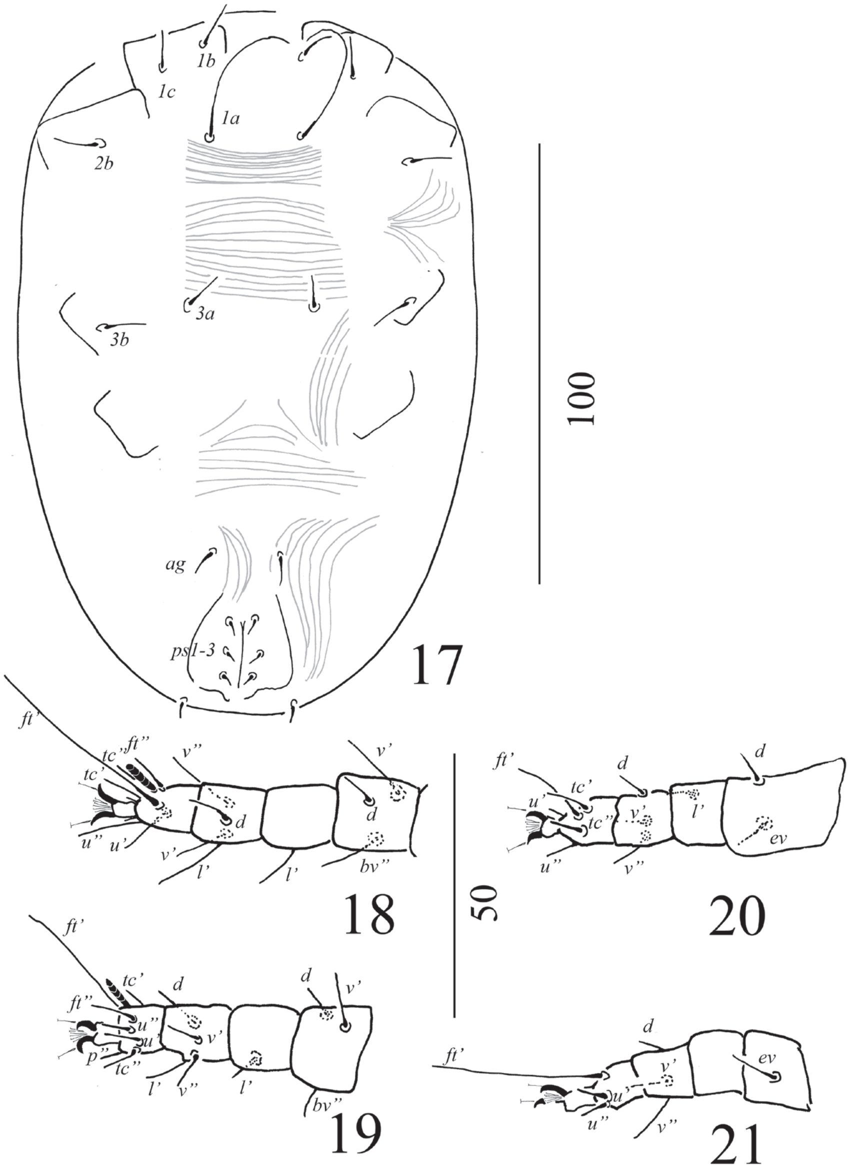


Figure 16. Dorsal view of *Aegyptobia bozaii* sp. n. paratype, protonymph.

Table 2. Distinguishing characteristics among *Aegyptobia bozaii, A. iranensis* and *A. wainsteini.*

Character	*Aegyptobia bozaii*	*Aegyptobia iranensis*	*Aegyptobia wainsteini*
Surface between *c1* and *d1*	with large reticulations	with large reticulations	smooth
Distance between setae *v2*	three times longer than length of *v2*	two times longer than length of *v2*	same as length of *v2*
Setae *3a*	1/2 the distance *3a-3a*	two times the distance *3a-3a*	1/2 the distance *3a-3a*



Figures 17–21. *Aegyptobia bozaii* sp. n., paratype, protonymph **17** Ventral view of idiosoma **18** Ventral view of leg I **19** Ventral view of leg II **20** Ventral view of leg III **21** Ventral view of leg IV.

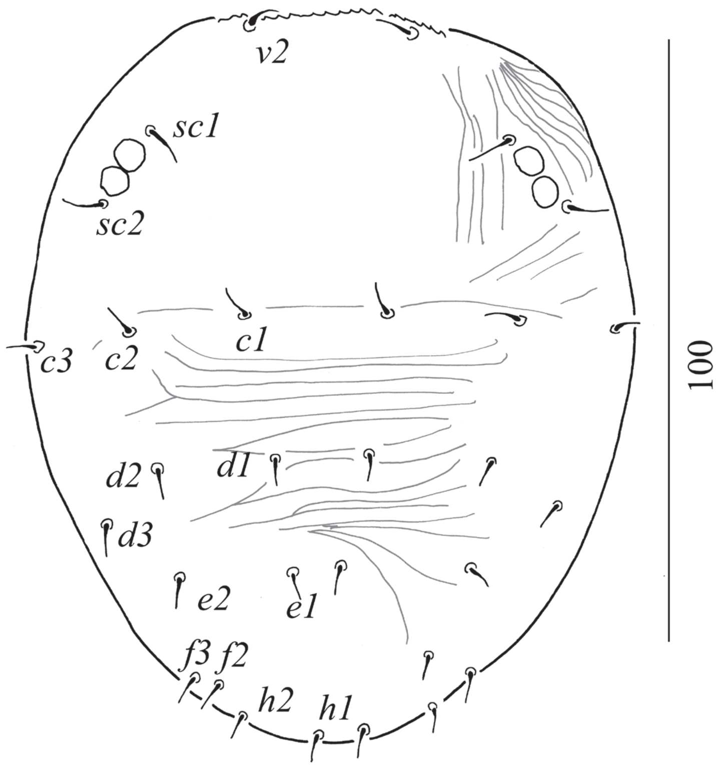


Figure 22. Dorsal view of *Aegyptobia bozaii* sp. n., paratype, larva.

Tenuipalpus szarvasensis Bozai, 1970

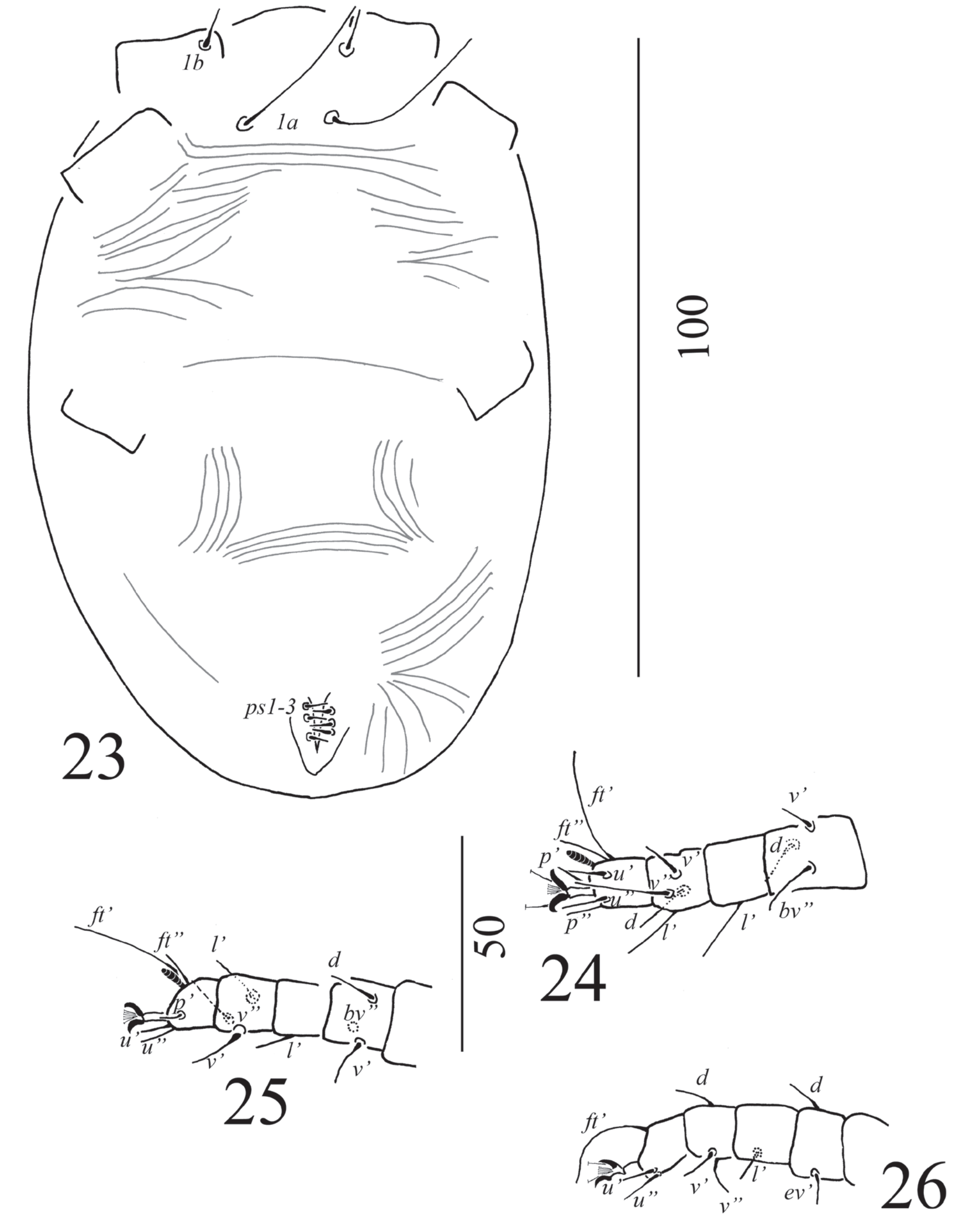
Tenuipalpus szarvasensis Bozai, 1970: 367.

Tenuipalpus cheladzeae Gomelauri, 1960 as senior synonym of *T. szarvasensis* by Mitrofanov and Strunkova 1979: 51.

Tenuipalpus cheladzeae: Kontschán and Ripka 2017.

Material examined. Holotype: female, HNHM Astig-242, Szarvas, 8 October 1968, from *Picea excelsa* Lk. No. 1250, Bozai, J. coll.

Diagnosis (based on female). Anterior margin of prodorsal shield with forked projection; prodorsum smooth medially, with some striae laterally; anterolateral projections carrying setae *sc2* weakly formed. Opisthosoma smooth anteriorly, with posteromedial reticulation and posterolateral longitudinal striation. Propodosomal setae as follows: *v2* short and smooth, *sc1* broad and obovate, *sc2* long and phylliform. Opisthosomal setae: *c1, c3* and *d1* broad, long, oblanceolate, *d3* short and oblanceolate, *e1* short and smooth, *h1, f1, f2* and *e3* long, oblanceolate, *h2* very long and smooth. Rostrum extending to middle of tibia I. Genital flap smooth. Intercoxal area



Figures 23–26. *Aegyptobia bozaii* sp. n., paratype, larva **23** Ventral view of idiosoma **24** Ventral view of leg I **25** Ventral view of leg II **26** Ventral view of leg III.

between *3a* and *4a* smooth, *1a* and *4a* very long, *1b, 2b, 2c, 3a, 3b, 4b, ag, g1, g2* short. Legs with large, broad and phylliform, smooth and pilose setae.

Description (female holotype). Colorization of idiosoma not observable in the holotype. Idiosoma (Figure 27) pentagonal in shape, body measured from *v2* to *h1* 305; from tip of rostrum 350; width between setae *sc2* 190.

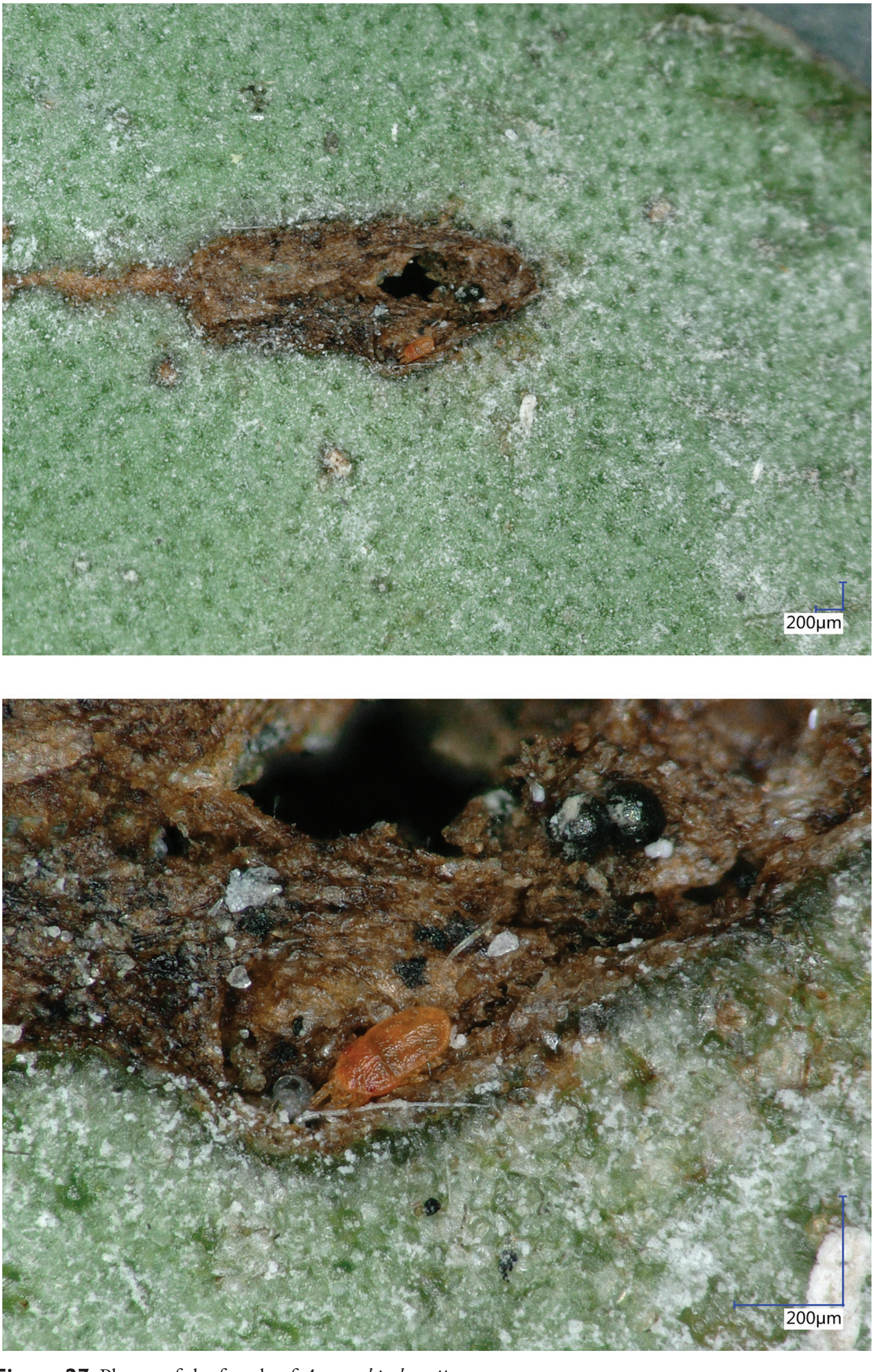


Figure 27. Photos of the female of *Aegyptobia bozaii* sp. n., paratype.

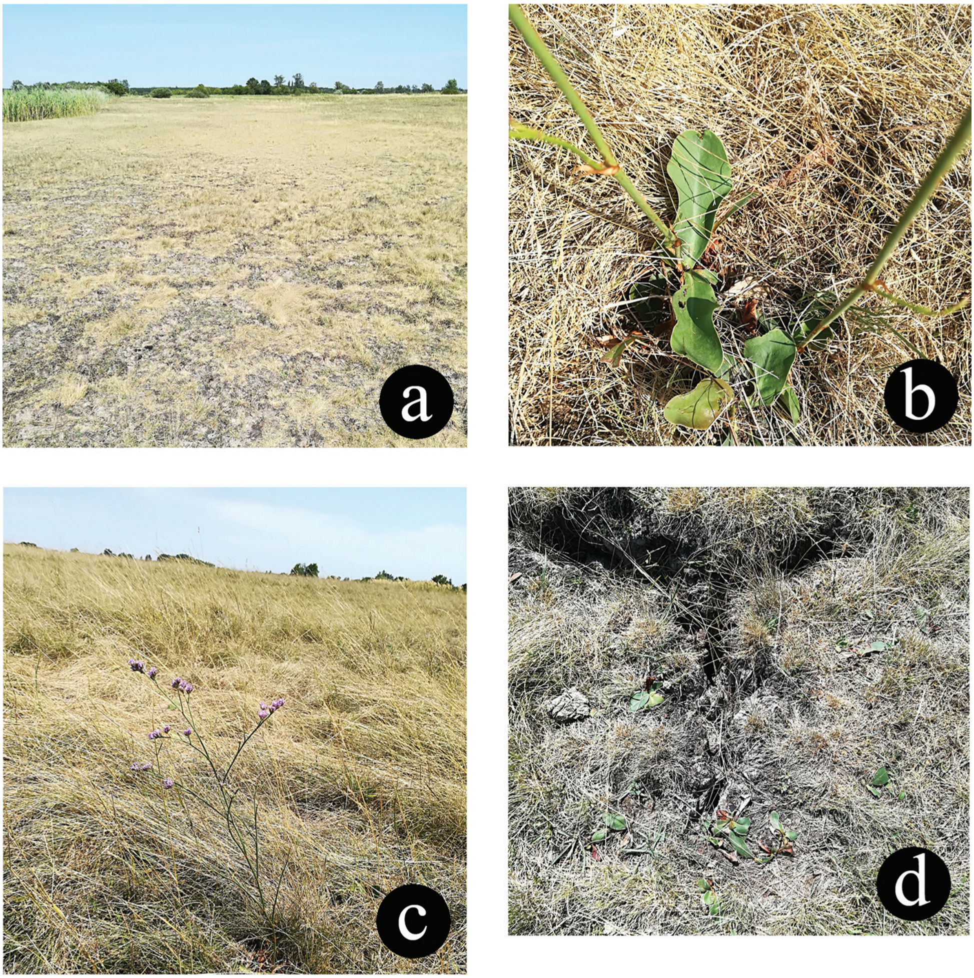


Figure 28. Habitat and details of the host plant. **a** Habitat **b** Host plant **c–d** Leaves of host plant.

Dorsum (Figure 29): Anterior margin of prodorsal shield with paired projections, depth of notch 16. Prodorsum smooth medially, with some striae laterally; anterolateral projections carrying setae *sc2* weakly formed. Opisthosoma smooth anteriorly, with posteromedial reticulation and posterolateral longitudinal striation. Propodosomal setae as follows: *v2* short and smooth, *sc1* broad and obovate, *sc2* long and phylliform. Opisthosomal setae: *c1, c3* and *d1* broad, long, oblanceolate, *d3* short and oblanceolate, *e1* short and smooth, *h1, f1, f2* and *e3* long, oblanceolate, *h2* very long and smooth. Rostrum extending to middle of tibia I. Opisthosomal pores between *d1* and *e1*. Length of dorsal setae: *v2* 9–10, *sc1* 30–32, *sc2* 65, *c1* 45–46, *c3* 32–34, *d1* 38–40, *d3* 12–14, *e1* 12, *e2* 45–47, *f2* and *f3* 45–46, *h1* 36–37, *h2* 105–110.

Venter (Figure 30): Very few striations observable in the holotype, only a few longitudinal striations visible posterior to *g1–g2*. Genital and anal plates smooth. Length of ventral setae, *1a* 120–122, *3a* 26–27, *4a* 130–133, *1b* 16, *2b* 16–17, *3b* 18–19, *4b*

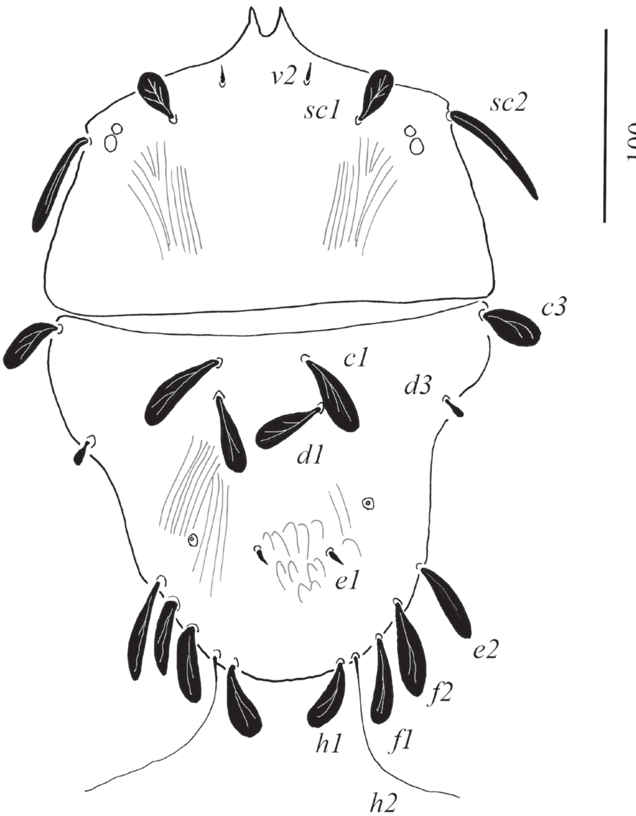


Figure 29. Dorsal view of *Tenuipalpus szarvasensis* Bozai, 1970, holotype, female.

13, *1c* and *2c* 24–25, *ag* 12, *g1–g2* 14–16. Pseudanal setae, all 12–13. All ventral setae simple and smooth.

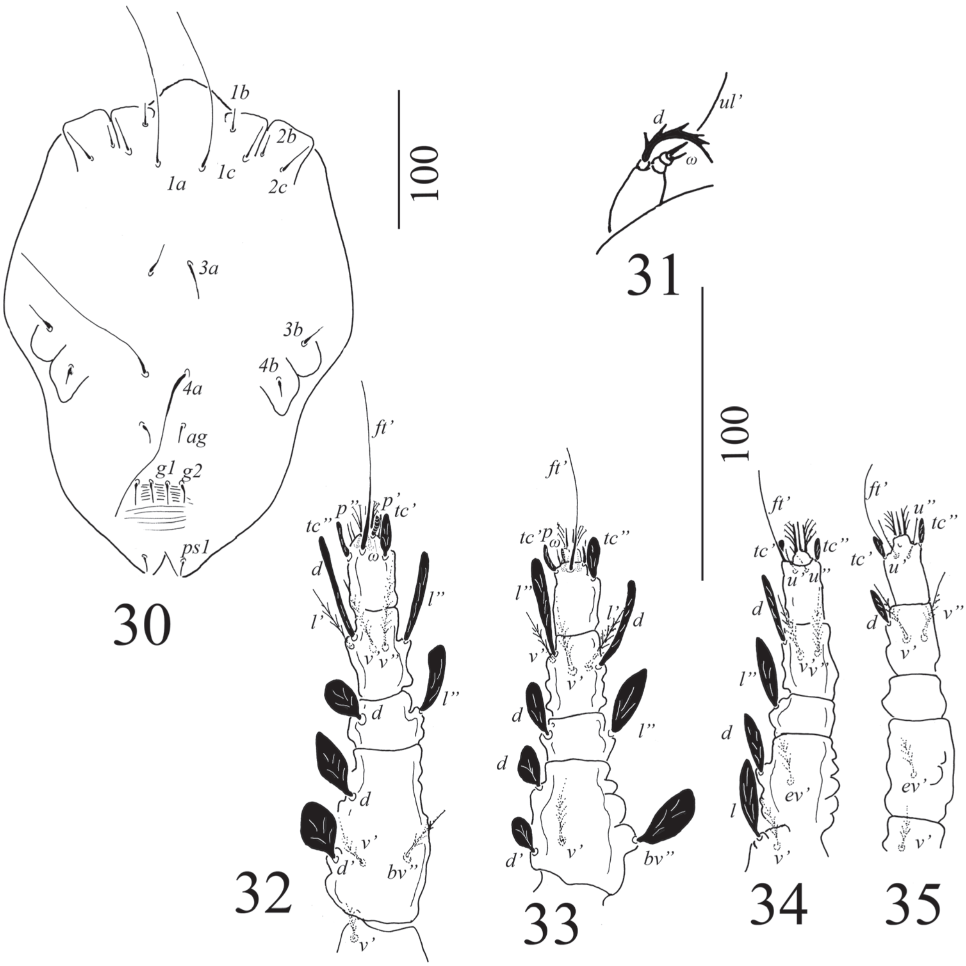
Gnathosoma: Rostrum extending to middle of tibia I; palp setal counts as in Figure 31.

Legs: Setal formula for leg I–IV (coxae to tarsi): 3-1-4-2-5-9, 2-1-4-2-4-9, 2-2-2-1-3-5, 2-1-1-0-3-5. Shape of the setae on legs illustrated on Figures 32–35.

Notes. Bozai's (1970) noted in his detailed description of *Tenuipalpus szarvasensis*, that the species is very similar to *T. cheladzeae*, but he mentioned some easy to observe differences (like shape and length of setae *c1, d1*) between these two species. Despite these known differences, Mitrofanov and Strunkova (1979) synonymized the name under *Tenuipalpus cheladzeae*. Mitrofanov and Strunkova (1979) did not study the type specimens of *T. szarvasensis*, therefore their opinion was questionable.

This year, we studied the types of Bozai's *T. szarvasensis* in order to confirm Bozai's hypothesis that *T. szarvasensis* differs from Gomelauri's *T. cheladzeae*. The differences are presented in Table 3 and are illustrated in Figures 36, 37.

Tenuipalpus is the largest genus of flat mites, but very few are known from Pinaceae. Apart from the above-mentioned two species, the only other species is *T. hondurensis* Evans, in Evans et al. (1993) (Mesa et al. 2009), which is considerably different from both the above species. *Tenuipalpus cupressoides* Smith, Meyer

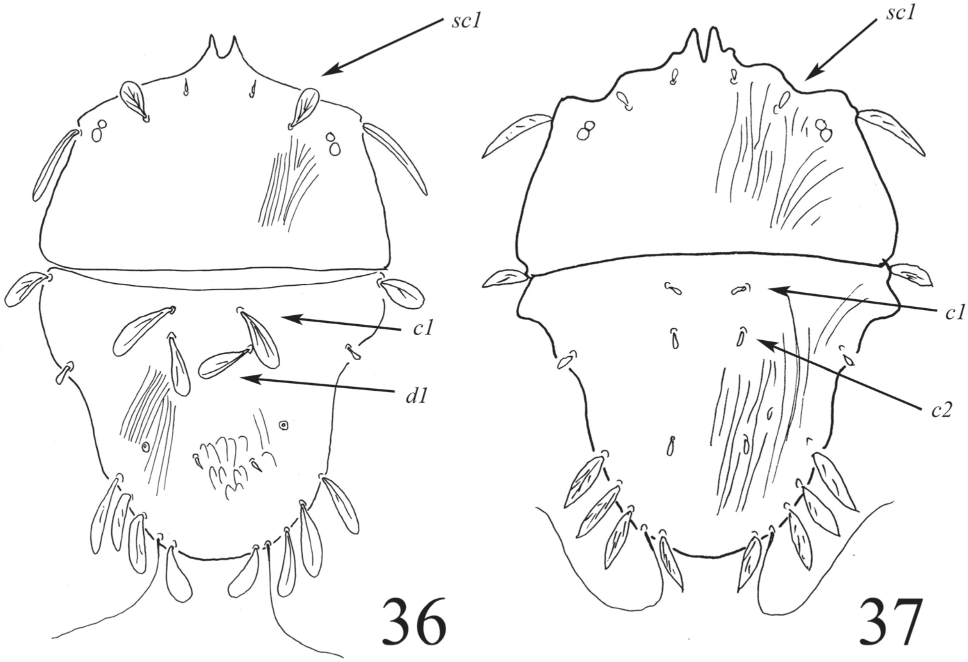


Figures 30–35. *Tenuipalpus szarvasensis* Bozai, 1970, holotype, female **30** Ventral view of idiosoma **31** Dorsal view of palp **32** Ventral view of leg I **33** Ventral view of leg II **34** Ventral view of leg III **35** Ventral view of leg IV.

Table 3. Distinguishing characters between *Tenuipalpus cheladzeae* and *T. szarvasensis*.

Character	*T. cheladzeae*	*T. szarvasensis*
Shape of *v2*	apically rounded	apically pointed
Shape of *sc1*	short (12–14) and bulbiform	long (30–32) and phylliform
Shape of *c1* and *d1*	short (*c1* 10–11, *d1* 9–11) and bulbiform	long (*c1* 45–46, *d1* 38–40) and phylliform

& Gerson, 1980 is very similar to *T. szarvasensis*, but the shape of *v2* and *e2* and the length of *sc1, c1* and *d1* are different. In addition, the host plant, *Cupressus sempervirens* of *T. cupressoides* belongs to the family Cupressaceae and not to Pinaceae (Ueckermann et al. 2018).



Figures 36–37. Illustrated differences between *T. szarvasensis* (**36**) and *T. cheladzeae* (**37**) Drawing of *T. cheladzeae* modified after Mitrofanov and Strunkova (1979).

Acknowledgements

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References

Bagdasarian AT (1962) Contribution to the fauna of false spider mites from Armenia. Izvestiia Akademii Nauk SSR, Moscow 15: 49–58.

Bozai J (1969) Új lapostestű atkák Magyarországon (Tenuipalpidae, Acari). (Some tenuipalpids (Acari) new for the fauna of Hungary.) Folia Entomologica Hungarica 22: 117–130.

Bozai J (1970) *Tenuipalpus szarvasensis* sp. n., a new mite species from Hungary (Acari: Tenuipalpidae). Acta Zoologica Academiae Scientiarum Hungaricae 16(3–4): 367–369.

Evans G, Cromroy HL, Ochoa R (1993) The Tenuipalpidae of Honduras (Tenuipalpidae: Acari). Florida Entomologist 76(1): 126–155. https://doi.org/10.2307/3496021

Gerson U, Smith Meyer MKP (1980) A new species of Capedulia (Acari: Tenuipalpidae) from a marine habitat in Israel. Israel Journal of Entomology 14: 9–12.

Gomelauri LA (1960) New species in the genus *Tenuipalpus* from the Georgia, Gruzia, SSR (Acarina: Tenuipalpidae). Reports of the Academy of Science of the Georgian SSR. Soobshcheniya Akademii Nauk Gruzinskoi 24(1): 77–79.

Khanjani M, Gotoh T, Varandi HB (2008) A new species of the genus *Aegyptobia* Sayed (Acari: Prostigmata, Tenuipalpidae) from Iran. Systematic & Applied Acarology 13(1): 65–69. https://doi.org/10.11158/saa.13.1.7

Kontschán J, Ripka G (2017) Checklist of the Hungarian spider mites and flat mites (Acari: Tetranychidae and Tenuipalpidae). Systematic & Applied Acarology 22(8): 1199–1225. https://doi.org/10.11158/saa.22.8.6

Mesa NC, Ochoa R, Welbourn WC, Evans G, Moraes GJ de (2009) A catalog of the Tenuipalpidae (Acari) of the World with a key to genera. Zootaxa 2098: 1–185.

Mitrofanov VI, Strunkova ZI (1979) Opredelitelj kleshchej-ploszkotelok. Izdateljsztvo „Donis" Dushanbe, 148 pp.

Seeman OD, Beard JJ (2011) A new species of *Aegyptobia* (Acari: Tenuipalpidae) from Myrtaceae in Australia. Systematic & Applied Acarology 16: 73–89. https://doi.org/10.11158/saa.16.1.10

Ueckermann EA, Palevsky E, Gerson U, Recht E, Theron PD (2018) The Tenuipalpidae (Acari: Trombidiformes) of Israel. Acarologia 58(2): 483–525.

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Establishment of a new genus, *Brephallus* Wang et al., gen. nov. (Blattodea, Blaberidae, Epilamprinae) based on two species from *Pseudophoraspis*, with details of polymorphism in species of *Pseudophoraspis*

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Abstract

Brephallus Wang et al., **gen. n.** is established as a genus distinct from *Pseudophoraspis* Kirby, 1903 because of the lack of a well-developed apical outgrowth on sclerite L2D and substantial genetic differences. Two species are transferred to the new genus from *Pseudophoraspis*, i.e., *Brephallus fruhstorferi* (Shelford, 1910), **comb. n.** and *Brephallus tramlapensis* (Anisyutkin, 1999), **comb. n.** We provide a detailed generic diagnosis of *Brephallus* Wang et al., **gen. n.** Based on COI data, males, females and nymphs of three *Pseudophoraspis* species (*P. clavellata* Wang et al., 2013, *P. recurvata* Wang et al., 2013 and *P. kabakovi* Anisyutkin, 1999) were successfully matched. The former two are sexually dimorphic with macropterous males and micropterous females. Photos of the species from China are presented.

Keywords

China, sexual dimorphism, species delimitation, taxonomy, cockroaches

Introduction

Pseudophoraspis Kirby, 1903 is a genus of Epilamprinae cockroaches from South-east Asia whose taxonomy and biogeography were recently discussed by Wang et al. (2013). They exhibit some parental care behaviors rare among cockroaches (Tallamy and Wood 1986; Clutton-Brock 1991). *Pseudophoraspis nebulosa*, the type species of the genus, has offspring that cling ventrally to the parent's body after hatching and feed on their mother's bodily secretions (Nalepa and Bell 1997). Yet, owing to the lack of research on *Pseudophoraspis*, this behavior in other members of the genus remains unknown.

Currently, the genus is composed of 18 species (Beccaloni 2014). According to original descriptions, 15 species are from South-east Asia (Cambodia, Thailand, Vietnam and Malaysia), and three from South China (Yunnan, Hainan). Among these, internal male genitalia are known for only 13 species (Anisyutkin 1999; Anisyutkin 2005; Wang et al. 2013). Meanwhile, only the external morphology of the remaining five species has been described, four of which are based on female specimens (Walker 1868; Hanitsch 1925, 1933).

In the past, some external morphological characters have been used to diagnose *Pseudophoraspis* (e.g. male and female with fully-developed tegmina and wings, and head entirely covered by the pronotum; Kirby 1903; Shelford 1910; Hanitsch 1915; Princis 1958; Wang et al. 2013). Additionally, the genus has been identified by the apical part of sclerite L2D having a well-developed apical outgrowth (Anisyutkin 1999; Wang et al. 2013). Yet, two species, *P. fruhstorferi* Shelford 1910 and *P. tramlapensis* Anisyutkin 1999 are distinctively different from their congeners by the absence of this genital character (Anisyutkin 1999; Wang et al. 2013). Anisyutkin (1999) mentioned that *P. fruhstorferi* and *P. tramlapensis* were included conditionally in *Pseudophoraspis*. Wang et al. (2013) subdivided this genus into two species groups, the *fruhstorferi* group and the *gorochovi* group, but only according to pronotal characteristics and without information on the females of the *gorochovi* group. Males, females and nymphs in this genus from the same locality are difficult to match accurately (Wang ZZ, pers. obs.). Sexual dimorphism can exaggerate male-female differences to the extent that the sexes appear to be entirely different species. In the genera *Escala* Shelford, 1906 and *Robshelfordia* Princis, 1954, for example, most females have micropterous tegmina that are reduced to small lateral pads without wings, and in the genus *Laxta* Walker, 1868, the females are apterous. But the males of these three genera usually have fully-developed tegmina and wings (Roth 2003).

The commonly-adopted, standard COI sequence has proven to be highly informative and successful in resolving problems of polymorphism, sexual dimorphism and identification of nymphs in cockroaches (Evangelista et al. 2013; Yue et al. 2014; Che et al. 2017; Bai et al. 2018). These issues highlight the need for determining the taxonomic status of *P. fruhstorferi* and *P. tramlapensis*, and clarifying approaches toward solving sexual dimorphism in cockroach species.

In this study, *Brephallus* Wang et al., gen. n. is established for two species, *Brephallus fruhstorferi* (Shelford, 1910), comb. n. and *Brephallus tramlapensis* (Anisyutkin, 1999), comb. n. A combination of newly generated and publicly available molecular data (COI) has been used to aid in associating adult sexual morphs and juveniles. Additionally, this study adds to the knowledge of cockroach diversity in China.

Material and methods

Specimen collection and morphological study

In this study, 32 specimens were collected at night with the help of headlight from dead leaves of grasses or shrubs in the litter layer. Other specimens were mostly collected with a net in daytime. Voucher specimens are deposited in the Institute of Entomology, College of Plant Protection, Southwest University (SWU), Chongqing, China.

Terminologies used for male genitalia mainly follow Klass (1997) and Anisyutkin (2014). The apical part of an abdomen was removed and macerated in 10% NaOH and observed in glycerin jelly using a Motic K400 stereomicroscope. The dissected genitalia were preserved in glycerin jelly. Specimens were photographed using a Canon50D with a Canon EF 100mm f/2.8L Macro IS USM Macro USM lens, and stacked with Helicon Focus software. All photos and images were edited with Adobe Photoshop CS5. Male adults were identified to species mainly based on morphological characters, including the apical part of sclerite L2D, the macula on the head, depressions and punctuation on the pronotal disk, and wing size.

Phylogenetic data collection and analysis

Tissue samples from adult females and nymphs were used directly for PCR analysis and DNA sequencing. The hind legs were used for DNA extraction. Other body parts were stored in 95% ethanol as voucher specimens. In total, 32 specimens were used for COI sequencing in this study and all sequences are deposited at the National Center for Biotechnology Information GenBank (Table 1).

DNA extraction, PCR amplification and sequencing follow Bai et al. (2018). COI specific primers were used: LCO1490 (GGTCAACAAATCATAAAGATATTGG); and HCO2198 (TAAACTTCAGGGTGACCAAAAAATCA).

PCR products were sent to BGI Technology Solutions Company Limited (BGI-Tech) (Beijing, China) for sequencing using the aforementioned primers.

A total of 48 COI sequences were analyzed (32 new sequences from this study, and 14 cockroach sequences and 2 mantis sequences downloaded from GenBank; Table 2). All COI sequences were aligned using MUSCLE 3.8 (Edgar 2004) and adjusted visually after translation into amino acid sequences. Intraspecific and interspecific genetic divergence values were quantified based on the Kimura 2-parameter (K2P) distance model (Kimura 1980), and variance was estimated by using bootstrap method with 1000 bootstrap replications in MEGA 6.0.6 (Tamura et al. 2013). Phylogenetic analysis was done using Maximum Likelihood (ML) in RAxML (Stamatakis et al. 2008) following the GTR GAMMA model with 1000 bootstrap replicates.

Table 1. Specimens for which COI DNA barcodes were sequenced.

Species	Specimen voucher	Sequence ID	Location (China)	Accession Number
P. clavellata	I01.1M	RhicClav01	Xishuangbanna, Yunnan	MH755944
	I01.2M	RhicClav03	Pu'er, Yunnan	MH755945
	I01.2F	RhicClav04	Pu'er, Yunnan	MH755946
	I01.3M	RhicClav02	Xishuangbanna, Yunnan	MH755947
	I01.4M	RhicClav05	Pu'er, Yunnan	MH755948
	I01.5N	RhicClav06	Xishuangbanna, Yunnan	MH755949
P. recurvata	I02.1M	RhicRecu01	Changjiang, Hainan	MH755950
	I02.2F	RhicRecu05	Sanya, Hainan	MH755951
	I02.3M	RhicRecu03	Baoting, Hainan	MH755952
	I02.3F	RhicRecu04	Baoting, Hainan	MH755953
	I02.4M	RhicRecu02	Changjiang, Hainan	MH755954
	I02.5F	RhicRecu06	Sanya, Hainan	MH755955
P. kabakovi	E04.1F	RhicKaba02	Menglun, Yunnan	MH755937
	E04.1M	RhicKaba01	Menglun, Yunnan	MH755938
	E04.2F	RhicKaba04	Xishuangbanna, Yunnan	MH755939
	E04.2N	RhicKaba05	Menglun, Yunnan	MH755940
	E04.2M	RhicKaba03	Xishuangbanna, Yunnan	MH755941
	E04.3M	RhicKaba06	Menglun, Yunnan	MH755942
	E04.4F	RhicKaba07	Menglun, Yunnan	MH755943
B. fruhstorferi	E01.1M	PseuFruh01	Jianfengling, Hainan	MH755924
	E01.2M	PseuFruh02	Limushan, Hainan	MH755925
	E01.4N	PseuFruh04	Diaoluoshan, Hainan	MH755926
	E01.5F	PseuFruh05	Jianfengling, Hainan	MH755927
	E01.5M	PseuFruh06	Jianfengling, Hainan	MH755928
	E01.7F	PseuFruh09	Wuzhishan, Hainan	MH755929
	E01.8F	PseuFruh11	Yinggeling, Hainan	MH755930
	E01.8M	PseuFruh10	Yinggeling, Hainan	MH755931
	E01.9F	PseuFruh12	Yinggeling, Hainan	MH755932
	E01.9M	PseuFruh13	Yinggeling, Hainan	MH755933
B. tramlapensis	E02.1M	PseuTram01	Damingshan, Guangxi	MH755934
	E02.2M	PseuTram02	Dayaoshan, Guangxi	MH755935
	E02.3M	PseuTram03	Mangshan, Hunan	MH755936

Table 2. Ectobiidae and Mantodea (outgroup) used in this study.

Species	Family	Accession number	Reference
Sorineuchora bivitta	Ectobiidae	KY349592, KY349593	Che et al. 2017
Sorineuchora nigra	Ectobiidae	KY349516-KY349522	Che et al. 2017
Allacta ornata	Ectobiidae	KY349665	Che et al. 2017
Balta jinlinorum	Ectobiidae	KY349666-KY349669	Che et al. 2017
Mantis religiosa	Mantidae	KR148854, KM529415	Hebert et al. 2016, Dewaard et al. (Unpublished)

Results

Phylogenetic analysis based on COI data

In this study, we acquired 32 COI sequences whose length, excluding primers, was 658bp each. All of the new sequences have been deposited in GenBank with accession numbers MH755924 to MH755955 (Table 1). The COI region we sequenced had a relatively high AT content (65.8%), with an average nucleotide composition of A = 30.3%, T = 35.5%, C = 18.3%, and G = 15.9%. Sequence analysis revealed that 156 (23.71%) sites were variable, of which 148 (22.49%) sites were parsimoniously informative.

The ML phylogeny of the COI data revealed that clades from the same species, including females and nymphs, constitute monophyletic groups with very strong bootstrap values (all MLB = 100) (Figure 1). Three recognized major lineages of *Pseudophoraspis* (*P. clavellata*, *P. recurvata* and *P. kabakovi*) are recognized, and cluster with the ectobiids *Sorineuchora*, *Allacta* and *Balta*, with high support values, but are more distant from the other two Epilamprinae, *P. fruhstorferi* and *P. tramlapensis.*

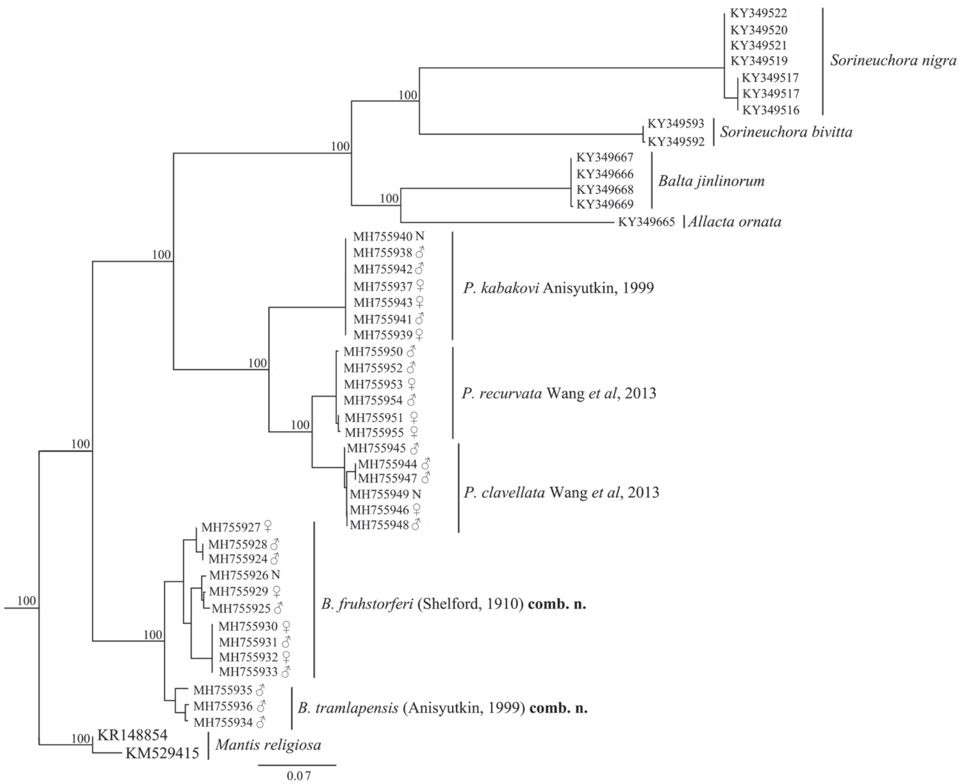

Figure 1. Maximum likelihood (ML) tree derived from COI gene analysis following GTR GAMMA model with 1000 bootstrap replicates. The bootstrap support are all 100%, in this phylogenetic tree.

Establishment of *Brephallus* Wang et al., gen. n.

Pseudophoraspis fruhstorferi and *P. tramlapensis* are easily distinguished from other congeners by the apical part of sclerite L2D lacking a well-developed apical outgrowth (Anisyutkin 1999; Wang et al. 2013). Other diagnostic morphological characters of these two species compared with other *Pseudophoraspis* members are shown in Table 3. Therefore, these two species are moved to *Brephallus* Wang et al., gen. n. (i.e., *Brephallus fruhstorferi* (Shelford, 1910), comb. n., and *Brephallus tramlapensis* (Anisyutkin, 1999), comb. n.). In addition, these two species were recovered as sister groups and show a close relationship to each other, but were distant from the other three *Pseudophoraspis* species (Figure 1).

Genus *Brephallus* gen. n.

http://zoobank.org/6023C59C-4D25-4730-9FB1-90FEAA7CD51F
Figures 2A–F, 3F–G, 4D–E, 4G, 5G–H

Species included. *Brephallus fruhstorferi* (Shelford, 1910), comb. n., *Brephallus tramlapensis* (Anisyutkin, 1999), comb. n.

Type species. *Pseudophoraspis fruhstorferi* Shelford, 1910, by present designation.

Generic diagnosis. Coloration brownish yellow. Pronotum smooth, completely covering vertex, anterior margin curved and posterior margin obtusely produced. Tegmina and wings fully developed in both sexes, entirely covering abdomen, tegmina about twice as long as broad, apices rounded (Figure 2A–F). Hind metatarsus shorter than succeeding tarsal segments combined, with two equal rows of spines along most of its length, 2^{nd}–4^{th} segments with large euplantulae. Supra-anal plate and hypandrium nearly symmetrical, posterior margin emarginate near mid-line (Figure 4G).

Male genitalia (Figure 4D–E). Right phallomere similar to that in *Morphna*, *Opisthoplatia*, and *Rhabdoblatta* with well-developed caudal part of sclerite R1T subrectangular in shape, R2 rounded, R3 well developed, widened caudally and fused with R5. Sclerite L2D similar to *Rhabdoblatta*, divided into basal and apical parts, basal part rod-like, apical part more or less rounded, cap-shaped, but with more bristles. Sclerite L3 with terminal rectangular apex pointed and folded, scattered with bristles.

The new genus differs from other genera of Epilamprinae as follows: 1) male tegmina about twice as long as broad (Figure 2A, E); 2) facial part of head with large brown spot from ocellus to clypeus, basal margin of ocellus with brown spot (Figure 2B, D, F); 3) one third of radius vein of tegmen from base yellowish white (Figure 2A, C, E); 4) sclerite L3 with terminal rectangular, apex pointed (Figure 4D–E).

Etymology: We propose the name *Brephallus*, based on the composition of two Latin words ("*brevis*" and "*phallus*") meaning "short phallomere", in reference to the short L2D sclerite of the male genitalia.

Remarks. This genus differs from *Pseudophoraspis* in the apical part of sclerite L2D without a well-developed apical outgrowth. Meanwhile, the mean sequence divergence among species of *Brephallus* and *Pseudophoraspis* ranged from 15.2% to 18.8%, larger

Table 3. Diagnostic morphological characters among *Brephallus* Wang et al., gen. n., the *nebulosa* group and the *gorochovi* group of *Pseudophoraspis*.

Species	Characters						
	I	II	III	IV	V	VI	VII
Brephallus Wang et al., gen. n.	0	1	1	2	0	1	0
Pseudophoraspis nebulosa group	0	1	0	0	1	0	1
Pseudophoraspis gorochovi group	1	0	0	1	1	0	1

I depressions and punctuation on pronotum present (1), absent (0) **II** females with tegmina and wings fully-developed (1), tegmina reduced to lateral scales without wings (0) **III** male tegmina about twice as long as broad (1), tegmina length more than twice as broad (0) **IV** facial part of head with large brown spot from ocellus to clypeus, basal margin of ocellus with brown spot (2), vertex to basal margin of ocellus with brown spot (1), inside and basal margin of ocellus with brown round spot (0) **V** female supra-anal plate with posterior margin distinctly exceeding posterior margin of subgenital plate (1), not beyond (0)**VI** R3 well-developed, widened caudally and fused with R5 of right phallomere (1), R3 not widened caudally and fused with R5 (0) **VII** the apical part of sclerite L2D with well-developed apical outgrowth (1), without (0)

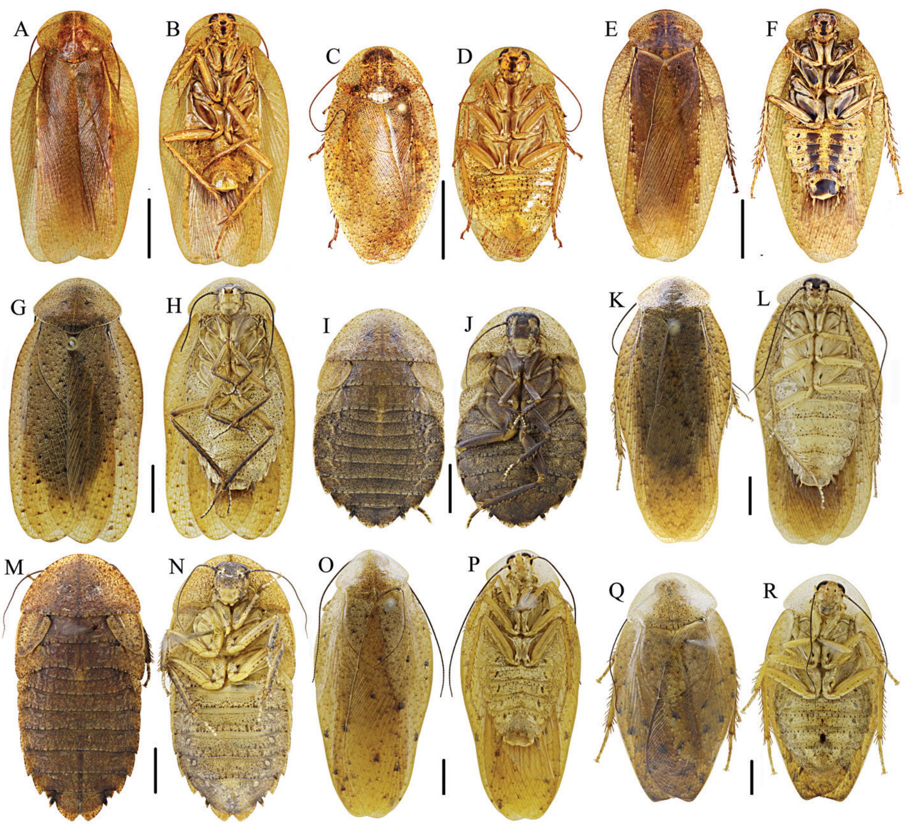

Figure 2. A–D *Brephallus fruhstorferi* (Shelford, 1910) **comb. nov.** (male **A–B** female **C–D**) **E–F** *Brephallus tramlapensis* (Anisyutkin, 1999) **comb. nov.** (male) **G–J** *P. recurvata* (male **G–H** female **I–J**) **K–N** *P. clavellata* (male **K–L** female **M–N**) **O–R** *P. kabakovi* (male **O–P** female **Q–R**). Scale bars = 10 mm (**A–F**) Scale bars = 5 mm (**G–R**).

than that of congeners (Table 4). Although *Brephallus fruhstorferi* and *B. tramlapensis* only have the mean interspecific genetic distance of 4.1% (Table 4) between them, they show distinct morphological differences as follows: 1) mid-abdomen of *B. tramlapensis* (Anisyutkin, 1999) has two brown stripes while *B. fruhstorferi* (Shelford, 1910) lacks stripes (Figure 2A–F); and 2) the apical part of sclerite L2D of *B. tramlapensis* (Anisyutkin, 1999) is large and long, with a protrusion in the middle (Figure 4E) while in *B. fruhstorferi* (Shelford, 1910) it is short, without a protrusion in the middle (Figure 4D).

***Pseudophoraspis* Kirby, 1903**

Figures 2G–R, 3A–E, 4A–C, 4F, 5A–F

Type species: *Epilampra nebulosa* Burmeister, 1838.

The species *P. clavellata* and *P. recurvata* exhibit sexual dimorphism (male with developed tegmina and wings, females with tegmina reduced to lateral scales and wings absent) (Figure 2G–N); therefore, we provide below supplementary information on the nymphs and females.

Generic description. Body slender, general color yellowish brown, head entirely covered by pronotum. Pronotum with numerous brown spots, smooth, without or with scattered punctuation. Male with fully-developed tegmina and wings, female with tegmina reduced to lateral scales without wings or with fully-developed tegmina and wings (Figure 2G–R). Hind metatarsus shorter than other tarsal segments combined, with small apical euplantulae along its lower margin, with spinules, euplantulae occupying less than half of its length, with two equal rows of spines along most of its length. Tarsal claws symmetrical and unspecialized. Supra-anal plate semicircular, meso-posterior margin emarginate (Figure 4F).

Male genitalia (Figure 4A–C). Right phallomere with well-developed caudal sclerite, R1T subrectangular in shape (Figure 4A–C “c.p.R1T”), R2 rounded, R3 weakly sclerotized, without branch, narrowed caudally. Sclerite L2D divided into basal and apical parts, basal part rod-like, apical part with well-developed apical outgrowth (Figure 4A–C “a.L2D”), with bristles. Sclerite L3 with apex pointed and folded structure scattered with bristles (Figure 4A–C “*f.s.*”).

Remarks. Wang et al. (2013) subdivided the Chinese *Pseudophoraspis* into two species groups: the *fruhstorferi* group and the *gorochovi* group, but the latter lacked information on females. The *fruhstorferi* group currently includes three species: *P. fruhstorferi* Shelford, 1910, *P. tramlapensis* Anisyutkin, 1999 and *P. kabakovi* Anisyutkin, 1999. Because we have transferred the former two species to the new genus, *Brephallus* Wang et al., gen. n., the *fruhstorferi* group is renamed as *nebulosa* group. Some diagnostic characters between the *nebulosa* group and the *gorochovi* group are shown in Table 3.

The mean interspecific sequence divergence among the three *Pseudophoraspis* members ranged from 4.1% to 9.0% (Table 4), but there are distinguishing differences among them, as described below.

Table 4. The variance of the underlying distribution of distances calculated by using K 2–P model and bootstrap method respectively in MEGA.

Species	*B. fruhstorferi*	*B. tramlapensis*	*P. kabakovi*	*P. clavellata*	*P. recurvata*
Brephallus fruhstorferi	–	–	–	–	–
Brephallus tramlapensis	0.041±0.007	–	–	–	–
P. kabakovi	0.188±0.018	0.172±0.017	–	–	–
P. clavellata	0.174±0.017	0.152±0.016	0.090±0.012	–	–
P. recurvata	0.171±0.017	0.157±0.016	0.087±0.011	0.041±0.008	–

Pseudophoraspis gorochovi group

Species included here. *P. clavellata* Wang et al., 2013; *P. recurvata* Wang et al., 2013; *P. incurvata* Wang et al., 2013; and *P. gorochovi* Anisyutkin, 1999.

Pseudophoraspis recurvata Wang et al., 2013

Figures 2G–J, 4A, 4F, 5A–B

Note. Wang et al. (2013) described the male of *P. recurvata* including detailed information on male genital structures (Figures 2G–H, 4A, 4F, 5B). The description of the female is provided here.

Material examined. China: Hainan: five males and one female, Baoting County, 2013.V.2, coll. Yan Shi and Shun-Hua Gui; three males, Changjiang County, Qicha Township, 2015.IV.28, coll. Lu Qiu and Qi-Kun Bai; one male and two females, Sanya City, Liupan Village, 2015.IV.8, coll. Lu Qiu and Qi-Kun Bai; two males (holotype and paratype), Baoting County, 1959.VII.10, coll. Yi-Chuan Hu. China: Guangxi: one male (paratype), Mt. Daqingshan, 1958.IX, coll. Yi-Xin Xu.

Female description. (Figures 2I–J, 5A). Body brownish-yellow. Vertex, eyes and between the antennal sockets black-brown. Ocellar spots pale yellowish. Antennae, legs, thorax and abdomen brown. Maxillary palp with 1st–2nd segments pale yellowish and 3rd–5th segments brown. Cerci brown with apical segment yellow.

Head longer than wide. Interocular space slightly less wide than interocellar space, ocellar spots rather small, eyes elongate. Antennae short, not reaching to half length of body, first segment of flagellum twice length of next segment; interantennal portion of frons concave. Frons moderately punctuated; clypeus and labrum unmarked. Pronotum covering vertex of head, anterior margin arcuate, posterior margin truncate, with scattered punctuation and a pair of impressions on disc. Thoracic and abdominal tergites with small tubercles and longitudinal inflations along posterior margins. Tegmina reduced to lateral scales, with nearly indistinct venation, veins reduced, wings absent. Anterior margin of fore femur type B, with six large spines and one single apical spine. Tibial spines well developed. 3rd–7th abdominal tergites with paired rounded impressions. Hind metatarsus with spines along most of its length, equal to remaining joints,

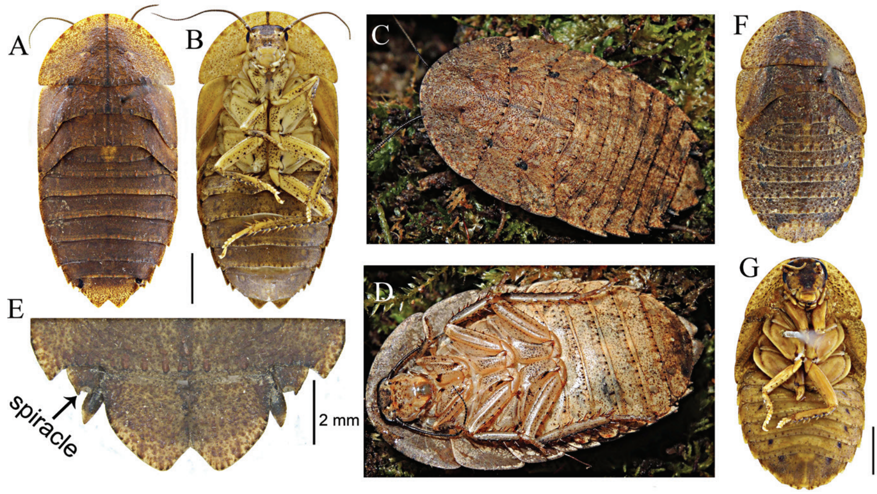

Figure 3. A–B *P. kabakovi* (nymph) scale bars = 5 mm **C–D** *P. clavellata* (nymph) **E** abdomen of female of *P. clavellata* **F–G** *Brephallus fruhstorferi* (Shelford, 1910) **comb. nov.** (nymph).

tarsal spines absent. Tarsal claws symmetrical, simple, arolia very small. Supra-anal plate transverse, beyond the subgenital plate, hind margin with a medial V-shaped excavation. Hypandrium widely rounded, caudal margin arcuate. Cerci abbreviated, apex blunt.

Variation. Morphology of paratypes is same as female type described above, but with following variation: five to six large spines scattered along anterior margin of fore femora; color of clypeus, labrum and abdomen tergites brown or yellow. Overall length: 20.1 ± 0.2 mm; head length × width: 3.6 ± 0.1 mm × 2.9 ± 0.1 mm; pronotum length × width: 6.2 ± 0.1 mm × 10.7 ± 0.1 mm.

Known geographic range. China (Hainan, Guangxi).

Pseudophoraspis clavellata Wang et al., 2013

Figures 2K–N, 3C–E, 4B, 5C–D

Note. Wang et al. (2013) described the male of *P. clavellata* including the male genitalic structures (Figures 2K–L, 4B and 5C). Description of the female and nymph is provided here.

Material examined. China: Yunnan: Thirty males and one female, Pu'er City, Meizi Lake, 2016.V.20, coll. Lu Qiu and Zhi-Wei Qiu; two males, Jinhong City, Dadugang, 2014.VI.29, coll. Conlin McCat (= Xin-Ran Li) and Hong-Guang Liu; one nymph, Xishuangbanna, Menghai County, Bulong Natural Reserve, 2017.I.31, coll. Jian-Yue Qiu and Hao Xu; male (holotype), Xishuangbanna, 1981.V.27-30, coll. Zhi-Gang Zheng.

Female description (Figures 2M–N, 3E). Identical to the female of *P. recurvata* but body larger; in addition, legs, venter of thorax and abdomen yellow.

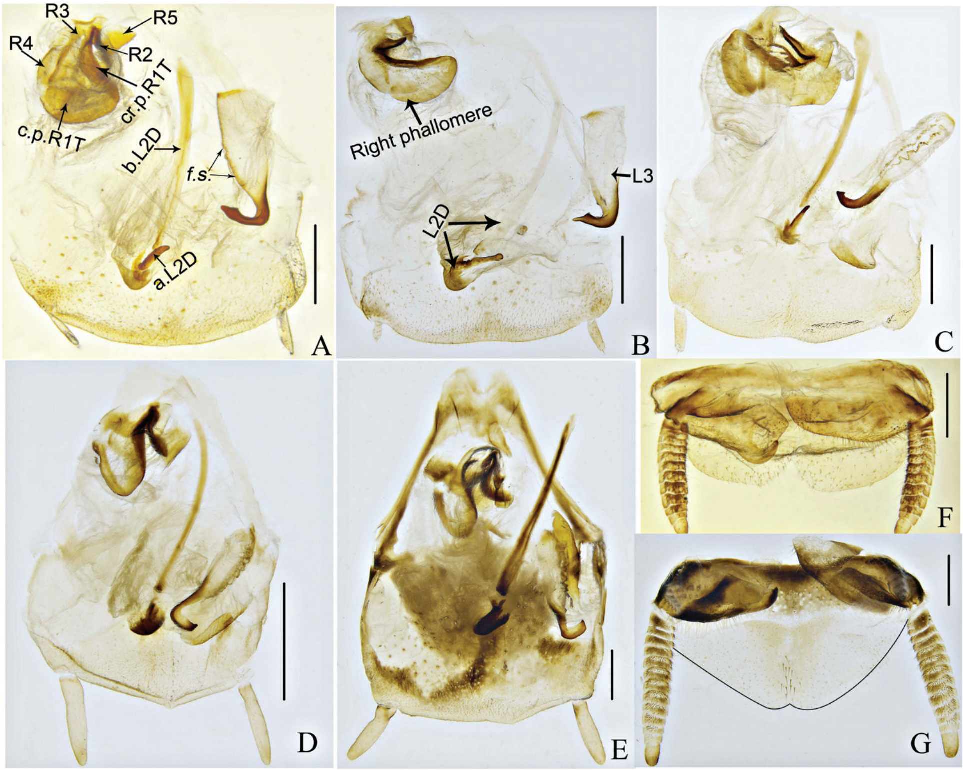

Figure 4. Male genitalia of *Pseudophoraspis* and *Brephallus* Wang et al., **gen. nov. A** *P. recurvata* **B** *P. clavellata* **C** *P. kabakovi* **D** *Brephallus fruhstorferi* (Shelford, 1910) **comb. nov. E** *Brephallus tramlapensis* (Anisyutkin, 1999) **comb. nov. F** supra-anal plate of *P. recurvata* **G** supra-anal plate of *Brephallus tramlapensis* (Anisyutkin, 1999) **comb. nov.** (Scale bars = 1 mm).

Female measurements. Overall length 28.1 mm; head length × width: 3.8 mm × 3.7 mm; pronotum length × width: 7.0 mm × 12.5 mm.

Nymph (Figure 3C–D). Body flattened. Identical to adult female but lacking wings.

Known geographic range. China (Yunnan).

Pseudophoraspis nebulosa group

According to the original descriptions of male genitalia of these species: *P. kabakovi* Anisyutkin, 1999, *P. marginata* Anisyutkin, 1999, *P. grigorenkoi* Anisyutkin, 1999, *P. argillacea* Anisyutkin, 1999, *P. truncatulus* Anisyutkin, 1999, *P. buonluoiensis* Anisyutkin, 1999 and *P. doroshenkoi* Anisyutkin, 2005, the apical part of sclerite L2D has a well-developed apical outgrowth, pronotum smooth without punctuation, and both male and female have fully developed tegmina and wings. We therefore assign these seven species to the *Pseudophoraspis nebulosa* group.

Pseudophoraspis kabakovi **Anisyutkin, 1999**
Figures 2O–R, 3A–B, 4C, 5E–F

Note. The male of *P. kabakovi* was described (Figures 2O–P, 4C, 5E) by Anisyutkin (1999) and Wang et al. (2013), but little was known about the female and nymph until now.

Materials examined. China: Yunnan: One male, Xishuangbanna, 1974.IV.13, coll. Yao Zhou and Feng Yuan; twenty males, five females and one nymph, Xishuangbanna, Menglun Town, 2016.V.27, coll. Lu Qiu and Zhi-Wei Qiu; one male and two females, Xishuangbanna, Mengla County, Wangtianshu, 2016.V.23, coll. Lu Qiu and Zhi-Wei Qiu.

Female description (Figures 2Q–R, 5F). Body yellowish brown. Eyes and antennae black, ocellar spots pale yellow. Pronotum with dense small brown spots. Tegmina with scattered large black spots. Abdominal sterna with small and fewer large black dots, large black dots along the hind margins of the segments. Cerci brown.

Similar to male in general appearance, but shorter and convex. Tegmina and wings shorter than in males. Fore femur with six spines along anterior margin and one single apical spine. Hind metatarsus with two rows of spines along most of its length. Claws symmetrical, simple; arolium well developed. Abdominal terga unspecialized. Supra-anal plate caudal margin with a medial V-shaped excavation. Hypandrium posterior margin emarginate near mid-line.

Female measurements. Overall length 32 ± 0.2 mm; head length × width: 4.2 ± 0.1 mm × 3.6 ± 0.1 mm; pronotum length × width: 8.3 ± 0.2 mm × 12.1 ± 0.2 mm; tegmina length × width: 25.4 ± 0.1 mm × 10.3 ± 0.2 mm.

Nymph. Identical to adult females of *P. recurvata* and *P. clavellata* except for undeveloped wing (Figure 3A–B).

Known geographic range. China (Yunnan); Vietnam.

Discussion

Five Epilamprine species were identified mainly on the basis of morphological and male genitalia data. Due to the apical part of sclerite L2D lacking a well-developed apical outgrowth, two species of *Pseudophoraspis* are transferred to *Brephallus* Wang et al., gen. n.

Our molecular results show two members of the *Pseudophoraspis gorochovi* group, *P. recurvata* Wang et al., 2013 and *P. clavellata* Wang et al., 2013, collected in China were sexually dimorphic. However, the other species group within this genus, *P. nebulosa* group, is not sexually dimorphic. As we have applied it, and as others have shown (Che et al. 2017; Bai et al. 2018; Evangelista et al. 2013), the integration of morphological and DNA-based approaches is useful for cockroach species identification and to supplement morphological keys, which are typically limited to adult male morphological characters.

Figure 5. A female of *P. recurvata* from Hainan Province. This specimen, collected as a nymph in 8 April 2015, was reared at Southwest University by Lu Qiu and adult emergence occurred in 21 May 2015 **B** male of *P. recurvata* from Hainan Province **C** male of *P. clavellata* from Yunnan Province **D** habitat of *P. clavellata* **E** male of *P. kabakovi* from Yunnan Province **F** female of *P. kabakovi* from Yunnan Province. **A–F** Photographed by Lu Qiu **G–H** *Brephallus fruhstorferi* (Shelford, 1910) **comb. nov.** from Hainan Province (Photographed by Xin-Ran Li).

Acknowledgements

We thank Xin-Ran Li and Lu Qiu for photos of these species in the wild and thank other collectors who contributed important specimens discussed in this paper. We also thank Dr. John Richard Schrock (Department of Biological Sciences, Emporia State University) for revising the manuscript.

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References

Anisyutkin LN (1999) Cockroaches of the subfamily Epilamprinae (Dictyoptera, Blaberidae) from the Indochina Peninsula. Entomological Review 79(4): 434–454.

Anisyutkin LN (2005) Two new species of Epilamprinae from Vietnam and Cambodia (Dictyoptera, Blattina: Blaberidae). Zoosystematica Rossica 14(1): 37–40.

Anisyutkin LN (2014) On cockroaches of the subfamily Epilamprinae (Dictyoptera: Blaberidae) from South India and Sri Lanka, with descriptions of new taxa. Zootaxa 3847(3): 301–332. https://doi.org/10.11646/zootaxa.3847.3.1

Bai QK, Wang LL, Wang ZQ, Lo N, Che YL (2018) Exploring the diversity of Asian *Cryptocercus* (Blattodea: Cryptocercidae): species delimitation based on chromosome numbers, morphology, and molecular analysis. Invertebrate Systematics 32(1): 69–91. https://doi.org/10.1071/IS17003

Beccaloni GW (2014) Cockroach Species File Online. Version 5.0/5.0. http://Cockroach.SpeciesFile.org [accessed 5 July 2016].

Bey-Bienko GY (1969) New genera and species of cockroaches (Blattoptera) from tropical and subtropical Asia. Entomologicheskoe Obozrenie 48(4): 831–862.

Che YL, Gui SH, Lo N, Andrew R, Wang ZQ (2017) Species delimitation and phylogenetic relationships in Ectobiid cockroaches (Dictyoptera, Blattodea) from China. PLoS ONE 12(1): e0169006. https://doi.org/10.1371/journal.pone.0169006

Clutton-Brock TH (1991) The Evolution of Parental Care. Princeton University Press, Princeton, 352 pp.

Edgar RC (2004) MUSCLE: multiple sequence alignment with high accuracy and high throughput. Nucleic Acids Research 32: 1792–1797. https://doi.org/10.1093/nar/gkh340

Evangelista DA, Bourn 33) XXI. The Blattidae of Mount Kinabalu, British North Borneo. Journal of the Federated Malay States Museums 17: 297–337.

Hebert PDN, Ratnasingham S, Zakharov EV, Telfer AC, Levesque-Beaudin V, Milton MA, Pedersen S, Jannetta P, Dewaard JR (2016) Counting animal species with DNA barcodes: Canadian insects. Philosophical Transactions of the Royal Society B-Biological Sciences 371(1702): 1–10. https://doi.org/10.1098/rstb.2015.0333

Kimura M (1980) A simple method for estimating evolutionary rates of base substitutions through comparative studies of nucleotide sequences. Journal of Molecular Evolution 16, 111–120. https://doi.org/10.1007/BF01731581

Kirby WF (1903) Notes on Blattidae, with descriptions of new genera and species in the collection of the British Museum, South Kensington. No. II. The Annals and Magazine of Natural History 12(7): 273–280. https://doi.org/10.1080/00222930308678853

Klass KD (1997) The external male genitalia and the phylogeny of Blattaria and Mantodea. Bonner Zoologische Monographien 42: 1–341.

Nalepa CA, Bell WJ (1997) Postovulation parental investment and parental care in cockroaches. In Social Behavior in Insects and Arachnids. J.C. Choe and B.J. Crespi, editors. Cambridge University Press, Cambridge, 26–51. https://doi.org/10.1017/CBO9780511721953.004

Princis K (1958) Revision der Walkerschen und Kirbyschen Blattarientyen im British Museum of Natural History, London. II. Opuscula Entomologica 23(1–2): 59–75.

Roth LM (2003) Systematics and phylogeny of cockroaches (Dictyoptera: Blattaria). Oriental Insects 37: 1–186. https://doi.org/10.1080/00305316.2003.10417344

Shelford R (1910) Orthoptera (Fam. Blattidae – Subfam. Epilamprinae). In: Wytsman P (Ed.) Genera Insectorum 101: 1–21.

Stamatakis A, Hoover P, Rougemont J (2008) A rapid bootstrap algorithm for the RAxML Web Servers. Systematic Biology 57: 758–771. https://doi.org/10.1080/10635150802429642

Tallamy DW, Wood TK (1986) Convergence patterns in social insects. Annual Review of Entomology 31: 369–390. https://doi.org/10.1146/annurev.en.31.010186.002101

Tamur K, Stecher G, Peterson D, Filipski A, Kumar S (2013) MEGA6: Molecular Evolutionary Genetics Analysis version 6.0. Molecular Biology and Evolution 30: 2725–2729. https://doi.org/10.1093/molbev/mst197

Walker FLS (1868) Catalogue of the Specimens of Blattariae in the Collection of the British Museum. Printed for The Trustees of The British Museum, London, 239 pp.

Wang ZQ, Wu KL, Che YL (2013) New record of the cockroach genus *Pseudophoraspis* (Blaberidae, Epilamprinae) from China with descriptions of three new species. ZooKeys 273: 1–14. https://doi.org/10.3897/zookeys.273.4122

Yue QY, Wu KL, Qiu D, Hu J, Liu D, Wei XY, Chen J, Cook CE (2014) A formal re-description of the cockroach *Hebardina concinna* anchored on DNA barcodes confirms wing polymorphism and identifies morphological characters for field identification. PLoS ONE 9: e106789. https://doi.org/10.1371/journal.pone.0106789

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RESEARCH ARTICLE

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Ericaphis voegtlini, a new, unusual aphid species from the USA (Hemiptera, Aphididae)

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Abstract

Ericaphis voegtlini **sp. n.** living on *Chamaebatia foliolosa* (Rosaceae) in California is described based on apterous and alate viviparous females. The new species differs from all other species of the genus *Ericaphis* Börner, 1939 in several important morphological characters including very long and rigid dorsal setae and distinctly swollen siphunculi with clearly visible polygonal reticulation.

Keywords

Chamaebatia, description, Macrosiphini, new species, taxonomy

Introduction

The genus *Ericaphis* was established by Börner (1939) for *E. ericae* (Börner, 1933), previously described in the genus *Myzaphis* van der Goot, 1913 (Remaudière and Remaudière 1997). The genus comprises 12 species and most are Nearctic (Blackman and Eastop 2018, Favret 2018, Kanturski et al. 2018). *Ericaphis* members are characterised by well–developed median and lateral frontal tubercles, somewhat spinulous or scabrous antennae that are shorter than the body, antennal segment III usually without secondary rhinaria, first tarsal segments with 3–3–3 or 5–5–5 setae and the siphunculi characteristically S–curved, the cauda tongue or finger–shaped with few setae. Secondary rhinaria in alate viviparous females often have cilia–like fimbriation or striation (Heie 1992, Foottit and Richards 1993, Blackman 2010). The species currently placed in *Ericaphis* are a diverse group, and some species currently placed in other genera, such as *Aulacorthum* Mordvilko, 1914 and *Wahlgreniella* Hille Ris Lambers, 1949 are probably closely related to some of them.

The plant genus *Chamaebatia* Benth. (Rosaceae) is a local endemic of California, USA with two shrub species: *Chamaebatia australis* (Brandegee) Abrams and *Chamaebatia foliolosa* Benth. (Munz 1973; The Plant List 2013). Two aphid species are recorded on *C. foliolosa* – *Macrosiphum euphorbiae* and "?*Ericaphis* sp." (Blackman and Eastop 2018). The latter species was mentioned as "*Ericaphis* sp. near *wakibae* (California; BMNH colln, leg. D Hille Ris Lambers)" in the identification key to *Chamaebatia*–feeding aphids in Blackman and Eastop (2006, p. 251).

During work in the Aphididae collection of the Natural History Museum in London (United Kingdom) specimens of the above-mentioned *Ericaphis*–like undescribed species collected by David Voegtlin on *C. foliosa* in California, USA were found by M. Kanturski. In addition, specimens of the same species were collected by A. Jensen on the same plant and in the same area of California in 2014.

The new species, living on *Chamaebatia foliolosa* from California, USA, is here described based on apterous and alate viviparous females sampled by David Voegtlin, D. Hille Ris Lambers, and Andrew Jensen.

Materials and methods

The specimens were examined using light microscope Nikon Eclipse E600 with differential interference contrast (DIC) and photographed by Nikon DS–Fi camera. The measurements were done according to Ilharco and van Harten (1987) and Blackman and Eastop (2006). Measurements are given in millimetres. The following abbreviations are used:

ANT	antennae or their lengths;
ANT I–VI	antennal segments I, II, III, IV, V, VI or their lengths (ratios between antennal segments are simply given as e.g. 'VI: III');
BASE	basal part of last antennal segment or its length;
BD III	basal articular diameter of ANT III;
BL	body length (from anterior border of the head to the end of cauda);
FEMORA III	hind femora length;
HW	greatest head width across compound eyes;
HT I	first segment of hind tarsus;
HT II	second segment of hind tarsus or its length;
LS ANT III	length of longest setae of ANT III;
PT	processus terminalis of last antennal segment or its length;

SIPH L	siphunculi length,
SIPH W	maximum width of swollen part of siphunculus;
TIBIAE III	hind tibiae length;
URS	ultimate segments of rostrum (IV + V) or their length.

Depositories of type material:

AJ	Andrew S. Jensen Aphididae Collection (USA);
BMNH	Natural History Museum, London (United Kingdom);
DZUS	Hemiptera Collection of the Department of Zoology, University of Silesia in Katowice (Poland);
ISU	Institute of Zoology at Ilia State University (Georgia);
USNM	National Collection of Aphidomorpha, Beltsville, MD. (USA).

Taxonomy

Aphididae Latreille, 1802

***Ericaphis* Börner, 1939**

***Ericaphis voegtlini* sp. n.**
http://zoobank.org/BBB29D9E-6287-416E-B2CD-246231AB4B57
Figures 1–4; Table 1

Diagnosis. Apterous viviparous females differ from other *Ericaphis* by having a well–developed quadrangular median frontal tubercle, and long and rigid dorsal setae on head, thorax, and abdominal dorsum. The siphunculus is also unusually swollen and has 4–7 rows of polygonal cells in its subapical zone. The new species shares with *E. avariolosa* (David, Rajasingh & Narayanan, 1971), *E. leclanti* Remaudière, 1971, and *E. wakibae* (Hottes, 1934) some features of the siphunculus (e.g. slightly swollen with row(s) of polygonal cells in the subapical zone) but differs in the other above-mentioned characters.

Type material. *Holotype*: UNITED STATES OF AMERICA, California: Calaveras Co., Board's Crossing, Stanislaus N. F. (38°18'13"N; 120°14'54"W, 1180 m a.s.l.), 15 April 2014, on *Chamaebatia foliolosa*, A. Jensen leg., 1 apterous viviparous female marked as holotype ("H") and circle on the slide, AJ7029, USNM. ***Paratypes***: the same data as the holotype, 2 apterous viviparous females, AJ7029, AJ; 3 apterous viviparous females, AJ7032, AJ; 4 apterous viviparous females, AJ7030, AJ; Sheep Ranch Rd. near Avery (38°12'02"N; 120°23'52"W, 1086 m a.s.l.), 15 April 2014, on *Ch. foliolosa*, A. Jensen leg., 2 apterous viviparous females, AJ7019; Placer Co., 3 mi. S.W. Dutch Flat HWY 80 (39°11'14"N; 120°50'47"W, 972 m a.s.l.), 22 April 1978, on *Ch. foliolosa*, D. Hille Ris Lambers no 33 leg., 1 apterous viviparous female, BM 1984–340, BMNH; near Dutch Flat (39°11'14"N; 120°50'47"W, 972 m a.s.l.), 22 April 1978, on *Ch. foliolosa*,

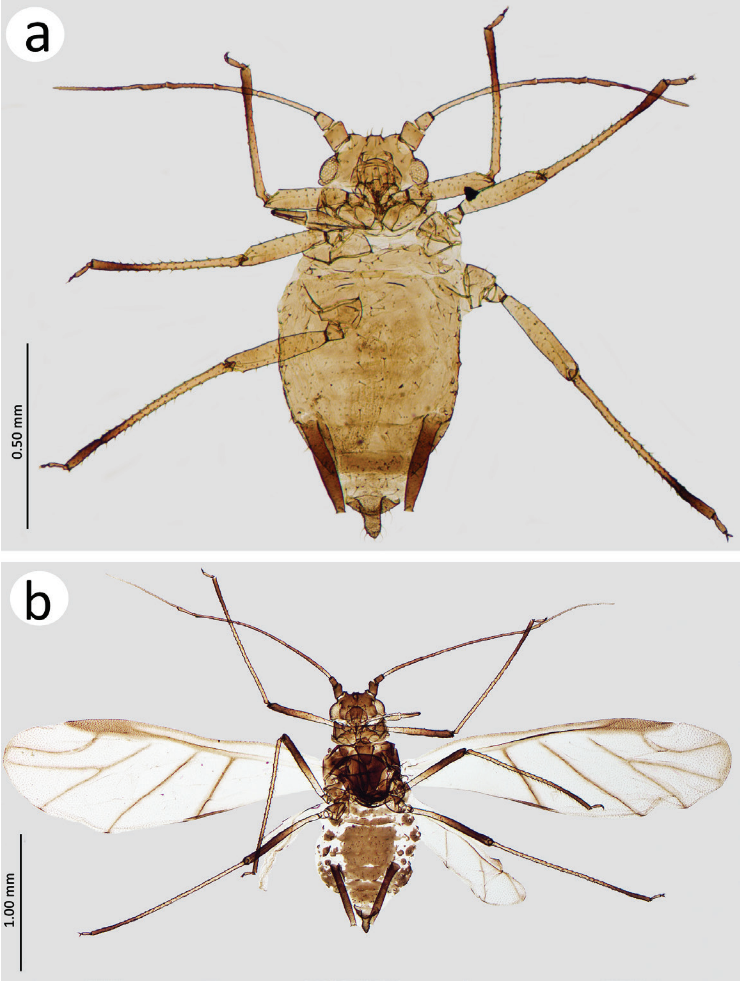

Figure 1. *Ericaphis voegtlini* sp. n. General view. **a** Apterous viviparous female **b** Alate viviparous female.

D. Hille Ris Lambers no 31 leg., 3 apterous viviparous females, BM 1984–340 (1 – present marking), DZUS; 3 mi. S.W. Dutch Flat HWY 80 (39°11'14"N; 120°50'47"W, 972 m a.s.l.), 23 May 1978, on *Ch. foliolosa*, D. Hille Ris Lambers (culture) leg., 2, 1, 2, 2, 2, 2, 2, 2, 2, 2 alate viviparous females (11 slides with the same data and number), BM 1984–340, BMNH; 3 alate viviparous females BM 1984-340, DZUS; El Dorado Co., Sand Mtn. Blodgett (38°54'22"N; 120°39'30"W, 1349 m a.s.l.), 21 August 1974, on *Ch. foliolosa*, D. Voegtlin leg., 2, 2, 2, 2, 2, 2, 2, 2, 2 apterous viviparous females (9 slides with the same data and number), BM 1984–340, BMNH; 2 apterous viviparous females, BM 1984–340, ISU; Sand Mtn. Blodgett (38°54'22"N; 120°39'30"W, 1349 m a.s.l.), 21 August 1974, on *Ch. foliolosa*, D. Voegtlin leg., 2 alate viviparous females, BM 1984–340, ISU; Sand Mtn. Blodgett (38°54'22"N; 120°39'30"W, 1349 m a.s.l.), 21 August 1974, on *Ch. foliolosa*, D. Voegtlin leg.

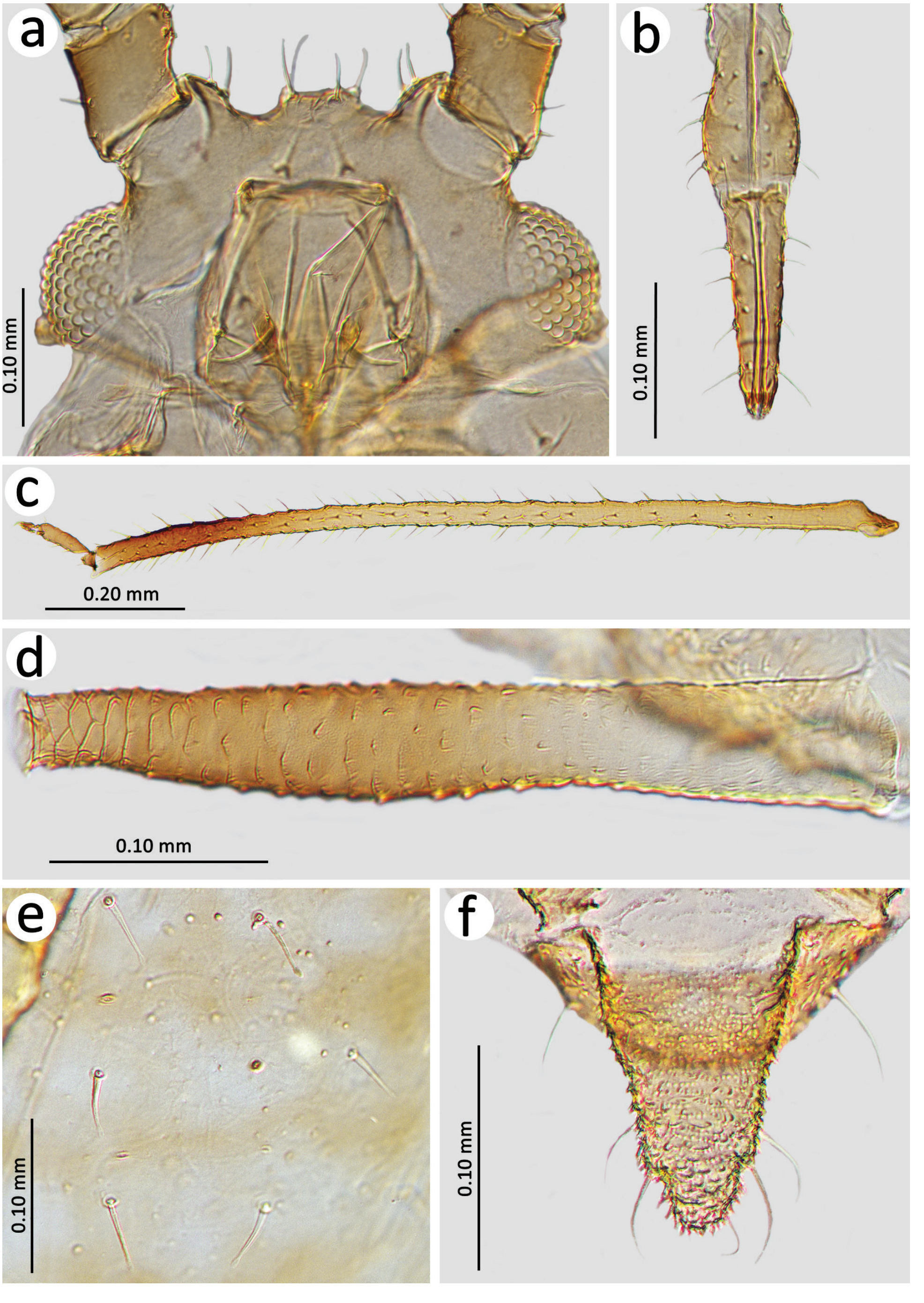

Figure 2. Apterous viviparous female of *Ericaphis voegtlini* sp. n. Characters. **a** Head with long frontal and antennal tubercle setae **b** Ultimate rostral segments **c** Hind tibia **d** Siphunculus **e** Dorsal chaetotaxy on ABD II–IV **f** Cauda.

Description. *Apterous viviparous female* (n = 34). Colour in life: dark green. On slide: body in general sclerotised, pale yellow to yellow. ANT yellow with brown distal part of ANT IV and whole ANT V–VI. Tibiae yellow with brown to dark brown distal parts (but the very apex of tibiae lighter). Tarsi light brown to brown. SIPH pale to yellow basally and brown to dark brown distally (Figure 1a).

Slide–mounted specimens: HW 0.23–0.36 × ANT. Head chaetotaxy: head with three dorsal pairs of setae; median tubercle with 4–5, ANT tubercles each with 3–5 long, rigid, thick setae with blunt or narrow capitate apices, 0.017–0.052 mm long. Frontal setae 0.037–0.050 mm long (Figure 2a). ANT 0.70–1.04 × BL. ANT III without secondary rhinaria, ANT IV slightly shorter or slightly longer than ANT V. ANT V with ciliated primary rhinarium at the distal part. PT 3.00–3.54 × BASE. Other antennal ratios: VI:III 1.31–1.87, V:III 0.67–0.78, IV:III 0.66–0.81, PT:III 1.02–1.45, PT:IV 1.30–1.93, PT:V 1.30–1.93. ANT chaetotaxy: ANT bearing very short and rigid setae with blunt apices. ANT III setae shorter than the width of the segment, 0.007–0.020 mm long, LS III 0.41–0.90 × BD III. ANT I with 7–10, ANT II with 4–5, ANT III with 11–17, ANT IV with 7–16, ANT V with 7–12 setae. ANT VI with 3–5 basal, 3 apical and 5–6 setae on the PT. Rostrum reaching from metasternum to ABD I. URS 0.36–0.60 × ANT III, 0.35–0.47 × PT, 1.20–1.50 × BASE and 1.66–1.87 × HT II with 11–19 fine and pointed accessory setae (Figure 2b). Mesosternal furca fused, wide, Y–shaped. III FEMORA bearing short, thick, rigid setae with ragged or pointed apices, 0.010–0.035 mm long. III TIBIAE bearing thick, rigid setae with ragged or flat apices, shorter than the width of tibiae, 0.007–0.041 mm long (Figure 2c). HT I with 3–3–3 ventral setae, HT II 0.21–0.35 × ANT III, 0.20–0.27 × PT and 0.70–0.82 × BASE. SIPH tubular, slightly curved, swollen from about mid–length with distinct zone of subapical reticulation formed from 4–7 rows (Figure 2d). The reticulated zone 0.07–0.16 × SIPH. SIPH 2.08–2.76 × cauda, 0.18–0.32 × BL, and 1.24–1.60 × ANT III. Abdomen sclerotised with long and thick setae in spinal, pleural and marginal positions. Dorsal setae with capitate apices, 0.015–0.047 mm long on ABD I–V and 0.040–0.065 mm long on ABD VI–VIII (Figure 2e). ABD VII with 0–2 and ABD VIII with 1–2 spinal tubercles (Figures 3a–d). Marginal tubercles on ABD II–VII, sometimes poorly–visible (Figure 3e). ABD VIII usually with 4–5 setae. Genital plate with two anterior setae which are longer than the others, 6–12 setae in the middle and 9–12 posterior setae. Cauda 1.30–2.00 × its width at base and 0.09–0.12 × BL, with 5–7 long and fine setae (Figure 2f).

Alate viviparous female (n=22). Colour in life: unknown. On slide: head and ANT light brown to brown with basal part of Ant III and PT lighter. Pronotum light brown, rest of thorax brown. Wings hyaline with light brown veins (cubital veins slightly darker). Femora brown with pale proximal part and dark distal part. Tibiae yellow to light brown with brown to dark distal part. Abdomen with brown sclerotisation, SIPH brown with lighter apical part, cauda brown (Figure 1b).

Slide–mounted specimens: HW 0.18–0.21 × ANT. Head chaetotaxy: head with four dorsal pairs of long, rigid, thick setae with capitate apices, 0.022–0.050 mm long. Frons with four setae, ANT tubercles with 2–4 setae (Figure 4a). ANT 1.01–1.12 ×

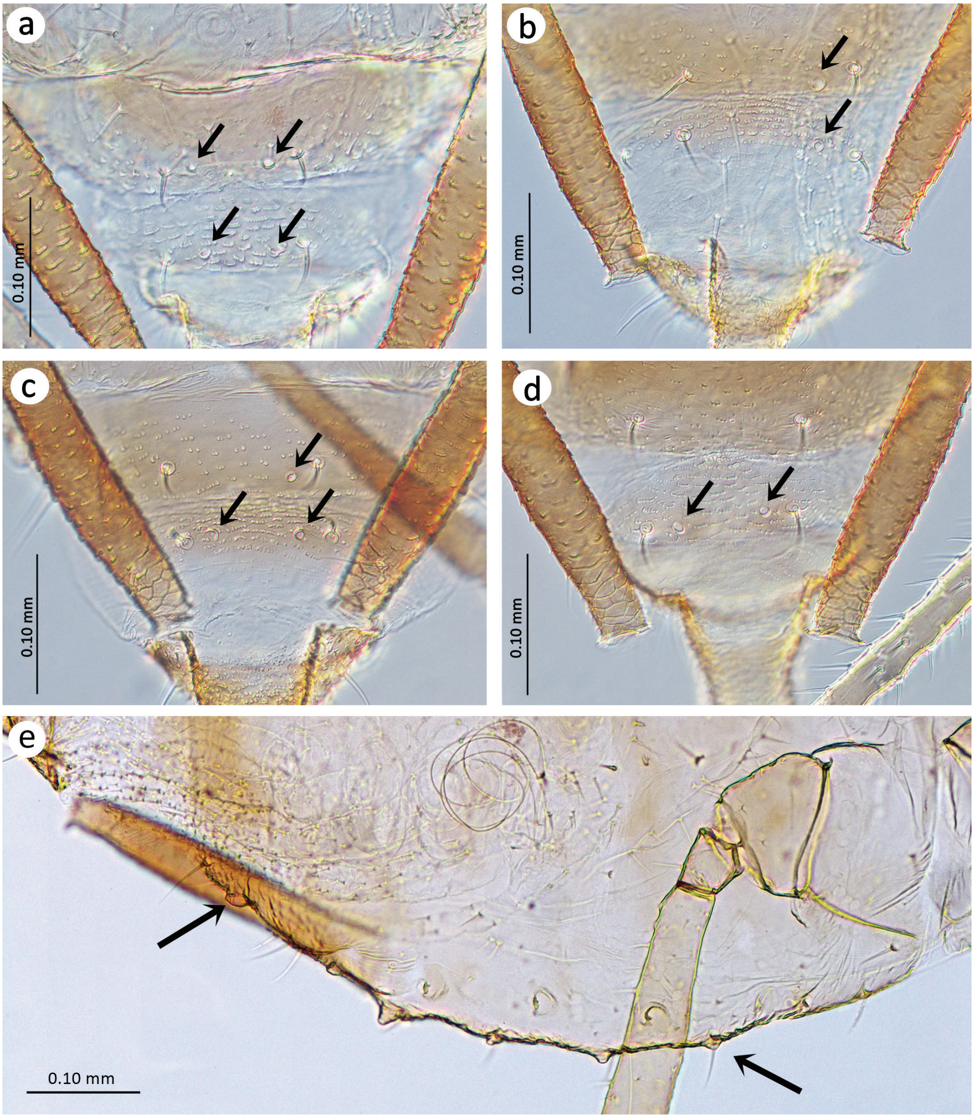

Figure 3. Spinal and marginal tubercles in apterous viviparous females of *Ericaphis voegtlini* sp. n. **a** Two pairs on ABD VII and ABD VIII **b** Only one tubercle on ABD VII and ABD VIII **c** One tubercle on ABD VII and two tubercles on ABD VIII **d** Only two tubercles on ABD VIII (The location of the marginal tubercles indicated by arrows) **e** Marginal tubercles on ABD II–VII (Tubercles on ABD I and ABD VIII indicated by arrows).

BL. ANT III with 6–9 secondary rhinaria (Figures 4b, c), ANT IV longer than ANT V without secondary rhinaria. ANT V with primary rhinarium with ciliated rim. PT 3.60–4.66 × BASE. Other antennal ratios: VI:III 1.43–1.74, V:III 0.72–0.87, IV:III 0.81–1.02, PT:III 1.12–1.43, PT:IV 1.25–1.53, PT:V 1.27–1.75. ANT chaetotaxy: ANT with short and rigid setae with blunt apices. ANT III setae shorter than the

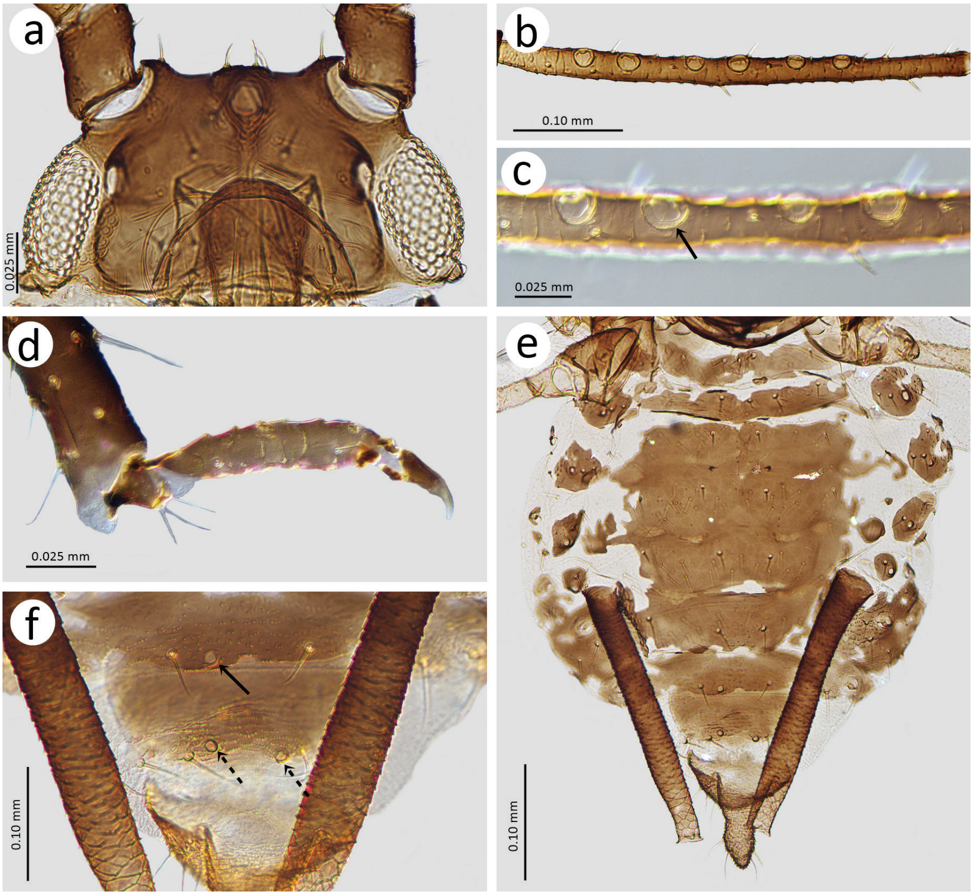

Figure 4. Alate viviparous female of *Ericaphis voegtlini* sp. n. Characters. **a** Head **b** ANT III with secondary rhinaria **c** Structure of the sensoria with visible fibriation (arrow) **d** Hind tarsus **e** Abdominal sclerotisation **f** Marginal tubercles on ABD VII and ABD VIII.

width of the segment, 0.015–0.017 mm. LS III 0.68–0.87 × BD III. ANT I with 7–11, ANT II with 4–5, ANT III with 14–20, ANT IV with 12–16, ANT V with 9–12 setae. ANT VI with 3–4 basal, 3–4 apical and 5–8 additional setae on the PT. Rostrum reaching mesosternum. URS 0.31–0.38 × ANT III, 0.25–0.30 × PT, 1.03–1.16 × BASE and 1.58–1.88 × HT II with 15–18 fine and pointed accessory setae. III FEMORA bearing thick, rigid setae with pointed or blunt apices, 0.015–0.027 mm long. III TIBIAE bearing long, slightly rigid, pointed or blunt setae, shorter or longer than the width of tibiae, 0.012–0.045 mm long. HT II (Figure 4d) 0.18–0.21 × ANT III, 0.14–0.18 × PT and 0.56–0.70 × BASE. SIPH 2.67–3.06 × cauda and 0.23–0.27 × BL. Abdomen with two crossbars on ABD I and II and a large spino–pleural sclerotic patch on ABD III–VIII and pleuro–marginal sclerites on ABD V–VII (Figure 4e). Dorsal setae long, thick, and rigid with pointed or slightly blunt apices, 0.017–0.049 mm long on ABD I–VI and 0.037–0.067 mm long on ABD VII–VIII. ABD VII and

Table 1. Measurements of apterous and alate viviparous females of *Ericaphis voegtlini* sp. n.

Character	Apterous viviparous females (n=34)	Alate viviparous females (n=22)
BL	1.299–1.90	1.67–2.00
BW	0.540–0.900	0.70–0.78
HW	0.32–0.39	0.37–0.394
ANT	0.97–1.65	1.80–2.026
ANT III	0.20–0.38	0.39–0.44
ANT IV	0.14–0.30	0.35–0.4423
ANT V	0.15–0.30	0.31–0.359
ANT VI	0.34–0.50	0.57–0.69
BASE	0.085–0.110	0.12–0.146
PT	0.25–0.39	0.45–0.57
III FEMORA	0.34–0.64	0.60–0.664
III TIBIAE	0.5–1.12	1.19–1.274
HT II	0.07–0.08	0.080–0.085
Rostrum	0.35–0.49	0.44–0.492
URS	0.12–0.14	0.135–0.154
SIPH L	0.26–0.53	0.46–0.472
SIPH W (most wide part)	0.04–0.07	0.05–0.06
SIPH W (most narrow part)	0.034–0.06	0.035–0.05
Cauda L	0.125–0.22	0.15–0.175
Cauda W (at base)	0.09–0.14	0.10–0.12

VIII with spinal tubercles (Figure 4f). ABD VIII with 4–5 setae. Subgenital plate with 19–23 setae. Cauda length 1.41–1.51 × width at base, with 5–6 setae.

Etymology. The authors have the pleasure in naming the new species to honour Dr. David Voegtlin, an aphid specialist from the Illinois Natural History Survey (University of Illinois, Urbana–Champaign, USA), who was also the first collector.

Biology and distribution. The new aphid species is associated with *Chamaebatia foliolosa* Benth. (Rosaceae). Its sexual morphs and life history are unknown, but probably it is monoecious holocyclic. The aphid species is presumably endemic to California, as is its host plant.

Discussion

Appropriate generic placement of this species was challenging due to its unusual features, including its prominent median frontal tubercle, robust dorsal setae, and swollen reticulated siphunculi. It was tempting to consider this aphid the first of a new genus. In the end we opted for placement in *Ericaphis* for a few reasons. First, *E. voegtlini* shares important features with most *Ericaphis*, including the presence of a median frontal tubercle (albeit more extreme), typically two pairs of lateral setae on the cauda (plus one dorso–apical seta), dorsal pigmented abdominal patch in the alate vivipara, no secondary rhinaria on antennal segment III in the apterous vivipara, and relatively few and large secondary rhinaria on antennal segment III in the alate vivipara. Second, there are western North American species scattered among at least three genera (*Aulacorthum*, *Ericaphis*, and *Wahlgreniella*) that share many features and that may be closely related. Ideally, the generic classification of these aphids should be done as a more comprehensive study, using all the similar and related species currently placed in these, and possibly other, genera. Third, the aphids of western North America are still in need of basic discovery work in the field. The second author spends hundreds of hours each year collecting aphids and making field observations, and has discovered, and continues to discover, many new species and host plant relationships (see http://aphidtrek.org/), including isolated samples and observations of aphids related to the above–mentioned genera. Comprehensive analysis of the relevant generic classification, therefore, is best delayed until more of the currently undescribed and undiscovered aphid species are documented and described. In the meantime, *E. voegtlini* is a distinctive, easily recognised species that feeds on an unusual plant with a very limited distribution, and interim placement of it in *Ericaphis* is a practical choice. We hope that by publishing its description we will draw attention to the possible undiscovered diversity of this aphid group in North America.

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We are sincerely grateful to Paul A. Brown and David Ouvrard (Natural History Museum, London, UK), for their kind help and support during visits to the collection as well as for the loan of the many *Ericaphis* slides. We would like to thank the reviewers Juan Manuel Nieto Nafría and Andrey V. Stekolshchikov as well as to Roger Blackman for all comments and suggestions that improved the first version of the manuscript.

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References

Blackman RL, Eastop VF (2006) Aphids on the World's Herbaceous Plants and Shrubs. John Wiley & Sons, Ltd., West Sussex, 1439 pp.

Blackman RL (2010) Aphids – Aphidinae (Macrosiphini). Handbook for identification of British insects. Vol. 2, Part 7. Royal Entomological Society, London, 413 pp.

Blackman RL, Eastop VF (2018) Aphids on the World's Plants. An online identification and information guide. http://www.aphidsonworldsplants.info [accessed June 2018]

Börner C (1939) Neue Gatungen und Arten der mitteleuropäischen Aphidenfauna. Arbeiten über physiologische und angewandte Entomologie aus Berlin-Dahlem 6: 75–83.

Favret C (2017) Aphid Species File. Version 5.0/5.0. http://Aphid.SpeciesFile.org [accessed June 2018]

Foottit RG, Richards WR (1993) The genera of the aphids of Canada. Homoptera: aphidoidea and Phylloxeroidea. The Insects and Arachnids of Canada 22: 1–766.

Heie OE (1992) Family Aphididae: Part 1 of tribe Macrosiphini of subfamily Aphidinae. Vol. IV. Fauna Entomologica Scandinavica 25: 1–189.

Ilharco FA, van Harten A (1987) Systematics. In: Minks AK, Harrewijn P (Eds) Aphids: their biology, natural enemies and control. Elsevier Science Publishers, Amsterdam, 51–77.

Kanturski M, Barjadze S, Jensen AS, Wieczorek K (2018) A comparative morphological revision of the aphid genus *Myzaphis* van der Goot, 1913 (Insecta: Hemiptera: Aphididae) revealed a new genus and three new species. PLoS ONE 13(3): e0193775. https://doi.org/10.1371/journal.pone.0193775

Munz PA (1973) A California Flora and Supplement. University of California Press, Berkeley and Los Angeles, 1905 pp.

Remaudière G, Remaudière M (1997) Catalogue des Aphididae du Monde. Catalogue of the World's Aphididae. INRA, Paris, 473 pp.

The Plant List (2013) The Plant List, Version 1.1. http://www.theplantlist.org/ [accessed August 2018]

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RESEARCH ARTICLE

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Empidinae (Diptera, Empididae) from Bulgaria with new records and descriptions of three new species

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Abstract

Empis (*Leptempis*) *rhodopensis* Barták, **sp. n.,** *Hilara bulgarica* Barták, **sp. n.,** and *Rhamphomyia* (*Amydroneura*) *stojanovae* Barták, **sp. n.** are described from Bulgaria. Altogether 32 species of Empididae are first reported from Bulgaria.

Keywords

Empis, Europe, *Hilara*, new species, Palaearctic region, *Rhamphomyia*

Introduction

The Empididae is a large family of Diptera Brachycera with approximately 1300 species known from the Palaearctic region and almost 1000 of them belonging to three genera: *Empis* Linnaeus, *Hilara* Meigen, and *Rhamphomyia* Meigen.

The Empididae fauna of Bulgaria has never been systematically studied and the results of chance findings are scattered among several papers (e.g., Loew 1862; Beschovski 1973; Straka 1976; Chvála 1977, 2002, 2005a, b, 2008; Chvála and Wagner 1989; Ceianu 1992; Beschovski and Dzhambazov 1998; Dzhambazov 1998;

Dzhambazov and Beschovski 2000; Çiftçi and Hasbenli 2008; Chvála and Merz 2009; Kustov and Shamshev 2011; Özgül and Civelek 2013; Hubenov 2015), but older records are generally not reliable. In our paper we provide numerous new records of the Empididae subfamily Empidinae from Bulgaria, including descriptions and illustrations of three new species.

General distributions of species are taken from Wyatt (2014) supplemented by recent checklist of Russian Empidoid flies (Shamshev 2016) and several revisions of *Hilara* (Chvála 2002, 2005a, b, 2008; Chvála and Merz 2009) and *Rhamphomyia* (Barták 2006a, b, 2007a, b).

Materials and methods

The material studied originated from recent collections of authors (MB and ŠK) in Bulgaria (Rhodopes Mountains, Pirin Mountains, Central Balkan) and it is deposited in the collection of the Czech University of Life Sciences, Prague (**CULSP**). The material was collected by means of sweeping vegetation and yellow and white water pan traps, and stored in ethyl alcohol. Voucher specimens were selected and dried using methods described by Barták (1997).

Genitalia preparations and drawings: genitalia, together with the preceding 2–3 abdominal segments were removed from the rest of the body using small scissors and macerated in potassium hydroxide solution (approx. 10%) in small vials submerged in hot water for 1–2 hours. After neutralizing with 8% acetic acid (5 minutes), the genitalia were dissected in glycerine and photographed using an Olympus E-410 digital camera mounted on an Olympus BX51 compound microscope. Resulting images were edited with the computer software Quick Foto micro 2.3 provided with deep focus 3.1. Final images were a montage composed usually of 7–15 layers and were further edited with ®Adobe Photoshop. Images served as model for hand drawings, details were added directly observing objects.

The morphological terms used here follow Merz and Haenni (2000), Sinclair (2000), and Sinclair and Cumming (2006). All body measurements (including body and setae length) were taken from dry specimens (therefore the actual length may differ from that of fresh or wet-preserved material) by means of an ocular micrometre mounted on Nikon SMZ 1500 binocular microscope. Abbreviations: M2/d ratio = length of vein M_2: greatest length of discal medial cell (discal cell); CuA1 ratio = length of apical: preapical sections of vein CuA_1; lw: ww ratio = greatest length of wing (from basicosta to apex): greatest width of wing. Antennal segments were measured in 0.01 mm scale. Male body length was measured from antennal base to the tip of genitalia and female body length from base of antennae to the tip of cerci. Thoracic setae are counted on one side of body except scutellars.

Geographical coordinates were either found with GPS using map datum WGS-84 or were obtained from Google Earth.

Descriptions of new species

***Empis* (*Leptempis*) *rhodopensis* Barták, sp. n.**
http://zoobank.org/CB20F48C-4546-47A9-A714-624D63BA9230
Figs 1–2

Type material. HOLOTYPE ♂, Bulgaria, Rhodopes Mountains, Pamporovo env., meadow, 41.65N, 24.73E, 1600 m, Barták, Kubík, 22.–24.vi.2016 (CULSP). **PARATYPES**: 4♂, 2♀, same data as holotype; 1♂ Bulgaria, Rhodopes Mountains, Sniezhanka peak, 1900m, hilltop, 41.637N, 24.680E, Barták, Kubík, 24.–25.vi.2016 (CULSP).

Diagnosis. Large species of the *E.* (*L.*) *rustica* group with yellow coxae, very long labrum (2.5–2.6× head height), grey abdomen incl. venter, brownish yellow epandrial lamella, and spinose ventral part of hind femur.

Etymology. The species epithet, *rhodopensis*, is derived from mountain range (Rhodopes Mountains) where the type material was collected.

Description. Male (Figure 1). Head black, rather light grey microtrichose, holoptic, eyes meeting over long distance. Frons withsmall triangles just above antennae and below front ocellus without setae. Dorsal half of eye with distinctly larger facets than ventral half. Ocellar setae black, broken in all male specimens. Occiput with two rows of long setae dorsally, ventral part with irregularly arranged, long and fine yellow setae. Face approx. 0.35 mm broad ventrally, microtrichose with shiny narrow ventral margin, without setae. Clypeus shiny, gena very narrow, microtrichose. Palpus yellow, with several short black setae, subapical seta longest. Labrum yellow with brown base and apex, 2.5–2.6× longer than head height. Antenna black, both basal segments short setose; length of antennal segments (scape: pedicel: postpedicel: basal joint of stylus: last joint of stylus) = 0.18–0.21 mm: 0.1–0.11 mm: 0.39–0.43 mm: 0.04–0.05 mm: 0.21–0.3 mm.

Thorax black, light grey microtrichose; mesoscutum with three stripes down rows of acrostichal and dorsocentral setae brown in anterior view and almost velvety blackish-brown in posterior view, postalar callus yellowish. Chaetotaxy: antepronotum with row of 4–6 black setae and several pale setulae laterally, proepisternum with many fine pale setae, prosternum bare; acrostichals biserial and approx. 0.20 mm long (subequally long as distance between rows of acrostichals and dorsocentrals); dorsocentrals longer and stronger, irregularly 2–3-serial (in some specimens almost uniserial anteriorly) ending in 2–4 longer prescutellar pairs; 1 long postpronotal and several smaller setulae; one long posthumeral (presutural supraalar), 1–2 long intrahumeral(s) (presutural intraalars); notopleuron with 2–3 long and strong setae and with several additional setae anteriorly (sometimes one of them equally strong as posterior ones); two postsutural supraalars (and 0–2 finer setae in prealar position); one long postalar (and several very small black setulae); two pairs of long scutellars (outer pair smaller); laterotergite in some specimens with yellow setae, in others mixed with black setae (on anterior part

Figure 1. *Empis rhodopensis* sp. n. Habitus, male, lateral view.

of laterotergite). **Legs** including coxae yellow, tips of all femora and tibiae, and whole tarsi (except sometimes basal part of hind basitarsus) black, all setae black except some pale setulae anteriorly on fore coxa. Fore femur very short setose, with rows of antero- and posteroventral very fine setulae shorter than half of femur depth. Fore tibia short setose, in some specimens with one to several setulae dorsally shorter than tibia depth, posterior setosity rather dense. Mid femur with fine and medium dense anterodorsal setosity shorter than femur depth, posterodorsal setulae much shorter, anteroventral row of setae slightly shorter than femur depth, posteroventral setae slightly longer. Mid tibia with two ventral rows of setae slightly longer than tibia depth, dorsally with two rows of 4–5 setae up to twice longer than tibia depth. Hind femur short setose

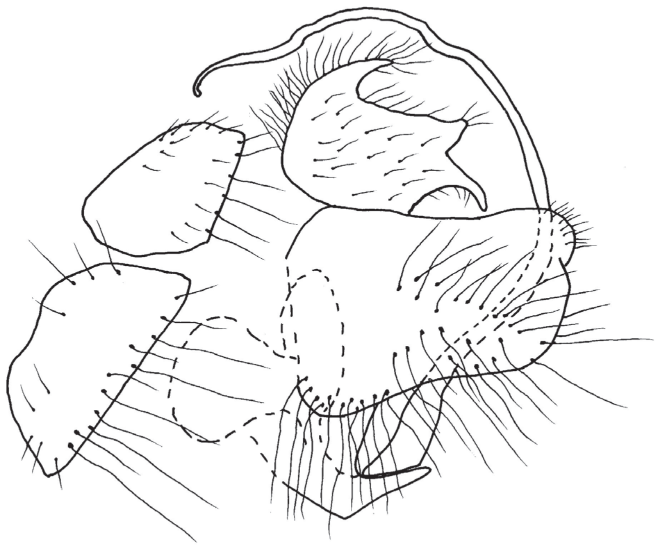

Figure 2. *Empis rhodopensis* sp. n. Male genitalia, lateral view.

dorsally except several somewhat longer fine anterodorsal setae on apical part, posteriorly and posteroventrally rather densely covered with fine setae slightly longer than femur depth, anteroventrally and ventrally with irregularly arranged short spine-like setae. Hind tibia with short ventral ciliation, two rows of 4–5 setae dorsally slightly longer than tibia depth. Basitarsi of all legs slender and short setose, hind one with short spine-like setae ventrally. Comb at tip of hind tibia without longer seta. **Wing** membrane distinctly brown clouded, veins yellowish to blackish brown, axillary angle slightly acute; costal seta present, fine and rather short. Measurements: M2/d ratio = 1.0–1.2, CuA1 ratio = 1.4–1.6, lw:ww ratio = 3.2–3.5. Halter yellow, calypter light brownish with yellow margin and yellow fringes.

Abdomen black, light grey microtrichose, lower part of cercus and epandrial lamellae brownish yellow. Tergites dorsally mostly with black setae and lateral parts of tergites and venter mostly with yellow setae. Lateral marginal setae on tergites 2–8 almost as long as segments, discal setae on dorsum of abdomen very short, venter sparsely short setose, with fine hind marginal setae best developed on segments 4–6. Genitalia (Fig 2): hypandrium small, bare; epandrium subovate, long setose, with slightly swollen dorsoapical part; cercus trilobate with broadly U-shaped dorsal incision; phallus long and thin, slightly undulating apically.

Length. body 7.8–8.7 mm, wing 8.5–8.8 mm.

Female. Dichoptic, all facets equal in size, frons approx. 0.25 mm broad with approx. 10 short black setae on each side. Labrum 2.8–3.2× longer than head height. Fore femur very short setose. Fore tibia short setose, anterodorsally and posteroventrally with several setae shorter than tibia depth. Mid femur short setose, anteroventrally with extremely short setae (0.03 mm), posteroventrally with row of setae approx. 1/3 of femur depth. Mid tibia with several anterodorsal, posterodorsal and posteroventral setae shorter than tibia depth and with rather dense row of slightly shorter anteroventral setae. Hind femur short setose, ventral setae equally extremely short as those on anteroventral side of mid femur.Hind tibia with several antero- and posterodorsal and anteroventral setae shorter than tibia depth. Tarsi of all legs narrow and short setose, basitarsi with short ventral spines. Abdomen with setae mostly black, yellow ones confined to lateral parts of basal segments.

Remarks. *Empis* (*Leptempis*) *rhodopensis* sp. n. is a member of the *E.* (*L.*) *rustica* group close to *E.* (*L.*) *trunca* Daugeron (subsequently abbreviated ET). However, the newly described species has longer labrum (1.7× head height in ET), brownish wing membrane (clear in ET), mesoscutum with three narrow not very distinct brown stripes along lines of setae (two broad stripes on dorsocentrals in ET), hind femur with strong and short irregularly arranged spines ventrally (absent in ET), epandrial lamellae brownish yellow (brown to black in ET) and phallus longer and thinner (compare figure 8 by Daugeron 1999 with Figure 2). Another species, with which the newly described species should be compared, is *E.* (*L.*) *lindneri* Oldenberg due to similarly very long labrum, however, *E.* (*L.*) *lindneri* has basally undulating phallus and different shape of the cercus. Spinose hind femur is also present in *Empis* (*Leptempis*) *tenuis* Bahid & Daugeron, 2017 however, this species differs from ER in many characters, especially it has quite different genitalia (see Bahid et al. 2017). Interestingly, in CULSP collections there is another still undescribed species of this group close to ET from Turkey, differing chiefly from both all above mentioned species by yellow tarsi.

Hilara bulgarica **Barták, sp. n.**

http://zoobank.org/EE4F1551-B5FE-457A-9E3E-2E8CD2CF07A1
Figs 3–4

Type material. HOLOTYPE ♂, **Bulgaria**, Rhodopes Mountains, Pamporovo env., meadow, 41.65N, 24.73E, 1600 m, Barták & Kubík, 22.–24.vi.2016 (CULSP). **PARATYPES:** 16♂, 2♀, same data as holotype; 6♂, 1♀, Rhodopes Mountains, Yundola, 1300 m, pasture 42.063N, 23.855E, Barták & Kubík, 30.vi.2016; 2♂, Rhodopes Mountains, Sniezhanka peak, 1900m, hilltop, 41.637N, 24.680E, Barták & Kubík, 24.–25.vi.2016; 1♂, Rhodopes Mountains, 25km SSW of Plovdiv, 1590 m, meadow, 41.935N, 24.679E, Barták & Kubík, 20.vi.2016; 4♂, 1♀, 9km NEE of Dospat, meadow nr. wood, 1170 m, 41.670N, 24.264E, Barták & Kubík, 23.vi.2016; 2♂, 1♀, Pirin Mountains, 6km SE of Bansko, 1300–1600 m, 41.78N, 23.48E, forest, Barták & Kubík, 1.vii.2016; 3♂, Pirin Mountains, Vikhren hut, 2000 m, alpine meadow, 41.756N, 23.415E, Barták & Kubík, 27.vi.2016 – (CULSP).

Diagnosis. Middle sized species of the *Hilara intermedia* group with mesoscutum light grey with four dark brown stripes visible in anterodorsal view, changing into one broad dark stripe in posterodorsal view, reaching anterior margin of prescutellar depression (in some specimens median stripe down acrostichals lighter even in poste-

Figure 3. *Hilara bulgarica* sp. n. Male fore leg, posterior view.

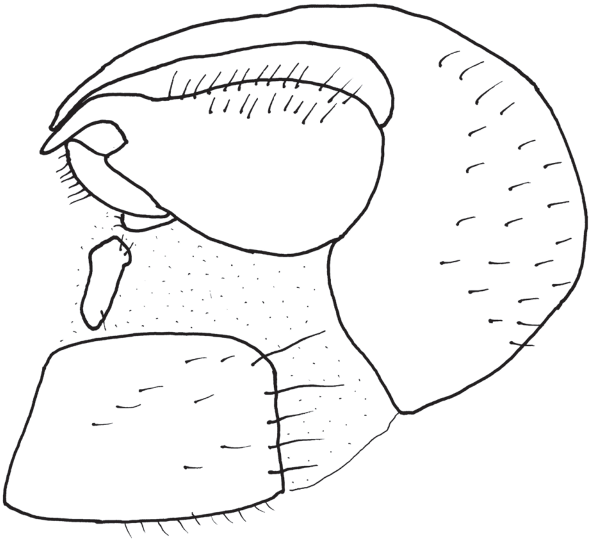

Figure 4. *Hilara bulgarica* sp. n. Male genitalia, lateral view.

rior view, more conspicuously in females); occiput uniformly dull black and male fore basitarsus extremely enlarged.

Etymology. The species is named after country of its origin (Bulgaria).

Description. Male head black, occiput dull black from dorsal view and brownish grey in posterior view with slight indication of somewhat lighter narrowly V-shaped spot behind ocelli; frons wide (0.1 mm broad at narrowest point – approx. twice as broad as anterior ocellus) dull black in dorsal view; rather light grey with dull black margins in anterior view; face light grey and broader than frons, black lateral margins narrower and less conspicuous than those on frons. Eyes with all facets of equal size. Both ocellar and one pair of frontal setae long (0.3 mm – slightly longer than postpedicel), frons with 3–7 pairs of much shorter hairs ventrally and 0–1 pairs of similar hairs dorsally of frontal pair. Postocular row of setae complete, setae black, rather fine and long, with shorter setae behind them, lower part of occiput with rather fine and somewhat longer setae, only several of them just below neck paler. Clypeus and narrow gena entirely almost silvery microtrichose. Palpus black, almost silvery grey microtrichose, usually with 1–2 long and strong ventral setae (longest seta up to 0.47 mm long, approx. as long as labrum) and with many additional fine rather long setae ventrally. Labrum brownish black, polished, 2/3 as long as head height; postmentum nearly as broad and long as labellae with apical circlet of black hairs similar to those on labellae. Antenna black, both basal segments short setose; length of antennal segments (scape: pedicel: postpedicel: 1st segment of stylus: stylus: bare part of stylus) = 0.06–0.08 mm: 0.06–0.08 mm: 0.2–0.25 mm: 0.02–0.03 mm: 0.13–0.18 mm: 0.03–0.04 mm.

Thorax black, grey microtrichose, mesoscutum with four dark brown stripes in anterodorsal view (inner pair of stripes between rows of acrostichal and dorsocentral setae narrow, running from antepronotum to posterior acrostichals, outer pair outside dorsocentrals broader), spaces occupied by rows of setae rather brownish grey; in posterodorsal view this pattern changes and mesoscutum except posterior part appears dark almost velvety black (in some specimens median stripe down acrostichals somewhat lighter even in posterior view); prescutellars depression and scutellum very light, and from almost all points of view almost silvery microtrichose; pleuron light (almost bluish) grey. Chaetotaxy: proepisternum with fine pale setulae; prosternum without setae; acrostichals black, irregularly biserial (with tendency to be triserial on middle or posteriorly) and short (approx. 0.09 mm); dorsocentrals uniserial, slightly longer than acrostichals, ending in two pairs of long prescutellars; postpronotal and posthumeral (presutural supraalar) setae long and strong, intrahumeral (presutural intraalar) fine and very short; antepronotum with two strong black setae on sides and 3–5 additional fine but rather long additional setae between them; notopleuron with 2–3 setae (and 6–8 fine yellowish brown setulae on anterior part); one supraalar and one postalar strong setae, prealar region with several setae similar to those on front part of notopleuron; two pairs of scutellars, outer pair shorter. **Legs:** coxae concolorous with pleura, with both yellow and brown setae (smaller setae usually pale, larger darker); more distal parts of legs brownish-black with nearly all setae black, tarsi almost black, microtrichose, knees narrowly yellowish. Fore femur (Figure 3) short setulose, posteroventrally almost bare except several preapicals. Fore tibia apically slightly swollen (at tip subequally deep as femur in middle), dorsally with 2–5 long setae, preapical circlet consists of 4–5 long setae, basitarsus extremely swollen and long, as long as or longer than tibia, rather flattened ventrally, short setulose, tarsomeres 2–4 short, approx. as long as deep. Mid femur short setose, subbasal ventral hair fine and short, anterior setae poorly differentiated. Mid tibia with 1–3 short anteroventral setae and with slightly elongated fine anterodorsal setae slightly longer than tibia depth. Hind femur with dorsal and ventral setae fine and shorter than tibia depth. Hind tibia thin, short setose, 1–3 anteroventral setae shorter than tibia depth, dorsal setae longer than tibia depth, preapical the longest; mid and hind basitarsi ventrally with short spines. **Wings** clear, veins brownish-black, stigma brown, anal vein long, radial fork long, axillary angle obtuse (approx. 130°) costal seta short (approx. as long as outer scutellar). Halter clear yellow, calypter grey with brownish margin and long yellow fringes.

Abdomen rather long and narrow, brownish-black, very light grey microtrichose, appearing lighter and more brownish than thorax. Lateral marginal setae on tergites 2–6 approx. as long as segments, those on segment 1 and partly (on sides) of segment 2 white to light brownish, on remaining segments black; discal setae very short and black (except somewhat longer whitish setae on segment 2), segment 7 very short setose and marginal setae on segment 8 short (longest setae up to 0.15 mm long, ventral marginal setae not distinctly longer than discal ones); sternites with very short white (on basal segments) to light brownish setae. Genitalia as in Fig 4: hypandrium almost equally strong nearly to apex; epandrial lamella with narrow and C-shaped apical outgrowth.

Length. body 4.1–6.1 mm, wing 4.0–4.7 mm.

Female. Very similar to male in all characters except legs. Fore tibia with 2–4 setae dorsally slightly longer than tibia depth. Mid tibia with only 1–2 setae ventrally shorter than tibia depth. Hind tibia practically unmodified, only very indistinctly curved in dorsal view, setae similar as in male but shorter. All tarsi slender and rather long, short setose. Abdomen with shorter marginal setae than in male. **Length.** body 4.0–4.8 mm, wing 3.6–4.1 mm.

Remarks. *Hilara bulgarica* sp. n. is a member of the *H. intermedia* group similar to *H. polleti* Chvála, also described from Bulgaria. Both species clearly differ by the shape of apical process of epandrial lamella, which is rounded and spinose in the latter species. Shape of this process in the newly described species (and four dark thoracic stripes broadly coalescent in posterior view) resembles that of *H. beckeri* Strobl. The latter species differs in many characters, for example, it has quadriserial acrostichals and strongly curved hind tibia in the female. Moreover, the species described above cannot be confused with any other member of the *H. intermedia* group due to extremely enlarged male fore basitarsus.

***Rhamphomyia* (*Amydroneura*) *stojanovae* Barták, sp. n.**
http://zoobank.org/E7671FE0-1D14-4AD8-9385-1C874ED47EBA
Figure 5

Type material. HOLOTYPE ♂, **Bulgaria**, 5 km W of Smolyan, clearing in wood, 1260 m, 41.569N, 24.632E, Barták, Kubík, 25.vi.2016 (CULSP). **PARATYPES:** 32♂, 9♀, same data as holotype (CULSP).

Diagnosis. Black species of the subgenus *Amydroneura* with abdomen generally shiny, black setose and with long bow-shaped phallus.

Etymology: The species epithet, *stojanovae*, is a Latin genitive patronym to honour Dr. Anelia Stojanova for her help with organizing our expeditions to Bulgaria.

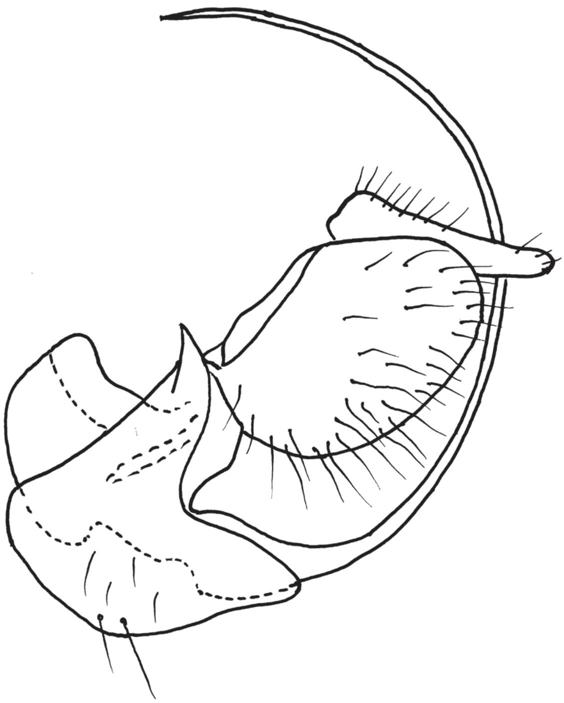

Figure 5. *Rhamphomyia stojanovae* sp. n. Male genitalia, lateral view.

Description. Male head black, black setose, narrowly dichoptic. Frons shiny, approx. 0.04 mm wide in middle, slightly widening dorsally, with 4–5 pairs of setae approx. as long as frons is broad. All eye facets approximately of the same size. Ocellar setae black, approx. 0.15 mm long, ocellar triangle microtrichose. Occiput subshiny, only finely microtrichose, with short black setae dorsally and somewhat longer ventrally. Face slightly broader than frons, shiny but somewhat rugose, without setae. Clypeus shiny on anterior half and microtrichose posteriorly, gena very narrow. Palpus black, short, with 5–6 setae approx. 0.10 mm long. Labrum blackish brown, shiny, slightly shorter than head height. Antenna black, both basal segments short setose; length of antennal segments (scape: pedicel: postpedicel: stylus) = 0.04–0.05 mm: 0.06–0.07 mm: 0.24–0.29 mm: 0.06–0.07 mm.

Thorax black, mesoscutum subshiny, sparsely microtrichose, more apparent in lateral view, all pleural parts grey microtrichose. All thoracic setae black. Chaetotaxy: antepronotum with several short setae, proepisternum with 1–3 setae, prosternum bare; acrostichals biserial, short (0.05 mm), shorter than distance between rows of acrostichals and dorsocentrals; dorsocentrals equally short, multiserial, spreading out laterally, ending in one long prescutellar pair; posthumeral (presutural supraalar) not differentiated from numerous similar thin setae, intrahumeral (presutural intraalar) present in rather posterior position; postpronotum with 1–2 long, strong setae and several shorter additional setae; notopleuron with 1 long, strong seta accompanied usually with another 1–2 shorter setae and additional smaller and finer setulae; supraalar and prealar regions with several setae similar to those before suture; one long postalar; two pairs of long scutellars; laterotergite black setose. **Legs:** coxae concolorous with pleura; legs brownish black, sparsely microtrichose, black setose. Fore femur with rows of antero- and posteroventral fine setae slightly shorter than femur depth. Fore tibia and tarsus short setose, posterodorsal fine setae slightly elongated, approx. as long as tibia depth. Mid femur with anteroventral row of setae approx. 2/3 as long as femur depth, posteroventrals irregular and short, somewhat longer apically. Mid tibia with short and somewhat stronger setae ventrally, posterodorsally with two setae on basal third almost 3X longer than tibia depth, posterodorsal setosity fine, elongated and almost curled apically, longer than tibia depth, similar setosity also present on mid tarsus. Hind femur rather densely covered with fine setae approx. as long as femur depth, ventral setae slightly shorter and more regularly arranged in row. Hind tibia with ventral ciliation very short, posterodorsally with elongated, fine and almost curled setosity similar to those on mid tibia. Tarsi of all legs with similar setosity as on corresponding tibiae. Seta in comb at tip of hind tibia very short, not longer than setae forming comb. **Wings** clear, slightly iridescent, veins not pigmented, only part of C vein from R_1 to its end and apical part of vein R_{4+5} somewhat darkened, axillary angle very obtuse; costal seta present, black and long. Measurements: M2/d ratio = 0.7–0.9, CuA1 ratio = 1.7–2.1, lw:ww ratio = 2.4–2.8. Halter brownish black, calypter brown with dark fringes. **Abdomen** black, tergites 2–7 and sternites 1–4 shiny, dorsal parts of tergites finely microtrichose. Lateral marginal setae on tergites 2–6 almost as long as segments, discal setae almost equally long. Genitalia (Figure 5): hypandrium strongly bowed, setose; epandrium subovate, moderately setose; cercus narrow and pointed apically; phallus long and very thin. **Length:** body 2.0–2.3 mm (this species has abdomen at tip bowed ventrally, so actually it is slightly larger), wing 1.9–2.0 mm.

Female. Dichoptic, all facets equal in size, frons approx. 0.10 mm broad with 5–6 short black setae on each side. Face broader than frons, shiny anteriorly. Labrum slightly longer than head height. Fore femur with 2 ventral rows of setae at most half as long as femur depth. Fore tibia with dorsal setae scarcely as long as tibia depth. Mid femur short setose, antero- and posteroventrals approx. third as long as femur depth, only somewhat longer preapically.

Mid tibia with submedian posterodorsal seta twice longer than tibia depth and another shorter posterodorsal seta subbasally. Hind femur short setose, ventral setae in middle less than half as long as femur depth. Hind tibia with 2–4 posterodorsal setae slightly longer than tibia depth, otherwise short setose. Tarsi of all legs short setose including basitarsi. Abdomen with tergites 2–6 and sternites 1–5 shiny, tergite 6 subshiny, remaining parts microtrichose. All setae black and very short.

Remarks. *Rhamphomyia* (*Amydroneura*) *stojanovae* sp. n. is most closely allied to *R. claripennis* Oldenberg (RC) and leads to this species in the key by Barták (2006a). However, the male differs in long setulae on basitarsi (short in RC) and different genitalia (with apically broadened cercus and much shorter phallus in RC – see figure 14e by Barták 1982). Distinguishing females is much more difficult. The female leads in the key by Barták (2006a) to *R. claripennis* except tergite 7, which is microtrichose. We found only three characters allowing to distinguish both species: *R. stojanovae* sp. n. has narrower frons (length: width ratio approx. 2) but broader in RC (approx. 1.6), sternite 1 is shiny in RS but microtrichose in RC, and tergite 7 is shiny in RC but microtrichose in RS. *Rhamphomyia bipila* Strobl is another species with which the above described species must be compared. This species, described and still known only from Spain, differs in male, besides many characters (different setosity of legs, longer stylus, narrower frons), by presence of long preapical setae on fore basitarsi and in female by narrower frons (2.5× longer than wide) as well as slightly flattened setae on mid and hind basitarsi.

Faunistic records

Empis (*Euempis*) *calcarata* Bezzi, 1899. 1♀, Rhodopes Mountains, Pamporovo env., meadow, 1600 m, 41.39N, 24.44E, Barták, Kubík, 22.-24.vi.2016; 1♀, 27 km N of Smolyan, on flowers, nr.river, 770 m, 41.82N, 24.68E, Barták, Kubík, 19.vi.2016; 6♂, 2 km NE of Hristo Danovo, SW, forest path, 1160 m, 42.73N, 24.62E, Barták, Kubík, 15.vi.2017. Remarks: species known from southern parts of the West Palaearctic (Italy, Turkey, Russia – Krasnodarskiy Terr.). These are the first records from Bulgaria.

Empis (*Leptempis*) *discolor* Loew, 1856. 7♂, 10♀, Pirin Mountains, 6 km SE of Bansko, 1300–1600 m, 41.78N, 23.48E, forest Barták, Kubík, 1.vii.2016; 1♂, Rhodopes Mountains, Yundola, 1300 m, pasture, 42.06N, 23.85E, Barták, Kubík, 30.vi.2016. Remarks: temperate and south European species. These are the first records from Bulgaria.

Empis (*Planempis*) *frauscheri* Linnaeus, 1758. 4♂, 1♀, 9km NEE of Dospat, meadow nr. wood, 1170 m, 41.67N, 24.26E, Barták & Kubík, 23.vi.2016. Remarks: species known only from Romania and Austria. These are the first records from Bulgaria.

Empis (*Xanthempis*) *semicinerea* Loew, 1867. 1♂, 1♀, 13 km SW of Troyan, wood+meadow, 1350 m, 42.78N, 24.62E, Barták, Kubík 15.-22.vi.2017; 1♂, 1♀, Pirin Mountains, Bezbog hut, 2200 m, alpine meadow, 41.73N, 23.52E, Barták, Kubík, 28.vi.2016; 1♀, Shipka pass, edge of fagetum, SW, 1240 m, 42.74N, 25.33E, Barták, Kubík 21.vi.2017. Remarks: Central European species.

Empis (*Xanthempis*) *stercorea* Linnaeus, 1761. 1♂, Rhodopes Mountains, Pamporovo env., meadow, 1600 m, 41.65N, 24.73E, Barták, Kubík, 22.-24.vi.2016. Remarks: Palaearctic species. This is the first record from Bulgaria.

Hilara albitarsis von Roser, 1840. 1♂, Rhodopes Mountains, 25 km SSW of Plovdiv, 1590 m, meadow, 41.93N, 24.67E, Barták, Kubík, 20.vi.2016; 2♂, 1♀, Rhodopes Mountains, Pamporovo env., meadow, 1600 m, 41.65N, 24.73E, Barták, Kubík, 22.–24.vi.2016. Remarks: a European species. These are the first records from Bulgaria.

Hilara albiventris von Roser, 1840. 3♂, Gorno Sahrane, pasture nr.river, sw, 480 m, 42.64N, 25.21E, Barták, Kubík, 18.vi.2017; 1♀, 3 km N of Kalofer, meadow nr.river, sw, 720 m, 42.63N, 24.97E, Barták, Kubík, 16.-26.vi.2017. Remarks: recorded from several European countries ranging from Britain to Romania. These are the first records from Bulgaria.

Hilara anglodanica Lundbeck, 1913. 5♂, 3♀, Koprinka lake, wood, 400 m, 42.62N, 25.28E, Barták, Kubík, 21.vi.2017; 2♂, 3 km N of Kalofer, meadow nr. river, sw, 720 m, 42.63N, 24.97E, Barták, Kubík, 16.-26.vi.2017. Remarks: known from several European countries ranging from Britain to Krasnodarskiy Territory of Russia. These are the first records from Bulgaria.

Hilara coracina Oldenberg, 1916. 1♀, 2 km NE of Hristo Danovo, forest path, 1160 m, 42.73N, 24.62E, Barták, Kubík, 15.vi.2017. Remarks: species distributed in temperate and North Europe. This is the first record from Bulgaria.

Hilara discalis Chvála, 1997. 1♀, 3 km N of Kalofer, meadow nr. river, sw, 720 m, 42.63N, 24.97E, Barták, Kubík, 16.-26.vi.2017; 1♂, Gorno Sahrane, pasture nr. river, sw, 480 m, 42.64N, 25.21E, Barták, Kubík, 18.vi.2017; 1♂, Pirin Mountains, 6 km SE of Bansko, forest, 1300-1600 m, 41.78N, 23.48E, Barták, Kubík, 1.vii.2016. Remarks: a European species. These are the first records from Bulgaria.

Hilara femorella Zetterstedt, 1842. 3♂, 2♀, Pirin Mountains, Vikhren hut, 2000 m, alpine meadow, 41.75N, 23.41E, Barták, Kubík, 27.vi.2016. Remarks: known from Europe except southernmost parts. These are the first records from Bulgaria.

Hilara fuscipes (Fabricius, 1794). 33♂, 13♀, 3 km N of Kalofer, meadow nr. river, sw, 720 m, 42.63N, 24.97E, Barták, Kubík, 16.×26.vi.2017. Remarks: widely distributed Palaearctic species. These are the first records from Bulgaria.

Hilara galactoptera Strobl, 1910. 1♀, Rhodopes Mountains, 25 km SSW of Plovdiv, 1590 m, meadow, 41.93N, 24.67E, Barták, Kubík, 20.vi.2016. Remarks: species known from temperate Europe. This is the first record from Bulgaria.

Hilara lasiopa Strobl, 1892. 2♂, Pirin Mountains, 6 km SE of Bansko, forest, 1300-1600 m, 41.78N, 23.48E, Barták, Kubík, 1.vii.2016. Remarks: distributed in several countries in West part of temperate Europe. These are the first records from Bulgaria.

Hilara longivittata Zetterstedt, 1842. 13♂, 2♀, Troyan pass, nr. brook, sw, 1400 m, 42.77N, 24.61E, Barták, Kubík, 22.–24.vi.2017; 3♂, 13 km SW of Troyan, wood+meadow, 1350 m, 42.78N, 24.62E, Barták, Kubík 15.×22.vi.2017; 4♂, Shipka pass, edge of Fagetum, sw, 1240 m, 42.74N, 25.33E, Barták, Kubík, 21.vi.2017. Remarks: Palaearctic species, ranging from Ireland to Far East of Russia, absent from southern parts. These are the first records from Bulgaria.

Hilara lurida (Fallén, 1816). 3♂, 3 km N of Kalofer, meadow nr. river, sw, 720 m, 42.63N, 24.97E, Barták, Kubík, 16.-26.vi.2017. Remarks: known from nearly all Europe except southernmost parts. These are the first records from Bulgaria.

Hilara nigrocincta de Meijere, 1935. 4♂, Gorno Sahrane, pasture nr. river, sw, 480 m, 42.64N, 25.21E, Barták, Kubík, 18.vi.2017. Remarks: a species of temperate and warm Europe, from the Netherlands, south through central parts of Europe including the Alpine region to the Mediterranean. These are the first records from Bulgaria.

Hilara nitidorella Chvála, 1997. 1♂, Troyan pass, nr. brook, sw, 1400 m, 42.77N, 24.61E, Barták, Kubík, 22.–24.vi.2017; 8♂, 1♀, Pirin Mountains, 6 km SE of Bansko, forest, 1300-1600 m, 41.78N, 23.48E, Barták, Kubík, 1.vii.2016. Remarks: distributed from British Isles to Slovenia, northwards to Leningradskaya Province of Russia. These are the first records from Bulgaria.

Hilara quadriseta Collin, 1927. 5♂, 4♀, Rhodopes Mountains, Yundola, 1300 m, pasture, 42.06N, 23.85E, Barták, Kubík, 30.vi.2016; 5♂, Pirin Mountains, 6 km SE of Bansko, forest, 1300–1600 m, 41.78N, 23.48E, Barták, Kubík, 1.vii.2016. Remarks: species known from only several countries of temperate Europe ranging from British Isles to Slovakia. These are the first records from Bulgaria.

Hilara splendida Straka, 1976. 8♂, 3♀, 3 km N of Kalofer, meadow nr. river, sw, 720 m, 42.63N, 24.97E, Barták, Kubík, 16.–26.vi.2017; Rhodopes Mountains, Pamporovo env., meadow, 1600 m, 41.65N, 24.73E, Barták, Kubík, 22.–24.vi.2016. Remarks: known from several European countries ranging from Germany and Switzerland to Romania and the Caucasus (also Turkey – our unpublished data). These are the first records from Bulgaria.

Hilara sturmii Wiedemann, 1822. 1♂, 3 km N of Kalofer, meadow nr. river, pt, 730 m, 42.63N, 24.97E, Barták, Kubík, 20.–27.vi.2017. Remarks: widely distributed in Europe from the British Isles and southern parts of Fennoscandia to the Mediterranean, east to Romania. These are the first records from Bulgaria.

Rhamphomyia claripennis Oldenberg, 1922. 1♂, 27 km N of Smolyan, on flowers, nr.river, 770 m, 41.82N, 24.68E, Barták, Kubík, 19.vi.2016; 1♂, 5 km W of Smolyan, clearing in wood, 1260 m, 41.56N, 24.63E, Barták, Kubík, 25.vi.2016; 1♂, Rhodopes Mountains, 25 km SSW of Plovdiv, 1590 m, meadow, 41.93N, 24.67E, Barták, Kubík, 20.vi.2016. Remarks: previously known from only several countries ranging from Germany to Italy. These are the first records from Bulgaria.

Rhamphomyia crinita Becker, 1887. 10♂, 3♀, Pirin Mountains, Vikhren hut, 2000 m, alpine meadow, 41.75N, 23.41E, Barták, Kubík, 27.vi.2016. Remarks: species distributed in mountains of Central Europe. Possibly complex of siblings. These are the first records from Bulgaria.

Rhamphomyia dudai Oldenberg, 1927. 1♂, 5 km W of Smolyan, clearing in wood, 1260 m, 41.56N, 24.63E, Barták, Kubík, 25.vi.2016. Remarks: species known from most parts of temperate and North Europe. This is the first record from Bulgaria and, contemporarily, southernmost distributional record.

Rhamphomyia magellensis Frey, 1922. 3♂, 2♀, Pirin Mountains, 6 km SE of Bansko, forest, 1300–1600 m, 41.78N, 23.48E, Barták, Kubík, 1.vii.2016. Remarks: species known from several European mountains ranging from Pyrenees to Slovakia. These are the first records from Bulgaria and, contemporarily, easternmost distributional records.

Rhamphomyia nudipes Oldenberg, 1927. 1♂, Rhodopes Mountains, 25 km SSW of Plovdiv, 1590 m, meadow, 41.93N, 24.67E, Barták, Kubík, 20.vi.2016; 1♂, Shipka pass, edge of Fagetum, sw, 1240 m, 42.74N, 25.33E, Barták, Kubík, 21.vi.2017. Remarks: reported only from Italy but we have other (unpublished) records from France, Austria and Greece. These are the first records from Bulgaria.

Rhamphomyia sphenoptera Loew, 1873. 2♂, Pirin Mountains, Vikhren hut, 2000 m, alpine meadow, 41.75N, 23.41E, Barták, Kubík, 27.vi.2016. Remarks: known with certainty from Italy, Serbia and Montenegro, and Albania. Records from Greece and Hungary need verification. These are the first records from Bulgaria.

Rhamphomyia umbripennis Meigen, 1822. 1♂, Pirin Mountains, Bezbog hut, 2200 m, alpine meadow, 41.73N, 23.52E, Barták, Kubík, 28.vi.2016. Remarks: species known from most of Europe except southernmost parts. This is the first record from Bulgaria.

Rhamphomyia umbripes Becker, 1887. 1♂, 13 km SW of Troyan, wood+meadow, 1350 m, 42.78N, 24.62E, Barták, Kubík 15.–22.vi.2017. Remarks: known only from several central European countries (Germany, Czech Republic, Slovakia, Austria, and Italy). Recently Chvála and Pont (2015) synonymised the subgenus *Aclonempis* Collin, 1926 (genus *Rhamphomyia*) with the genus *Empis* but at this moment (prior to complete re-classification of the whole tribe Empidini) this is not accepted here. This is the first record from Bulgaria.

Discussion

The degree of knowledge of Empididae from Bulgaria has been very low. Altogether 106 species have been previously published from this country but several published records remain doubtful (including *Rhamphomyia simplex, R. lamelliseta*). An additional study is necessary to elucidate their identity.

In this paper, *Empis* (*Leptempis*) *rhodopensis* sp. n., *Hilara bulgarica* sp. n., and *Rhamphomyia* (*Amydroneura*) *stojanovae* sp. n. are described from Bulgaria as new species and 29 species are first reported from this country. These findings increased the total number of Bulgarian Empididae to 138.

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References

Bahid F-Z, Kettani K, Daugeron C (2017) Two new species of the *Empis* (*Leptempis*) *rustica* group of the Mediterranean basin (Diptera: Empididae: Empidinae). Annales de la Société Entomologique de France, Nouvelle Série 53(6): 422–427.

Barták M (1982) The Czechoslovak species of *Rhamphomyia* (Diptera: Empididae), with the description of a new species from Central Europe. Acta Universitatis Carolinae-Biologica 1980[1982]: 381–461.

Barták M (1997) The biomonitoring of Diptera by means of yellow pan water traps. Folia Facultatis Scientiarum Naturalium Universitatis Masarykianae Brunensis, Biologia 95: 9–16.

Barták M (2006a) Two new European species of *Rhamphomyia* subgenus *Amydroneura* (Diptera: Empididae). Entomologica Fennica 17: 359–365.

Barták M (2006b) Three new West Palaearctic species of *Rhamphomyia* subgenus *Lundstroemiella* (Diptera, Empididae). Biologia (Bratislava) 61(5): 503–508. https://doi.org/10.2478/s11756-006-0083-z

Barták M (2007a) Five new European species of the *Rhamphomyia* (s.str.) *albosegmentata* group (Diptera: Empididae). Revue Suisse de Zoologie 114(2): 417–435. https://doi.org/10.5962/bhl.part.80397

Barták M (2007b) Catalogue of the Palaearctic species of the *Rhamphomyia* subgenus *Lundstroemiella* (Diptera: Empididae), with new distribution records. Acta Zoologica Universitatis Comenianae 47(2): 101–104.

Beschovski V (1973) Contribution to the dipterous fauna (Diptera, Brachycera) of the Bulgarian Black Sea Coast. III. Bulletin de l'Institut de Zoologie et Museé 37: 33–41. [In Bulgarian, English summary]

Beschovski V, Dzhambazov B (1998) New species from the family Empididae for the Bulgarian fauna (Diptera, Empidoidea, Empididae). Acta Entomologica Bulgarica 50(1): 57–59.

Ceianu I (1992) Contribution to the knowledge of superfamily Empidoidea (Diptera) in Romania I. National Museum of Natural History "Grigore Antipa" 32: 11–48.

Chvála M (1977) Revision of the *Empis rustica* Fall. species-group of the subgenus *Leptempis* Coll. in Europe, with the description of a new species (Diptera, Empididae). Acta Entomologica Bohemoslovaca 74: 41–55.

Chvála M (2002) Revision of European species of the *Hilara* "*quadrivittata*" group (Diptera: Empididae). Acta Universitatis Carolinae, Biologica 46: 229–276.

Chvála M (2005a) The Empidoidea (Diptera) of Fennoscandia and Denmark. IV Genus Hilara. Fauna Entomologica Scandinavica 40: 1–233.

Chvála M (2005b) Descriptions of three new *Hilara* species (Diptera: Empididae) from the Central European and Balkan mountains. Acta Universitatis Carolinae, Biologica 49: 99–110.

Chvála M (2008) Monograph of the genus *Hilara* Meigen (Diptera: Empididae) of the Mediterranean region. Studia Dipterologica, Supplement 15: 1–138.

Chvála M, Merz B (2009) The *Hilara* species (Diptera, Empididae) of Switzerland, with respect to the fauna of the Alps and other central European mountains. Revue suisse de Zoologie 116(3–4): 509–633.

Chvála M, Pont AC (2015) Revision of the European *Empis* (s. str.) *alpicola*-group of species (Diptera: Empididae), with a new synonymy of *Rhamphomyia* subgenus *Aclonempis* Collin with the subgenus *Empis* Linnaeus s. str. Studia Dipterologica, 21(1)[2014]: 53–68.

Chvála M, Wagner R (1989) Empididae, 228–336. In: Soós Á, Papp L (Eds) Catalogue of Palaearctic Diptera. Akadémiai Kiadó, Budapest, 435 pp.

Çiftçi MC, Hasbenli A (2008) Contribution to the *Empis* (Subgenus *Empis*) (Empididae, Diptera) Fauna of Turkey. Turkish Journal of Zoology 32: 433–435.

Daugeron C (1999) Monophyly of the subgenus *Leptempis*, and description of seven new species of the *Empis* (*Leptempis*) *rustica*-group (Diptera: Empididae). European Journal of Entomology 96: 439–449.

Dzhambazov B (1998) *Hilara bechevi* spec. nov. from Bulgaria (Insecta: Diptera: Empididae). Reichenbachia 32: 327–328.

Dzhambazov B, Beschovski V (2000) New records of Empidoidea fauna from Bulgaria (Diptera: Atelestidae, Microphoridae, Hybotidae, Empididae. Acta Zoologica Bulgarica 52(1): 3–7.

Hubenov Z (2015) Two-winged insects (Insecta: Diptera) of Pirin. Historia Naturalis Bulgarica 21: 215–256.

Kustov SY, Shamshev IV (2011) [The review of dance-flies of the subgenus *Leptempis* Collin, 1926 of the genus *Empis* Linnaeus, 1758 (Diptera: Empididae) from the Caucasus with description of three new species]. Caucasian Entomological Bulletin 7(2): 241–251. [In Russian, English summary]

Loew H (1862) Ueber einige bei Varna gefangene Dipteren. Wiener entomologische Monatschrift 6: 161–175.

Merz B, Haenni JP (2000) Morphology and terminology of adult Diptera. In: Papp L, Darvas B (Eds) [Contributions to a Manual of Palaearctic Diptera. Volume 1. Science Herald]. Budapest, 21–51.

Özgül O, Civelek HS (2013) Contributions to the Empididae (Diptera) fauna of Turkey, with two new records. Türkiye Entomoloji Bülteni 3(4): 121–124.

Shamshev IV (2016) An annotated checklist of empidoid flies (Diptera: Empidoidea, except Dolichopodidae) of Russia. Proceedings of the Russian Entomological Society 87: 1–184.

Sinclair BJ (2000) Morphology and terminology of Diptera male terminalia. In: Papp L, Darvas B (Eds) [Contributions to a Manual of Palaearctic Diptera. Volume 1. Science Herald]. Budapest, 53–84.

Sinclair BJ, Cumming JM (2006) The morphology, higher-level phylogeny and classification of the Empidoidea (Diptera). Zootaxa 1180: 1–172.

Straka V (1976) Description of new European species of the genus *Hilara* Meigen (Diptera, Empididae). Annotationes Zoologicae et Botanicae 116: 1–36.

Wyatt N (2014) Empididae. In: Costello MJ, Bouchet P, Boxshall G, Arvantidis C, Appeltans W (Eds) European Register of Marine Species. http://www.eu-nomen.eu/portal/taxon.php?GUID=urn:lsid:marinespecies.org:taxname:150933 [December 2017]