

A new species of the *Marphysa sanguinea* complex from French waters (Bay of Biscay, NE Atlantic) (Annelida, Eunicidae)

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Abstract

A new species of Eunicidae, *Marphysa victori* sp. n., has been identified from Arcachon Bay, Bay of Biscay, NE Atlantic. This new species, belonging to the *sanguinea* complex, is characterised by branchiae with long filaments from chaetigers 26–34, the presence of four types of pectinate chaetae with first ones present from chaetiger 2, a large number of both pectinate chaetae and compound spinigers, and the pygidium with only one pair of pygidial cirri. An identification key for European species of the genus *Marphysa* is provided.

Keywords

Bait worms, eastern Atlantic, France, *Marphysa*, molecular, morphology, Polychaeta, taxonomy

Introduction

In Arcachon Bay, blood worms of the genus *Marphysa* Quatrefages, 1866 are widely collected as bait both by recreational and professional fishermen. Since 2011, 13 companies (with a total of 26 employees) were operating in the lagoon and they

recorded that 1.3–2.5 tons/year (wet weight) of *Marphysa* were collected which represents approximately 400,000 worms. In reality, around 1 million of these worms could be fished each year in the bay. Most of these worms are shipped alive by air (in boxes with plant litter) to sellers situated on the western French Mediterranean coasts. Then, they are sold to recreational fishermen and used locally. Until now, these blood worms were misidentified as *Marphysa sanguinea* (Montagu, 1813), which was originally described from the south coast of Devon, UK (Hutchings and Karageorgopoulos 2003).

The family Eunicidae Berthold, 1827 is a very speciose family with nine genera and with more than 400 valid species distributed worldwide (Zanol and Read 2012). The genus *Marphysa* comprises around 81 nominal species with five valid species only known from European waters (Read and Bellan 2016): *Marphysa bellii* (Audouin & Milne Edwards, 1833), *Marphysa fallax* Marion & Bobretzky, 1875, *Marphysa kinbergi* McIntosh, 1910, *Marphysa sanguinea* and *Marphysa toto-spinata* Lu & Fauchald, 1998. *Marphysa saxicola* Langerhans, 1881 was recently transferred to the genus *Nicidion* Kinberg, 1865 (Arias and Nuñez 2016) and *Marphysa simplex* (Langerhans, 1884) should be regarded as an invalid species (Gil 2011). Finally, we consider that *Marphysa grunwaldi* (Risso, 1826) and *Marphysa triantennata* (Risso, 1826), described from French Mediterranean Sea, should be considered as *nomen nuda* because of very brief descriptions, lack of any figures, and absence of type material.

According to Fauchald (1970), species of the genus *Marphysa* can be grouped into four artificial groups based on the type of compound chaetae: no compound chaetae present (Group A), only compound spinigers present (Group B), only compound falcigers present (Group C) and both compound spinigers and falcigers present (Group D). Glasby and Hutchings (2010) added a fifth group, having compound spinigers only anteriorly and posterior segments only with simple limbate chaetae, and also encapsulating embryos in jelly cocoons. Each group can also then be divided into species having branchiae present only on anterior parapodia (subdivision 1) or branchiae present over most of the body (subdivision 2). In European waters, *M. sanguinea* is the only representative of the Group B2 currently reported.

Marphysa sanguinea has been recorded in Arcachon Bay by numerous workers (Lafont 1871; Boisseau 1962; Auby 1991; Blanchet 2004; Salvo 2010). However, all these papers just list the fauna present as a result of ecological studies without commenting on the species. It appears that no material was deposited in a museum and so could not be examined for this study. These records are not surprising as this species is originally described from the northern coast of the English Channel. Fauvel (1923) in his monograph of French polychaetes lists *M. sanguinea* and provides description and illustrations but without commenting on what material he examined. Nevertheless, recent re-descriptions of this species (Hutchings and Karageorgopoulos 2003; Hutchings et al. 2012) suggest that records of this species from outside the type locality should be checked, and that many records have been misidentified and represent new species (Zanol et al. 2016, 2017). Hutchings and Kupriyanova (2017) encourage taxonomists to check carefully their specimens.

Both morphological and molecular analyses confirm the existence of an undescribed species of *Marphysa* in Arcachon Bay. The present paper provides the description of this species as well as a key for European described species of this genus.

Materials and methods

Sampling and morphological analyses

Specimens examined in this study were collected in Arcachon Bay (Fig. 1) in September 2016 by hand, using a shovel and spade from intertidal mud flats. Live specimens

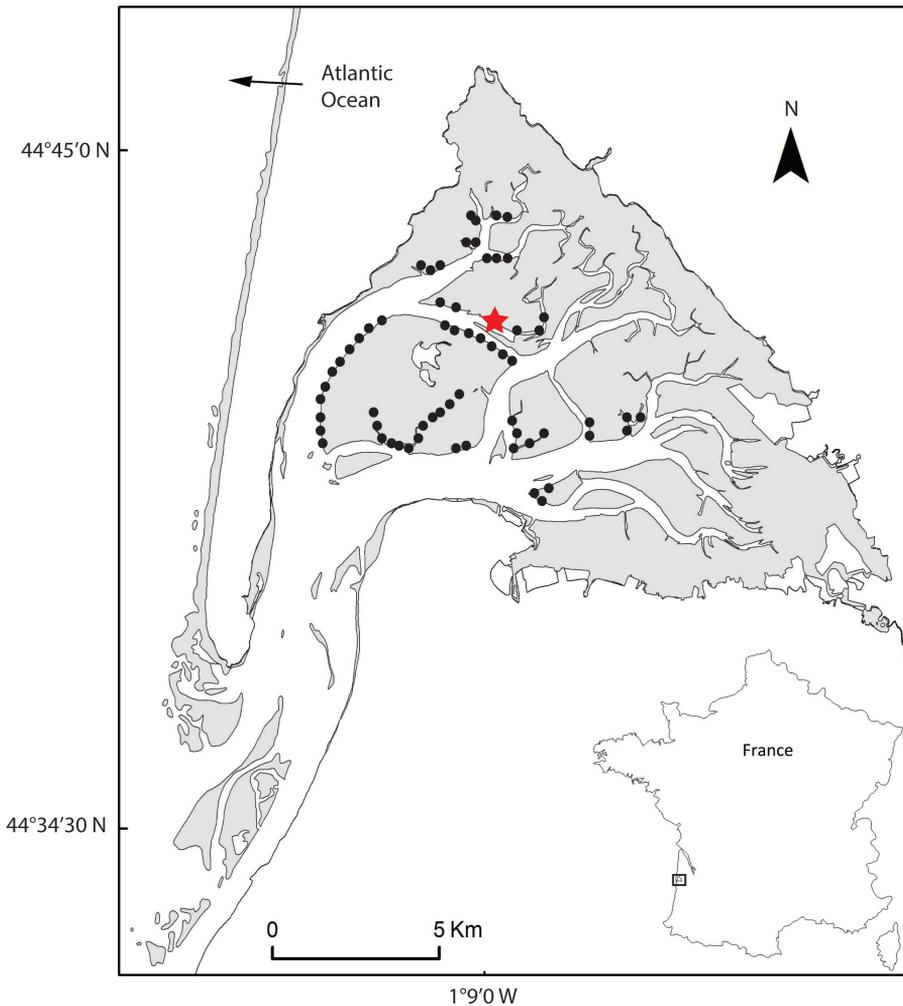


Figure 1. Sampling sites of *Marphysa victori* sp. n. in Arcachon Bay (Bay of Biscay, western France). Black dots: presence (according to fishermen); red star: type locality.

were anaesthetized with 7% magnesium chloride (MgCl_2). A small piece of body was removed from several specimens and fixed in 96% ethanol for molecular studies. The rest of each specimen was fixed in 4% formaldehyde seawater solution, then transferred to 70% ethanol for morphological analyses. Preserved specimens were examined under a Nikon SMZ25 stereomicroscope and a Nikon Eclipse E400 microscope, and photographed with a Nikon DS-Ri 2 camera. Measurements were made with the NIS-Elements Analysis software. Drawings were made from pictures using Inkscape software and Wacom Intuos 5 tablet.

Selected parapodia along the body were removed from the holotype AM W.49047, dehydrated in ethanol, critical point dried, covered with 20 nm of gold, examined under the scanning electron microscope (JEOL JSM 6480LA) and imaged with a secondary detector at Macquarie University, Sydney, Australia. These parapodia included chaetiger 3 and then chaetigers at 20% intervals along the body (chaetigers 83, 163, 243, 323, 403, and 470). Additionally, the following parapodia were removed from holotype (chaetigers 4, 93, 166, 259, 352, and 445) mounted and examined under the light microscope, with permanent slides made.

The studied material is deposited at the Australian Museum, Sydney (AM) and the Muséum National d'Histoire Naturelle, Paris (MNHN). Additional material is lodged in the collection housed at the Arcachon Marine Station.

Molecular data and analyses

Sub-samples for DNA analysis were removed from live specimens, placed in ethanol 96% and frozen at -20°C . Extraction of DNA was done with QIAamp DNA Micro Kit (QIAGEN) following protocol supplied by the manufacturers. Approximately 400 bp of 16S and 700 bp of COI (cytochrome c oxidase subunit I) genes were amplified using primers diop16SF (TGCAAAGGTAGCATAATCATTTG) and diop16SR (ACTCAGATCACGTAGGA) for 16S were designed, and polyLCO and polyHCO for COI (Carr et al. 2011).

The PCR (Polymerase Chain Reaction) was realised with Gotaq G2 Flexi DNA Polymerase (PROMEGA), with 50 μL mixtures contained: 10 μL of 5X Colorless GoTaq[®] Reaction Buffer (final concentration of 1X), 1.5 μL of MgCl_2 solution (final concentration of 1.5mM), 1 μL of PCR nucleotide mix (final concentration of 0.2 mM each dNTP), 0.5 μL of each primer (final concentration of 1 μM), 0.2 μL of GoTaq[®] G2 Flexi DNA Polymerase (5U/ μL), 1 μL template DNA and 33.8 μL of nuclease-free water. The temperature profile was as follows for 16S: $94^\circ\text{C}/600\text{s} - (94^\circ\text{C}/60\text{s}-59^\circ\text{C}/30\text{s}-72^\circ\text{C}/90\text{s}) *40$ cycles - $72^\circ\text{C}/600\text{s} - 4^\circ\text{C}$, for COI: $94^\circ\text{C}/600\text{s} - (94^\circ\text{C}/40\text{s}-44^\circ\text{C}/40\text{s}-72^\circ\text{C}/60\text{s}) *5$ cycles - $(94^\circ\text{C}/40\text{s}-51^\circ\text{C}/40\text{s}-72^\circ\text{C}/60\text{s}) *35$ cycles - $72^\circ\text{C}/300\text{s} - 4^\circ\text{C}$. Amplified PCR products were analysed by electrophoresis in a 1 % p/v agarose gel stained with ethidium bromide and were sent to GATC Biotech Company to complete double strain sequencing, using same set of primers as used for PCR.

Overlapping sequence (forward and reverse) fragments were merged into consensus sequences and aligned using Clustal Omega. For COI, sequences were translated into amino acid alignment and checked for stop codons to avoid pseudogenes. The minimum length coverage was around 430bp for 16S and 660 bp for COI. All sequences obtained in this study have been deposited in GenBank (Table 1).

Pair-wise Kimura 2-parameter (K2P) genetic distance and maximum likelihood tree using K2P model and non-parametric bootstrap branch support (1000 replicates) were performed using MEGA version 7.0.26. Tree-based analysis was obtained with all *Marphysa* species having COI sequences available in GenBank and considering other genera of Eunicidae as outgroup (Table 1).

Table 1. List of terminal taxa used in molecular analysis, GenBank accession numbers, genes analysed, and voucher specimen catalog numbers.

Species	GenBank accession number	Gene	Voucher specimen catalog number
<i>Eunice</i> cf. <i>violaceomaculata</i> Ehlers, 1887	GQ497542 ¹	COI	
<i>Palola viridis</i> Gray in Stair, 1847	GQ497556 ¹	COI	
<i>Lysidice ninetta</i> Audouin & Milne Edwards, 1833	GQ497564 ¹	COI	
<i>Leodice rubra</i> (Grube, 1856)	GQ497528 ¹	COI	
<i>Marphysa</i>			
<i>M. brevitentaculata</i> Treadwell, 1921	GQ497548 ¹	COI	
<i>M. californica</i> Moore, 1909	GQ497552 ¹	COI	
<i>M. disjuncta</i> Hartman, 1961	GQ497549 ¹	COI	
<i>M. regalis</i> Verrill, 1900	GQ497562 ¹	COI	
<i>M. sanguinea</i> (Montagu, 1813)	GQ497547 ¹	COI	
<i>M. sanguinea</i> (Montagu, 1813)	GQ478157 ¹	16S	
<i>M. viridis</i> Treadwell, 1917	GQ497553 ¹	COI	
<i>M. bifurcata</i> Kott, 1951	KX172177 ²	COI	
<i>M. fauchaldi</i> Glasby & Hutchings, 2010	KX172165 ²	COI	
<i>M. kristiani</i> Zanol, da Silva & Hutchings, 2017	KX172141 ²	COI	
<i>M. mossambica</i> (Peters, 1854)	KX172164 ²	COI	
<i>M. mullawa</i> Hutchings & Karageorgopoulos, 2003	KX172166 ²	COI	
<i>M. pseudosessilola</i> Zanol, da Silva & Hutchings, 2017	KY605405 ³	COI	
<i>M. victori</i> sp. n.	MG384997	COI	MNHN-IA-TYPE 1803
<i>M. victori</i> sp. n.	MG385000	16S	MNHN-IA-TYPE 1803
<i>M. victori</i> sp. n.	MG384998	COI	MNHN-IA-TYPE 1804
<i>M. victori</i> sp. n.	MG385001	16S	MNHN-IA-TYPE 1804
<i>M. victori</i> sp. n.	MG384999	COI	MNHN-IA-TYPE 1806
<i>M. victori</i> sp. n.	MG384996	COI	W.49048

¹ Sequences from Zanol et al. (2010)

² Sequences from Zanol et al. (2016)

³ Sequences from Zanol et al. (2017)

Systematics

Taxonomic Account

Family Eunicidae Berthold, 1827

Genus *Marphysa* Quatrefages, 1866

Type species. *Nereis sanguinea* Montagu, 1813

Marphysa victori sp. n.

<http://zoobank.org/7643A33E-94ED-4DB2-9D47-20A28E808E30>

Figs 2–4

Material examined. Holotype: AM W.49047, complete, with 470 chaetigers, ~300 mm long, with a length through chaetiger 10 of 12 mm and width of 13 mm at chaetiger 10 (11 mm without parapodia), regenerating posterior segments. Paratypes: MNHN-IA-TYPE 1805, complete, with 537 chaetigers, 386.06 mm long (approx. 77 cm live), with a length through chaetiger 10 of 15.32 mm and a width of 9.17 mm at chaetiger 10 (7.74 mm without parapodia); MNHN-IA-TYPE 1803, complete, with 414 chaetigers, 255.25 mm long, with length through chaetiger 10 of 13.70 mm and width of 10.76 mm (8.46 mm without parapodia) at chaetiger 10; MNHN-IA-TYPE 1804, complete, with 260 chaetigers, 113 mm long, with length through chaetiger 10 of 9.28 mm and width of 6.68 mm (5.9 mm without parapodia) at chaetiger 10; MNHN-IA-TYPE 1806, complete, with 307 chaetigers, 211.3 mm long, with length through chaetiger 10 of 13.17 mm and width of 8.31 mm (6.93 mm without parapodia) at chaetiger 10; MNHN-IA-TYPE 1807, complete (two fragments), with 260 chaetigers, 110 mm long, with length through chaetiger 10 of 9.87 mm and width of 7.85 mm (6.36 mm without parapodia) at chaetiger 10; MNHN-IA-TYPE 1808, complete, with 267 chaetigers, 135 mm long, with length through chaetiger 10 of 8.2 mm and width of 7.40 mm (6.39 mm without parapodia) at chaetiger 10; MNHN-IA-TYPE 1809, incomplete, with 217 chaetigers, 125.3 mm long, with length through chaetiger 10 of 11.53 mm and width of 8.7 mm (7.19 mm without parapodia) at chaetiger 10; AM W.49048, complete with 530 chaetigers, with length through chaetiger 10 of 11 mm and width of 12 mm at chaetiger 10 (10 mm without parapodia), regenerating posterior segments; AM W.49049, complete with ~350 segments, damaged in 3 places, with length through chaetiger 10 of 10 mm and width of 10 mm (8 mm without parapodia). All type material collected from Carret channel, Arcachon Bay, Bay of Biscay, France (44°40'35"N, 1°6'58"W), intertidal in muddy sediments, 20 September 2016, coll. by G. Binois.

Description (based on holotype and paratypes). Live specimens iridescent, dark red with lighter spots, prostomium appendages and parapodia green olive, end of prostomial appendages whitish, branchial filaments red and iridescent. Recently fixed specimens olive-green to brown with lighter spots, prostomium appendages and parapodia pinkish. Preserved holotype with brown mottled pigmentation anteriorly increases in intensity towards prostomium, antennae, and palps whitish.

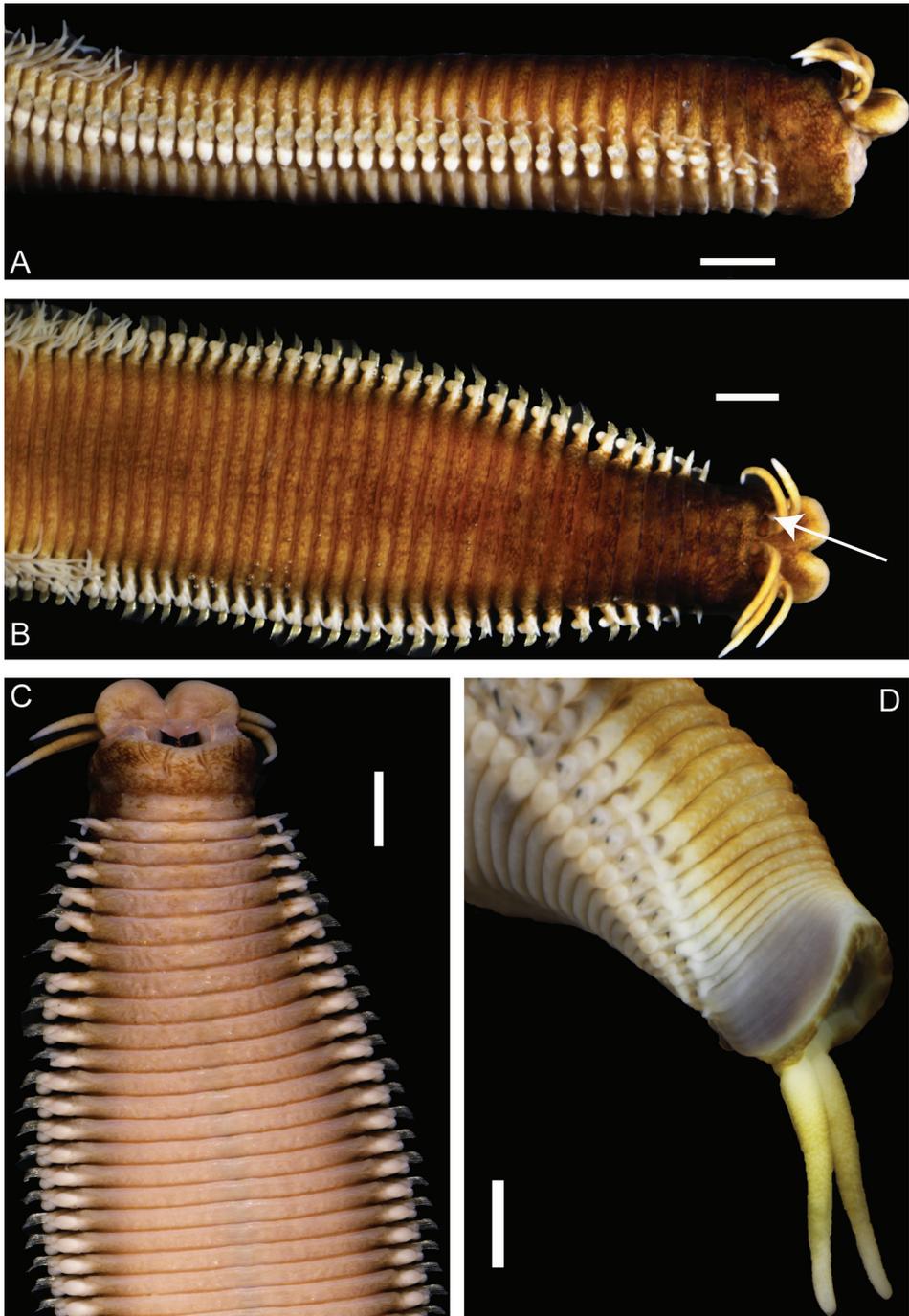


Figure 2. *Marphysa victori* sp. n.: **A** Anterior part, lateral view (paratype MNHN-IA-TYPE 1807) **B** Anterior part, dorsal view (paratype MNHN-IA-TYPE 1807) **C** Anterior part, ventral view (paratype MNHN-IA-TYPE 1807) **D** Pygidium, lateral view (paratype MNHN-IA-TYPE 1803). White arrow showing eye. Scale bars: 2 mm (A, B, C), 1 mm (D).

Body long, with same width throughout, slightly tapering at anterior and posterior ends. Prostomium shorter than anterior ring of peristomium, as wide as peristomium, bilobed with buccal lips separated by deep ventral and dorsal notch with each lobe rounded with base of them strongly pigmented (Fig. 2A–C). Anterior ring of peristomium longer than posterior ring (2.2 to 3 times) (Fig. 2A, C). Eyes present, positioned between palps and lateral antennae (Fig. 2B), faded in larger specimens (not visible on holotype). Prostomial appendages smooth, arranged in horseshoe, slightly tapering; median antenna longer than lateral antennae, palps shortest appendages (paratypes exhibit considerable variation in the ratio of length of median and lateral antennae and of palps to a lesser extent). Antennal styles and palpostyles smooth although surface slightly wrinkled. MxI more than twice as long as carrier and five times longer than closing system. MxIII at least in part located ventral to MxII. Attachment lamella of MxIII short with irregular shape, placed at the middle of the plate. Left MxIV with attachment lamella semicircular, situated along posterior edge. Right MIV with attachment lamella semicircular, more developed in the central portion, situated along posterior edge. Maxillary formula: I=1+1, II=5+5, III=5–6+6–7, IV=3–4+0, V=1+1 (Fig. 3E).

Pre-chaetal neuropodia lobe inconspicuous. Post-chaetal neuropodial lobe conical in the 2–3 first chaetigers, elongate rectangular from chaetiger 4, gradually thereafter becomes wider and rounded; longer than chaetal lobe in anterior chaetigers, shorter in median and posterior chaetigers (Figs 3A–D, 4A). Notopodial cirri triangular, occasionally digitiform in last chaetigers; longer than chaetal lobe in anterior chaetigers, shorter than chaetal lobe in median chaetigers and as long as chaetal lobe in posterior chaetigers (Figs 3A–D, 4A). Ventral cirri from chaetiger 1 to 4–5 conical to tapering, with round wide tips, almost as long as notopodial cirri; basally inflated from chaetiger 5–6, inflated base of round shape with round tip (Figs 3D, 4A), around 1/2 as long as notopodial cirri, gradually decreasing from chaetiger 60 to 110; round with distinct tip from chaetiger 111, around 1/3 as long as notopodial cirri. Ventral cirri as long as or longer than neurochaetal lobe at anterior region (Figs 2A, 3D), slightly shorter to as long as neurochaetal lobe at median and posterior region, sometimes longer than neurochaetal lobe in posteriormost chaetigers.

Branchiae pectinate (Fig. 3A–B), from chaetiger 32, extending posteriorly by last few chaetigers; number of branchial filaments increasing from 3 in first chaetigers to maximum 6 in mid-body, posterior chaetigers with 2 long filaments (Fig. 3C); filaments increasing in size from around 5 times longer than notopodial cirri in anterior chaetigers, around 7 times in mid-body and around 13 times in posterior chaetigers (Fig. 3C), filaments slightly annulated.

Chaetae arranged in two bundles: supra-acicular and sub-acicular, separated by a row of aciculae (Fig. 3A–C). Aciculae dark, with lighter blunt tips, very protruding, 4–6 per parapodium in anterior chaetigers and 2–3 in mid and posterior chaetigers. Subacicular hooks absent. Supra-acicular bundle with limbate and pectinate chaetae; sub-acicular with compound spiniger chaetae (Fig. 4A). Between 25 to 35 limbate chaetae (numbers reducing posteriorly), chaetae of different lengths with hirsute blades, similar to each other. Compound spinigers present, throughout, with more than 40 spinigers within a parapodia, along whole body except last few chaetigers (Fig. 4A, B). Compound falcigers

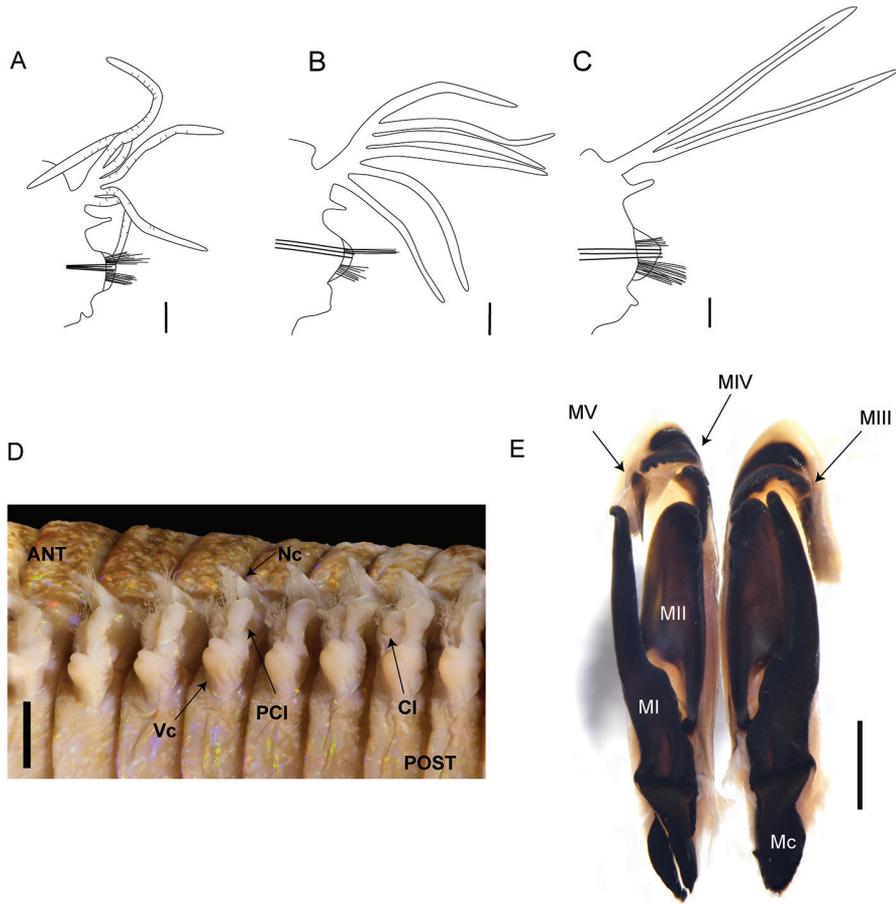


Figure 3. *Marphysa victori* sp. n.: **A** Parapodia from anterior chaetiger (chaetiger 57, paratype MNHN-Arc4) **B** Parapodia from mid-body (chaetiger 127, paratype MNHN-IA-TYPE 1803) **C** Parapodia from posterior chaetiger (chaetiger 352, paratype MNHN-IA-TYPE 1803) **D** Anterior parapodia (from chaetiger 8 to 15), lateral view **E** Maxillae dorsal view (paratype MNHN-IA-TYPE 1809). ANT: anterior part; Cl, Chaetal lobe; Mc, maxillary carriers; MI to MV, maxillae I to V; Nc, notopodial cirri; PCI, postchaetal lobe; POST, posterior part; Vc, ventral cirri. Scale bars: 0.5 mm (**A**, **B**, **C**), 1 mm (**D**, **E**).

absent. Pectinate chaetae present from chaetiger 2. Up to 34 pectinate chaetae within a parapodia restricted to supra-acicular fascicle of chaetae. Pectinate chaetae of four types. In anterior parapodia, isodont, symmetrical pectinate chaetae ($n < 10$) with 12–16 tapering minute teeth and two long outer winged teeth (nearly 3–4 times longer than inner teeth) (type 2) (Fig. 4C–E). Median parapodia with four types of pectinate chaetae (Fig. 4C–E): isodont, symmetrical pectinate chaetae of type 2; isodont, symmetrical pectinate chaetae with approximately 14 teeth (type 4); anodont, asymmetrical pectinate chaetae with approximately 14 teeth (type 3); anodont, asymmetrical pectinate chaetae with 2–4 large teeth (type 1) (Fig. 4C–E). Posterior parapodia with 3 types of pectinate chaetae: isodont, symmetrical pectinate chaetae with 28 teeth (type 2); anodont,

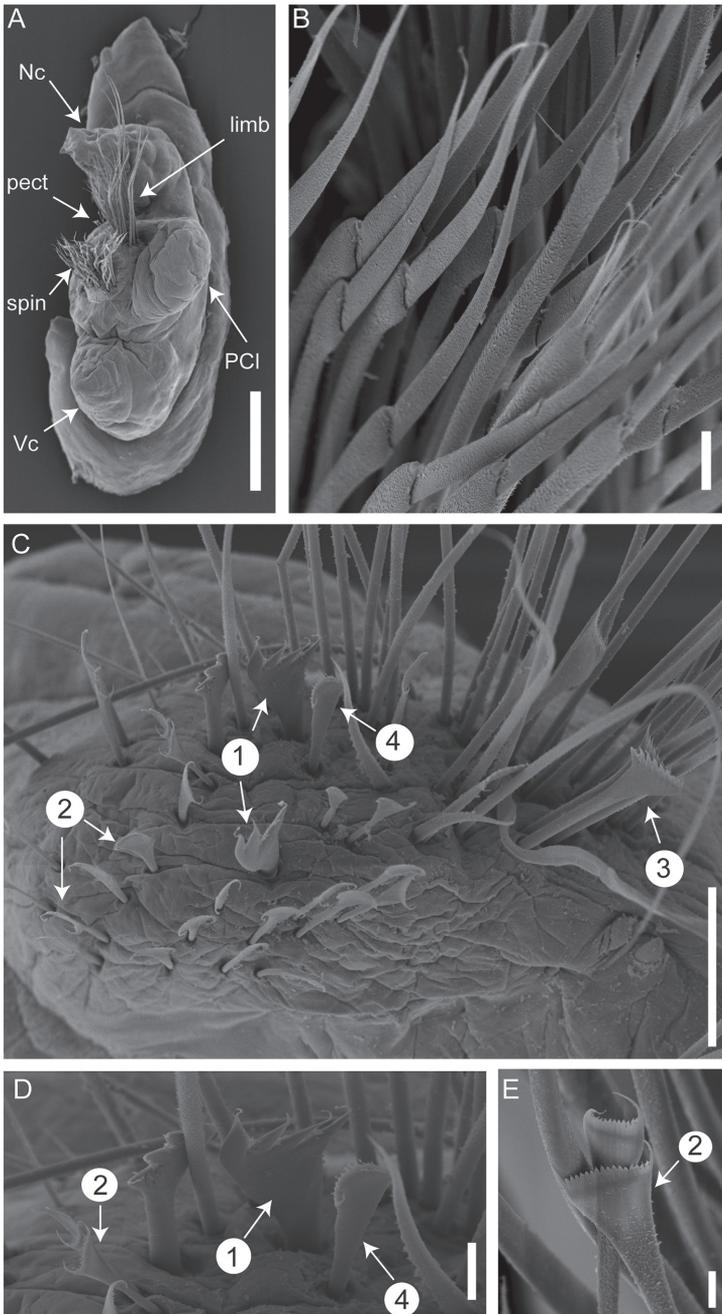


Figure 4. SEM images of *Marphysa victori* sp. n. (holotype AM W.49047): **A** entire lateral view of chaetiger 3 **B** Compound spiniger chaetae (chaetiger 83) **C–D** Different types of pectinate chaetae (chaetiger 243) **E** Isodont, symmetrical chaetae with many teeth (chaetiger 03). Numbers in white circles indicate the type of pectinate chaetae; limb, limbate chaetae; Nc, notopodial cirri; PCI, postchaetal lobe; pect, pectinate chaetae; spin, spiniger chaetae; Vc, ventral cirri. Scale bars: 500 μm (A), 200 μm (B), 100 μm (C), 20 μm (D), 10 μm (E).

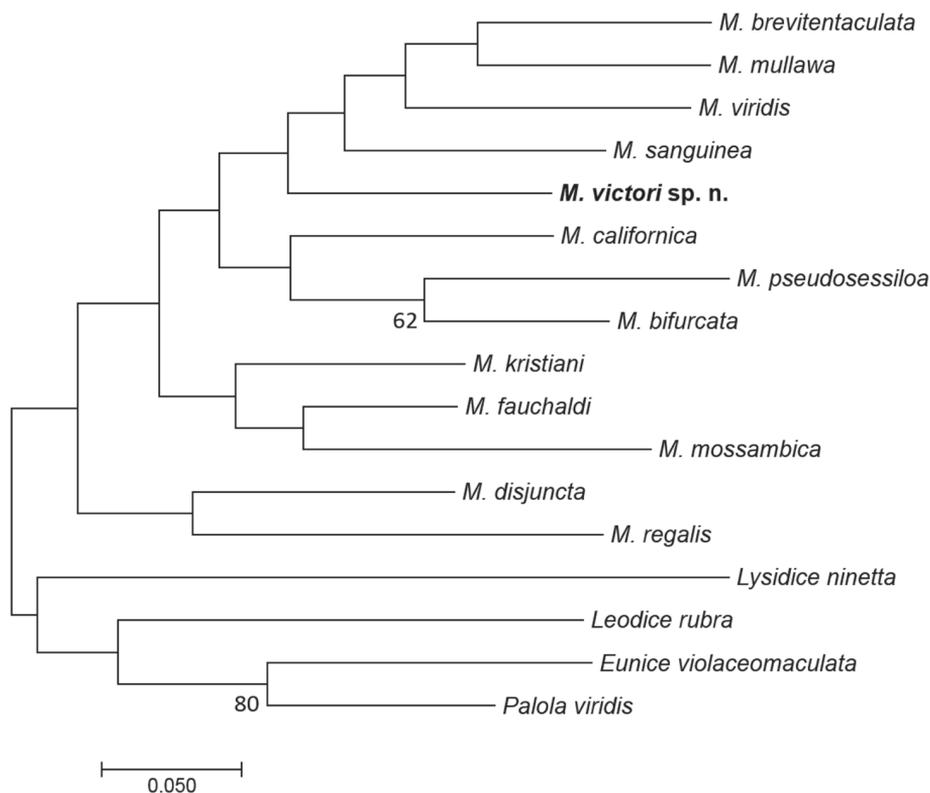


Figure 5. Maximum likelihood tree based on cytochrome oxidase I (COI) sequences and Kimura-2-parameters model. Bootstrap values on nodes if >50.

asymmetrical pectinate chaetae with nine parallel teeth (type 3); anodont, asymmetrical pectinate chaetae with 2–4 large teeth (type 1). Subacicular bundle comprising up to 40 compound spiniger chaetae in anterior chaetigers, with surface of blade hirsute (Fig. 4B).

Pygidium with only one pair of long pygidial cirri on ventral margin (approximately as long as last 15 segments), anus slightly crenulated with 12 small indentations (Fig. 2D).

Morphological variations. Paratypes with branchiae starting from chaetigers 26 (MNHN-IA-TYPE 1808) to 28 for smaller specimens and from 28 to 34 for larger ones. Eyes clearly visible on small (MNHN-IA-TYPE 1807 and MNHN-IA-TYPE 1808) and medium specimens, more difficult to see on larger ones. One exceptional specimen (MNHN-IA-TYPE 1805) with one pair of small papillae in addition to one pair of pygidial cirri, with papillae placed more ventrally than cirri.

Etymology. This species is named after Victor Lavesque, first and second authors' son.

Type locality. NE Atlantic, France, Arcachon Bay.

Habitat. Intertidal on mudflats, under or close to oyster reefs or abandoned oyster farms, 5 to 60 cm depth. Few specimens were found in galleries into old piece of driftwood.

Genetic data. COI gene was successfully sequenced and published at NCBI GenBank for four paratypes: MNHN-IA-TYPE 1803 (accession number: MG384997), AMW.49048 (accession number: MG384996), MNHN-IA-TYPE 1804 (accession number: MG384998) and MNHN-IA-TYPE 1806 (accession number: MG384999). 16S gene was sequenced and published at NCBI GenBank for two paratypes: MNHN-IA-TYPE 1803 (accession number: MG385000) and MNHN-IA-TYPE 1804 (accession number: MG385001) (Table 1).

As the identification of *Marphysa* species from the *sanguinea* group is very complex, molecular tools are very important. First of all, comparison of COI and 16S sequences confirmed that *M. victori* sp. n. was different from *M. sanguinea* (census Zanol et al. 2014) (Fig. 5): interspecific pairwise genetic distances were 21.8% for COI and 15.2% for 16S. Secondly, molecular analysis clearly distinguished *M. victori* sp. n. from other species with sequences available in GenBank (Fig. 5). Finally, they permitted us to link morphological differences to age of specimens. Indeed, intraspecific pairwise genetic distance was zero among specimens and allow to conclude that intensity of eye pigments and the segment on which the branchiae first appear was related to the size (age) of worms and not to the presence of different species.

Discussion

Marphysa sanguinea (Montagu, 1813) is the type species of the genus and has been widely reported from around the world. This is partly because the original description was very brief and poorly illustrated, and because all species superficially look similar. Hartman (1959) complicated the issue by synonymising several species with *M. sanguinea* with no explanation and the species joined a list of so-called “cosmopolitan species” (Hutchings and Kupriyanova 2017). Hutchings and Karageorgopoulos (2003) while trying to resolve the true identity of a commercially important species in Moreton Bay (Queensland, Australia) which had always been called *M. sanguinea*, examined material from SW England and designated a neotype of *M. sanguinea* and then redescribed the species. This then allowed the species from Moreton Bay to be described as a new species, and subsequently other species of *Marphysa* were described from along the east coast of Australia (Zanol et al. 2016, 2017). In the same way, a new species of the *sanguinea* group from French Atlantic coasts is described in this study. In Europe, only two species belong to the B2 group (Fauchald 1970). *Marphysa victori* sp. n. can be distinguished from *M. sanguinea* in having branchiae from chaetiger 26–34 (instead of 13–27), pectinate chaetae of four types (instead of two types, with an absence of anodont, asymmetrical pectinate chaetae with 2–4 large teeth), lacking subacicular hooks (see key above). Moreover, the neotype of *M. sanguinea* was described from south coast of England living intertidally in rocks which are easily identified and which are in a very different habitat to that of *M. victori* sp. n. (mudflats).

Three species are known to occur in Arcachon bay: *M. bellii*, *M. fallax*, and *M. sanguinea*. In the absence of specimens stored in a collection, it is very difficult to know how long *M. victori* sp. n. has been present in Arcachon Bay and confused with *M. sanguinea*. Moreover, the hypothesis that this new species is a non-indigenous species (NIS) cannot be completely dismissed. Arcachon Bay is one of the major French oyster farming sites with a production of 7,000–8,000 t per year of exotic Pacific cupped oyster *Crassostrea gigas* (Thunberg, 1793). In the early 1970s, the Portuguese cupped oyster *Crassostrea angulata* (Lamarck, 1819), which has been farmed in the bay since the end of the 19th century, was decimated by a viral disease (Gouletquer et al. 2002). To sustain the local oyster industry, the exotic Pacific cupped oyster *C. gigas* was then introduced into Arcachon Bay between 1971 and 1975, as spat from Senday Bay, NE Honshu Island, Japan (1,176 t of spat collectors from 1971 to 1975) and as adults from British Columbia, Canada (137.5 t from 1971 to 1973) (Grizel and Héral 1991). Several non-indigenous species, probably introduced with oyster transfers, were recently found in Arcachon Bay (see references in Gouillieux et al. 2016). As *M. victori* sp. n. is very abundant close to oyster reefs, specimens could have been hitchhiked in oyster shells coming from Japan or Pacific coasts of USA. Worldwide, among the B2 group, only two species are characterized by the presence of four types of pectinate chaetae: *Marphysa multipectinata* (Liu, Hutchings & Sun, 2017) recently described from south coast of China and *M. victori* sp. n. *Marphysa multipectinata* differs from *M. victori* sp. n. in the appearance of pectinate chaetae (from chaetiger ~ 70 instead of chaetiger 2 for *M. victori* sp. n.), the maximal number of spiniger compound chaetae (27 vs >40 for *M. victori* sp. n.) and pectinate chaetae (22 vs 34 for *M. victori* sp. n.), the presence of subacicular hooks, the absence of inflated base of ventral cirri, the number of teeth of Mx II (3+3 vs 5+5 for *M. victori* sp. n.) and the presence of two pairs of pygidial cirri (instead of one single pair for *M. victori* sp. n.).

Alternatively, *M. victori* sp. n. could be native from Arcachon Bay and subsequently have been introduced into other European localities. Indeed, local oyster farmers often transfer their spat and juveniles between rearing areas in France (both on the Atlantic and Mediterranean coasts) (Gouletquer et al. 2002) or even to other European countries (Gouillieux et al. 2016). Moreover, thousands (probably millions) of specimens of *M. victori* sp. n. are shipped alive with litter to resellers situated on the western French Mediterranean coasts and then are used as bait by anglers. Recent studies have highlighted the possibility of these practises facilitating the introduction of invasive species (Olive 1994). Bait worm packaging are considered to be an important vector for transporting non-native algae, microorganisms and other invertebrates (Haska et al. 2012; Fowler et al. 2016). For example, a total of 114 taxa have been identified by Fowler et al. (2016) in baitworm shipments from Maine. Moreover, use of live baits contributes to the dispersal of worms in new marine ecosystems. Kilian et al. (2012) showed that a certain number of anglers in Maryland (USA) released their unused baits into the water at the end of a fishing trip. In this way, *M. victori* sp. n. might become a non-indigenous species in the Mediterranean Sea. Finally, the presence of *M. victori* sp. n. in driftwood could also lead to an extension of its geographical distribution in the Bay of Biscay via water currents.

To conclude, we suggest that all records of *Marphysa* from northern Europe need to be carefully checked to see if they represent a currently known species including *M. sanguinea* or represent an undescribed species. As well, the pattern of chaetal arrangement along the body need to be examined under the SEM, and combined with molecular data to correctly identify these species which often superficially resemble each other and vouchers need to be deposited in a museum.

Key to the European species of *Marphysa*

- 1 Compound spinigers only 2
- Both compound falcigers and spinigers 4
- 2 Branchiae limited to anterior chaetigers *M. kinbergi* McIntosh, 1910
- Branchiae present over most of the body 3
- 3 Branchiae from chaetigers 13 to 27, absence of anodont, asymmetrical pectinate chaetae with 2–4 teeth, subacicular hooks present
..... *M. sanguinea* (Montagu, 1813)
- Branchiae from chaetigers 26 to 34, presence of anodont, asymmetrical pectinate chaetae with 2–4 teeth, no subacicular hooks *M. victori* sp. n.
- 4 Branchiae with up to 2 filaments *M. fallax* Marion & Bobretzky, 1875
- Branchiae with 6 or more filaments 5
- 5 Compound spinigers limited to anterior 1/3 or less
..... *M. bellii* (Audouin & Milne Edwards, 1833)
- Compound spinigers along nearly entire body
..... *M. tospinata* Lu & Fauchald, 1998

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References

- Arias A, Núñez J (2016) Redescription and ontogeny of the controversial eunicid *Marphysa saxicola* Langerhans, 1881. 12th International Polychaete Conference, National Museum Wales, Cardiff, 1–5 August 2016.

- Audouin JV, Milne Edwards H (1833) Classification des Annélides et description de celles qui habitent les côtes de la France. *Annales des sciences naturelles* (1)30: 411–425.
- Auby I (1991) Contribution à l'étude des herbiers de *Zostera noltii* dans le Bassin d'Arcachon: dynamique, production et dégradation, macrofaune associée. PhD thesis, Bordeaux, France, University of Bordeaux 1.
- Berthold AA (1827) Latreille's Natürliche Familien des Thierreichs. Aus dem Französischen, mit Anmerkungen und Zusätzen. Verlage Landes-Industrie-Comptoires, Weimar, 606 pp.
- Boisseau J (1962) Contribution à la faune du Bassin d'Arcachon. Annélides, Sipunculien, Echiuriens. *Procès-verbaux de la Société Linnéenne de Bordeaux* 99: 113–126.
- Blanchet H (2004) Structure et fonctionnement des peuplements benthiques du Bassin d'Arcachon. PhD thesis, Bordeaux, France, University of Bordeaux 1.
- Carr CM, Hardy SM, Brown TM, Macdonald T, Hebert PDN (2011) A tri-oceanic perspective: DNA barcoding reveals geographic structure and cryptic diversity in Canadian polychaetes. *PLoS ONE* 6 e22232. <https://doi.org/10.1371/journal.pone.0022232>.
- Fauchald K (1970) Polychaetous annelids of the families Eunicidae, Lumbrineridae, Iphitimidae, Arabellidae, Lysaretidae and Dorvilleidae from western Mexico. Allan Hancock Monograph in Marine Biology 5: 1–335.
- Fauvel P (1923) Polychètes errantes. Faune de France. Librairie de la Faculté des Sciences, Paris, 488 pp.
- Fowler AE, Blakeslee AM, Canning-Clode J, Repetto MF, Phillip AM, Carlton JT, Moser FC, Ruiz GM, Miller AW (2016) Opening Pandora's bait box: a potent vector for biological invasions of live marine species. *Diversity and Distributions* 22(1): 30–42. <https://doi.org/10.1111/ddi.12376>
- Gil JCF (2011) The European Fauna of Annelida Polychaeta. PhD thesis, Lisboa, Portugal, University of Lisboa.
- Glasby CJ, Hutchings PA (2010) A new species of *Marphysa* Quatrefages, 1865 (Polychaeta: Eunicida: Eunicidae) from northern Australia and a review of similar taxa from the Indo-West Pacific, including the genus *Nauphanta* Kinberg, 1865. *Zootaxa* 2352: 29–45.
- Gouillieux B, Lavesque L, Blanchet H, Bachelet G (2016) First record of the non-indigenous *Melita nitida* Smith, 1873 (Crustacea: Amphipoda: Melitidae) in the Bay of Biscay (NE Atlantic). *BioInvasions Records* 5(2): 85–92. <http://dx.doi.org/10.3391/bir.2016.5.2.05>.
- Gouilletquer P, Bachelet G, Sauriau PG, Noel P (2002) Open Atlantic coast of Europe – a century of introduced species into French waters. In: Leppäkoski E, Gollasch S, Olenin S (Eds) *Invasive aquatic species of Europe. Distribution, impacts and management*. Kluwer Academic Publishers, Dordrecht, 276–290.
- Grizel H, Héral M (1991) Introduction into France of the Japanese oyster (*Crassostrea gigas*). *Journal du Conseil International pour l'Exploration de la Mer* 47: 399–403.
- Hartman O (1959) Catalogue of the Polychaetous annelids of the world. Part 2. Sedentaria. Allan Hancock Foundation Occasional Paper 23: 355–628.
- Haska CL, Yarish C, Kraemer G, Blaschik N, Whitlatch R, Zhang H, Lin S (2012) Bait worm packaging as a potential vector of invasive species. *Biological Invasions* 14(2): 481–493. <https://doi.org/10.1007/s10530-011-0091-y>

- Hutchings PA, Karageorgopoulos P (2003) Designation of a neotype of *Marphysa sanguinea* (Montagu, 1813) and a description of a new species of *Marphysa* from Eastern Australia. *Hydrobiologia* 496: 87–94. <https://doi.org/10.1023/A:1026124310552>
- Hutchings PA, Glasby CJ, Wijnhoven S (2012) Note on additional diagnostic characters of *Marphysa sanguinea* (Montagu, 1813) (Annelida: Eunicida: Eunicidae), a recently introduced species in Netherlands. *Aquatic Invasions* 7: 277–282. <http://dx.doi.org/10.3391/ai.2012.7.2.014>
- Hutchings PA, Kupriyanova E (2017) Cosmopolitan polychaetes - fact or fiction? Personal and historical perspectives. *Invertebrate Systematics*. <http://dx.doi.org/10.1071/IS17035>
- Kilian JV, Klauda RJ, Widman S, Kashiwagi M, Bourquin R, Weglein S, Schuster J (2012) An assessment of a bait industry and angler behavior as a vector of invasive species. *Biological Invasions* 14: 1469–1481.
- Kinberg JGH (1865) *Annulata Nova. Öfersigt af Kongliga Vetenskaps-Akademiens Förhandlingar*, Stockholm 21(10): 559–574.
- Lafont A (1871) Note pour servir à la faune de la Gironde contenant la liste des animaux marins dont la présence a été constatée à Arcachon pendant les années 1869–1870. *Actes de la Société Linnéenne de Bordeaux* 28: 237–280.
- Lamarck JBM (1819) *Histoire naturelle des animaux sans vertèbres. Tome sixième, 1ère partie*. Paris, published by the Author, 343 pp.
- Langerhans P (1881) Ueber einige canarische Anneliden. *Nova Acta Leopoldina* 42: 93–124.
- Langerhans P (1884) Die Würmfauna von Madeira. IV. *Zeitschrift für wissenschaftliche Zoologie* 40(2): 247–285.
- Liu Y, Hutchings PA, Sun S (2017) Three new species of *Marphysa* Quatrefages, 1865 (Polychaeta: Eunicida: Eunicidae) from the south coast of China and redescription of *Marphysa sinensis* Monro, 1934. *Zootaxa* 4263(2): 228–250.
- Lu H, Fauchald K (1998) *Marphysa belli* (Polychaeta: Eunicidae) and two related species, *Marphysa oculata* and *M. totopspinata*, a new species, with notes on size-dependent features. *Proceedings of the Biological Society of Washington* 111(4): 829–842.
- McIntosh WC (1910) A monograph of the British annelids. Polychaeta. Syllidae to Ariciidae. Ray Society, London, 524 pp.
- Marion AF, Bobretzky N (1875) Annélides du Golfe de Marseille. *Annales des Sciences Naturelles. Zoologie et Paléontologie* 6(2): 1–106.
- Molina-Acevedo IC, Carrera-Parra LF (2015) Reinstatement of three Grand Caribbean species of the *Marphysa sanguinea* complex (Polychaeta: Eunicidae). *Zootaxa* 3925(1): 37–55. <http://dx.doi.org/10.11646/zootaxa.3925.1.3>
- Montagu G (1813) Descriptions of several new or rare animals, principally marine, found on the south coast of Devonshire. *Transactions of the Linnean Society of London* 11: 18–21.
- Olive PJW (1994) Polychaetes as a world resource: a review of patterns of exploitation as sea angling baits and the potential for aquaculture based production. *Mémoires du Muséum National d'Histoire Naturelle* 162: 603–610.
- Quatrefages A (1866) *Histoire naturelle des Annelés marins et d'eau douce. Annélides et Géphyriens. Tome second*. Librairie Encyclopédique de Rôret, Paris, 337–794.
- Read G, Bellan G (2016) *Marphysa* Quatrefages, 1866. In: Read G, Fauchald K (Eds) World Polychaeta database. www.marinespecies.org/aphia.php?p=taxdetails&id=129281.

- Risso A (1826) Histoire naturelle des principales productions de l'Europe Méridionale et particulièrement de celles des environs de Nice et des Alpes Maritimes. Tome quatrième. Levrault FG, Paris, 439 pp.
- Salvo F (2010) Approche comparée des populations naturelles et cultivées d'huitre japonaise *Crassostrea gigas* dans une lagune macrotidale (Bassin d'Arcachon) : cycle biologique, relations trophiques et effet sur le benthos. PhD thesis, Bordeaux, France, University of Bordeaux 1.
- Thunberg CP (1793) Tekning och Beskrifning på en stor Ostronsort ifrån Japan. Kongliga Vetenskaps Academiens Nya Handlingar 14(4-6): 140–142.
- Zanol J, Halanych KM, Struck TH, Fauchald K (2010) Phylogeny of the bristle worm family Eunicidae (Eunicida, Annelida) and the phylogenetic utility of noncongruent 16S, COI and 18S in combined analyses. *Molecular Phylogenetics and Evolution* 55: 660–676. <https://doi.org/10.1016/j.ympev.2009.12.024>
- Zanol J, Read G (2012) Eunicidae Berthold, 1827. In: Read G, Fauchald (Eds) World Polychaeta database. <http://www.marinespecies.org/aphia.php?p=taxdetails&id=966>
- Zanol J, Halanych KM, Fauchald K (2014) Reconciling taxonomy and phylogeny in the bristleworm family Eunicidae (polychaete, Annelida). *Zoologica Scripta* 43: 79–100. <https://doi.org/10.1111/zsc.12034>
- Zanol J, da Silva T dos SC, Hutchings P (2016) Integrative taxonomy of *Marphysa* (Eunicidae, Polychaeta, Annelida) species of the Sanguinea-group from Australia. *Invertebrate Biology* 135(4): 328–344. <http://dx.doi.org/10.1111/ivb.12114>
- Zanol J, da Silva T dos SC, Hutchings P (2017) One new species and two redescriptions of *Marphysa* (Eunicidae, Annelida) species of the Aenea-group from Australia. *Zootaxa* 4268(3): 411–426. <http://dx.doi.org/10.11646/zootaxa.4268.3.6>

Variation in colour markings of an unusual new *Asprothrips* species from China (Thysanoptera, Thripidae)

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Abstract

The second species of the genus *Asprothrips* with a bicoloured body, *A. atermaculosus* sp. n., is described and illustrated from China. This is characterised by considerable intra-population variation in the number and size of brown markings on the abdominal tergites. *Asprothrips fuscipennis* Kudô, previously described from Japan, is newly recorded in China.

Keywords

Asprothrips, Dendrothripinae, new species, thrips, Thripidae

Introduction

The genus *Asprothrips* Crawford, a small genus of the subfamily Dendrothripinae, currently comprises seven described species (ThripsWiki 2017), and Tong et al. (2016) briefly summarised the generic diagnosis and provided a key to the world species. *Asprothrips* species generally exhibit two colour types, with the body either brown or white (Mound 1999; Tyagi 2011). In contrast, Michel and Ryckewaert (2014a, b) described *A. bimaculatus* as the first bicoloured species in the genus. Here a second



Figure 1. *Lophatherum gracile*, host plant of *Asprothrips atermaculosus* sp. n.

bicoloured *Asprothrips* species is described, which was collected from *Lophatherum gracile* (Fig. 1), a ubiquitous grass found throughout southern China. This thrips was collected during recent surveys on the thrips fauna of China, and *A. fuscipennis* Kudô that was previously known only from Japan is also recorded in China for the first time.

Materials and methods

The thrips were collected by beating vegetation over a white plastic tray using a stick, and then sorted and preserved in 90 % alcohol. Examined specimens were mounted

in Canada balsam using the method outlined by Zhang et al. (2006). Details of the morphological structures were examined with a ZEISS Imager A1 microscope, and the photos were taken by a Photometrics CoolSNAP camera. All type specimens are deposited in the Insect Collection, South China Agricultural University (SCAU).

Taxonomy

Asprothrips atermaculosus sp. n.

<http://zoobank.org/AEA30996-615F-4E7E-A000-21E3EC4AA61F>

Figs 2–16

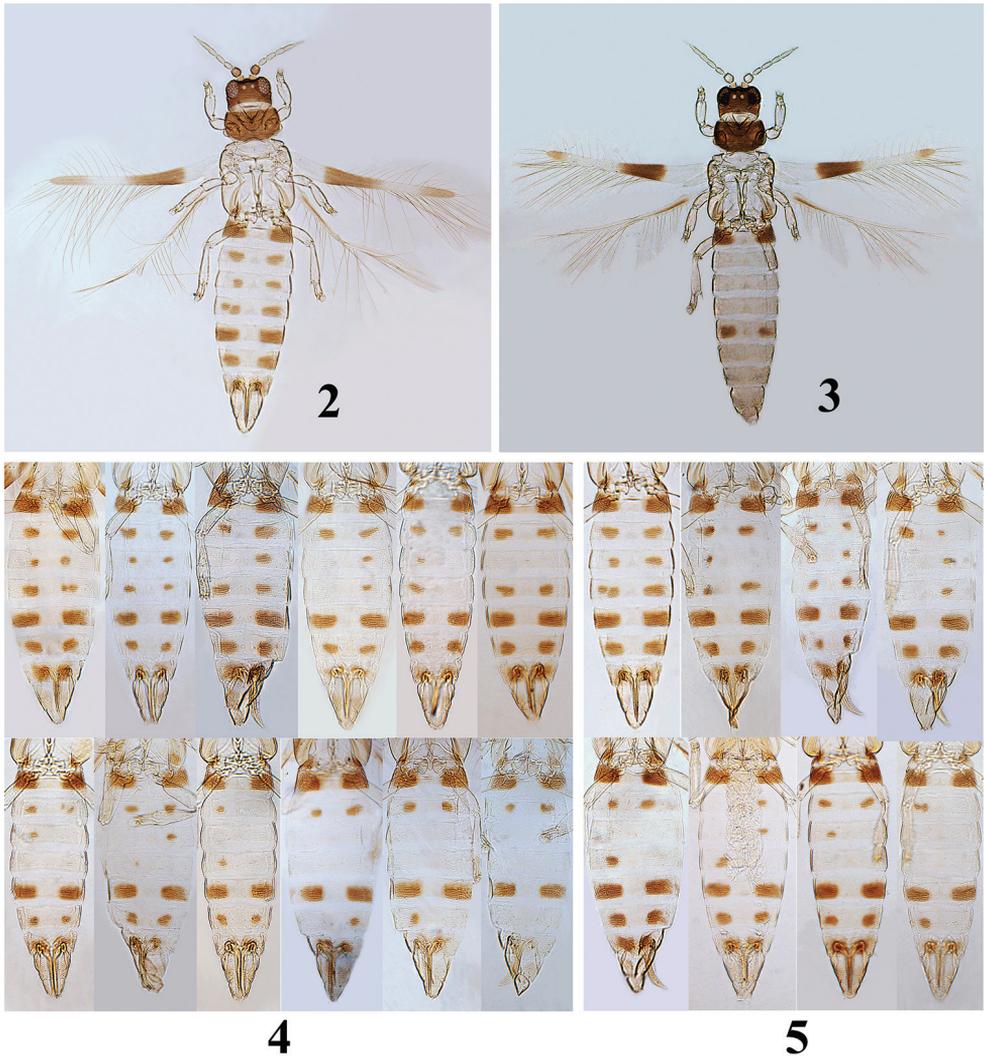
Material examined. **Holotype** female (in SCAU): **CHINA**, Hunan province, Chaling County, Yunyangshan National Forest Park (26°47'58"N, 113°30'18"E, alt. 300m), collected from leaves of *Lophatherum gracile* (Poaceae), 8.viii.2017, leg. Zhaohong Wang.

Paratypes (in SCAU): 20 females, 25 males, taken with holotype. Fujian province, Sanming City, Sanyuan National Forest Park (26°10'N, 117°28'E, alt. 200m), 21 females and 31 males from leaves of *Lophatherum gracile* (Poaceae), 24.viii.2017, leg. Zhaohong Wang. Hunan province, Hengyang City, Mt. Hengshan (26°16'22"N, 112°42'22"E, alt. 530m), 2 females, collected from *L. gracile* (Poaceae), 6.viii.2017, leg. Zhaohong Wang.

Diagnosis. Female body bicoloured, head, pronotum and antennal segments I–II brown; abdomen white except for the intra-population variation in the number and size of brown markings on the abdominal tergites I–VIII; fore wing white with two dark brown bands and the surface uniformly covered with microtrichia. Male body is similar to female in structure and colour pattern, but antennae white or yellowish white and the paired brown markings exist only in abdominal tergites I–II and VI; abdominal sternites III–VIII each with a small and oval pore plates.

Description. Female (macropterous) (Fig. 2). Body bicoloured, dark brown and white; head and pronotum dark brown; antennal segment I pale brown, II dark brown, III–VIII white (Fig. 7); pterothorax and all legs white; fore wing white with two dark brown bands submedially and apically (Fig. 9); abdomen white except for tergites I–II and VI stably with the paired dark brown markings laterally, but those on tergites III–V and VII–VIII are variable individually in numbers and size within the same population as showed as figures 3–4, tergite IX white with a pale brown tint and X white.

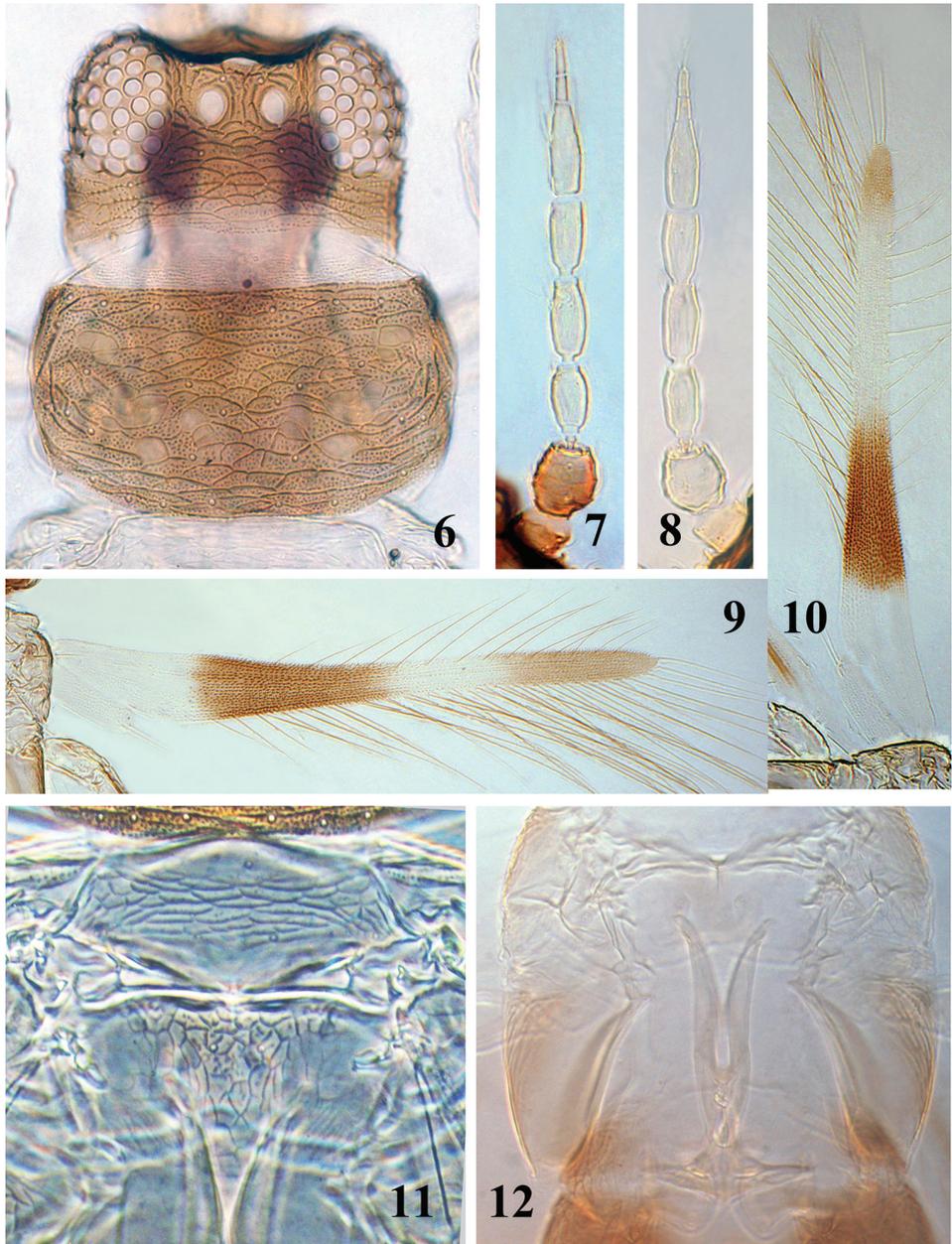
Head (Fig. 6) approximately 2.0 times as wide as long; two pairs of minute ocellar setae present, pair II situated at middle between anterior ocellus and compound eye, pair III arising near anterior margin of posterior ocelli within ocellar triangle; four pairs of minute postocular setae present, first pair below the hind ocelli, second and third one near the compound eyes and fourth pair near the cheeks; vertex between eyes including ocellar triangle irregularly reticulate, occipital region of vertex reticulate with transverse dotted lines and internal granules within the reticules; cheeks serrated. Mouth cone short and rounded; maxillary palps three-segmented. Antennae 8-seg-



Figures 2–5. *Asprothrips atermaculosus* sp. n. **2** female **3** male **4** variation of colour markings on abdominal tergites in “Sanming” population **5** variation of colour markings on abdominal tergites in “Chaling” population.

mented (Fig. 7), antennal segment II large and globular with ridges on striae, III with a pedicel, III and IV each with a forked sense cone, V with a short simple outer sense cone, VI with three sense cones, inner one longest arising medially, reaching apex of segment VIII; microtrichia rows present on segments III–VI, III–V with three rows, VI with sparse microtrichia.

Pronotum (Fig. 6) approximately 2.0 times as wide as long, irregularly reticulate with numerous internal granules within the reticules; dorsal surface covered with approximately 26–32 short discal setae and four pairs of posteromarginal setae; ferna



Figures 6–12. *Asprothrips atermaculosus* sp. n. **6** head & pronotum **7** antenna of female **8** antenna of male **9** fore wing of female **10** fore wing of male **11** meso- and metanotum **12** lyre-shaped metathoracic endofurca, female

complete and narrower at middle. Mesonotum (Fig. 11) with transverse anastomosing striae without internal wrinkles or granules within the reticules, a pair of campaniform sensilla on anterior fourth, median setal pair situated submedially. Metanotum

(Fig. 11) reticulate medially without granules within the reticules, median setae far back from anterior margin, campaniform sensilla present or absent. Metafurca bearing two lyre-shaped anterior arms extending into the mesothorax (Fig. 12). Fore wing uniformly covered with microtrichia (Fig. 9); fore wing apex with two long terminal setae, costa with 14–15 setae, first vein with 5–6 proximal and two distal setae, second vein with 4–5 setae; main posterior fringe hairs weakly wavy. Legs reticulate weakly; fore and mid tarsi 2-segmented, hind tarsus one-segmented; Hind tibiae with two apical stout setae.

Abdominal tergites I–VII smooth medially between setal pair S2, with transverse sculpture lines bearing microtrichia laterally; S1 setae (median pair) on abdominal tergites II to VII small, the distance between their basal pores much greater than their length; paired campaniform sensilla between setae S1 and S2, much closer to S2 on tergites II–VII (Fig. 13); VIII–IX entirely covered with transverse sculpture bearing microtrichia except for groove medially; VIII with posterior marginal comb of small microtrichia only at middle; posterior margin of IX medially with a pair of fine and pointed setae directed medially (Fig. 14); tergite X without longitudinal dorsal split. Abdominal sternites II–VII weakly reticulate; II with one pair of setae and III–VII each with three pairs on posterior margin.

Measurements (holotype female in microns). Total distended body length 960. Head length (width) 63 (122); eye length (width) 47 (32). Pronotum length (width) 79 (147). Length of antenna 182; length (width) of antennal segments I 15 (20), II 22 (24), III 30 (14), IV 30 (13), V 26 (13), VI 36 (12), VII 10 (4) and VIII 13 (3). Fore wing length 1250.

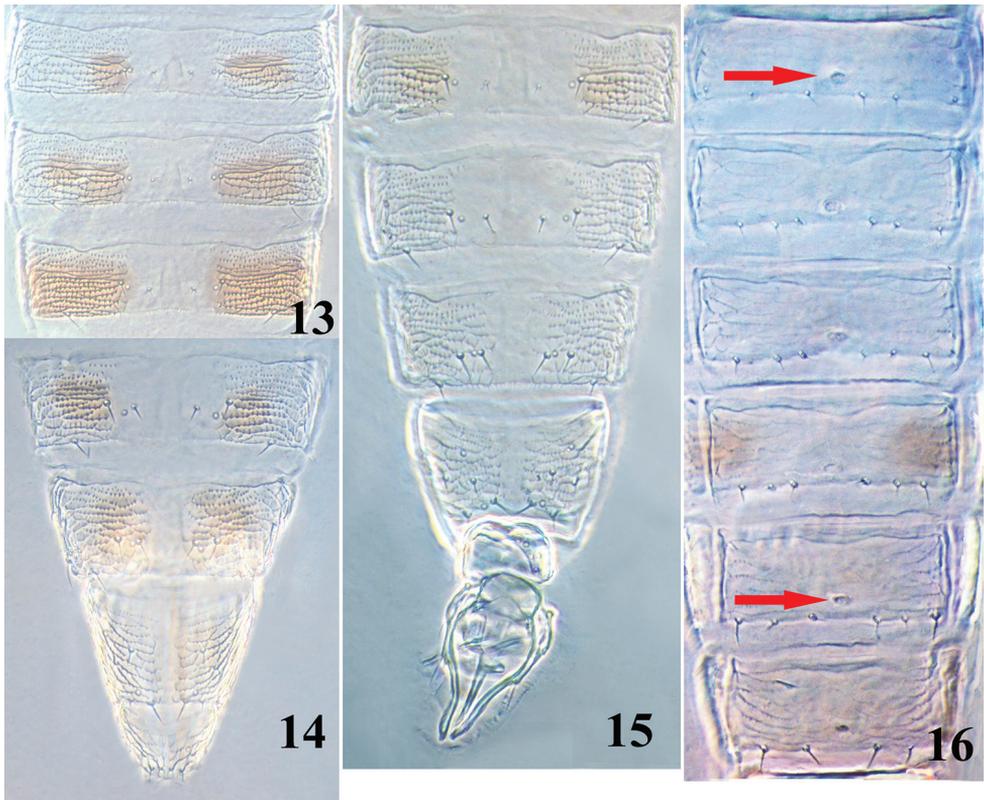
Male (macropterous) (Fig. 3). Similar to female in structure and colour except for following characters: antennal segments I–II yellowish white (Fig. 8); fore wing with two brown bands submedially and apically, but the apical one much shorter than that of the female (Fig. 10); the paired brown markings exist only in abdominal tergites I–II and VI and without any markings on other tergites (Figs 3, 15); abdominal sternites III–VIII each with a small and oval pore plates (Fig. 16).

Measurements (paratype male in microns). Total distended body length 840. Head length (width) 60 (110); eye length (width) 50 (32). Pronotum length (width) 76 (130). Length of antenna 173; length (width) of antennal segments I 15 (19), II 22 (22), III 30 (12), IV 30 (11), V 26 (12), VI 31 (11), VII 9 (4) and VIII 10 (3). Fore wing length 1090.

Etymology. The species name is an arbitrary combination of two Latin adjective, “*ater*” meaning black, and “*maculosus*” meaning spotted or markings, in reference to the abdominal tergites with many dark brown markings.

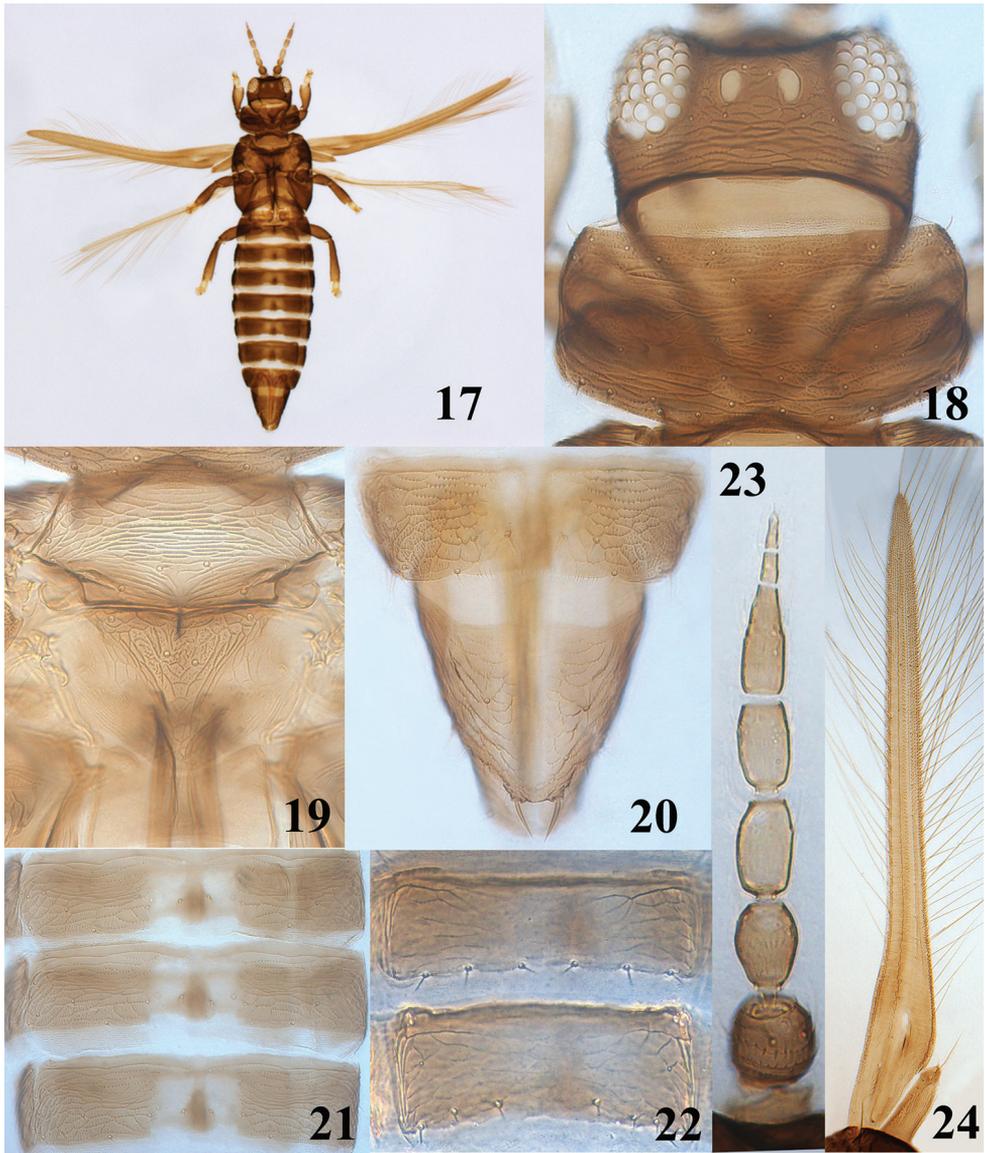
Distribution. China (Hunan, Fujian).

Remarks. This species can be distinguished from other members of the genus *Asprothrips* by the variable number and size of brown markings on the abdominal tergites (Figs 2–5). These dark brown markings are obviously not subintegumental pigment because they are present on specimens before and after treatment with NaOH. Intraspecific variation in colour and structure within and between populations is com-



Figures 13–16. *Asprothrips atermaculosus* sp. n. **13** abdominal tergites IV–VI, female **14** abdominal tergites VII–X, female **15** abdominal tergites VI–X, male **16** abdominal sternites III–VIII, male

mon in Thysanoptera (Mound 2005b). Historically, it was not unusual for thrips taxonomists to describe one species under many different names because of failure to recognise such phenotypic plasticity (Mound 2005a). For example, *Ecacanthothrips tibialis* (Ashmead) had been given 18 different names (Palmer and Mound 1978). Similarly, *Frankliniella occidentalis* (Pergande), the Western flower thrips, has been reported to exist in three colour morphs, with light, dark, and bicoloured forms from different populations or seasons, resulting in at least 16 described species being placed as synonyms of *F. occidentalis* (Mound and Marullo 1996). Environmental conditions are probably of importance in determining such colour differences (Mound 2005a, b). However, *A. atermaculosus* is unusual because the brown markings on III–V and VII–VIII of females vary in number and size within the same population. In this study, we collected mainly at Chaling (Hunan province) and Sanming (Fujian province) respectively, these two localities are approximately 400 km apart. In “Chaling” population, there are eight colour patterns of brown markings on tergites III–V in female (Fig. 5), whereas in the “Sanming” population there are 12 kinds of brown markings (Fig. 4). Despite this, the colour morph with paired markings on tergites I–VIII is dominant and found in both populations. Furthermore, the paired brown markings are stable in



Figures 17–24. *Asprothrips fuscipennis* Kudô, 1984, female. **17** female adult **18** head & pronotum **19** meso- and metanotum **20** abdominal tergites VIII–X **21** abdominal tergites IV–VI **22** abdominal sternites VI–VII **23** antenna **24** fore wing.

their presence on tergites I–II and VI in the sexes. Therefore, much is yet to be learnt about the biological significance of the variation in colour markings of this new species. Such variation also occurs in the female of *A. bimaculatus* Michel & Ryckewaert, which has a pair of dark brown markings on abdominal tergite VI (Michel and Ryckewaert 2014a, b), but in Chinese specimens, these markings are faded and only faintly visible (Tong et al. 2016).

***Asprothrips fuscipennis* Kudô**

Figs 17–24

Asprothrips fuscipennis Kudô, 1984: 487

Material examined. CHINA, Jiangxi province, Jiujiang City, Mt. Lushan (29°33'41"N, 115°58'19"E), 12 females collected from leaves of *Ilex crenata* (Aquifoliaceae), 9.xi.2015, leg. Xiaoli Tong.

Diagnosis. Female full winged and body brown except for all tarsi yellow (Fig. 17). Antennae 8-segmented (Fig. 23); segment II with a subbasal dorsal seta, segments III and IV paler than other segments and each with a forked sense cone, VI longer than IV. Pronotum, meso- and metanotum reticulate and without long setae (Figs 18,19); tarsi all bi-segmented; fore wing without uniform covering of microtrichia (Fig. 24), first vein with 5–6 proximal and two distal setae, second vein with 7–9 setae; main posterior fringe hairs largely straight. Abdominal tergites I–VII smooth medially and reticulate laterally (Fig. 21); tergite VIII with posterior marginal comb of microtrichia, posterior margin of IX with a pair of long and fine setae medially (Fig. 20) and X with complete longitudinal dorsal split; abdominal sternites III–VII each with three pairs of setae at posterior margin (Fig. 22).

Distribution. Japan and China (Jiangxi).

Remarks. *Asprothrips fuscipennis* Kudô is newly recorded from China in this study. Although Zhang and Tong (1988) reported this species from China, the specimens on which that record was based were subsequently described by Tong et al. (2016) as a new species, *A. bucerus*. These two species are very similar in colouration and structure, but *fuscipennis* can be distinguished from *bucerus* by (1) antennal segment II with a sub-basal dorsal seta (this seta absent in *bucerus*); (2) antennal segment IV shorter than VI (segment IV longer than VI in *bucerus*); (3) posterior margin of tergite IX with a pair of long and fine setae medially (IX with a pair of short horn-like setae directed medially in *bucerus*), and (4) abdominal tergite X with complete longitudinal dorsal split (longitudinal dorsal split incomplete, divided only in distal half in *bucerus*).

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References

- Kudô I (1984) The Japanese Dendrothripini with descriptions of four new species (Thysanoptera, Thripidae). *Kontyû* 52(4): 487–505. <http://www.cabdirect.org/abstracts/19850524115.html>
- Michel B, Ryckewaert P (2014a) *Asprothrips bimaculatus* sp. n. (Thripidae, Dendrothripinae) from Martinique. *Zootaxa* 3793(4): 496–498. <http://dx.doi.org/10.11646/zootaxa.3793.4.7>
- Michel B, Ryckewaert P (2014b) *Asprothrips bimaculatus* sp. n. (Thripidae, Dendrothripinae). *Zootaxa* 3821(4): 500–500. <http://dx.doi.org/10.11646/zootaxa.3821.4.9>
- Mound LA (1999) Saltatorial leaf-feeding Thysanoptera (Thripidae, Dendrothripinae) in Australia and New Caledonia, with newly recorded pests of ferns, figs and mulberries. *Australian Journal of Entomology* 38(4): 257–273. <https://doi.org/10.1046/j.1440-6055.1999.00112.x>
- Mound LA (2005a) Fighting, Flight and Fecundity: Behavioural Determinants of Thysanoptera Structural Diversity, In: Ananthakrishnan TN, Whitman D (Eds) *Insects Phenotypic Plasticity*, Science Publishers, Inc., Enfield, NH, USA, 81–106.
- Mound LA (2005b) Thysanoptera: Diversity and Interactions. *Annual Review of Entomology* 50: 247–69. <http://dx.doi.org/10.1146/annurev.ento.49.061802.123318>
- Mound LA, Marullo R (1996) The Thrips of Central and South America: An Introduction. *Memoirs on Entomology, International* 6: 1–488.
- Palmer JM, Mound LA (1978) Nine genera of fungus-feeding Phlaeothripidae (Thysanoptera) from the Oriental Region. *Bulletin of the British Museum (Natural History)*. Ent. 37: 153–215.
- ThripsWiki (2017) ThripsWiki-providing information on the World's thrips. http://thrips.info/wiki/Main_Page [accessed 7 Sept 2017]
- Tyagi K (2011) A new species of *Asprothrips* Crawford (Thysanoptera, Thripidae) from India. *Entomological News* 122: 183–187. <http://dx.doi.org/10.3157/021.122.0212>
- Tong XL, Wang ZH, Mirab-balou M (2016) Two new species and one new record of the genus *Asprothrips* (Thysanoptera: Thripidae) from China. *Zootaxa* 4061(2): 181–188. <http://doi.org/10.11646/zootaxa.4061.2.8>
- Zhang HR, Okajima S, Mound LA (2006) Collecting and slide preparation methods for thrips. *Chinese Bulletin of Entomology* 43(5): 725–728.
- Zhang WQ, Tong XL (1988) The Chinese species of tribe Dendrothripini with descriptions of two new species (Thysanoptera, Thripidae). *Entomotaxonomia* 10(3–4): 275–282. http://en.cnki.com.cn/Article_en/CJFDTotal-KCFL1988Z2029.htm

A new species of the carpenter bee genus *Xylocopa* from the Sarawat Mountains in southwestern Saudi Arabia (Hymenoptera, Apidae)

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Abstract

A new species of the carpenter bee genus *Xylocopa* Latreille (Xylocopinae: Xylocopini) is described and figured from two localities in southern Saudi Arabia. *Xylocopa* (*Koptortosoma*) *sarawatica* Engel, **sp. n.** is a relatively small species similar to the widespread *X. pubescens* Spinola, but differs in the extent of maculation in males, setal coloration of both sexes, and male terminalia. A revised key to the species of *Xylocopa* in Saudi Arabia is provided.

Keywords

Apodea, Anthophila, Xylocopini, Arabian Peninsula, taxonomy, carpenter bees

Introduction

The genus *Xylocopa* Latreille (Xylocopinae: Xylocopini) comprises approximately 375 species of large, robust bees, superficially resembling bumble bees (Apinae: Bombini), that are distributed throughout the world (Michener 2007). Species are commonly dubbed ‘large carpenter bees’ as most species, like their relatives among the small carpenter bees (genus *Ceratina* Latreille), typically nest in dead wood, stems, or similar cavities (Michener 2007). During recent collecting in southern Saudi Arabia we have encountered small individuals of *Xylocopa* superficially resembling the larger and more widespread *Xylocopa* (*Koptortosoma*) *pubescens* Spinola (treated in an earlier work as *X. aestuans* (Linnaeus) (Hannan et al. 2012), a species with which it has been comingled: e.g., Lieftinck 1964). Herein we provide a formal description of this species in the hopes that it might be sought from additional localities and its nests discovered. *Xylocopa pubescens* and *X. (Ctenoxylocopa) sulcatipes* Maa nest frequently in *Calotropis procera* (Aiton) (Asclepiadaceae) or *Phoenix datylifera* L. (Arecaeae) elsewhere in Saudi Arabia (Hannan et al. 2012), and the former was found nesting in *C. procera* at sites near the type locality for the species described herein (Engel pers. obs.). It is hoped that continued hunting for the new species in the Al-Baha or ‘Asir Regions might eventually recover nests and immature stages of this smaller Arabian *Xylocopa*.

Materials and methods

Material is deposited in the King Saud University Museum of Arthropods, Plant Protection Department, College of Food and Agriculture Sciences, King Saud University, Riyadh, Kingdom of Saudi Arabia (**KSMA**), and the Division of Entomology (Snow Entomological Collections), University of Kansas Natural History Museum, Lawrence, Kansas, USA (**SEMC**). Morphological terminology in the description and key is based on that of Engel (2001) and Michener (2007). Photomicrographs were prepared with a Canon 7D digital camera attached to an Infinity K-2 long-distance microscope lens and illuminated by a Xenon flash system. Measurements were taken with an ocular micrometer on an Olympus SZX12 stereomicroscope. The formats for the diagnosis and description follows those used elsewhere in the systematics of African-Asiatic *Xylocopa* (e.g., Eardley 1983; Hannan et al. 2012), and these data are presented to enhance our current circumscriptions of species of *Koptortosoma* (e.g., Engel 2011, Gonzalez et al. 2013), provide basic information from which broader synthetic patterns may eventually be established (Grimaldi and Engel 2007), and build a richer understanding of the Saudi bee fauna, particularly of the Al-Baha Region (El-Hawagry et al. 2013).

Systematics

Genus *Xylocopa* Latreille

Subgenus *Koptortosoma* Gribodo

Xylocopa (*Koptortosoma*) *sarawatica* Engel, sp. n.

<http://zoobank.org/E5684338-7F59-4100-952B-641B9E1A37E7>

Figs 1–10

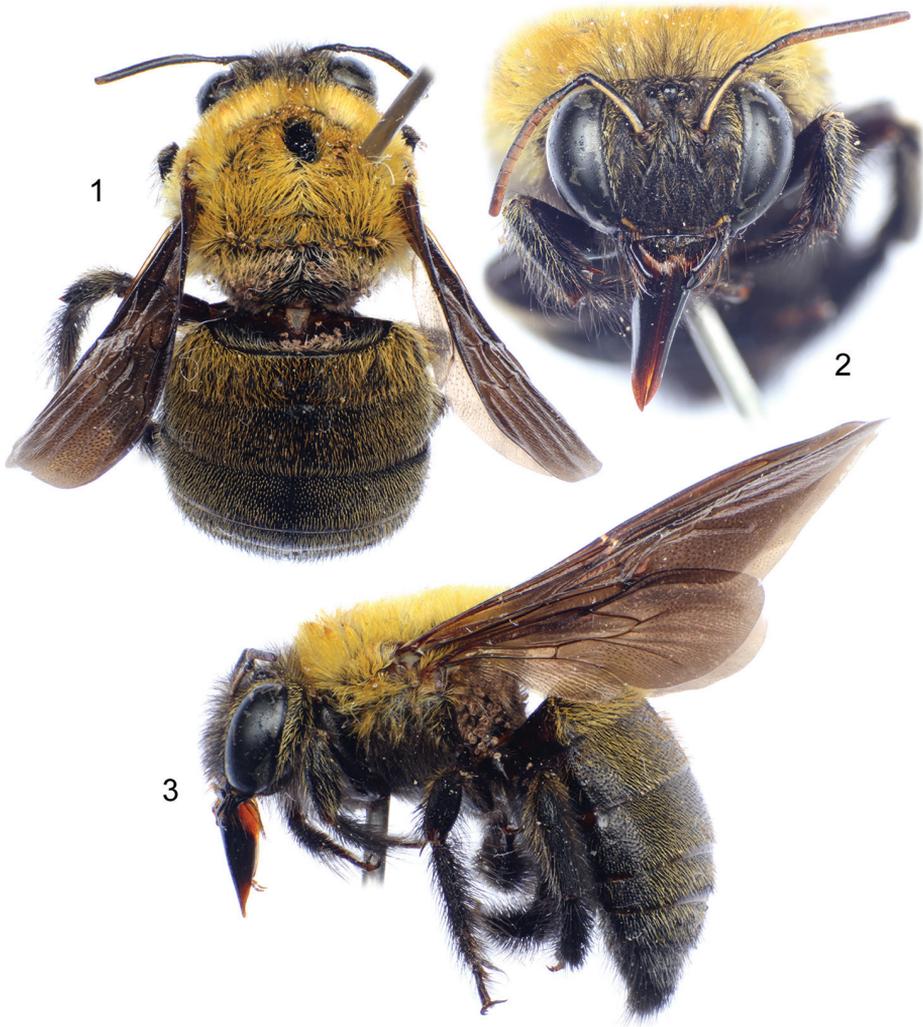
Diagnosis. The new species most closely resembles the more widespread *X. pubescens*, albeit at about three-quarters of the body size or less (*vide* Key, *infra*). Aside from size, *X. sarawatica* can be most easily distinguished in females by the entirely black or dark fuscous facial setae (versus white to off-white setae intermixed with black setae in *X. pubescens*) and the presence of yellow setae on the metanotum (entirely black to dark fuscous in *X. pubescens*). Males can be recognized by the presence of yellow maculation along the apical margin of the clypeus and on the procoxal spine (absent in *X. pubescens*), the entirely black or dark fuscous setae of the basitarsi (some white to yellow setae present in *X. pubescens*), and in the form of the male terminalia (*cf.* Figs 4–7 with those from Hannan et al. 2012: their figures 7–11, listed as *X. aestuans* but actually *X. pubescens*). In particular, the paramedial lobes of the eighth metasomal sternum are more widely spaced and broader, much broader than the spiculum (Fig. 4) (together scarcely broader than spiculum in *X. pubescens*: fig. 11 in Hannan et al. 2012), the genital capsule is broader anteriorly (Figs 6, 7) (anteriorly narrowed in *X. pubescens*: figs 7, 9 in Hannan et al. 2012), the medial dorsal margins of the gonocoxae meet along approximately the basal one-half of length before diverging to the broad mediodorsal lobes (Fig. 7) (margins meet along approximately basal one-quarter to one-third of length in *X. pubescens*: fig. 7 in Hannan et al. 2012); the gonostylar apex is much broader (Figs 6, 7) (more slender in *X. pubescens*: figs 7, 9 in Hannan et al. 2012); and the penis valves are widened apically at point of arching ventrally before tapering to acute apex (Fig. 6) (penis valves uniformly slender along apical portion of length at same point in *X. pubescens*: fig. 9 in Hannan et al. 2012).

Description. ♂: Total body length 14.9 mm; forewing length (excluding tegula) 11.7 mm. Head broader than long; head length (vertex to clypeal apical margin in facial view) 2.7 mm, maximum width 4.2 mm. Compound eyes slightly more convergent below than above, with inner orbit weakly concave; inner orbital margin well separated from antennal torulus; upper interorbital distance 2.2 mm, lower interorbital distance 1.9 mm, maximum interorbital distance 2.4 mm; compound eye length 2.5 mm. Ocelli situated high on face, posterior tangent of ocelli at about upper orbital tangent; ocellocular distance approximately twice diameter of median ocellus; interocellar distance approximately 2.5 times diameter of median ocellus; ocelloccipital distance approximately 1.5 times diameter of median ocellus. Scape long, length 1.3 mm, exceeding upper compound eye tangent; first flagellomere elongate, longer than combined lengths of second and third flagellomeres; antennal toruli separated

from clypeus by slightly less than torular diameter. Clypeus flat, without median ridge or line, longer than frons, with dorsolateral margins raised above bordering paraocular areas; paraocular areas without sulci, carinae, or depressions. Labrum transverse, with apical margin medially concave, surface with rounded, transverse ridge at midlength and short mediolongitudinal ridge from base to transverse ridge. Mandible bidentate, without internal tooth; malar area linear. Intertegular distance 4.2 mm; apical margin of mesoscutellum sharply angled, sharp angle separating dorsal surface from obliquely ventral subvertical surface, in profile projecting over metanotum and strongly declivitous propodeum as a short, thin flange; metanotum subhorizontal; propodeum entirely declivitous, triangular area of propodeum absent. Forewing with basal vein confluent with 1cu-a; three submarginal cells; 1Rs+M with minute veinal stub extending into first submarginal cell at about midlength; 2Rs elongate, apically arched, giving second submarginal cell an elongate posterobasal extension; 1rs-m comparatively straight, slightly distad 1m-cu; 2rs-m broadly arched, greatly distad 2m-cu; 2m-cu entering third submarginal cell at approximately apical third of cell length. Procoxal spine short; apex of metabasitibial plate acute, situated slightly before metatibial midlength, its anterior margin short and posterior border extending as a carina for some distance basally. Metasoma with dorsal-facing and anterior-facing surfaces of tergum I abruptly and with an angular separation; vertical fold of tergum I with foveate depression; apical margin of sternum I entire and medially pointed (not emarginate or concave); sternum V with broad, medial lobe along apical margin; male hidden sterna and genital capsule as in Figures 4–7.

Integument black or dark brown throughout without metallic highlights, except yellow on following surfaces: small spot at extreme base of mandible, four narrow streaks along apical margin of clypeus, underside of scape along its length, and procoxal spine. Ventral surface of flagellum, excluding first flagellomere, lighter reddish brown; mouthparts dark brown to black; apical tarsomeres and pretarsal claws reddish brown. Wing membranes infusate and apically papillate, with exceedingly faint violaceous highlights anteriorly; veins dark brown.

Clypeus with coarse, small punctures separated by less than a puncture width, slightly more widely spaced in small area centrally, integument between dull and microscopically imbricate, without impunctate medial line or ridge; punctures of face as on clypeus except largely contiguous, impunctate around frontal line and ocelli; ocellocular area with punctures separated by less than a puncture width, integument between dull and imbricate; punctures posterior to ocelli similar to those of ocellocular area; vertex with punctures separated by less than a puncture width; punctures of gena largely separated by less than a puncture except in some areas separated by up to a puncture width, integument between punctures imbricate. Mesoscutum and mesoscutellum with small, nearly contiguous punctures at base of setae, impunctate on central disc of mesoscutum, surface polished, integument between setigerous punctures apparently faintly imbricate; tegula largely impunctate and shining; punctures of pleura small and coarse, separated by a puncture width or less, becoming slightly more widely spaced ventrally; metanotum imbricate and largely impunctate except faint punctures



Figures 1–3. Male of *Xylocopa* (*Koptortosoma*) *sarawatica* Engel, sp. n., from southern Saudi Arabia. **1** Dorsal habitus **2** Facial view **3** Lateral habitus.

at bases of setae; propodeum with setigerous punctures separated by a puncture width or slightly more, integument between punctures imbricate. Metasomal tergum I with small punctures separated by a puncture width or more, integument between punctures dull and imbricate, punctures becoming progressively more densely packed laterally; punctures centrally on terga II–III similar to those on tergum I except slightly more closely spaced, particularly so apically on tergum III; punctures centrally on terga IV–V less well defined and denser than those on discs of preceding terga; punctures centrally on tergum VI similar to preceding terga except even more poorly defined and shallow; sterna with setigerous punctures widely spaced in basal halves, becoming more closely spaced apically and laterally on each sternum.

Pubescence generally yellow on face and upper surfaces, intermingled with dark fuscous to black setae and some areas of white as noted; dark fuscous to black setae dominant on lower surfaces. Face with darker, branched setae erect to suberect dominant on clypeus, lower paraocular areas, and lower face, intermingled with long, branched, erect to suberect yellow setae, such yellow setae becoming more numerous in upper half of face, with short, branched, appressed to subappressed setae present along upper ocular borders, ocellocular area, vertex, and gena; vertex with erect, simple, black setae intermingled among other setal types; gena with long, yellow setae similar to those on face dominating, blending to longer, dark fuscous to black setae ventrally and on postgena. Setae on mesosomal dorsum, including tegula, long, branched, yellow, and densely covering integument except centrally on disc of mesoscutum and on undersurface of projecting mesoscutellum; setae on upper portion of pleura and upper border of propodeal lateral surface yellow, blending ventrally to fuscous setae, all such setae erect, long, and branched; setae on posterior surface of propodeum largely, erect, long, branched, and white, more sparsely distributed than on pleura. Legs with predominantly black setae except intermixed with yellow setae on outer anterior surfaces of tibiae, particularly basally; posterior setae of pro- and mesotibiae and pro- and mesobasitarsi extremely elongate, those of basitarsi nearly as long as basitarsi; metabasitarsus with greatly elongate setae albeit distributed more regularly on anterior and posterior surfaces. Metasomal terga I and II with predominantly moderately long, suberect to erect, yellow setae with few or no branches, such setae becoming white at extreme lateral margins except on tergum II where such white and yellow setae are intermixed with some long, suberect, black setae, particularly posterolaterally; long yellow setae of tergum II gradually sparser toward apex and replaced by shorter, subappressed, stouter, simple, yellow setae; terga III–V with such short, appressed to subappressed, stout, simple, yellow setae predominant except laterally with long, black or white, simple, setae; tergum VI with short, subappressed, yellow setae dominant over basal half then gradually replaced by longer, suberect, white or black, setae in apical half, black setae particularly elongate apicolaterally; sterna with largely suberect, simple, white setae; sternum IV with white setae replaced apically by subappressed to suberect, simple, black setae; sternum V with black, subappressed to suberect, simple setae although a few with minute branches, such setae of moderate length over disc and greatly elongate and more erect apicolaterally.

♀: Total body length 14.8–17.0 mm; forewing length (excluding tegula) 11.7–12.6 mm. Head broader than long; head length (vertex to clypeal apical margin in facial view) 3.3–3.7 mm, maximum width 4.6–5.2 mm. Compound eyes slightly more convergent below than above, with inner orbit weakly concave; inner orbital margin well separated from antennal torulus; upper interorbital distance 2.6–2.9 mm, lower interorbital distance 2.2–2.5 mm, maximum interorbital distance 2.8–3.2 mm; compound eye length 2.9–3.3 mm. Ocelli situated high on face, posterior tangent of ocelli at about upper orbital tangent; ocellocular distance approximately 2.5 times diameter of median ocellus; interocellar distance approximately 2.5 times diameter of median ocellus; ocellocapital distance approximately twice diameter of median ocellus. Scape long, length 1.5–1.7 mm, exceeding upper compound eye tangent; first flagellomere elongate, longer



Figures 4–7. Male terminalia of *Xylocopa (Koptortosoma) sarawatica* Engel, sp. n. **4** Metasomal sternite VII+VIII **5** Genital capsule in profile **6** Genital capsule in ventral view **7** Genital capsule in dorsal view.

than combined lengths of second and third flagellomeres; antennal toruli separated from clypeus by slightly less than torular diameter. Clypeus flat, without median ridge or line, longer than frons, with dorsolateral margins raised above bordering paraocular areas; paraocular areas without sulci, carinae, or depressions. Labrum transverse, with four blunt tubercles medially. Maxillary palpus pentamerous (as in *X. pubescens*, and contrary to many *Koptortosoma s.str.*). Mandible bidentate, without internal tooth; malar area linear. Intertegular distance 4.5–4.9 mm; apical margin of mesoscutellum sharply angled, sharp angle separating dorsal surface from obliquely ventral subvertical surface, in profile projecting over metanotum and strongly declivitous propodeum as a short, thin flange; metanotum subhorizontal; propodeum entirely declivitous, triangular area of propodeum absent. Apex of metabasitibial plate acute, situated slightly beyond metatibial midlength, its anterior margin short and posterior border extending as a carina for some distance basally. Metasoma with dorsal-facing and anterior-facing surfaces of tergum I abruptly and angulately separated; vertical fold of tergum I with foveate depression; terga II–VI lacking graduli; pygidial spine narrow, parallel-sided, unarmed; apical margin of sternum I entire and medially pointed (not emarginate or concave); sternal margins unmodified, straight.

Integument black or dark brown throughout, without yellow maculation or metallic highlights. Wing membranes infuscate, with exceedingly faint violaceous highlights anteriorly; veins dark brown.

Clypeus with coarse, small punctures separated by much less than a puncture width, slightly more widely spaced in small area centrally, integument between dull and microscopically imbricate, without impunctate medial line or ridge; punctures of face as on clypeus except largely contiguous, impunctate around frontal line and ocelli; ocellocular area with punctures separated by a puncture width or frequently less, integument between dull and imbricate; punctures posterior to ocelli similar to those of ocellocular area; vertex with punctures separated by less than a puncture width; punctures of gena largely separated by less than a puncture width except in some small places separated by up to a puncture width, integument between punctures imbricate. Mesoscutum and mesoscutellum with small punctures at base of setae, impunctate on central disc of mesoscutum, surface polished, integument between setigerous punctures apparently faintly imbricate; tegula largely impunctate and shining, with some punctures anteriorly; punctures of pleura small and coarse, separated by a puncture width or less, becoming slightly more widely spaced ventrally; metanotum imbricate and largely impunctate except faint punctures at bases of setae; propodeum with setigerous punctures separated by a puncture width or slightly more, integument between punctures imbricate. Metasomal tergum I with small punctures separated by a puncture width or more, integument between punctures dull and imbricate, punctures becoming progressively more densely packed laterally until nearly contiguous; punctures centrally on terga III–V more widely spaced than those of preceding terga; tergum VI with punctures of disc less well defined and denser than those on discs of preceding terga; sterna with setigerous punctures largely separated by more than a puncture width except becoming dense and somewhat smaller laterally and apically, narrow impunctate area medially on sternum II and less so on sternum III.

Pubescence generally dark fuscous to black throughout except bright yellow on mesoscutum, tegula, mesoscutellum, metanotum, and uppermost borders of pleura and propodeum. Setae of face, vertex, gena, and postgena moderately long to long, suberect to erect, and with a few branches to simple, those with branches typically somewhat shorter, setae never obscuring integument; setae on mesosomal dorsum long and with minute branches, densely covering integument except centrally on disc of mesoscutum and on undersurface of projecting mesoscutellum, and exceptionally sparse on metanotum; pleura and propodeal lateral surface with long, erect setae with many branches, such setae somewhat obscuring integument; posterior surface of propodeum with short, largely simple setae, more sparsely distributed. Legs with abundant, long setae. Metasomal terga with short setae scattered over integument, those of dorsal-facing surface of tergum I largely erect and longer than those of discs of remaining terga; remaining terga with setae largely appressed to suberect, largely simple, not obscuring integument, setae more numerous and longer to sides and on apicalmost terga; sterna with long, suberect, simple setae.

Holotype. ♂, Saudi Arabia, Baha [Al-Baha Region], Thee Ain [Thy 'Ain] Village, 690 m, 19°55'59.61"N, 41°26'41.41"E, 25-v-2012 [25 May 2012], M.A. Hannan (SEMC).



Figures 8–10. Female of *Xylocopa* (*Koptortosoma*) *sarawatica* Engel, sp. n. **8** Dorsal habitus **9** Facial view **10** Lateral habitus.

Paratypes. 1♀, Saudi Arabia, Asir [‘Asir Region], Abha, Sodah, nr. dam, 2500 m, 18°14'11.64"N, 42°24'49.96"E, 22-v-2012 [22 May 2012], M.S. Engel (SEMC); 1♀, Saudi Arabia, Al Baha [Al-Baha Region], Thy Ein [Thy ‘Ain] village, 690 m, 19°55'59.61"N, 41°26'41.41"E, 25-v-2012 [25 May 2012], M.S. Engel (SEMC); 4♀♀, Saudi Arabia, Baha [Al-Baha Region], Thee Ain [Thy ‘Ain] Village, 690 m, 19°55'59.61"N, 41°26'41.41"E, 25-v-2012 [25 May 2012], M.A. Hannan (3♀♀ SEMC, 1♀ K SMA); 1♂, 1♀, Saudi Arabia, Al Baha [Al-Baha Region], The Ain [Thy ‘Ain], 5.5.2015 [5 May 2015], M. Shebl (K SMA); 1♀, Saudi Arabia, [Al-Baha Region],

Thee Ain [Thy 'Ain], 20 km S. of Baha, 13.X.2010 [13 October 2010], N 19°55'54", E 41°26'29", Al Dafer, H., Kondratieff, B., Fadl, H. & El Gharbawy, A. (KSMA).

Remarks. As is the case with many *Xylocopa*, the male holotype has a profusion of immature mites present on the propodeum.

Etymology. The specific epithet is based on the Sarawat Mountain range from which the species was collected, either at elevation or along the escarpment over the Tihāmah.

Key to species of *Xylocopa* in Saudi Arabia (updated from Hannan et al. 2012)

- 1 Males..... 2
- Females..... 4
- 2 Body with abundant, dense, yellow pubescence throughout, particularly dorsally; first metasomal tergum with subhorizontal dorsal surface abruptly and angulately separated from declivitous anterior-facing surface; first metasomal tergum with gradulus transverse, lateral extremities not directed posteriorly 3
- Body covered by largely fuscous to black pubescence except face, dorsum of mesosoma, and apicolateral patches of first metasomal tergum with predominantly white or pale setae; first metasomal tergum with subhorizontal dorsal surface rounding into declivitous anterior surface; first metasomal tergum with gradulus laterally curved posteriorly..... *X. sulcatipes* Maa
- 3 Clypeus without maculation, entirely black; procoxal spine black; basitarsi with white or yellow setae on outer anterior surfaces; large bees, body length over 18.5 mm, forewing length over 15 mm..... *X. pubescens* Spinola
- Clypeus with some small yellow maculation along apical margin; procoxal spine yellow; basitarsi with setae entirely black to dark fuscous; smaller bees, body length under 15.5 mm, forewing length under 12.5 mm *X. sarawatica* Engel, sp. n.
- 4 Mesosomal dorsum densely covered by yellow pubescence, such setae obscuring integument; face with largely white or pale pubescence; pygidial plate unarmed; posterodorsal margin of mesoscutellum projecting beyond posterior margin of metanotum; mandible bidentate at apex..... 5
- Mesosomal dorsum largely covered by black pubescence, such setae not obscuring integument; face with largely black pubescence; pygidial plate armed on each side with subapical spine; mesoscutellum not projecting over metanotum, apical margin rounded in profile; mandible tridentate at apex..... *X. sulcatipes* Maa
- 5 Face (including clypeus) with abundant white setae intermingled with black setae; metanotal setae entirely dark fuscous; large bees, body length over 22 mm, forewing length over 16.5 mm..... *X. pubescens* Spinola
- Face (including clypeus) with setae entirely dark fuscous to black; metanotal setae yellow; smaller bees, body length under 17.5 mm, forewing length under 13 mm..... *X. sarawatica* Engel, sp. n.

Discussion

The new species from Saudi Arabia belongs to the diverse and widespread subgenus *Koptortosoma* Gribodo, a group that was once split into several different subgenera (e.g., Hurd and Moure 1963). Over the last half of the 20th century, these other subgeneric units were gradually synonymized with *Koptortosoma*. In a study of Central Asiatic Xylocopini, Maa (1954) united *Koptortosoma* with *Maiella* Michener (followed by Hurd 1959), while following a cladistic analysis of the tribe Xylocopini, Minckley (1998) united *Cyaneoderes* Ashmead, *Afroxylocopa* Hurd & Moure, *Oxyxylocopa* Hurd & Moure, and *Cyphoxylocopa* Hurd & Moure. Lastly, Michener (2000) added *Lieftinckella* Hurd & Moure to this list of synonyms, arriving at our modern concept of the subgenus. As currently constituted, *Koptortosoma* encompasses approximately 150 species ranging from sub-Saharan Africa to Europe, across Asia into Australasia (Michener 2007). However, it is increasingly apparent that *Koptortosoma* as so defined is not monophyletic (e.g., Leys et al. 2000, 2002, Kawazoe et al. 2008). Indeed, *Koptortosoma* perhaps represents one of the greatest challenges in the systematics of the large carpenter bees, and its species should likely be relegated again into three or four subgenera, with *Koptortosoma s.str.* (including *Afroxylocopa* and *Oxyxylocopa*) applicable



Figures 11–13. Habitat at the Thy 'Ain type locality, near Al-Baha in Al-Baha Region, Saudi Arabia (photographs by M.S. Engel, May 2012). **11** The ancient village (the 'Marble Village') and surrounding vegetation **12** General vegetation at locality **13** Vegetation alongside part of small water seep.

for those African species. For the Australasian, Indomalayan, and other Asiatic groups, it may prove worthwhile to resurrect the names *Cyaneoderes*, *Maiella* (including *Cyphoxyllocopa*), and *Lieffinckella* (best united with *Alloxylocopa*). Future cladistic analyses should strive to expand sampling of African and Asiatic species of *Koptortosoma* as currently defined in order to ascertain the proper boundaries of its constituent subunits.

The locality from which most of the available specimens were captured is an often-visited historical site, ‘Thy ‘Ain’ (the so-named, ‘Marble Village’: Fig. 11), along the steep road leading from the city of Al-Baha at the top of the Sarawat escarpment down to the Tihāmah. The fauna is largely Afrotropical in composition but intermingles Palearctic and Oriental elements (El-Hawagry et al. 2013), and has a rather lush desert vegetation (Figs 12, 13). Both of Arabia’s natively occurring honey bees, *Apis* (*Apis mellifera* L. and *A. (Micrapis) florea* Fabricius, are common at the locality, along with various halictines, anthidiines, apine genera such as *Amegilla* Friese and *Thyreus* Panzer, as well as the xylocopines *Ceratina (Pithitis) tarsata* Morawitz, *Braunsapis alqarnii* Engel & Michener, and *X. (C.) sulcatipes* (Engel et al. 2014, Engel unpubl. data). Under the restricted subgeneric circumscriptions of Hurd and Moure (1963), *X. sarawatica* would fall among the typical African species of *Koptortosoma*, thereby further supporting the null hypothesis of a predominantly Afrotropical influence on the faunal composition of the region (El-Hawagry et al. 2013).

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References

- Eardley CD (1983) A taxonomic revision of the genus *Xylocopa* Latreille (Hymenoptera: Anthophoridae) in southern Africa. Entomology Memoir, Department of Agriculture, Republic of South Africa 58: 1–67.
- El-Hawagry MS, Khalil MW, Sharaf MR, Fadl HH, Aldawood AS (2013) A preliminary study on the insect fauna of Al-Baha Province, Saudi Arabia, with descriptions of two new species. ZooKeys 274: 1–88. <https://doi.org/10.3897/zookeys.274.4529>
- Engel MS (2001) A monograph of the Baltic amber bees and evolution of the Apoidea (Hymenoptera). Bulletin of the American Museum of Natural History 259: 1–192. [https://doi.org/10.1206/0003-0090\(2001\)259<0001:AMOTBA>2.0.CO;2](https://doi.org/10.1206/0003-0090(2001)259<0001:AMOTBA>2.0.CO;2)
- Engel MS (2011) Systematic melittology: where to from here? Systematic Entomology 36(1): 2–15. <https://doi.org/10.1111/j.1365-3113.2010.00544.x>

- Engel MS, Alqarni AS, Hannan MA, Hinojosa-Díaz IA, Michener CD (2014) Allodapine bees in the Arabian Peninsula (Hymenoptera: Apidae): a new species of *Braunsapis* from the Sarawat Mountains, with an overview of the Arabian fauna. *American Museum Novitates* 3801: 1–15. <https://doi.org/10.1206/3801.1>
- Gonzalez VH, Griswold T, Engel MS (2013) Obtaining a better taxonomic understanding of native bees: where do we start? *Systematic Entomology* 38(4): 645–653. <https://doi.org/10.1111/syen.12029>
- Grimaldi DA, Engel MS (2007) Why descriptive science still matters. *BioScience* 57(8): 646–647. <https://doi.org/10.1641/B570802>
- Hannan MA, Alqarni AS, Owayss AA, Engel MS (2012) The large carpenter bees of central Saudi Arabia, with notes on the biology of *Xylocopa sulcatipes* Maa (Hymenoptera, Apidae, Xylocopinae). *ZooKeys* 201: 1–14. <https://doi.org/10.3897/zookeys.201.3246>
- Hurd PD Jr (1959) Some nomenclatorial problems in the genus *Xylocopa* Latreille (Hymenoptera: Apoidea). *Pan-Pacific Entomologist* 35(3): 135–148.
- Hurd PD Jr, Moure JS (1963) A classification of the large carpenter bees (Xylocopini) (Hymenoptera: Apoidea). *University of California Publications in Entomology* 29: 1–365.
- Kawazoe K, Kawakita A, Sugiura S, Kato M (2008) Phylogenetic position of the endemic large carpenter bee of the Ogasawara Islands, *Xylocopa ogasawarensis* (Matsumura, 1912) (Hymenoptera: Apidae), inferred from four genes. *Zoological Science* 25(8): 838–842. <https://doi.org/10.2108/zsj.25.838>
- Leys R, Cooper SJB, Schwarz MP (2000) Molecular phylogeny of the large carpenter bees, genus *Xylocopa* (Hymenoptera: Apidae), based on mitochondrial DNA sequences. *Molecular Phylogenetics and Evolution* 17(3): 407–418.
- Leys R, Cooper SJB, Schwarz MP (2002) Molecular phylogeny and historical biogeography of the large carpenter bees, genus *Xylocopa* (Hymenoptera: Apidae). *Biological Journal of the Linnean Society* 77(2): 249–266.
- Lieftinck MA (1964) The identity of *Apis aestuans* Linné, 1758, and related Old World carpenter-bees (*Xylocopa* Latr.). *Tijdschrift voor Entomologie* 107(3): 137–158 [2 pls. [pls. 16–17]]
- Maa T-C (1954) The xylocopine bees (Insecta) of Afghanistan. *Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening* 116: 189–231.
- Michener CD (2000) *The Bees of the World*. Johns Hopkins University Press, Baltimore, xiv+[1]+ 913 pp. [16 pls]
- Michener CD (2007) *The Bees of the World* [2nd Edition]. Johns Hopkins University Press, Baltimore, xvi+[1]+ 953 pp. [20 pls]
- Minkley RL (1998) A cladistic analysis and classification of the subgenera and genera of the large carpenter bees, tribe Xylocopini (Hymenoptera: Apidae). *Scientific Papers, Natural History Museum, University of Kansas* 9: 1–47.

New records of helminths of *Sceloporus pyrocephalus* Cope (Squamata, Phrynosomatidae) from Guerrero and Michoacán, Mexico, with the description of a new species of *Thubunaea* Seurat, 1914 (Nematoda, Physalopteridae)

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Abstract

A total of 61 specimens of the Red-headed Spiny Lizard *Sceloporus pyrocephalus* Cope (Phrynosomatidae) collected during the breeding season (June/July 2003, 2004 and 2005) from Western Mexico were examined for helminths. The morphological characterization of the helminths found was made through light microscopy and scanning electron microscopy. Nine taxa of helminths were identified, two cestodes: *Mesocestoides* sp. and *Oochoristica* sp., and seven nematodes: *Parapharyngodon ayotzinapaensis* Garduño-Montes de Oca, Mata-López & León-Règagnon, 2016, *Parapharyngodon tikuinii* Garduño-Montes de Oca, Mata-López & León-Règagnon, 2016, *Parapharyngodon* sp., Physalopterinae gen. sp., *Skrjabinoptera scelopori* Caballero-Rodríguez, 1971, *Strongyluris similis* Caballero, 1938 and a new species of *Thubunaea* Seurat, 1914. Larvae of *Mesocestoides* sp. and Physalopterinae gen. sp. were found in the body cavity and digestive tract, respectively. Excluding the species of *Parapharyngodon* Chatterji, 1933, *S. pyrocephalus* is recorded for the first time as a host of the remaining seven taxa of helminths. Additionally, *Thubunaea*

leonregagnonae sp. n. is described and illustrated as a new nematode species, parasite of *S. pyrocephalus* from Mexico. This new species can be differentiated from the majority of its congeners by the absence of spicules, the particular pattern of caudal papillae in males and the small ratio of oesophagus length: male total body length (0.1–0.16).

Keywords

Anoplocephalidae, Helminths, Heterakidae, Mesosestoididae, Pharyngodonidae, Physalopteridae, Reptilia, *Thubunaea*, Western Mexico.

Introduction

Mexico is ranked as a country with the second highest diversity of reptiles, 864 species of which 493 are endemic to the country (Flores-Villela and García-Vázquez 2014). Lizards are the species-richest reptilian group with 417 species, and among them the Phrynosomatidae are the most diverse family (representing 15.9% of the total lizard diversity from Mexico). Despite this, our knowledge regarding the helminth fauna of this family is limited. Parasite records exist for only 15.3% of the total taxa within the Phrynosomatidae (Paredes-León et al. 2008).

Sceloporus Wiegmann (Phrynosomatidae) is a genus of New World lizards composed of 92 nominal species, of which 59 are endemic to Mexico (Uetz et al. 2016). Particularly, *Sceloporus pyrocephalus* Cope is an endemic lizard of Western Mexico associated with streams and rivers within tropical deciduous and semi-deciduous forest (Uetz et al. 2016), and distributed along the Pacific coast of the southwestern states of Jalisco, Colima, Michoacán and Guerrero as well as Central Mexico, and Southern Morelos. Despite some efforts to characterize the parasites of this species of lizard (Calisi et al. 2008), current knowledge of its helminth fauna is still far from being complete.

The purpose of the present study is to report on the helminth fauna of *S. pyrocephalus*, including the description of a new species of *Thubunaea* Seurat, 1914.

Materials and methods

A total of 61 specimens of *S. pyrocephalus* were collected during the breeding season from June/July in 2003, 2004 and 2005 (permit FAUT-0056 issued to Virginia León-Règagnon by Secretaría del Medio Ambiente y Recursos Naturales, SEMARNAT). The specimens were captured by noosing or by hand in 12 localities from Michoacán state, and three localities from Guerrero state, Mexico (Table 1). These localities include tropical-wet and hot-semi-arid climates and elevations ranging from 18–1462 m a.s.l. Lizards were euthanized with an intraperitoneal overdose of pentobarbital sodium. The mouth, peritoneal cavity, and all internal organs were examined for helminths under a stereoscopic microscope. Helminths obtained were counted, fixed, and preserved following the procedure proposed by Lamothe-Ar-

Table 1. Sampling localities in Mexico for *Sceloporus pyrocephalus* examined in this study.

Locality	GPS coordinates	Collection	Accession number
Michoacán			
Maruata	18°16'29"N, 103°20'51"W	July 2004	58252 ‡, JAC-25491, JAC-25513
Caleta de Campos	18°04'48"N, 102°45'56"W	July 2004	58245‡, 58246‡, JAC-25529
Aguila	18°35'27.96"N, 103°34'0.12"W	July 2003	17445 [†] -17447 [†]
Nuevo Corongoros	19°06'14.5"N, 102°53'52"W	July 2005	18321 [†] , 18322 [†] , 18324 [†]
Artega	18°38'48.48"N, 101°58'6.24"W	July 2005	18349 [†] , JAC-26111, JAC-26112, JAC-26114, JAC-26115
La Huacana	18°40'24.2"N, 101°59'42.5"W	July 2005	18320 [†] , 18343 [†] -18348 [†]
Los Laureles	18°58'14"N, 103°05'27"W	June 2004	58221‡, JAC-24752
San Isidro Tecuiluca	19°04'33"N, 102°53'37"W	June 2004	58232‡, 58235‡, JAC-24776, JAC-24778
Los Avillos	19°02'19"N, 102°58'28"W	June 2004	JAC-24755
Buenavista Tomatlán	19°10'35.8"N, 102°39'48.6"W	July 2005	18313 [†] -18315 [†] , 18317 [†] , 18318 [†] , 18332 [†] , 18334 [†] -18337 [†] , 18340 [†] , JAC-26102
Apatzingan	19°07'29"N, 102°24'05"W	July 2003	53473‡, 53474‡
Lombardia	19°10'35"N, 102°03'48"W	June 2004	58207‡, 58213‡, 58216‡, 58238‡, 58240‡, JAC-24718, JAC-24878
Guerrero			
Coyuquilla	17°17'48.12"N, 101°02'48.12"W	July 2004	JAC-25311
Tecpan de Galeana	17°10'37.20"N, 100°35'43.1"W	July 2005	JAC-25575, JAC-26136-JAC-26141
Coyuca de Catalán	17°59'41.2"N, 101°11'43.5"W	July 2004	JAC-25218

[†]MZFC-HE;

[‡]ARDRC-UTA; the specimens labeled as JAC are expected to be cataloged in the MZFC-HE.

gumedo (1997). Nematodes and cestodes were fixed in hot 4% and 10% formaldehyde solution, respectively, and stored in 70% ethanol. For morphological examination, nematodes were cleared in alcohol-glycerol, and mounted on temporary slides. Cestodes were stained with Mayer's paracarmine and mounted on permanent slides using Canada balsam. Preserved specimens were observed under a light microscope. Original drawings were made with an Olympus BX53 microscope equipped with a drawing tube. For scanning electron microscopy (SEM), worms were dehydrated through a graded series of ethanol and then critical point dried with carbon dioxide, coated with a gold/palladium mixture using a Q150R Modular Coating System, and examined in a Hitachi S-2460N microscope and SU1015 SEM (Hitachi). Measurements of the new species are presented in micrometres, unless otherwise indicated; the range is followed by the mean in parentheses. Quantitative descriptors of parasite populations were calculated based on Bush et al. (1997). The helminths were deposited in the Colección Nacional de Helminths (CNHE), Instituto de Biología (UNAM). Specimens of lizards were deposited in the Colección Herpetológica, Museo de Zoología, Facultad de Ciencias, UNAM (MZFC-HE) and the Collection of the Amphibian and Reptile Diversity Research Center at the University of Texas at Arlington (ARDRC-UTA).

Results

A total of nine helminth taxa was found parasitizing *S. pyrocephalus*: two cestodes and seven nematodes (Table 2). Only *Mesocestoides* sp. and Physalopterinae gen. sp. were found as larval stages in the body cavity and digestive tract, respectively. The remaining taxa were found as adults located in the intestine. In the following section, we list the helminth species from *S. pyrocephalus* found during the present study, along with previous records of each parasite taxon in different *Sceloporus* spp. from Mexico, where applicable.

Phylum Platyhelminthes Gegenbaur, 1859

Class Cestoda Rudolphi, 1808

Family Mesocestoididae Fuhrmann, 1907

Genus *Mesocestoides* Vaillant, 1863

Mesocestoides sp.

Specimens deposited. CNHE 9464, 9465.

Other hosts. *Sceloporus jarrovi* Cope in Chihuahua, Morelos and San Luis Potosí (Goldberg et al. 1996); *S. grammicus* Wiegmann in Mexico City (Goldberg et al. 2003); *S. torquatus* Wiegmann in Querétaro (Goldberg et al. 2003).

Remarks. Four species of *Mesocestoides* are distributed in Mexico in carnivorous mammals: *M. bassarisci* MacCallum, 1921 in *Bassariscus astutus* Lichtenstein (Procyonidae) and *M. lineatus* (Goeze, 1782) in *Mephitis macroura* Lichtenstein (Mephitidae), both from Guerrero; *M. variabilis* Mueller, 1928 and *M. vogae* Etges, 1991 in *Canis lupus familiaris* Linnaeus (Canidae) from Mexico City (Paredes-León et al. 2008). Unfortunately, the specimens found in *S. pyrocephalus* could not be identified to species level because they were at the tetratriridium larval stage. Molecular analyses are needed to determinate the species identity of the larvae found in reptilian hosts, which serve as intermediate hosts (Santoro et al. 2012).

Family Anoplocephalidae Cholodkovsky, 1902

Genus *Oochoristica* Lühe, 1898

Oochoristica sp.

Specimens deposited. CNHE 9469.

Remarks. Eight species of *Oochoristica* have been recorded in Mexico: *O. aca-pulcoensis* Brooks, Pérez-Ponce de León & García-Prieto, 1999; *O. leonregagnonae* Arizmendi-Espinosa, García-Prieto & Guillén-Hernández, 2005; *O. osberoffi* Meggitt, 1934 and *O. whitentoni* Stellman, 1939, all parasites of *Ctenosaura pectinata* Weigmann (Iguanidae) from Acapulco, Guerrero (Brooks et al. 1999), Mixtequilla,

Table 2. Helminth taxa collected from *Sceloporus pyrocephalus* Cope (Phrynosomatidae) at various localities in Mexico. Values presented for 3 locality are number of hosts examined (n), followed by prevalence (P%) and mean abundance (MA – range or number of specimens recovered when number of hosts parasitized was 1).

Locality	Cestoda		Nematoda					<i>Thubunaea leonregagnoniae</i> sp. n. ^{1, A}	
	<i>Mesocostoides</i> sp. ^{1, L}	<i>Oochoristica</i> sp. ^{1, A}	<i>Parapharyngodon ayotzinapaensis</i> Garduño-Montes de Oca et al., 2016 ^{8, A}	<i>Parapharyngodon tikuitii</i> Garduño-Montes de Oca et al., 2016 ^{8, A}	<i>Parapharyngodon</i> sp. ^{8, A}	Physalopterinae gen. sp. ^{1, L}	<i>Skjabinoptera scelopori</i> Caballero-Rodríguez, 1971 ^{11, A}		<i>Strongylaris similis</i> Caballero, 1938 ^{8, A}
Michoacán	n						3	n=3	
	P%						100	33.33	
Maruata	MA						13.33 (7-24)	2.33 (7)	
	n						3	3	3
Calera de Campos	P%						33.33	33.33	100
	MA						7.67 (23)	2.67 (8)	17.67 (9-23)
Aquila	n	3					3		
	P%	33.33					66.67		
Nuevo Corongoros	MA	42.33 (127)					1.33 (4)		
	n							3	
Artega	P%							100	
	MA							6 (2-11)	
La Huacana	n						7		7
	P%						28.57		57.14
Los Laureles	MA						14.29		4.28 (3-18)
	n						0.28 (2)	0.28 (2)	
San Isidro Te-cuiluca	P%						7		7
	MA						14.29		85.71
Los Avillos	n						0.14 (1)		9.57 (1-17)
	P%							4	
Los Avillos	MA							50	
	n						5		4.75 (5-14)
Los Avillos	P%						20		
	MA						0.2 (1)	0.6 (3)	
Los Avillos	n						1		
	P%						100		
Los Avillos	MA						- (1)		

Locality	Cestoda			Nematoda					<i>Thubunaea leonregognoniae</i> sp. n. ^{1, A}
	<i>Mesocostoides</i> sp. ^{†, L}	<i>Oocharistica</i> sp. ^{‡, A}	<i>Parapharyngodon ayotzinapaensis</i> Garduño-Montes de Oca et al., 2016 ^{§, A}	<i>Parapharyngodon tikuitii</i> Garduño-Montes de Oca et al., 2016 ^{§, A}	<i>Parapharyngodon</i> sp. ^{§, A}	Physalopterinae gen. sp. ^{1, L}	<i>Skjabinoptera scelopori</i> Caballero-Rodríguez, 1971 ^{‡, A}	<i>Strongylaris similis</i> Caballero, 1938 ^{§, A}	
Buenavista	n	22		22	22	22	22		
Tomatlán	P%	4.54		9.09	27.27	18.18			
July 2005	MA	0.13 (3)		0.23 (2–3)	1.14 (1–8)	11.32 (14–235)			
Apatzingan	n			2	2				
	P%			50	50				
	MA			0.5 (1)	0.5 (1)				
Lombardia	n	12		12	12	12			
	P%	8.3		16.67	16.67	8.33			
	MA	0.08 (1)		0.33 (1–3)	0.33 (4)	2.42 (29)			
Guerrero									
Coyuquilla	n			2	2				
	P%			50	50				
	MA			1.5 (3)	0.5 (1)				
Tecpan de Galeana	n			7	7				7
	P%			14.29	57.14				14.29
	MA			1.71 (12)	2.14 (3–4)				1 (7)
Coyuca de Catalán	n				1				
	P%				100				
	MA				– (4)				
Hosts parasitized/ hosts examined		2/61	1/61	11/61	20/61	5/61	6/61	7/61	14/61
Specimens recovered		130	1	42	58	278	77	52	157
Intensity range		3–27	–	2–17	1–25	29–249	14–40	7–19	7–67

Site in host: † Body cavity; ‡ Small intestine; § Large intestine; | Stomach. L = larval stage; A = adult stage.

Oaxaca (Arizmendi-Espinoza et al. 2005), Alpuyecá, Morelos (Flores-Barroeta et al. 1960), and Iguala, Guerrero (Flores-Barroeta 1955). *Oochoristica whitfieldi* Guillén-Hernández, García-Prieto & Arizmendi-Espinoza, 2007 was found parasitizing *C. oaxacana* Köhler & Hasbun (Iguanidae) (Guillén-Hernández et al. 2007); *O. parvula* Stunkard, 1938 was found in *Coleonyx elegans* Gray (Eublepharidae) from Oxlutzcab, Yucatán (Stunkard 1938); *O. phrynosomatis* Harwood, 1932 in *Phrynosoma braconieri* Dugès, and *P. taurus* Duméril & Bocourt (Phrynosomatidae) from Cacaloapan and Caltepec, both in Puebla (Goldberg and Bursey 1991). *Oochoristica scelopori* Vogé & Fox, 1950 was found infecting species of the family Phrynosomatidae: *S. jarrovi* (Goldberg et al. 1996); *S. parvus* Smith, *S. grammicus*, *S. megalepidurus* Smith, *S. variabilis* Wiegmann, *S. mucronatus* Cope, and *P. ditmarsii* Stejneger (Goldberg et al. 2003). Only one adult specimen of *Oochoristica* was found in the present study; however, it was not identified to specific level due to the absence of gravid proglottids.

Phylum Nematoda Cobb, 1932

Class Chromadorea Inglis, 1983

Family Pharyngodonidae Travassos, 1920

Genus *Parapharyngodon* Chatterji, 1933

***Parapharyngodon ayotzinapaensis* Garduño-Montes de Oca, Mata-López & León-Règagnon, 2016**

Specimens deposited. CNHE 9432–9438.

Remarks. Eleven species of *Parapharyngodon* have been recorded in Mexico (Garduño-Montes de Oca et al. 2016), eight of them endemic, representing 10% of the world diversity of this genus. The high species richness of *Parapharyngodon* is probably related to the geographical and environmental heterogeneity of this region, and was recently revealed by parasitological surveys of host species not considered in previous studies (Jiménez et al. 2008, Bursey and Goldberg 2015, Velarde-Aguilar et al. 2015, Garduño-Montes de Oca et al. 2016).

***Parapharyngodon tikuinii* Garduño-Montes de Oca, Mata-López & León-Règagnon, 2016**

Specimens deposited. CNHE 9439–9447.

Remarks. See *P. ayotzinapaensis* remarks.

***Parapharyngodon* sp.**

Specimens deposited. CNHE 9448–9454, 9470, 9471.

Remarks. Female specimens of *Parapharyngodon* sp. were recovered from hosts in the same localities as *P. ayotzinapaensis* and *P. tikuinii*. The almost identical morphology of females in both species did not allow us to discriminate between them on species level (Garduño-Montes de Oca et al. 2016).

Family Heterakidae Railliet & Henry, 1912

Genus *Strongyluris* Müller, 1894

Strongyluris similis Caballero, 1938

Specimens deposited. CNHE 9455–9459.

Other hosts. *S. torquatus* in Mexico City (Cid del Prado 1971); *S. jarrovi* in Durango, Guanajuato, Hidalgo, Morelos, San Luis Potosí, Sinaloa, Sonora, Tamaulipas and Veracruz (Goldberg et al. 1996); *S. grammicus* and *S. mucronatus* in localities not further specified (Goldberg et al. 2003); *S. formosus* Wiegmann in Oaxaca (Goldberg et al. 2003).

Remarks. Specimens recovered during the present study share certain morphological characters with *S. panamaensis* Bursey, Goldberg & Telford, 2003 and *S. similis* such as spicule length and number of caudal papillae. Our specimens were identified as *S. similis* since they possess two pairs of lateral subterminal papillae at the base of the caudal appendage (Caballero 1938), which is a diagnostic feature of this species, contrary to the three pairs of papillae observed at the base of the caudal appendage in *S. panamaensis* (Bursey et al. 2003).

Family Physalopteridae (Railliet, 1893) Leiper, 1908

Subfamily Physalopterinae Railliet, 1893

Physalopterinae gen. sp.

Specimens deposited. CNHE 9466–9468.

Other hosts. *Abbreviata terrapenis* Hill, 1941 in *S. jarrovi* from Tamaulipas (Goldberg et al. 1996). *Physaloptera retusa* Rudolphi, 1819 in *S. jarrovi* from Aguascalientes, Chihuahua, Coahuila, Durango, Guanajuato, Morelos, Nuevo León, Querétaro, San Luis Potosí, Sinaloa, Sonora and Tamaulipas (Goldberg et al. 1996); in *S. acanthinus* Bocourt from Motozintla, Chiapas (Caballero 1951); in *S. jarrovi* (Goldberg et al. 1996) and *S. parvus* (Goldberg et al. 2003) from Hidalgo; in *S. formosus* from Oaxaca (Goldberg et al. 2003); in *S. mucronatus* from Puebla (Goldberg et al. 2003); in *S. torquatus* from Zacatecas (Goldberg et al. 2003). *Skrjabinoptera phrynosoma* (Ortlepp, 1922) Schulz, 1927 in *S. jarrovi* from Guanajuato (Goldberg et al. 1996); in *S. spinosus* Wiegmann from Actopan, Hidalgo (Caballero 1937); in *S. jarrovi* from Querétaro (Goldberg et al. 1996), and finally, in *S. grammicus* and *S. variabilis* from localities not further specified (Goldberg et al. 2003).

Remarks. Representatives of the subfamily Physalopterinae use ants and beetles as intermediate hosts, which are part of the diet of *S. pyrocephalus*. By eating that sort of prey, this group of lizards becomes a potential intermediate or paratenic host of these nematodes (Petri 1950, Schell 1952, Lee 1957, Kabilov 1980).

Genus *Skrjabinoptera* Schulz, 1927

Skrjabinoptera scelopori Caballero-Rodríguez, 1971

Specimens deposited. CNHE 9460–9463.

Other hosts. *S. grammicus* in San Andrés Totoltepec and San Ángel, Mexico City (CNHE); *S. torquatus* in Mexico City (Caballero-Rodríguez 1971). *Skrjabinoptera* sp. in *S. torquatus* from San Ángel, Mexico City (Cid del Prado 1971).

Remarks. *Skrjabinoptera* is a genus of nematodes poorly represented around the world with only 10 species described as parasites, mainly of lizards, and only one species recorded from a snake (Rudolphi 1819). In Mexico, only *S. scelopori* has been recorded in three species of lizards: *S. torquatus*, *S. grammicus*, and *Phyllodactylus lanei* Smith (Gekkonidae) (Goldberg and Bursey 2000, Paredes-León et al. 2008). *Sceloporus pyrocephalus* is the fourth host species recorded for this helminth in the country.

Subfamily Thubunaeinae Sobolev, 1949

Genus *Thubunaea* Seurat, 1914

Thubunaea leonregagnonae sp. n.

<http://zoobank.org/E2747F2B-1083-45B4-876C-D83E13A9F3AA>

Figs 1A–H; 2A–F

Type host. *Sceloporus pyrocephalus* Cope (Squamata: Phrynosomatidae).

Symbiotype. MZFC-HE 18345

Type locality. Los Pocitos, La Huacana, Michoacán, Mexico (18°40'24.2"N, 101°59'42.5"W). Collected on July 7, 2005.

Site in host. Stomach.

Prevalence and intensity of infection. 23% (14 of 61 hosts examined), with a mean intensity of 11 (7–67).

Type specimens. Holotype: CNHE 9426 (1 male); allotype: CNHE 9427 (1 female); paratypes CNHE 9428, 9429, 9430 and 9431 (9 females and 7 males).

Etymology. This species is named in honour of Virginia León-Règagnon (Instituto de Biología, UNAM), who was the mentor of the authors of this paper, and for her valuable contribution to our knowledge of helminth parasites in Mexico.

General description. Medium-sized nematodes, filiform body, cuticle with fine transverse striations along entire body. Males smaller than females. Round cephal-

ic plate in both sexes (Figs 1B, 2B). Deirids symmetrical, simple with rounded tip (Fig. 2A, C), located immediately posterior to nerve ring. Mouth with two round and simple lateral lips, each with three small teeth on its internal surface; each lip bears a lateral amphid, and a pair of sub-median papillae (Figs 1B, 2B). Pharynx short, cylindrical, opening into oesophagus. Oesophagus divided into anterior muscular portion and posterior glandular portion. Excretory pore in anterior region of body, posterior to nerve ring and located at level of division of muscular and glandular oesophagus. Posterior end conical and rounded in both sexes (Figs 1F, H, 2D, F).

Description of male (based on eight specimens; the number of measurements, where different from eight, is given in parentheses): Total body length (MTBL) 4.85–8.03 mm (6.19), width at mid-body 200–300 (243). Deirids 150–185 (166; $n = 7$) from anterior end. Nerve ring and excretory pore 100–168 (125) and 125–295 (179, $n = 6$) from anterior end, respectively. Pharynx length 23–45 (33). Oesophagus total length 613–1038 (800, $n = 7$), muscular portion length 108–170 (128, $n = 7$), glandular portion length 488–913 (671, $n = 7$). Ratio oesophagus total length: MTBL 0.1–0.16 (0.13, $n = 7$). Testis elongated, distributed in zigzag from anterior intestinal portion to posterior region, near cloaca. Caudal alae well developed, bearing ventrally numerous papilliform plates. Cloaca surrounded by numerous papillae (24–28), 11–14 sessile papillae and 10–16 pedunculate papillae distributed asymmetrically in the following arrangement: ventrolateral: 4–8 pedunculate on right, 6–9 pedunculate on left side; ventral, sessile: 5–8 on right and 4–8 on left side (Figs 1F, 2E, F). Number and disposition of papillae variable with respect to cloaca, thus, precloacal, paracloacal, and postcloacal positions not established. Spicules and gubernaculum absent. Tail 50–67 (59, $n = 6$) long.

Description of female (based on ten gravid specimens; the number of measurements, where different from ten, is given in parentheses): Total body length (FTBL) 8.72–21.46 mm (14.61), width at mid-body 270–440 (349). Deirids 125–250 (173, $n = 8$) from anterior end. Nerve ring and excretory pore 100–188 (147, $n = 8$) and 193–343 (256, $n = 6$) from anterior end, respectively. Pharynx length 30–58 (41, $n = 9$). Oesophagus total length 853–1500 (1227, $n = 7$); muscular portion length 125–325 (220, $n = 8$), glandular portion length 703–1220 (996, $n = 7$); ratio oesophagus total length:FTBL 0.1–0.16 (0.14, $n = 7$). Didelphic, opisthodelphic, ovaries distributed in posterior region of body, uteri extended parallel along almost entire body. Vagina muscular, directed posteriorly, located in anterior region of body close to anterior end of intestine, vulva at 1130–2570 (1770) from anterior end (Fig. 1C). Ratio distance vulva to anterior end of body: FTBL 0.11–0.13 (0.12). Tail 25–30 (27, $n = 8$) long. Embryonated eggs occupying almost entire uterus, thick shelled with smooth surface, 39–44 (41, $n = 15$) long by 29–33 (31, $n = 15$) wide (Fig. 1D); larvated eggs located near vulva, 45–50 (48, $n = 15$) long by 38–40 (39, $n = 15$) wide (Fig. 1E).

Remarks. The family Physalopteridae is composed of three subfamilies: Thubunaeinae Sobolev, 1949, Proleptinae Schulz, 1927 and Physalopterinae Railliet, 1893 (Chabaud 1975). Thubunaeinae comprises two genera *Thubunaea* and *Physalopteroides* Wu & Liu, 1940, both of which are parasites of reptiles and are characterized by the absence of a cephalic ring, the presence of numerous caudal papillae, and an ornamented

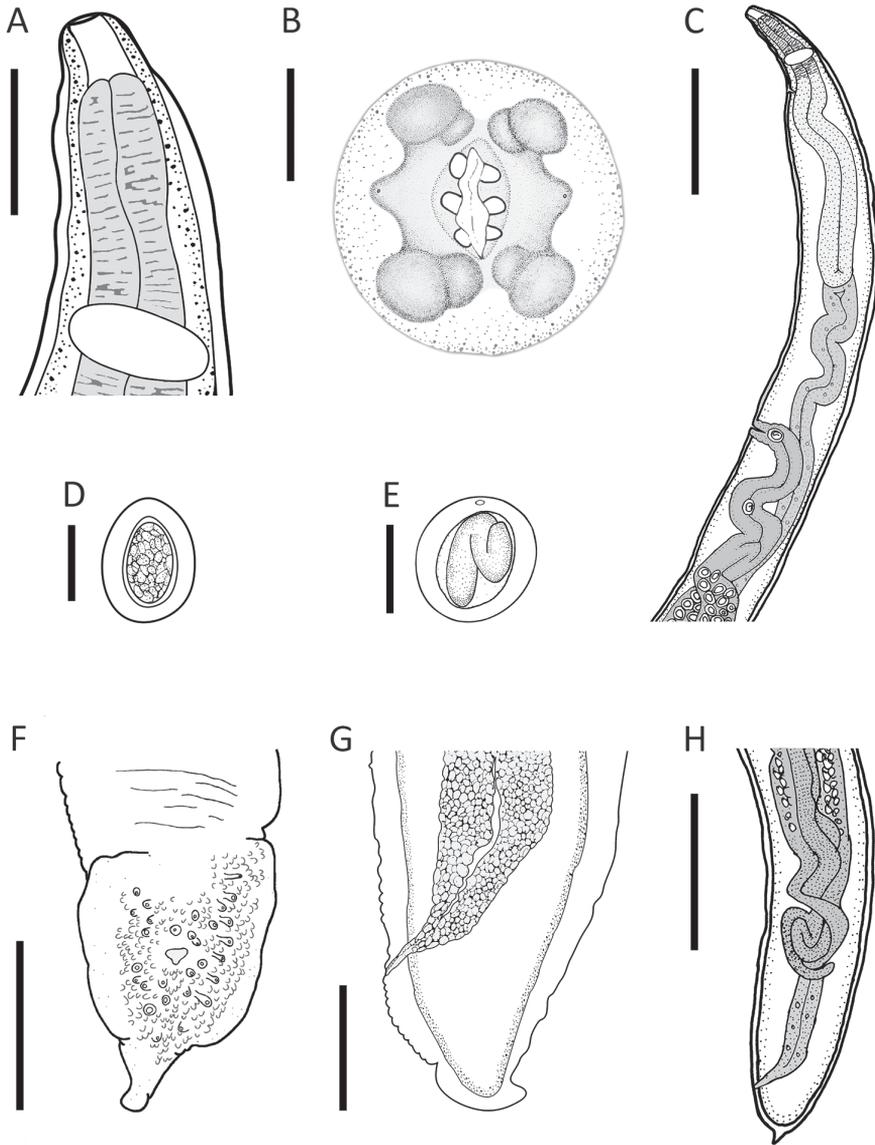


Figure 1. *Thubunaea leonregagnonae* sp. n. **A** Anterior end, female, lateral view **B** Apical view, female **C** Anterior end, female, lateral view showing excretory pore and vulva **D** Embryonated egg, lateral view **E** Larvated egg, lateral view **F** Caudal end, male, ventral view **G** Caudal end, male, lateral view, caudal papillae and ornamentation not shown **H** Caudal end, female, lateral view. Scale bars: **A** 90 μm ; **B** 20 μm ; **C** 370 μm ; **D** 25 μm ; **E** 30 μm ; **F** 250 μm ; **G** 50 μm ; **H** 370 μm .

cuticle forming papillary plates distributed on the surface of the cauda in males (Chabaud 1975). These two genera differ from each other mainly by the symmetry of their cephalic structures; in *Thubunaea* these structures are symmetrical, while they are asymmetrical in *Physalopteroides* (Chabaud 1975). Some authors, for example Moravec et al. (1997),

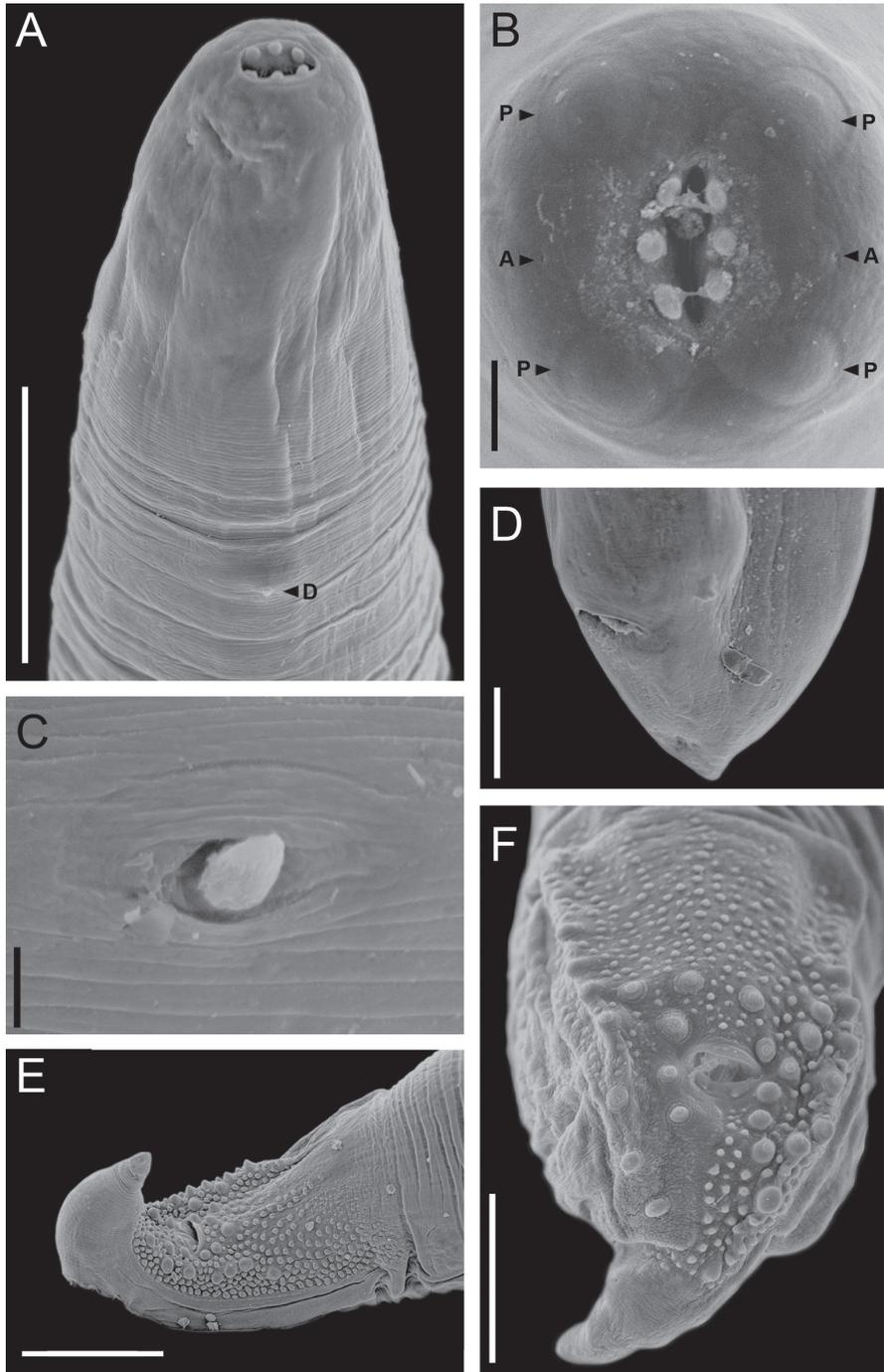


Figure 2. *Thubunaea leonregagnonae* sp. n. Scanning electron micrographs. **A** Anterior end, male, lateral view showing deirid (**D**) **B** Apical view, female, showing sub-median papillae (**P**) and amphids (**A**) **C** Deirid, lateral view **D** Posterior end, female, ventrolateral view **E** Posterior end, male, ventral view **F** Caudal end, male, ventral view. Scale bars: **A** 50 μm ; **B** 10 μm ; **C** 2.5 μm ; **D** 50 μm ; **E** 100 μm ; **F** 50 μm .

considered that the morphological features of *Thubunaea* and *Physalopteroides* have rarely been analysed using techniques such as SEM, and that these observations could provide detailed information to assess the validity of these two genera. However, to the best of our knowledge, SEM studies are still scarce in both genera, being available for only three species of *Thubunaea* (Moravec et al. 1997, Pazoki and Rahimian 2014, Ramallo et al. 2016) and two species for *Physalopteroides* (Elwasila 1990, Goswami et al. 2016). The specimens described in the present study show a symmetrical cephalic structure, as in *Thubunaea*.

Currently, 20 species of *Thubunaea* are considered as valid: one in the Afrotropical region, *T. fitzsimonsi* Ortlepp, 1931; five in the Nearctic region, *T. cnemidophorus* Babero & Matthias, 1967, *T. ctenosauri* Moravec, Salgado-Maldonado & Mayen-Peña, 1997, *T. iguanae* Telford, 1965, *T. intestinalis* Bursey & Goldberg, 1991 and *T. leiolopismae* Harwood, 1932; two in the Neotropics, *T. parkeri* Baylis, 1926, and *T. eleodori* Ramallo, Goldberg, Bursey, Castillo & Acosta, 2016; six in the Oriental region, *T. aurangabadensis* Deshmukh, 1969, *T. brooki* Deshmukh, 1969, *T. hemidactylae* Oshmarin & Demshin, 1972, *T. mirzai* Narayan, 1941, *T. singhi* Deshmukh, 1969, and *T. syedi* Deshmukh, 1969; two in the Palearctic region, *T. schukurovi* Annaev, 1973 and *T. smogorzhevskii* Sharpilo, 1966; and four species in the Saharo-Arabian region, *T. baylisi* Akhtar, 1939, *T. desetiae* Barus & Tenora, 1976, *T. mobedii* Pazoki & Rahimian, 2014 and *T. pudica* Chabaud & Golvan, 1957 (Ramallo et al. 2016).

Six of these species lack spicules, as is the case in *T. leonregagnonae* sp. n.: *T. cnemidophorus*, *T. eleodori*, *T. fitzsimonsi*, *T. mobedii*, *T. parkeri* and *T. schukurovi* (Table 3). Males of four of these species (*T. eleodori*, *T. fitzsimonsi*, *T. parkeri* and *T. mobedii*) are larger in body length than *T. leonregagnonae* sp. n. (10.25–11.16, 8.5–9, 10.5, 11.4–15.4 vs 4.85–8.03 mm, respectively). In the number of papillae, pedunculate or sessile, the new species also differs from most of these six species. *Thubunaea leonregagnonae* sp. n. has 10–16 pedunculate papillae and 11–14 sessile papillae, *T. mobedii* does not have pedunculate papillae; in contrast, *T. fitzsimonsi* and *T. parkeri* lack sessile papillae, and in this latter species the number of caudal papillae is smaller (16–20) than in the present specimens (24–28) (Table 3). *Thubunaea leonregagnonae* sp. n. is most similar to *T. cnemidophorus*, *T. eleodori* and *T. schukurovi*, however, it can be distinguished from the last two species in the number of sessile papillae: *T. eleodori* has ten and *T. schukurovi* has 16, instead of 11–14 in *T. leonregagnonae* sp. n. Males of *T. leonregagnonae* sp. n. and *T. cnemidophorus* can be differentiated mainly by having a different oesophagus length/MTBL ratio (0.1–0.16 vs 0.26) and by the former having a smaller body width (200–300 vs 350–390).

Discussion

Many authors have argued that the inventory of the parasite fauna of host species is of critical importance in biodiversity management and conservation efforts (Brooks and Hoberg 2000, Brooks and McLennan 2002, Funks and Richardson 2002). Parasite studies help to reveal other biological aspects of the hosts such as their natural history and ecology. The close link between parasites and their hosts causes these studies to

Table 3. Morphological characters of *Thubunaea* spp. lacking spicules in males. Measurements in micrometres, unless otherwise indicated.

Species	<i>T. cnemidophorus</i> Babero & Marthias, 1967	<i>T. eleodori</i> Ramallo, Goldberg, Burse, Castillo & Acosta, 2016	<i>T. fitzsimonsi</i> Ortlepp, 1931	<i>T. mopediti</i> Pazoki & Rahimian, 2014	<i>T. parkeri</i> Baylis, 1926	<i>T. schukurovi</i> Annaev, 1973	<i>Thubunaea leonregionae</i> sp. n.
Source	Babero and Marthias (1967)	Ramallo et al. (2016)	Ortlepp (1931)	Pazoki and Rahimian (2014)	Baylis (1926)	Annaev (1973)	Present study
Type host	<i>Aspidoscelis tigris</i> (Baird & Girard) (Teiidae)	<i>Liolaemus eleodori</i> Cei, Etheridge & Videla (Liolaemidae)	<i>Merops squamulosus</i> (Peters) (Lacertidae)	<i>Laudakia nupta nupta</i> (De Filippi) (Agamidae)	<i>Microlophus occipitalis</i> (Peters) (Tropiduridae)	<i>Ablepharus deserti</i> Strauch (Scincidae)	<i>Sceloporus pyrocephalus</i> Cope (Phrynosomatidae)
Country	USA	Argentina	South Africa	Iran	Peru	Turkmenistan	Mexico
Biogeographical realm	Nearctic	Neotropical	Afrotropical	Saharo-Arabian	Neotropical	Palaearctic	Nearctic
MTBL (mm)	5.7–6.6	10.25–11.16	8.5–9.0	11.4–15.4	10.5	7.8	4.85–8.03
MTBW	350–390	360	290–330	190–330	300–340	300	200–300
PP	14–16	12	29–31	0	16–20	12	10–16
SP	12	10	0	23–37	0	16	11–14
OE/MTBL	0.26†	0.12	0.11	0.12	0.1	0.15	0.1–0.16
Eggs	38–45 × 23–30 (38 × 23)	(48 × 41)	(45 × 38)	44–45 × 36–39 (48 × 38)	58–63 × 48–53 (60 × 50)	(43 × 33)	45–50 × 38–40

MTBL: male total body length (mm); MTBW: male total body width; PP: number of pedunculate papillae; SP: number of sessile papillae; OE: oesophagus length. † data from Burse and Goldberg (1991).

have a cascade effect on our knowledge of the biology of the interaction between host and parasite, as well as with the environment in which this association developed. For this reason, helminthological studies on hosts distributed in areas with high potential for endemism, such as in the present study, are highly relevant for understanding the ecology and evolution of parasite-host interactions.

Presently, for *S. pyrocephalus*, a single study was conducted, evaluating parasite load in conjunction with hormone concentration (Calisi et al. 2008). In this study, only nematodes and cestode larvae were found, without, however, identifying these to species level.

In the present study, nine helminth taxa were found parasitizing *S. pyrocephalus*: two tapeworms of the order Cyclophyllidea (*Mesocestoides* sp. and *Oochoristica* sp.), one nematode of the order Ascaridida (*S. similis*), three of the order Rhabditida (*P. ayotzinapaensis*, *P. tikuinii*, and *Parapharyngodon* sp.), and three of the order Spirurida (Physalopterinae gen. sp., *S. scelopori* and *T. leonregagnonae* sp. n.). Most of these taxa coincide with previous reports on the helminth fauna from lizards in Mexico (Caballero 1938, Telford 1965, Goldberg et al. 1996, Moravec et al. 1997, Goldberg et al. 2003, Paredes-León et al. 2008). *Parapharyngodon ayotzinapaensis*, *P. tikuinii* and *T. leonregagnonae* sp. n. have been recorded as specific nematode species for this lizard. The current results increase from 35 to 40 the number of helminths recorded as parasites of *Sceloporus* spp. and from 17 to 18 the number of species of this lizard genus for which parasite records are available (Paredes-León et al. 2008).

Oochoristica sp., *P. ayotzinapaensis*, *P. tikuinii*, *Parapharyngodon* sp., *S. scelopori*, *S. similis*, and *T. leonregagnonae* sp. n. use *S. pyrocephalus* as a definitive host, and *Mesocestoides* sp. and Physalopterinae gen. sp. were recorded as larval stages. *Mesocestoides* sp. is a common metacestode found in the body cavity and mesentery of amphibians and reptiles, which serve as paratenic hosts, with carnivorous mammals being the definitive hosts (Santoro et al. 2012). Specimens of Physalopterinae gen. sp. were found in the stomach and large intestine; species belonging to this subfamily are adult parasites of amphibians, reptiles and mammals, so their presence in *S. pyrocephalus* was probably a result of a recent recruitment.

It has been suggested that reptiles that use a passive feeding strategy (i.e. sit-and-wait) have a less diverse and less complex helminth fauna than those with an active searching behaviour (e.g. widely foraging) (Roca 1999), and that these foraging strategies are directly related to the diet of the lizards, with a passive strategy used by predominantly herbivorous lizards and an active search used by carnivorous ones. Nematodes with a direct life cycle, such as pinworms (Oxyurida: Pharyngodonidae), best reveal the differences between herbivore and carnivore hosts. Within the Pharyngodonidae, a family of Oxyuroidea that are characteristic parasites of amphibians and reptiles, are two evolutionary lineages that show a diversification that mirrors that of their hosts' diets. (Roca 1999). Some genera of Pharyngodonidae infect only carnivorous saurian reptiles: *Parapharyngodon*, *Spauligodon* Skrjabin, Schikhobalova & Lagodovskaja, 1960, *Skrjabinodon*, *Pharyngodon* and *Parathelandroidros* Baylis, 1930; while the second lineage is composed of pharyngodonid parasites of herbivorous iguanids and testudines: *Tachygonetria* Wedl, 1862, *Mehdiella* Seurat,

1918, *Alaeuris* Seurat, 1918, *Thaparia* Ortlepp, 1933, *Ortleppnema* Petter, 1966, *Ozolaimus* Dujardin, 1845, *Travassozolaimus* Viguera, 1938 and *Mamillomacraxis* Dosse, 1939. Given the particular species of Oxyuroidea found in *S. pyrocephalus*, along with the presence of *S. similis*, a typical nematode found in carnivorous reptiles (Núñez 2005), it can be inferred that this lizard is mainly carnivorous. The remaining taxa of helminths found in the present study, including the nematodes *T. leonregagnonae* sp. n. and *S. scelopori*, have an indirect life cycle, in which beetles and ants are probably acting as intermediate hosts. Studies in other species of *Sceloporus* have determined that termites are an important food source for *S. gadoviae* Boulenger, *S. horridus* Wiegmann, and *S. jalapae* Günther (Serrano-Cardozo et al. 2008); hence, termites could likely be the intermediate hosts of the heteroxenous parasites found in *S. pyrocephalus*.

Since five of the nine parasite taxa recorded for *S. pyrocephalus* have an indirect life cycle, with arthropods as intermediate hosts, diet might be the predominant factor structuring the helminth fauna in this lizard. This opposes the idea proposed by Aho (1990), who found that most of the parasite species that inhabit the intestine of amphibians and reptiles, are nematodes with a direct life cycle. Studies assessing the helminth fauna associated with Mexican reptiles are of great value to have a better understanding of the factors that influence the ecological dynamics within helminth communities and to establish comparisons between Nearctic and Neotropical populations of hosts.

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References

- Aho JM (1990) Helminth communities of amphibians and reptiles: comparative approaches to understanding patterns and processes. In: Esch GW, Bush AO, Aho JM (Eds) Parasite communities: patterns and processes. Chapman and Hall, London, 157–195. https://doi.org/10.1007/978-94-009-0837-6_7

- Annaev D (1973) *Thubunaea schukurovi* n. sp. (Physalopteridae, Nematoda) from lizards in Turkmenia. Izvestia Akademii Nauk Turkmenskoi SSR 1: 72–75. [In Russian]
- Arizmendi-Espinosa MA, García-Prieto L, Guillén-Hernández (2005) A new species of *Oochoristica* (Eucestoda: Cyclophyllidea) parasite of *Ctenosaura pectinata* (Reptilia: Iguanidae) from Oaxaca, Mexico. Journal of Parasitology 91: 99–101. <http://dx.doi.org/10.1645/GE-337R>
- Babero BB, Matthias D (1967) *Thubunaea cnemidophorus* n. sp., and other helminths from lizards, *Cnemidophorus tigris*, in Nevada and Arizona. Transactions of the American Microscopical Society 86: 173–177. <https://doi.org/10.2307/3224688>
- Baylis HA (1926) On a new species of the nematode genus *Thubunaea*. Annals and Magazine of Natural History 17: 361–364. <https://doi.org/10.1080/00222932608633527>
- Brooks DR, Hoberg EP (2000) Triage for the biosphere: the need and rationale for taxonomic inventories and phylogenetic studies of parasites. Comparative Parasitology 68: 1–25.
- Brooks DR, McLennan DA (2002) The nature of diversity: an evolutionary voyage of discovery. University of Chicago Press, Chicago, 676 pp. <https://doi.org/10.7208/chicago/9780226922478.001.0001>
- Brooks DR, Pérez-Ponce de León G, García-Prieto L (1999) Two new species of *Oochoristica* Lühe, 1898 (Eucestoda: Cyclophyllidea: Anoplocephalidae: Linstowiinae) parasitic in *Ctenosaura* spp. (Iguanidae) from Costa Rica and Mexico. Journal of Parasitology 85: 893–897. <https://doi.org/10.2307/3285828>
- Bursey CR, Goldberg SR (1991) *Thubunaea intestinalis* n. sp. (Nematoda: Spiruroidea) from Yarrow's spiny lizard, *Sceloporus jarrovi* (Iguanidae), from Arizona, USA. Transactions of the American Microscopical Society 110: 269–278. <https://doi.org/10.2307/3226661>
- Bursey CR, Goldberg SR (2015) Description of a new species of *Parapharyngodon* (Nematoda: Pharyngodonidae) from Mexico with a list of current species and key to species from the Panamanian region. Journal of Parasitology 101: 374–381. <https://doi.org/10.1645/13-460.1>
- Bursey CR, Goldberg SR, Telford SR Jr (2003) *Strongyluris panamaensis* n. sp. (Nematoda: Heterakidae) and other helminths from the lizard, *Anolis biporcatus* (Sauria: Polychrotidae), from Panamá. Journal of Parasitology 89: 118–123. [http://dx.doi.org/10.1645/0022-3395\(2003\)089\[0118:SPNSNH\]2.0.CO;2](http://dx.doi.org/10.1645/0022-3395(2003)089[0118:SPNSNH]2.0.CO;2)
- Bush AO, Lafferty KD, Lotz JM, Shostak AW (1997) Parasitology meets ecology on its own terms: Margolis et al. revisited. Journal of Parasitology 83: 575–583. <https://doi.org/10.2307/3284227>
- Caballero CE (1937) Nemátodos de algunos vertebrados del Valle del Mezquital, Hidalgo. Anales del Instituto de Biología, Universidad Nacional Autónoma de México 8: 189–200.
- Caballero CE (1938) Nematodes parasites des reptiles de Mexique. Annales de Parasitologie Humaine et Comparée 16: 327–333. <https://doi.org/10.1051/parasite/1938164327>
- Caballero CE (1951) Estudios helmintológicos de la región oncocercosa de México y de la República de Guatemala. Nematoda. 6ª parte. Y algunas consideraciones en torno a los géneros *Onchocerca* Diesing, 1841 y *Acanthospiculum* Skrjabin y Schikobalowa, 1948. Anales del Instituto de Biología, Universidad Nacional Autónoma de México 22: 141–158.
- Caballero-Rodríguez G (1971) Contribución al conocimiento de los nemátodos que parasitan a los reptiles de México. II. Sobre una nueva fisalóptera parásita de iguanidos (*Sceloporus torquatus torquatus* Wiegmann, 1828). Revista de Biología Tropical 19: 165–179.

- Calisi RM, Malone JH, Hews DK (2008) Female secondary coloration in the Mexican boulder spiny lizard is associated with nematode load. *Journal of Zoology* 276: 358–367. <https://doi.org/10.1111/j.1469-7998.2008.00499.x>
- Chabaud AG (1975) No. 3. Keys to genera of the order Spirurida. Part 1. Camallanoidea, Dracunculoidea, Gnathostomatoidea, Physalopteroidea, Rictularioidea and Thelazioidea. In: Anderson RC, Chabaud AG, Willmott S (Eds) *CIH Key to the nematode parasites of vertebrates*. CAB International, Wallingford, 29–58.
- Cid del Prado VI (1971) Estudio taxonómico de algunos nemátodos parásitos de reptiles de México. B.S. Thesis, Facultad de Ciencias, Universidad Nacional Autónoma de México, Mexico City, 102 pp.
- Elwasila M (1990) *Physalopteroides tarentolae* n. sp. (Nematoda: Physalopteridae) from the gecko *Tarentola annularis* in the Sudan. *Systematic Parasitology* 15: 121–125. <https://doi.org/10.1007/BF00009989>
- Flores-Barroeta L (1955) Céstodos de vertebrados. II. *Revista Ibérica de Parasitología* 15: 115–134.
- Flores-Barroeta L, Hidalgo-Escalante E (1960) Céstodos de vertebrados. VII. In: Bravo-Hollis M, Zerecero C, Flores-Barroeta L, Hidalgo-Escalante E, Winter HA (Eds) *Libro Homenaje al Dr. Eduardo Caballero y Caballero*. Secretaría de Educación Pública, Instituto Politécnico Nacional, Mexico City, 357–376.
- Flores-Villela O, García-Vázquez U (2014) Biodiversidad de reptiles en México. *Revista Mexicana de Biodiversidad* 85: S467–S475. <http://dx.doi.org/10.7550/rmb.43236>
- Funks VA, Richardson KS (2002) Systematic data in biodiversity studies: use it or lose it. *Systematic Biology* 51: 303–316. <https://doi.org/10.1080/10635150252899789>
- Garduño-Montes de Oca EU, Mata-López R, León-Règagnon V (2016) Two new species of *Parapharyngodon* parasites of *Sceloporus pyrocephalus*, with a key to the species found in Mexico (Nematoda, Pharyngodonidae). *ZooKeys* 559: 1–16. <https://doi.org/10.3897/zookeys.559.6842>
- Goldberg SR, Bursey CR (1991) Gastrointestinal helminths of the Mexican lizards, *Phrynosoma braconnieri* and *Phrynosoma taurus* (Iguanidae). *Southwestern Naturalist* 36: 365–368. <https://doi.org/10.2307/3671694>
- Goldberg SR, Bursey CR (2000) Helminths of Mexican lizards: geographical distribution. In: Salgado-Maldonado G, García-Aldrete AN, Vidal-Martínez VM (Eds) *Metazoan parasites in the Neotropics: a systematic and ecological perspective*. Universidad Nacional Autónoma de México, Instituto de Biología. D. F., Mexico, 175 – 191.
- Goldberg SR, Bursey CR, Bezy RL (1996) Gastrointestinal helminthes of Yarrow’s spiny lizard, *Sceloporus jarrovi* (Phrynosomatidae) in Mexico. *American Midland Naturalist* 135: 299–309. <https://doi.org/10.2307/2426713>
- Goldberg SR, Bursey CR, Camarillo JL (2003) Gastrointestinal helminths of seven species of sceloporine lizards from Mexico. *Southwestern Naturalist* 48: 208–217. [https://doi.org/10.1894/0038-4909\(2003\)048<0208:GHOSSO>2.0.CO;2](https://doi.org/10.1894/0038-4909(2003)048<0208:GHOSSO>2.0.CO;2)
- Goswami U, Chaudhary A, Verma C, Singh HS (2016) Molecular and ultrastructure characterization of two nematodes (*Thelandros scleratus* and *Physalopteroides dactyluris*) based on ribosomal and mitochondrial DNA sequences. *Helminthologia* 53: 165–171. <https://doi.org/10.1515/helmin-2016-0013>

- Guillén-Hernández S, García-Prieto L, Arizmendi-Espinosa MA (2007) A new species of *Oochoristica* (Eucestoda: Cyclophyllidae) parasite of *Ctenosaura oaxacana* (Reptilia: Iguanidae) from Mexico. *Journal of Parasitology* 93: 1136–1139. <http://dx.doi.org/10.1645/GE-1118R.1>
- Jiménez FA, León-Règagnon V, Pérez-Ramos E (2008) Two new species of *Parapharyngodon* (Oxyuroidea: Pharyngodonidae) from the enigmatic *Bipes canaliculatus* and *Bipes tridactylus* (Squamata: Bipedidae). *Revista Mexicana de Biodiversidad* 79: 1136–1206. <http://www.scielo.org.mx/pdf/rmbiodiv/v79sago/v79sagoa16.pdf>
- Kabilov TK (1980) The life cycle of *Abbreviata kazachstanica*. *Parazitologija* 14: 263–270.
- Lamothe-Argumedo R (1997) Manual de técnicas para preparar y estudiar los parásitos de animales silvestres. AGT, Mexico, 43 pp.
- Lee SH (1957) The life cycle of *Skrjabinoptera phrynosoma* (Ortlepp) Schulz, 1927 (Nematoda: Spiruroidea), a gastric nematode of Texas horned toads, *Phrynosoma cornutum*. *Journal of Parasitology* 43: 66–75. <https://doi.org/10.2307/3274761>
- Moravec F, Salgado-Maldonado G, Mayén-Peña E (1997) *Thubunaea ctenosauri* sp. n. (Nematoda: Physalopteridae) from the iguanid lizard *Ctenosaura pectinata* and other lizard helminths from Mexico. *Journal of the Helminthological Society of Washington* 64: 240–247. <http://bionames.org/bionames-archive/issn/1049-233X/64/240.pdf>
- Núñez VS (2005) Dieta de la lagartija *Sceloporus pyrocephalus*. Bachelor Thesis. Universidad Muchoacana de San Nicolás de Hidalgo. Morelia, Michoacán. México, 49 pp.
- Ortlepp RJ (1931) *Thubunaea fitzsimonsi* sp. n., a fourth species of the genus *Thubunaea* Seurat, 1914. *Journal of the South African Veterinary Medical Association* 2: 128–131. https://journals.co.za/content/savet/2/2/AJA00382809_2117
- Paredes-León R, García-Prieto L, Guzmán-Cornejo C, León-Règagnon V, Pérez TM (2008) Metazoan parasites of Mexican amphibians and reptiles. *Zootaxa* 1904: 1–166. http://www.realitat.com/websites/zoologia/zoo_08/tecnicos_s_853645/archivos/Metazoan%20parasites.pdf
- Pazoki S, Rahimian H (2014) New species of *Spauligodon* Skrjabin, Schikhobalova & Lagodovskaja, 1960 and *Thubunaea* Seurat, 1914 (Nematoda) from the gastro-intestinal tract of lizards in Iran. *Systematic Parasitology* 89: 259–270. <https://doi.org/10.1007/s11230-014-9527-y>
- Petri LH (1950) Life cycle of *Physaloptera rara* Hall and Wigdor, 1918 (Nematoda: Spiruroidea) with the cockroach, *Blattella germanica*, serving as the intermediate host. *Transactions of the Kansas Academy of Science* 53: 331–337. <https://doi.org/10.2307/3626145>
- Ramallo G, Goldberg S, Bursey C, Castillo G, Acosta JC (2016) *Thubunaea eleodori* sp. nov. (Nematoda: Physalopteridae) from *Liolaemus eleodori* (Sauria: Liolaemidae) from Argentina. *Parasitology Research* 16: 293–297. <https://doi.org/10.1007/s00436-016-5290-0>
- Roca V (1999) Relación entre las faunas endoparásitas de reptiles y su tipo de alimentación. *Revista Española de Herpetología* 13: 101–121. http://www.lacerta.de/AS/Bibliografie/BIB_1784.pdf
- Rudolphi CA (1819) *Entozoorum synopsis, cui accedunt mantissa duplex et indices locupletissimi*. Sumtibus Augusti Rücker, Berolini, 811 pp. <https://doi.org/10.5962/bhl.title.9157>
- Santoro M, Aznar EJ, Mattiucci S, Kinsella JM, Pellegrino F, Cipriani P, Nascetti G (2012) Parasite assemblages in the Western whip snake *Hierophis viridiflavus carbonarius* (Colubridae) from southern Italy. *Journal of Helminthology* 87: 1–9. <https://doi.org/10.1017/S0022149X12000338>

- Schell SC (1952) Studies on the life cycle of *Physaloptera hispida* Schell (Nematoda: Spiruroidea) a parasite of the cotton rat (*Sigmodon hispidus littoralis* Chapman). *Journal of Parasitology* 38: 462–472. <https://doi.org/10.2307/3273926>
- Serrano-Cardozo VH, Lemos-Espinal JA, Smith GR (2008) Comparative diet of three sympatric *Sceloporus* in the semiarid Zapotitlán Valley, México. *Revista Mexicana de Biodiversidad* 79: 427–434. <http://www.scielo.org.mx/pdf/rmbiodiv/v79n2/v79n2a17.pdf>
- Stunkard HW (1938) Parasitic flatworms from Yucatan. *Publications of the Carnegie Institution of Washington* 491: 33–50. <http://hdl.handle.net/11154/162411>
- Telford SR (1965) A new species of *Thubunaea* (Nematoda: Spiruroidea) from California lizards. *Japanese Journal of Experimental Medicine* 35: 111–114.
- Uetz P, Freed P, Hošek J (Eds) (2016) *The Reptile Database*. <http://www.reptile-database.org> [accessed May 11, 2017]
- Velarde-Aguilar MG, Mata-López R, Guillén-Hernández S, León-Règagnon V (2015) *Parapharyngodon* n. spp. (Nematoda: Pharyngodonidae) parasites of hylid frogs from Mexico and review of species included in the genus. *Journal of Parasitology* 101: 212–230. <https://doi.org/10.1645/13-328.1>

Half-jumping plant lice – a taxonomic revision of the distinctive psyllid genus *Togepssylla* Kuwayama with a reassessment of morphology (Hemiptera, Psylloidea)

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Abstract

Togepssyllinae is a distinctive group within Psylloidea, with its systematic status treated variously by different authors. Of the only two known genera, *Togepssylla* is better known and distributed in temperate and tropical East Asia. In this study, the taxonomy and morphology of *Togepssylla* was studied in detail. Keys to adults and fifth instar immatures of the genus are provided. *Togepssylla glutinosae* sp. n. is described, and *T. matsumurana*, *T. takabashii*, and *T. tibetana* are redescribed. *Syncoptozus* is compared with *Togepssylla* for differences in morphology. Modern psyllids have evolved their jumping hind legs via the elongation of the dorsal edge of coxa, the broadening of coxal wall, the thickening of meron, the backward twisting of the plane of trochanter, femur, and tibia, and the enlargement of trochanteral tendon. However, in *Togepssylla*, this modification has progressed halfway. The metapleuron of *Togepssylla* is arranged in a different way than other psyllids. The pleural sulcus is short, and the metepisternum and trochantin are not divided. Wax-secreting fields on abdominal sternites, resembling those of whiteflies, are found on all *Togepssylla* species, and described for the first time. Other distinctive characters of the genus are also revealed, e.g. frons completely fused with gena, a pair of extra sclerites present behind the base of thoracic furca, one-segmented aedeagus, and absence of a flag lobe on valvula dorsalis of ovipositor. Based on various similarities in morphology, Togepssyllinae may have a close relationship with Aphalaridae-Rhinocolinae and is possibly related to Homotomidae, Liviidae-Liviinae and *Atmetocranium* (Calophyidae). All the distinctive characters of Togepssyllinae suggest that the current placement of the group is doubtful, and the phylogeny of Aphalaridae needs to be resolved.

Keywords

Aphalaridae, morphological characters, Oriental region, Togeipsyllinae

Introduction

Psylloidea, the superfamily of jumping plant lice, is a group of phloem-sucking insects with strict host specificity. Among all its subordinate taxa, the Oriental and Palaearctic genus *Togeipsylla* is undoubtedly one of the most distinctive. Named after the symmetrical and articulated thick ‘spines’ on the dorsum of head and thorax, it is readily diagnosed by these spine-like setae and wings held flat over its dorsum instead of roof-wise, in addition to the more intrinsic characters identified in this article. The genus contains only three known species to date: *Togeipsylla matsumurana* Kuwayama, 1949, *T. takahashii* Kuwayama, 1931 (type species), and *T. tibetana* (Yang & Li, 1981). The few known species develop exclusively on Lauraceae plants, often inducing pit galls or leaf-rolling galls (Takahashi 1936; Miyatake 1970; Li 2011), in contrast to their spine-lacking Neotropical relative *Syncoptozus* Enderlein, which develops on plants of Magnoliaceae. The two genera compose the small taxon Togeipsyllinae/-ini with valid monophyly. Yang and Li (1981) erected *Hemipteripsylla* to contain *H. tibetana* and *T. matsumurana*, which possess relatively short setae based on short projections and lack tiny spines on the dorsum of aedeagus. These characters were accurately recognized, although considered insufficient to support an alternative genus, by Hodkinson (1990), who synonymized *Hemipteripsylla* with *Togeipsylla*.

Togeipsyllini was established by Bekker-Migdisova (1973), who assigned it to her sense of Carsidaridae-Tenaphalarinae. Before Bekker-Migdisova, Kuwayama (1931) placed *Togeipsylla* in Carsidarinae, whereas Miyatake (1970) moved the genus into Pauripsyllinae. White and Hodkinson (1985) presented the first calculated cladogram of Psylloidea, using a numerical method. They treated the group as Togeipsyllinae, assigning it in Aphalaridae, one of the eight families recognized in their classification. The authors postulated an extinct Rutales-feeding ancestor of all modern psyllids; however, they also mentioned in the last sentence of that paragraph that “*Togeipsylla* (Aphalaridae), which feeds on Lauraceae (Annonales), may possibly be a relic genus of a psyllid group which antedates the Rutales-feeders.” On the other hand, using the now synonymized *Hemipteripsylla* as the type genus, Li (2011) elevated Togeipsyllinae to superfamily level, Hemipteripsylloidea, containing a single family with three genera. He recognized Hemipteripsylloidea as a primitive member of ‘Psyllidomorpha’ without a supporting phylogenetic analysis, simply based on the flat-held wings and one-segmented instead of two-segmented aedeagus in males. In the most recent, influential classification of Burckhardt and Ouvrard (2012), Togeipsyllinae was treated as one of the five subfamilies of Aphalaridae whose fifth-instar immatures lack an unguitactor on the tarsal arolium, closer related with Rhinocolinae and Spondyliaspidae.

Based on a synthesis of fossil studies, the defining character of Psylloidea *sensu stricto* is the mutual modification of the metacoxa and furca of the metathorax (Ouvrard et

al. 2010) to allow the attachment of jumping muscles (Bekker-Migdisova 1971), thus enabling psyllids to jump. According to limited observations, psyllids appears to do a mid-air somersault in jumping. The jumping of *Psylla alni* (Linnaeus), *Cacopsylla peregrina* (Foerster) and *Psyllopsis fraxini* (Linnaeus) is triggered by pressing hind trochanters and femora against the coxal wall, then a quick release of the tension, powered by the metathoracic internal muscles attached to the furca and trochanteral tendon (Burrows 2012). The release is strong enough to rotate the entire body upside down, but the fore legs provide a support to maintain balance, and then the entire insect is cast airborne and starts to rotate forward rapidly, sometimes with the wings opening in mid-air to commence flight. The “non-jumping plant lice” of the extinct families Liadopsyllidae and Malmopsyllidae, which date back to the Mesozoic and possess unmodified metacoxa, provides further support that the modified hind legs are monopolized by modern Psylloidea (Ouvrard et al. 2010). Occasionally, some extant psyllids, such as *Togepsyllinae* and *Apsylla cistellata* (Buckton 1896) (Aphalaridae: Rhinocolinae), are not known to jump. These exceptions are regarded by Ouvrard et al. (2010) as secondary reductions.

A new species, *Togepsylla glutinosae* sp. n., has been collected on *Litsea glutinosa* from tropical China recently. During the taxonomic work on Chinese Aphalaridae, many previously overlooked characters of *Togepsylla* were revealed, including the half-modified metacoxae which do not provide sufficient jumping force, and wax secreting fields on abdominal sternites first found on a psyllid. Based on an integration of East Asian collections, this study aims to revise the taxonomy of the genus *Togepsylla*, and reassess the distinctive morphological characters of it.

Materials and methods

This study is based on the collections of the Entomological Museum of China Agricultural University (CAU), the Natural History Museum, London (BNHM), Hiro-mitsu Inoue’s personal collection (HIC), and the Osaka Museum of Natural History (OMNH). The type series of *Togepsylla takahashii* and *T. matsumurana*, previously preserved in Hokkaido University, were lost according to Jin Hyung Kwon (personal communication). Specimens examined regarding the non-*Togepsylla* species involved in discussion are listed as follows:

- BNHM** *Atmetocranium myersi* Ferris & Klyver, 1932: 1 ♂;
CAU *Cacopsylla* sp.: numerous adults of both sexes;
BNHM *Syncoptozus mexicanus* Hodkinson, 1990: 1 ♂;
CAU *Trialeurodes vaporariorum* Westwood, 1856: numerous adults of both sexes.

Slides were prepared following this protocol: whole insect soaked in boiling potassium hydroxide (KOH) solution for 10 minutes, naturally cooled down after heating stopped, washed in distilled water, and finally mounted on a slide in glycerine. All drawings and examinations were undertaken with an Olympus BX41 microscope. One dry-mounted adult of each *Togepsylla* species was coated with gold using a Leica

EM SCD050 Super Cool Sputter Coater and prepared for Scanning Electron Microscope (SEM) examination and photography, using an FEI® Quanta 450 Environmental Scanning Electron Microscope.

Measurements were taken with a Keyence VHX-1000 digital microscope using the measuring function and are given in millimeters (mm). For adults:

HW head width,
AL antennal length,
SL length of the posterior pair of prickly setae on the median of the vertex,
TW mesoscutum width,
WL fore wing length,
TL metatibial length.

For fifth instar immatures:

BL total body length,
AL antennal length,
HW head width,
FL fore wing pad length, measured as the distance between the transverse tangents of the anterior angle and posterior margin.

Total body length of adults was not determined because most dry-mounted specimens examined were in distinct positions and therefore incomparable.

Comparisons of morphological characters were based on direct observations of specimens, drawings, SEM photos, measurements, and sometimes on the literature. Putatively homologous characters were compared across the concerned taxa. Diagnostic characters are described for each species, with emphasis on the differences. Characters potentially useful for systematic studies are noted and are referred to in the discussion.

Terminology primarily follows Brown and Hodkinson (1988), Ouvrard et al. (2002), and Yang et al. (2009) for adults and White and Hodkinson (1985) for immatures.

Scientific names of plants follow the Missouri Botanical Garden (2016), and higher systematics of plants (except for the direct citation of older literatures) follow The Angiosperm Phylogeny Group (2016).

Taxonomy

Togepsylla Kuwayama, 1931

Togepsylla Kuwayama, 1931: 121. Type species: *Togepsylla takahashii* Kuwayama, 1931, by original designation.

Togepsylla Kuwayama: Li 2011: 213.

Hemipteripsylla Yang & Li, 1981: 182. Type species: *Hemipteripsylla tibetana* Yang & Li, 1981, by original designation. Synonymized by Hodkinson 1990: 716.

Diagnosis. Body relatively flat. Vertex, thoracic dorsum and most of fore wing veins with symmetrical long and thick setae, which possess tiny spinules on the surface (Fig. 63, termed 'prickly setae' below). Wings held flat over back. Fore wing lacking pterostigma. Hind wing with a single thick anal vein (A) which may result from the reduction of vein A_1 or A_2 or from the combination of them. Posterior aspect of male proctiger enveloped. Aedeagus uni-segmented. Female subgenital plate simple and situated much more proximal than proctiger. Valvula dorsalis of ovipositor lacking flag lobe. Fifth instar immature with symmetrical sectasetae on body dorsum, lacking tarsal arolium on legs.

Redescription. Adult. Body flat, with abdomen significantly wider than tall. Body dorsum with symmetrical prickly setae on the surface, situated on bulges or projections, distribution as: 4+4 on vertex, 4+4 on pronotum, 1+1 on mesopraescutum, 4+4 (Fig. 53) or 5+5 (Fig. 52) on mesoscutum, 1+1 on mesoscutellum, 1+1 on tegula, 1+1 on humeral plates, 1+1 on metascutellum. Surface of vertex and thoracic dorsum sculptured with granular microscopic structures.

Head slightly inclined from longitudinal body axis. Vertex lacking median suture; two tubercles present along the median line, each bearing a pair of prickly setae. Base of lateral ocelli moderately bulging, each bearing two prickly setae. Vertex consistent with gena. Plane of torulus about perpendicular to that of the vertex. Frons completely fused with vertex and gena, only moderately raised from the surface. Gena not divided into two lateral parts, but firmly compact as one, with roughly symmetrical simple setae (Fig. 47); parts below torulus sometimes produced. Occiput smoothly connected with vertex, not folded below it. Plane of postocular sclerite about perpendicular to that of vertex, not nearly parallel with it. Antennae 10-segmented, surface sculptured with minute spinules arranged in transverse rows; at least six rhinaria present on apices of segments IV-IX, apex of segment III sometimes also with one; segments IV, VI and VIII sometimes possess extra rhinaria; rhinarium with closely packed minute spinules lining below, usually bearing horn-like projections. Clypeus rather short, with no extra seta except the apical pair of setae. Labium rather short, two-segmented, lacking 'conical sensoria' (as termed by Liang et al. 2013) on the tip (Fig. 48).

Preepimeron significantly wider than preepisternum. Notopleural sulcus of prothorax well developed. Mesopraescutum near semicircular, not protruding forward to force pronotum to arch. Pleural sulcus of mesothorax reduced, with pleural apophysis relatively small; posterior margin of mesopleurite directed forward. Mesepisternum rather narrow and bulging (Fig. 57). Trochantinal apodeme shallow, present on anterior margin of mesopleurite (Fig. 57). Anapleural cleft of mesothorax widely split (Fig. 57). 1+1 extra sclerites present behind the base of mesothoracic furca (Fig. 59). Heel of mesepimeron swollen, bearing a small tubercle (Fig. 57). Metathoracic pleural sulcus reduced, pleural apophysis poorly developed; metepisternum and trochantin not completely divided (Fig. 57). Trochantinal apodeme of metathorax shallow, present on the anterior margin of metapleurite (Fig. 57). Katepisternum and trochantin of metathorax possess well developed ventral aspect which are convergent in the middle, forming a large and solid plate ventrally (Fig. 59). 1+1 extra sclerites present behind the base of metathoracic furca (Fig. 59) (in contrast with most other psyllids, e.g. *Cacopsylla*, Fig. 60).

Legs long and slender. The three sensory pores on femora ventrum arranged in a row. Plane of hind legs almost parallel with that of middle legs. Metacoxa with rather large tubercle above apical opening, and lacking meracanthus (Fig. 56). Metafemur without a cluster of thick setae on the outside of apex. Metatibia without genual spine, with 1-3 rows of thick setae; apical part often with a row of tightly packed setae dorsally; apical spurs relatively long and slender, sclerotized at different extents but never reaching the hard and black status as in most other psyllids, forming an open crown. Metabasisarsus lacking sclerotized spurs on the apex, but with one or two (in other psyllids there is only one) pairs of simple setae. Apical tarsus with a pair of short and tapered apical setae. Claws with rounded or rather narrow pulvilli.

Fore wing narrowest in the base and gradually becoming much wider apically, usually widest at subapex or apical 1/4. Costal break present. Pterostigma absent. Vein Rs reaching anterior margin instead of apical margin. Cell cu_1 rather long and flat. Veins A_1 and A_2 touching in the middle. Anal break adjacent to the apex of vein Cu_{1b} .

Hind wing with partially thickened anterior margin. Veins A_1 and A_2 combined or one is lost (probably A_1), leaving a thickened vein A; cell a_1 lost (Fig. 49).

Tergite of abdominal segment 1 better developed, with a median sclerite present (Fig. 50). Spiracles of segments 1 and 2 invisible. Sternites of segments 4-6 each with a pair of wax-secreting pore fields laterally, with shape variable.

Male terminalia: In natural status, proctiger, aedeagus and parameres all oriented caudally instead of upwards. Posterior aspect of proctiger enveloped. Aedeagus unisegmented and simple, sometimes with tiny spines on dorsum. Sperm pump with only basal end plate, lacking apical end plate (Fig. 51).

Female terminalia: Subgenital plate placed much more proximal than proctiger and simple, lacking tip sometimes. Proctiger lacking rows of long setae on the dorsum. Valvula dorsalis of ovipositor without flag lobe. Median valve slender and placed more terminal, apex touching the subapex of ovipositor.

Fifth instar immature. Body dorsum with symmetrical sectasetae. Antennal 7- or 9-segmented, with three rhinaria. Compound eyes with 1+1 or 2+2 ocular setae. Postocular setae present in 2+2 or more. Fore wing pads simple, without humeral lobe. Legs long and slender, lacking specialized seta. Both tarsal segments differentiated. Tarsal claws with pulvilli and without arolium. Apical setae of tarsus both long and capitate. Abdominal sclerites firm, not broken in the middle. Abdominal apex with a pair of bulges. Circum anal pore field lacking additional rings.

Key to adults of *Togepsylla*

- 1 Mesoscutum with 5+5 prickly setae (Fig. 52). Antennal segment III lacking rhinarium on the apex **2**
- Mesoscutum with 4+4 prickly setae (Fig. 53). Antennal segment III with one rhinarium on the apex **3**
- 2 Fore wing colorless, with one prickly seta on the base of vein M_{3+4} (Fig. 12). Inner surface of paramere with large area of netlike grains covering the whole

- apical half, anterior margin serrated (Fig. 28). Female terminalia rather small compared with body size, proctiger curved upwards only at the tip (Fig. 32)....
 *Togepsylla tibetana* (Yang & Li)
- Fore wing with black sections on veins, without prickly setae on vein M_{3+4} (Fig. 10). Inner surface of paramere with a small area of netlike grains in the centre, anterior margin not serrated (Fig. 23). Female terminalia relatively large compared with body size, apical 1/3 of proctiger strongly curved upwards (Fig. 30)..... *Togepsylla matsumurana* Kuwayama
- 3 Fore wing with yellow bands, with rather long prickly setae on veins but M_{3+4} (Fig. 11). Dorsum of metatibia with a closely packed row of short setae (Fig. 15). Paramere with a sclerotized tooth anteriorly (Figs 25, 26). Female proctiger smoothly tapered apically (Fig. 31)..... *Togepsylla takahashii* Kuwayama
- Fore wing without color patterns, with relatively short prickly setae on veins including M_{3+4} (Fig. 9). Dorsum of metatibia lacking a closely packed row of short setae (Fig. 13). Paramere without sclerotized tooth (Figs 19-21). Female proctiger constricted at apical 1/3 (Fig. 29)..... *Togepsylla glutinosae* sp. n.

Key to the fifth instar immature of *Togepsylla* (*T. tibetana* unknown)

- 1 Body dorsum with acute-tipped sectasetae (Figs 38, 40). Circum anal ring strongly winding, expanded in lateral aspect (Fig. 42).....
 *Togepsylla takahashii* Kuwayama
- Body dorsum with truncate sectasetae. Circum anal ring simple, both outer and inner rings composed of single row of pores. **2**
- 2 Outer margin of head and fore wing pad with closely packed sectasetae (Fig. 43)..... *Togepsylla matsumurana* Kuwayama
- Outer margin of head and fore wing pad with fewer and scattered sectasetae (Figs 33, 35) *Togepsylla glutinosae* sp. n.

***Togepsylla glutinosae* sp. n.**

<http://zoobank.org/F4C2FD9E-E5BC-4F35-B7AA-AA10A2F69194>

Figs 1, 5, 9, 13, 16, 19–21, 29, 33–37, 64, 65

Diagnosis. Vein M_{3+4} of fore wing with 3 prickly setae (Fig. 9). Tarsal pulvilli rounded (Fig. 13). Male subgenital plate without long seta on the dorsal-apical angle (Fig. 19). Female proctiger steeply narrowed in the apical 1/3 (Fig. 29).

Description. Adult coloration. Ground color yellow. Long and thick setae on dorsum black. Compound eyes grey. Ocelli yellow. Antennae yellow, with black apices on segments IV, VI, VIII; segments IX-X entirely black. Pronotum, meso- and metascutum each with one pair of orange markings. Legs yellow. Fore wing hyaline and colorless (Fig. 9). Tergites of abdominal segments 3-5 brown. Male and female terminalia yellow.

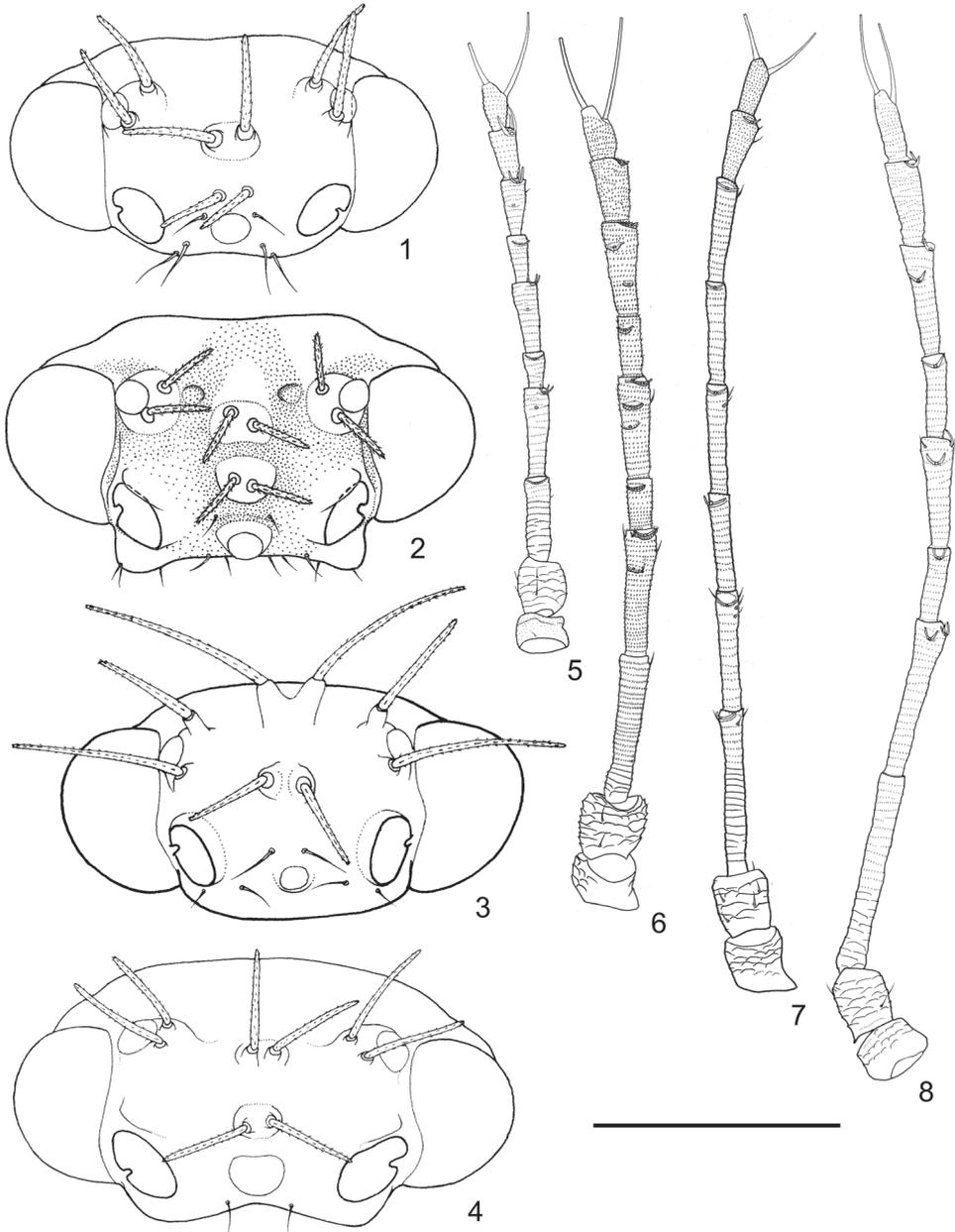


Figure 1–8. Head and antennae of *Togeptyssa* spp. **1, 5** *Togeptyssa glutinosae* sp. n. **2, 6** *Togeptyssa matsumurana* **3, 7** *Togeptyssa takahashii* **4, 8** *Togeptyssa tibetana* **1–4** Head **5–8** Antenna. Scale bar: 0.2 mm.

Structures: Setae on dorsum of body relatively long (Table 1) and based on prominent projections. Gena flat (Fig. 1). Antennal segments III–IX each with a single rhinarium on apex, segments IV, VI and VIII each with one extra rhinarium; rhinarium

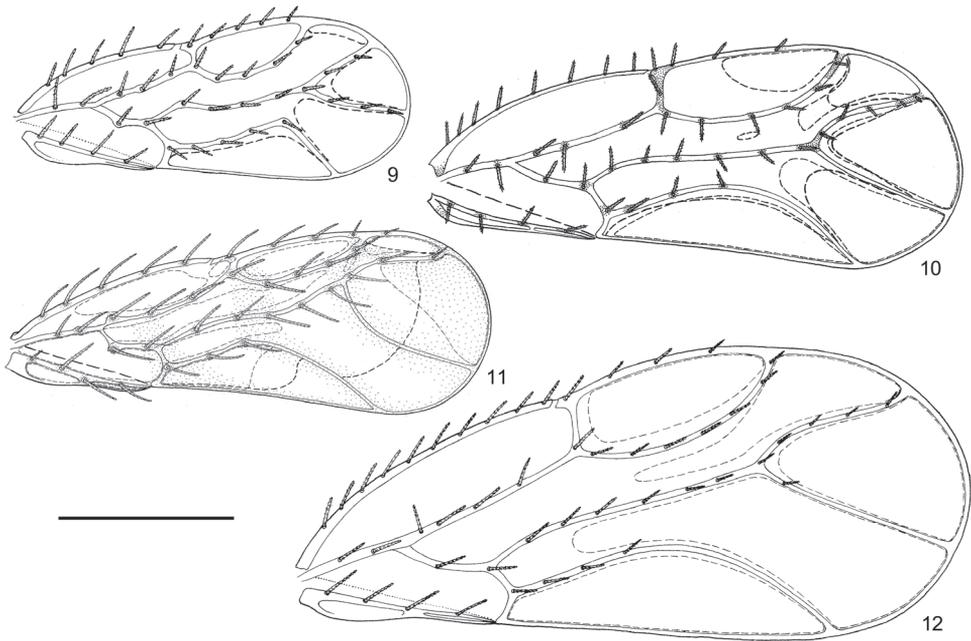


Figure 9–12. Fore wing of *Togepsylla* spp. **9** *Togepsylla glutinosae* sp. n. **10** *Togepsylla matsumurana* **11** *Togepsylla takahashii* **12** *Togepsylla tibetana*. Scale bar: 0.5 mm.

on segment IX double-pored and with complex horn-shaped projections; proximally based terminal seta about twice as long as the distally based one (Fig. 5).

Mesoscutum with four pairs of prickly setae. Metatibia with three short rows of thick setae, lacking a tightly packed row of short setae on the dorsum (Fig. 13). Apex of metabasitarsus with only one pair of simple setae (Fig. 13). Pulvilli broadly rounded (Fig. 13). Fore wing cell cu_1 tallest in apical 1/3, with vein Cu_{1a} abruptly curved at the point; vein M_{3+4} completely decorated with setae; surface spinules absent; fields of radular spinules relatively large (Fig. 9).

Pore fields on abdominal ventrum small oval; pores loosely packed (Fig. 16).

Male terminalia: Proctiger slightly curved backwards (Fig. 19). Paramere small lamellar; apical half of anterior margin with a thin lobe stretching inwards; anterior margin of basal 1/3 emarginated; two long and thick setae present on inner surface, near the anterior margin; inner surface with a curved ridge decorated with thick setae on apical half (Figs 19–21). Aedeagus with a few tiny spines on the dorsum (Fig. 19). Base of subgenital plate with a small cluster of setae (Fig. 19).

Female terminalia (Fig. 29): Oblong in overall shape. Base of proctiger slight raised, anus partly sunken; dorsal view of proctiger constricted at apical 1/3; apical process with small amounts of tiny setae. Subgenital plate lacking tip, with sparse setae on ventral surface.

Fifth instar immature. Body dorsum strongly sclerotized, ventrum weakly sclerotized. Dorsum of head, thorax and abdomen with symmetrical truncate sectasetae

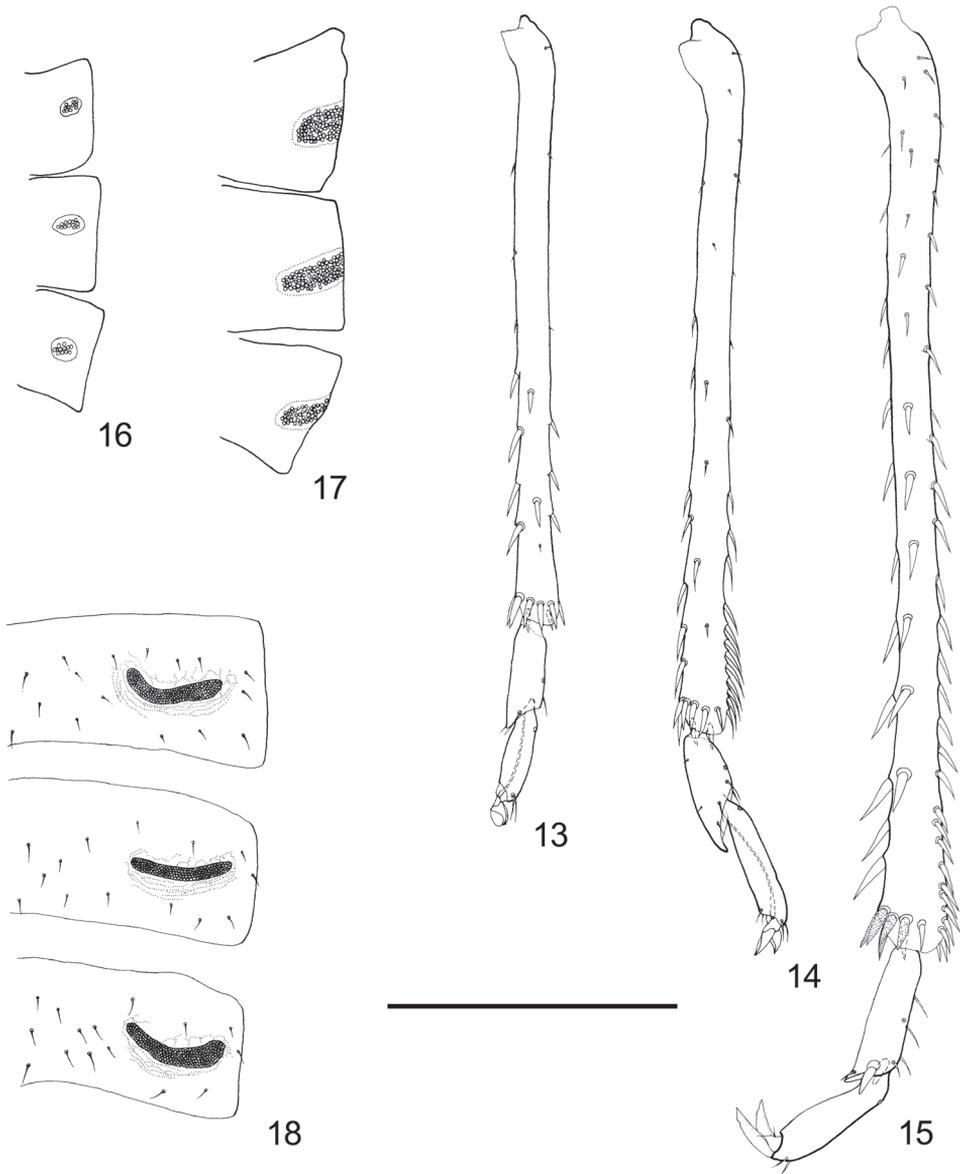


Figure 13–18. Hind legs and wax-secreting fields of *Togepsylla* spp. **13, 16** *Togepsylla glutinosae* sp. n.; **14, 17** *Togepsylla matsumurana* **15, 18** *Togepsylla takahashii* **13–15** Metafemora and tibia **16–18** Wax-secreting fields on lateral aspect of sternites of abdominal segments IV–VI. Scale bar: 0.2 mm.

varying in size, mixed with a few simple setae (Fig. 33); dorsum and margin of wing pads with roughly symmetrical truncate sectasetae (Fig. 35). Antennae 7-segmented, apices of segments 4–6 each with one single rhinarium, segments 3–6 each with one single truncate sectaseta (Fig. 34). Compound eyes with 2+2 ocular truncate sectasetae,

Table I. Measurements in mm.

Adults		HW	AL	SL	TW	WL	TL
<i>Togepsylla glutinosae</i>	4♂♂	0.34–0.36	0.36–0.47	0.65–0.92	0.32–0.35	1.00–1.08	0.40–0.45
	2♀♀	0.36–0.38	0.40–0.48	1.04–1.06	0.38–0.39	1.23–1.24	0.46–0.48
<i>Togepsylla matsumurana</i>	4♂♂	0.42–0.44	0.71–0.76	0.80–0.88	0.49–0.50	1.84–1.92	0.70–0.72
	4♀♀	0.44–0.46	0.65–0.73	0.83–0.95	0.52–0.56	2.10–2.23	0.59–0.67
<i>Togepsylla takahashii</i>	4♂♂	0.36–0.38	0.87–0.92	1.37–1.54	0.36–0.38	1.38–1.41	0.56–0.59
	3♀♀	0.39–0.41	0.92–0.96	1.47–1.58	0.42–0.44	1.53–1.62	0.67–0.69
<i>Togepsylla tibetana</i>	4♂♂	0.42–0.43	0.77–0.80	0.74–0.81	0.40–0.48	1.80–2.01	0.64–0.72
	4♀♀	0.42–0.44	0.71–0.85	0.83–0.88	0.45–0.48	1.98–2.20	0.60–0.64
Fifth instar immatures		BL	AL	HW	FL		
<i>Togepsylla glutinosae</i>	n = 5	0.89–0.99	0.34–0.38	0.29–0.33	0.30–0.35		
<i>Togepsylla matsumurana</i>	n = 2	1.14–1.30	0.38–0.47	0.35–0.42	0.42–0.51		
<i>Togepsylla takahashii</i>	n = 5	1.32–1.46	0.56–0.61	0.40–0.41	0.46–0.52		

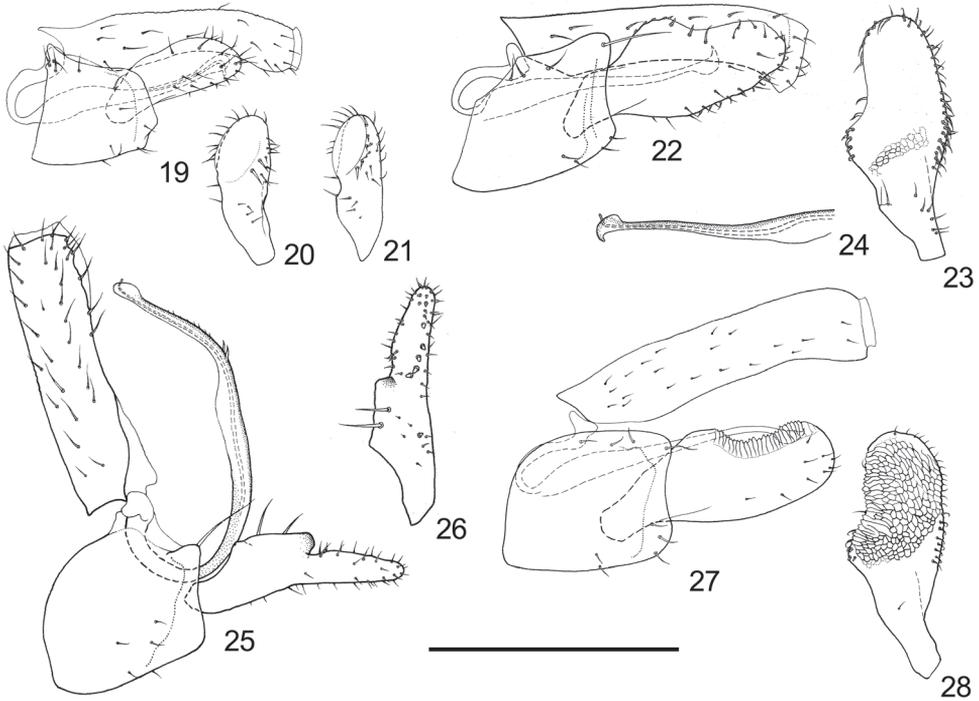


Figure 19–28. Male terminalia of *Togepsylla* spp. **19–21** *Togepsylla glutinosae* sp. n. **22–24** *Togepsylla matsumurana* **25, 26** *Togepsylla takahashii* **27, 28** *Togepsylla tibetana* **19, 22, 25, 27** Male terminalia, in profile **20, 23, 26, 28** Paramere, inner surface **21** Paramere, posterior view **24**. Apical half of aedeagus. Scale bar: 0.2 mm.

postocular truncate setasetae present in 2+2 (Fig. 33). Fore wing pad with two pores on dorsum (Fig. 35). Tarsal pulvilli broad and rounded (Fig. 36). Abdominal ventrum with four pairs of spiracles surrounded by peritremes partly fused with central sclerites. Abdominal apex produced as a pair of rounded bulges (Fig. 37). Circum anal pore field

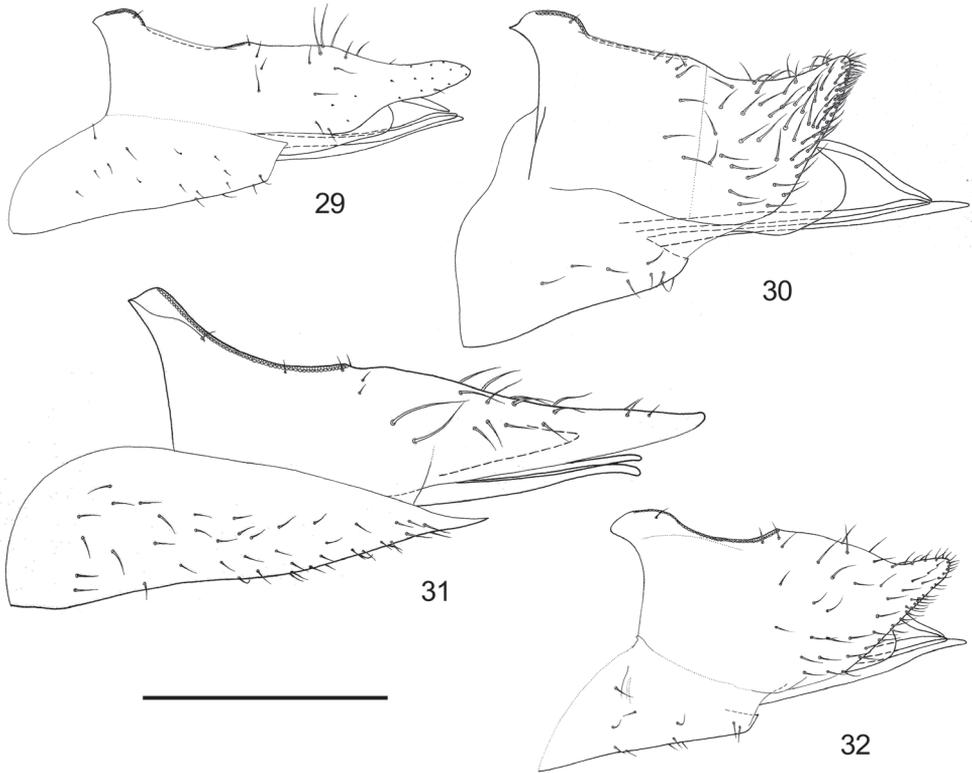


Figure 29–32. Female terminalia of *Togepssylla* spp. **A** *Togepssylla glutinosae* sp. n. **B** *Togepssylla matsumurana* **C** *Togepssylla takahashii* **D** *Togepssylla tibetana*. Scale bar: 0.2 mm.

present in between the bulges, both outer and inner ring consisting of neat single row of oval pores (Fig. 37).

Material examined. Holotype: ♂, CHINA: Hainan, Danzhou, Nada, 131 m, 19°30.878'N, 109°31.085'E, ex *Litsea glutinosa*, 12.iv.2016, Xinyu Luo (CAU). Paratypes: 10 ♂, 12 ♀, 15 immatures, same data as holotype (CAU).

Host plant. *Litsea glutinosa* (Lour.) C. B. Rob. (Lauraceae)

Distribution. **China:** Hainan.

Etymology. Named after the scientific name of the host plant.

Biology. Based on a brief observation in the field, this species was found free living, both immatures and adults are sparsely scattered across the abaxial surface of leaves (no preference for young leaves or shoots is displayed). The immatures do not induce any form of gall or leaf rolling, and from the setae on body margin they produce wax threads of varying lengths, of which the ones from the terminal bulges of abdomen are longest (Fig. 65).

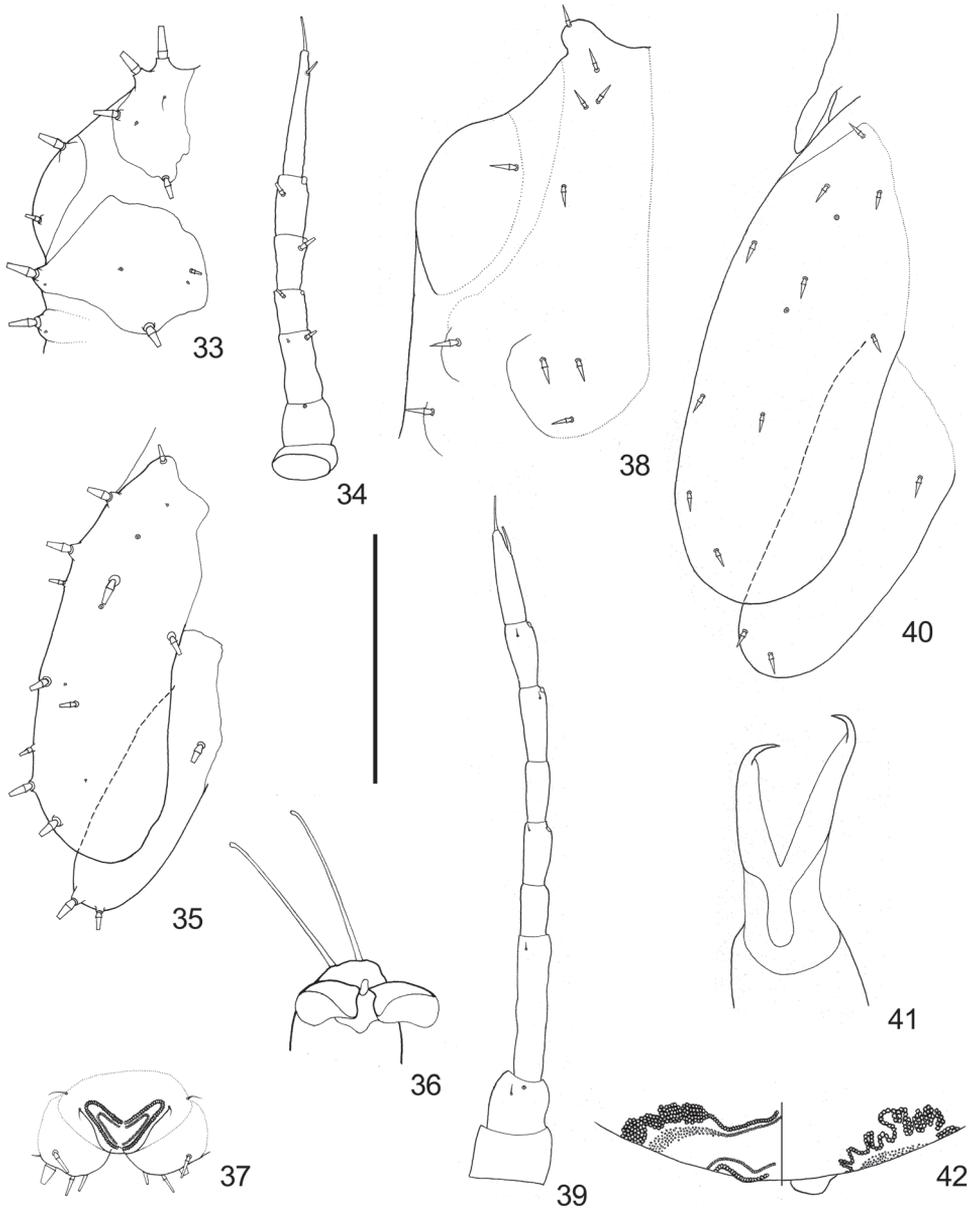


Figure 33–42. Fifth instar immature of *Togepsylla* spp. **33–37** *Togepsylla glutinosae* sp. n. **38–42** *Togepsylla takahashii* **33, 38** Half of head, dorsal view **34, 39** Antenna, dorsal view **35, 40** Wing pads, dorsal view **36** Claws, showing pulvilli and apical setae of tarsus **37** Circum anal ring, ventral view **41** Claws, showing pulvilli **42** Circum anal ring, dorsal view on the left half, ventral view on the right half. Scale bar: 0.2 mm (**33–35, 37, 38–40, 42**), 0.05 mm (**36, 41**).

***Togepssylla matsumurana* Kuwayama, 1949**

Figs 2, 6, 10, 14, 17, 22–24, 30, 43–46, 52, 62–63

Togepssylla matsumurana Kuwayama, 1949: 48; Miyatake 1970: 1; Yang 1984: 192.*Togepssylla matsumurai* Kuwayama: Miyatake 1981: 52. Misspelling.*Hemipteripsylla matsumurana* (Kuwayama): Yang and Li 1981: 182; Li 2011: 212.*Togepssylla zheana* Yang, 1995: 109. Synonymized by Li 2011: 212.

Diagnosis. Dorsum of head and thorax brown with large areas of brown patterns. Antennal segments VI and VIII each with two additional rhinaria (Fig. 6). Paramere with a small area of netlike grains on inner surface (Fig. 23). Apical 1/3 of female proctiger strongly curved upwards (Fig. 30).

Redescription. Adult coloration. Head yellow, vertex with brown patterns. Long and thick setae on dorsum black. Compound eyes light brown. Ocelli yellow. Antennae yellow, segments I-II light brown, apices of segments III, IV, VI, VIII black, segments IX-X entirely black. Thoracic dorsum brown, except for bases of setae which are yellow. Thoracic pleurites light brown. Legs yellow, with apical half of femora light brown, apex of tibiae brown. Fore wing membrane hyaline and colorless; R_1 , apices of R_s and M_{1+2} black (Fig. 10). Abdominal tergites of segments 1-5 black, sternites brown. Male proctiger brown. Female terminalia yellow.

Structures: Setae on dorsum of body relatively short (Table 1) and based on smooth projections. Vertex with a pair of small foveae between median-posterior tubercle and lateral ocelli (Fig. 2). A pair of small tubercles present above toruli (Fig. 2). Genal tubercles strongly protruding (Fig. 2). Antennal segments IV-IX each with a single rhinarium on apex, segment IV with one, segments VI and VIII each with two extra rhinaria; rhinaria without horn-shaped projection; proximally based terminal seta slightly longer than the distally based one (Fig. 6).

Mesoscutum with 5 pairs of prickly setae (Fig. 52). Metatibia with one row of thick setae ventrally, and with a tightly packed row of long setae on the dorsum (Fig. 14). Pulvilli narrow (Fig. 14). Fore wing with broad cell r_1 , cell cu_1 tallest in the middle; vein M_{3+4} without seta; surface spinules rather minute, widely spread across a relatively small area in distal cells; fields of radular spinules relatively large (Fig. 10).

Pore fields on abdominal ventrum large oval, with pores loosely packed (Fig. 17).

Male terminalia: Proctiger slightly curved backwards apically (Fig. 22). Paramere broad lamellar, with rather slender base; anterior margin of apical half emarginated and thin; posterior margin with a basal ridge on outer surface; middle of inner surface with a small area of netlike grains; anterior angle with a few short and thick setae on inner surface; posterior margin with a band of inner-curved short setae on apical 2/3 (Figs 22, 23). Tip of aedeagus forming an acute small hook, dorsum of aedeagus lacking tiny spines (Fig. 24). Subgenital plate with moderately produced dorsal-apical angle, and with a few setae on the base (Fig. 22).

Female terminalia (Fig. 30): Short and broad in overall shape. Apical 1/3 of proctiger strongly curved upwards; apical half of proctiger with nearly evenly spaced setae,

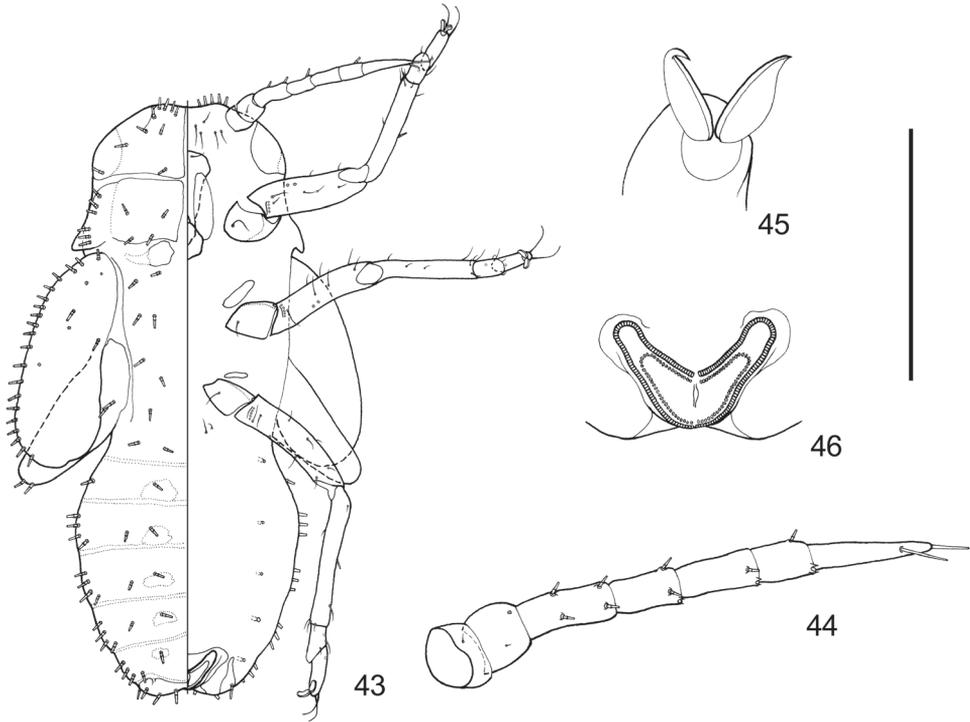


Figure 43–46. Fifth instar immature of *Togepssylla matsumurana*. **43** Overall view, dorsal view on the left half, ventral view on the right half **44** Antenna, dorsal view **45** Claws, showing pulvilli **46** Circum anal ring, ventral view. Scale bar: 0.5 mm (**43**), 0.2 mm (**44, 46**), 0.05 mm (**45**).

and with a row of setae along ventral margin of apical process. Subgenital plate with blunt and retracted apex, ventral surface with sparse setae.

Fifth instar immature. Body dorsum firmly sclerotized, with sclerites of thorax and abdomen almost unseparated; body ventrum weakly sclerotized (Fig. 43). Dorsum of head, thorax, and abdomen with symmetrical truncate sectasetae varying in size (Fig. 43). 1+1 projections present before fore wing pads, sheathing the 2+2 long setae on lateral margins of adult pronotum (Fig. 43). Antennae 7-segmented, apices of segments 4-6 each with one single rhinarium; segment 3-6 with truncate sectasetae on dorsum (Fig. 44). Compound eyes with 1+1 ocular truncate sectasetae, postocular truncate sectasetae present in 6+6 (Fig. 43). Fore wing pad with three pores on dorsum, and with outer margin completely decorated with truncate sectasetae (Fig. 43). Tarsal pulvilli narrow (Fig. 45). Abdominal ventrum with five pairs of spiracles (Fig. 43). Abdominal apex emarginated (Fig. 46). Circum anal pore field with both outer and inner ring consisting of neat single row of oval pores (Fig. 46).

Material examined. CHINA: 2 ♀, Zhejiang, Qingyuan, Baishanzu, 1300-1500 m, ex *Litsea cubeba*, 24.ix.1993, Hong Wu (CAU) (type series of *Togepssylla zheana*); 1 ♂, 2 ♀, Yunnan, Yiliang, Xiaobanchang, 1883 m, 27°48.227'N, 104°21.155'E,

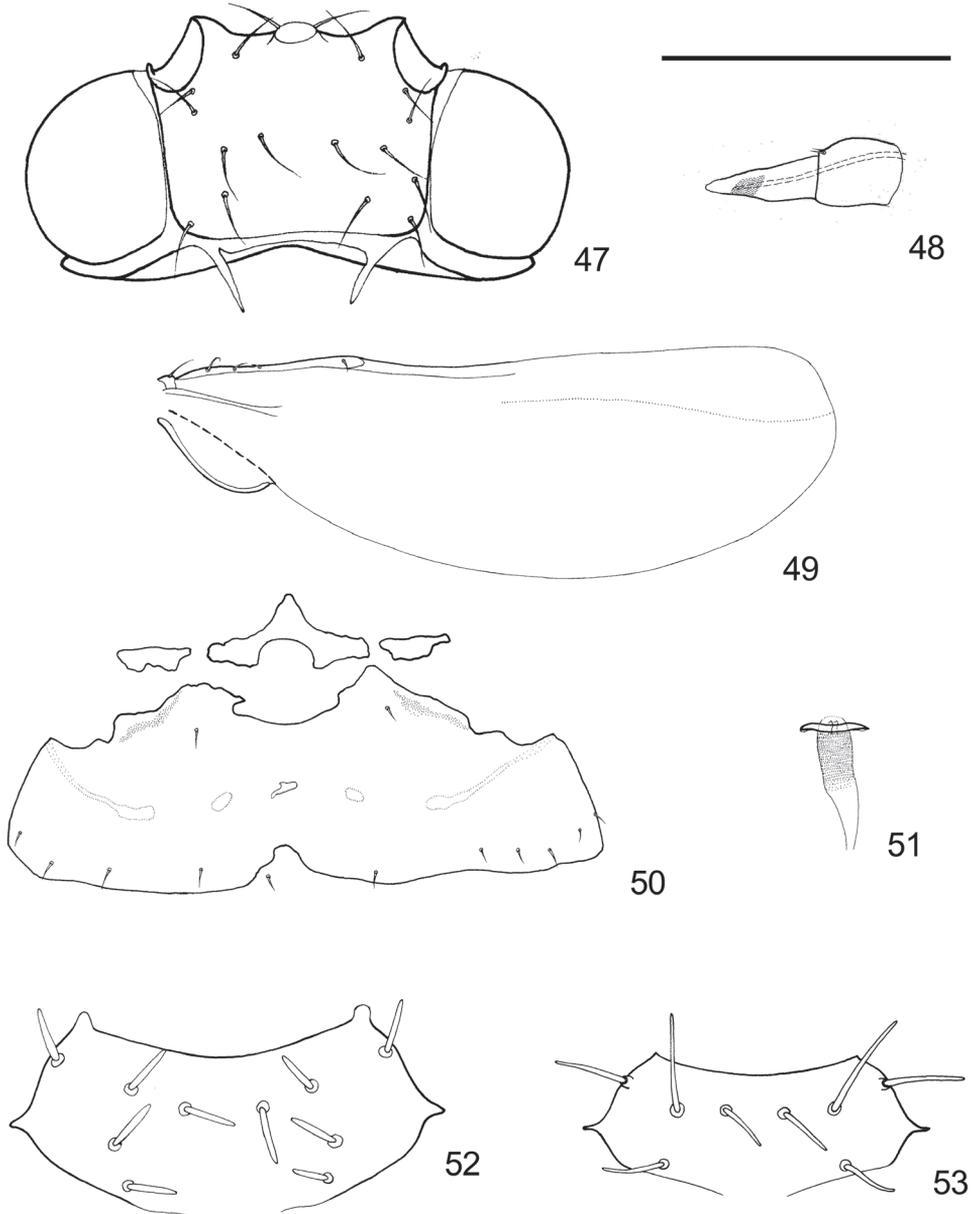


Figure 47–53. Various parts of *Togepsylla* spp. **47–51, 53** *Togepsylla takahashii* **52** *Togepsylla matsumurana* **47** Head, ventral view **48** Labium **49** Hind wing **50** Tergites of abdominal segments 1–3 **51** Sperm pump. Scale bar: 0.2 mm (**47, 48, 50, 51**), 0.5 mm (**49**), 0.32 mm (**52, 53**).

27.iv.2014, Xinyu Luo (CAU); 2 ♂, 3 ♀, Guangxi, Wuming, Mt. Daming, 1341 m, 23°30.421'N, 108°26.084'E, 12.v.2014.v.12, Xinyu Luo (CAU). JAPAN: 2 ♂, 2 ♀, 5 fifth instar immatures, Ibaraki Prefecture, Tsuchiura City, Shishisuka, 15 m,

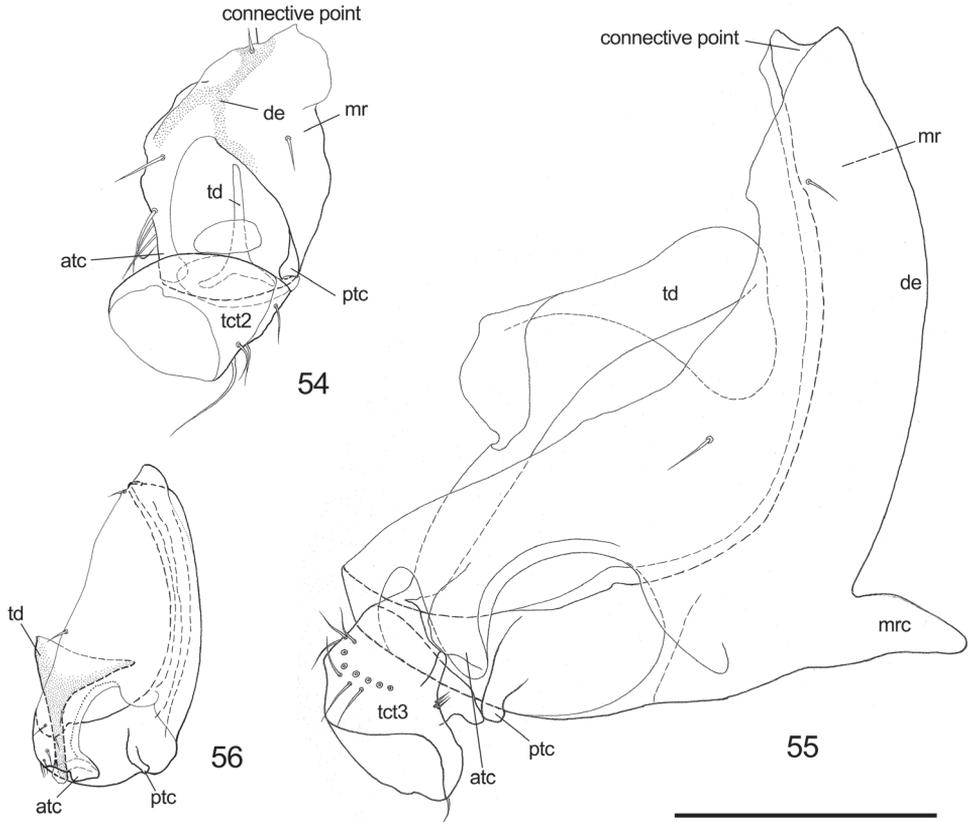


Figure 54–56. Comparison of coxa of different psyllid taxa. **54, 55** *Cacopsylla* sp. **56** *Togepsylla takahashii* **54** Mesocoxa and trochanter **55** Metacoxa and trochanter; **56**. Metacoxa. Scale bar: 0.2 mm. Abbreviations: atc = anterior trochanteral condyle; de = dorsal edge; mr = meron; mrc = meracanthus; ptc = posterior trochanteral condyle; tct = trochanter; td = trochanteral tendon.

36°4.8'N, 140°9.54'E, ex *Neolitsea sericea*, 29.iv.2004, Hiromitsu Inoue (HIC); 3 ♂, 3 ♀, Tochigi Prefecture, Kaminokawa, Kamigo, 65 m, 36°26.4'N, 139°55.98'E, ex *Neolitsea sericea*, 24.iii.2015, Rikio Sonobe (HIC); 1 ♂, 1 ♀, Fukuoka Prefecture, Mt. Hiko, 26.iv.2001, Hiromitsu Inoue (HIC).

Host plant. *Litsea cubeba* (Lour.) Pers. (Yang 1995), *Lindera erythrocarpa* Makino, *Lindera glauca* (Zieb. et Zucc.) Bl (Miyatake 1970), *Lindera* sp. (Miyatake 1981), *Neolitsea sericea* (Bl.) Koidz (HIC). (Lauraceae)

Distribution. **China:** Guangxi, Taiwan, Yunnan, Zhejiang (Yang 1984; Yang 1995); **Japan:** Ehime, Fukuoka, Gunma, Ibaraki, Kagoshima, Nagasaki, Nara, Oita, Osaka, Saga, Tochigi, Tokyo (Kuwayama 1949; Miyatake 1970; HIC, OMNH); **Nepal:** Kathmandu Valley, Mt. Phulchowki (Miyatake 1981).

Biology. Miyatake (1970) elaborately recorded the biology of the species on *Lindera erythrocarpa* and *L. glauca*. The females lay scattering eggs on the adaxial side

of spread young leaves, and by oviposition, pit galls which protrude on the abaxial surface are formed, each is occupied by one later molted immature. The species seems bivoltine, and overwinters as adults on ever green trees (at least in temperate areas of Japan).

***Togepssylla takahashii* Kuwayama, 1931**

Figs 3, 7, 11, 15, 18, 25, 26, 31, 38-42, 47-51, 53, 56, 57, 59

Togepssylla takahashii Kuwayama, 1931: 121; Takahashi 1936: 292; Yang 1984: 188; Li 2011: 213.

Togepssylla minana Yang & Li, 1981: 179. Synonymized by Li 2011: 213.

Diagnosis. Fore wing with yellow bands (Fig. 11). Metabasisarsus with a pair of thickened setae on apex (Fig. 15). Paramere with a sclerotized tooth anteriorly (Figs 25, 26). Female proctiger long and smoothly tapering apically (Fig. 31).

Redescription. Adult coloration. Ground color yellow. Compound eyes grey. Long and thick setae on dorsum black. Ocelli yellow. Antennae yellow, with black spicules on segments III-VIII; segments IX-X entirely black. Fore wing hyaline, with four obliquely transverse yellow stripes (Fig. 11). Legs yellow. Abdominal tergites brown. Male and female terminalia yellow.

Structures: Setae on dorsum of body relatively long (Table 1) and based on prominent projections. Torulus produced and slightly turned outwards (Fig. 3). Gena flat (Fig. 3). Antennal segments III-IX each with a single rhinarium on the apex, the ones on segments V and VII with small horn-shaped projections; proximally based terminal seta slightly longer than the distally based one (Fig. 7).

Mesoscutum with four pairs of prickly setae (Fig. 53). Metatibia with two rows of thick setae lateral-ventrally, and with a tightly packed row of short setae on the dorsum (Fig. 15). Apex of metabasisarsus with a pair of thick setae (Fig. 15). Pulvilli narrow (Fig. 15). Fore wing with long and narrow cell r_1 , vein M_{1+2} rather close to vein Rs, cell cu_1 tallest in the middle; vein M_{3+4} lacking seta; surface spinules as tiny thick spines, widely spread across a large area on wing membrane; fields of radular spinules relatively large (Fig. 11).

Pore fields on abdominal ventrum long, narrow and curved; pores tightly packed (Fig. 18).

Male terminalia: Distal 1/3 of proctiger with posterior surface split and replaced with membranous tissue (Fig. 25). Paramere slender and bilobed; apex of anterior lobe developed into a sclerotized tooth; anterior margin of basal 1/3 emarginated; two long and thick setae present on inner surface, near the anterior margin; apical half with a curved vertical row of small peg setae on inner surface, near posterior margin (Fig. 25, 26). Aedeagus curved forward at apical 1/4, dorsum with a short row of spines that gradually turn smaller apically (Fig. 25). Dorsal-apical angle of subgenital plate produced and with a long seta (Fig. 25).

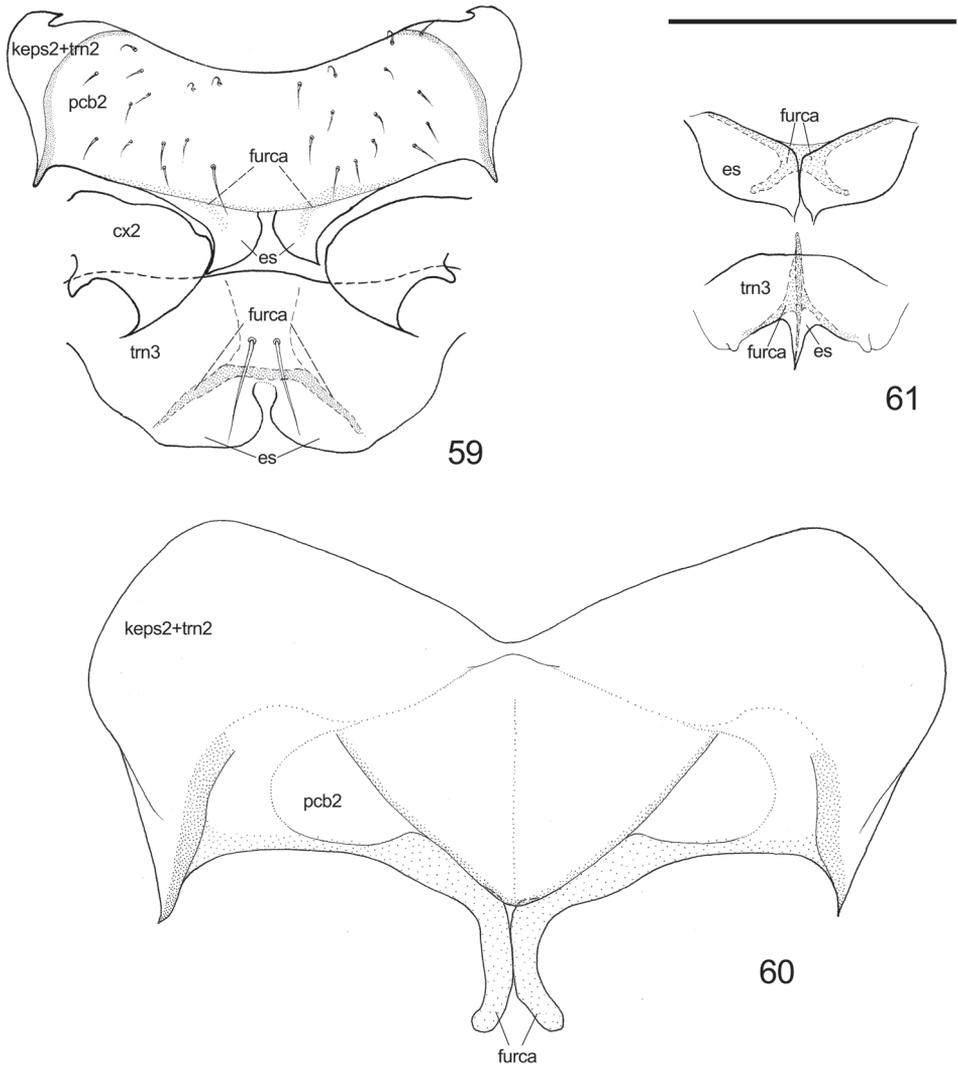


Figure 59–61. Comparison of ventral aspect of thorax. **59** *Togepssylla takahashii*, ventral aspect of meso- and metathorax **60** *Cacopsylla* sp., ventral aspect of mesothorax **61** *Trialeurodes vaporariorum*, ventral aspect of meso- and metathorax. Scale bar: 0.2 mm. Abbreviation: es = extra sclerites.

Female terminalia (Fig. 31): Long and straight in overall shape. Base of proctiger slight raised, apical process without tiny setae. Subgenital plate with acute apex, ventral surface with relatively dense and nearly evenly spaced setae.

Fifth instar immature. Body dorsum firmly sclerotized, with sclerites of thorax and abdomen almost unseparated; body ventrum weakly sclerotized. Dorsum of head, thorax, and abdomen with symmetrical acute sectasetae varying in size (Fig. 38); dorsum and margin of wing pads with roughly symmetrical acute sectasetae (Fig.

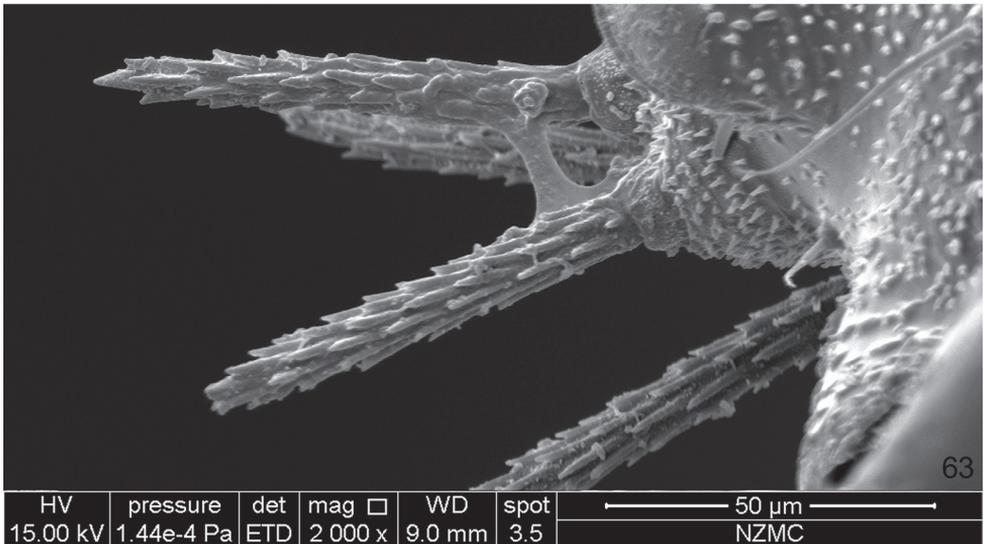
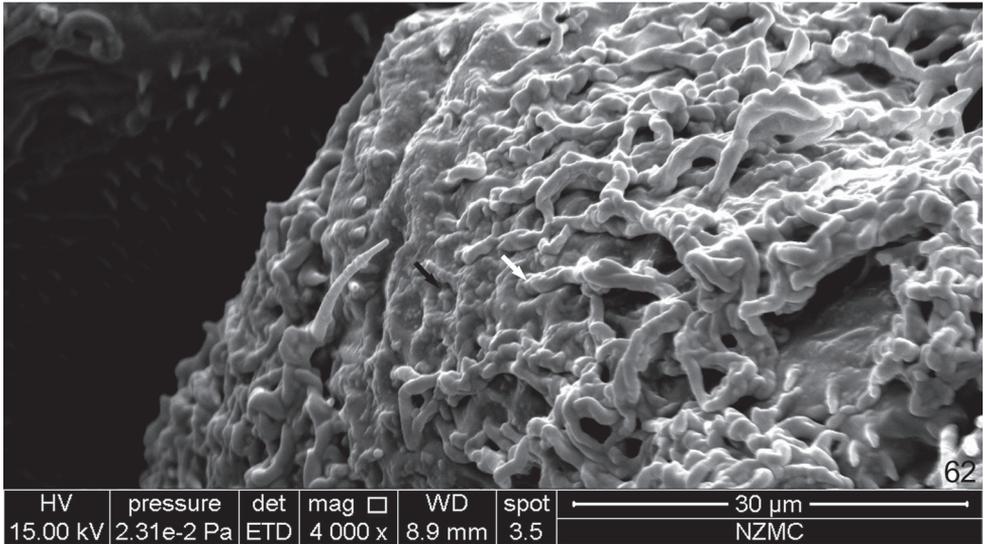


Figure 62–63. SEM photographs of *Togepsylla matsumurana*. **62** Wax-secreting field on the sternite of abdominal segment 5, black arrow showing empty pore, white arrow showing wax thread secreted **63** Prickly setae on the vertex, showing detailed structure.

40). Head with 1+1 bulges, sheathing the central two pairs of long setae of adult head (Fig. 38); 1+1 projections present before fore wing pads, sheathing the 2+2 long setae on lateral margins of adult pronotum (Fig. 40). Antennae 9-segmented, apices of segments 5, 7 and 8 each with one single rhinarium (Fig. 39). Compound eyes with 1+1 ocular acute sectasetae, postocular acute sectasetae present in 2+2 (Fig. 38). Fore wing pad with two pores on dorsum (Fig. 40). Tarsal pulvilli narrow (Fig. 41). Abdominal

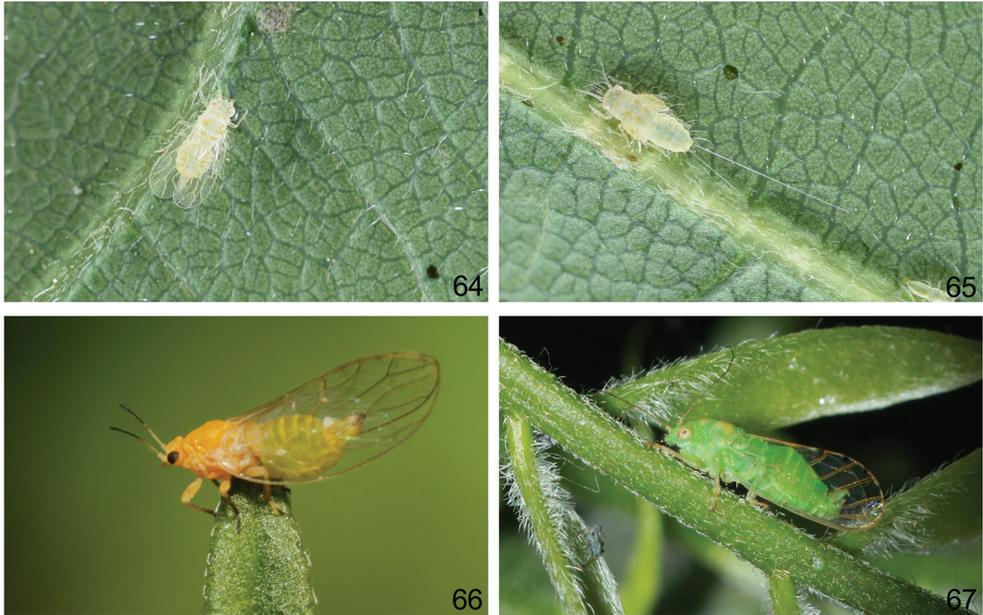


Figure 64–67. Habitus, showing difference in the ways that hind legs are held. **64** *Togepsylla glutinosae* sp. n., adult **65** *Togepsylla glutinosae* sp. n., immature **66** *Trioza urticae* (Linnaeus), adult **67** *Cyamophila hexastigma* (Horvath), adult.

ventrum with 5 pairs of spiracles surrounded by peritremes fused with central sclerites. Abdominal apex produced as a small pair of rounded bulges (Fig. 42). Anus terminal, circum anal rings present both dorsally and ventrally. Outer circum anal ring composed of oval pores, significantly expanded bilaterally, anterior aspect strongly crooked; inner circum anal ring composed of minute oval pores, expanded bilaterally, single rowed in the middle (Fig. 42).

Material examined. CHINA: 18 ♂, 21 ♀, 10 fifth instar immatures, Fujian, Shaxian, ex *Lindera communis*, 1.ix.1974, Chikun Yang and Fasheng Li (CAU, type series of *Togepsylla minana*); 35 ♂, 82 ♀, Guangxi, Liuzhou, 8.vi.1984, Fasheng Li (CAU); 40 ♂, 51 ♀, Guangxi, Lingchuan, Longkou, 5.vi.1984, Fasheng Li (CAU); 10 ♂, 5 ♀, Taiwan, New Taipei, Wulai, Fushan Nature Reserve, ex *Lindera communis*, 8.vi.2013, Xinyu Luo (CAU).

Host plant. *Lindera communis* Hemsl., *L. megaphylla* Hemsl. (= *L. oldhamii*) (Lauraceae) (Takahashi 1936).

Distribution. **China:** Fujian, Guangxi, Taiwan.

Biology: Takahashi (1936) and Li (2011) recorded that the immatures of the species feed on the abaxial surface of young leaves, inducing the edge of leaves to curl downwards, forming leaf-rolling galls that harbor large amounts of the insect. The immatures also secrete wax and honey dew. Severe damages to the host can cause most of the shoots to twist and shrink.

***Togepssylla tibetana* (Yang & Li, 1981)**

Figs 4, 8, 12, 27, 28, 32

Hemipteripsylla tibetana Yang & Li, 1981: 182; Li 2011: 209.

Togepssylla tibetana (Yang & Li): Hodkinson 1990: 716.

Diagnosis. Paramere with large area of netlike grains covering the inner surface of apical half, anterior margin serrated (Figs 27, 28). Female proctiger short, curved upwards only at the tip (Fig. 32).

Redescription. Adult coloration. Ground color yellow. Long and thick setae on dorsum yellow. Compound eyes grey. Ocelli yellow. Antennae yellow, with black spines on segments IV, VI, VIII; segments IX-X entirely black. Fore wing hyaline and colorless (Fig. 12). Male and female terminalia yellow.

Structures: Setae on dorsum of body relatively short (Table 1) and based on smooth projections. A pair of small tubercles present above toruli (Fig. 4). Gena moderately swollen bilaterally (Fig. 4). Antennal segments IV-IX each with a single rhinarium on the apex, segments IV, VI and VIII each with an extra rhinarium; all rhinaria with horn-shaped projections; proximally based terminal seta about equally long with the distally based one (Fig. 8).

Mesoscutum with five pairs of prickly setae. Metatibia with one row of thick setae ventrally, and with a tightly packed row of long setae on the dorsum. Pulvilli narrow. Fore wing with broad cell r_1 , cell cu_1 tallest in the middle; vein M_{3+4} with one seta on the base; surface spinules rather minute, widely spread across a large area in distal cells; fields of radular spinules unclear (Fig. 12).

Pore fields on abdominal ventrum large oval, with pores loosely packed.

Male terminalia: Proctiger completely sealed, with apex slightly thickened (Fig. 27). Paramere broad lamellar, with rather slender base; anterior margin of apical half emarginated, thin and serrated; posterior margin with a basal ridge; apical half of inner surface with netlike grains; anterior angle with a few short and thick setae on inner surface; posterior margin with a row of inner-curved short setae on apical half (Figs 27, 28). Aedeagus curved backwards apically, dorsum lacking tiny spines, tip forming a small acute hook (Fig. 27). Subgenital plate near rectangular in profile, dorsal-apical angle with one long seta, ventral surface with sparse setae (Fig. 27).

Female terminalia (Fig. 32): Short and broad in overall shape. Apex of proctiger moderately curved upwards; apical half of proctiger with nearly evenly spaced setae, and with a row of setae along ventral margin of apical process. Subgenital plate with blunt and retracted apex, ventral surface with sparse setae.

Fifth instar immature. Unknown.

Material examined. CHINA: 49 ♂, 69 ♀, Tibet, Nyingchi, Mafenggou, 3050 m, ex *Litsea sericea*, 1.vi.1978, Fasheng Li (CAU, type series).

Host plant. *Litsea sericea* (Nees.) Hook. f. (Lauraceae)

Distribution. China: Tibet.

Biology. Yang and Li (1981) recorded that the adults gather among the clusters of young leaves by large amount. The record of a habit similar with *T. takahashii* by Li (2011) seems artificial.

Differences between *Togepssylla* and *Syncoptozus*

The similarities and differences of the two genera have been listed by Hodkinson (1990). Nevertheless, some supplements can still be made here. *Togepssylla* possesses no median suture or discal foveae on the vertex; while *Syncoptozus* has the anterior section of median suture present, and *S. bifurcatus* possesses discal foveae (Brown and Hodkinson 1988). *Togepssylla* has rhinaria on antennal segments IV-IX, sometimes even segment III, and often with additional rhinaria; *Syncoptozus* has only one rhinarium on apex of segments IV, VI, VIII, and IX each.

Reassessment of morphology

Hind legs

Psyllids jump powerfully, then cast a mid-air rotation. Such a somersault, however, involves not only the strong muscles supported by the specialized metathoracic furca, enlarged metatrochanteral tendon and expanded meral part of the metacoxa but also a kicking of both hind legs on parallel planes (Burrows 2012), which are also parallel to the longitudinal body axis. This longitudinal placement of hind legs is caused by an inward twist of the metacoxa.

To discuss the formation of the enlarged and twisted metacoxa, one must seek reference from the mesocoxa. Mid and hind legs are both appendages of winged thoracic segments; additionally, in immature psyllids, they are equal in every detail, although differing from the forelegs in some aspects, indicating that hind legs of adults emerged from the model of mid legs. An undescribed *Cacopsylla* species is used as example:

The mesocoxa (Fig. 54) are relatively small and are connected to the coxal condyle of the mesopleurite by a dorsal-most articulation. Starting from the articulation, a thickened vertical edge runs down the outer surface, facing the lateral aspect, and is termed here as the 'dorsal edge' of the coxa. The coxa connects to the trochanter via two 'trochanteral condyles', which are longitudinally positioned, thus respectively termed 'anterior-' and 'posterior trochanteral condyle'. Such longitudinal positioning of trochanteral condyles places the mid legs on a transverse plane, a plane nearly perpendicular to the longitudinal body axis. Besides, a normally developed trochanteral tendon originates on the inner-dorsal edge of the mesotrochanter, stretching into the chamber of the mesocoxa, clinging onto the corresponding muscles.

Compared with mesocoxa, the metacoxa (Fig. 55) first experienced an enlargement of the coxal wall, which pivots over the elongation of the dorsal edge and is primarily

characterized as the expansion of the prearticular part of the coxal wall and thickening of the meron. Simultaneously, because of the unequal development of the prearticular part and the meron, the entire metacoxa is twisted backwards at approximately 90°, turning the two trochanteral condyles into a transverse position. The plane of hind leg is therefore turned longitudinal (Figs 66, 67). This pair of straightly backwards-reaching hind legs provides a much better concentration of jumping force, thereby driving the powerful jump described above. Additionally, the trochanteral tendon is magnified and possesses a tortuous apex, serving to support the strong jumping muscles.

By contrast, *Togepsylla* possesses half-modified metacoxae (Fig. 56). The enlargement is almost complete, but the positioning of the two trochanteral condyles is shifted at a limited level. For this reason, the hind legs of *Togepsylla* retain a posture similar to that of the middle legs, as shown in the habitus photograph (Fig. 64). Additionally, the trochanteral tendon is also half-enlarged: the relative size is much smaller, and the apex, although also expanded, is a simple flat surface instead of tortuous. According to the field observations by Xinyu Luo, adults of *Togepsylla glutinosae* sp. n. can only leap forward like frogs, at a short distance and without mid-air rotations.

Lateral aspect of thorax

Most psyllids possess an apophysis on meso- and metepisternal complex, termed ‘trochantinal apodeme’ (Ouvrard et al. 2002). This is an autapomorphy of Psylloidea. For mesopleuron, this structure may be on the anterior margin or median portion, depending on the taxon (Ouvrard et al. 2002). However, there are some cases like *Togepsylla* and *Pseudophacopteron* in which the trochantinal apodeme is placed on the anterior margin and reduced to an obscure vestige.

According to Ouvrard et al. (2002), the modification of psyllid metapleurite relative to mesopleurite is due to a curving of the pleural sulcus. For the metapleurite of most psyllids, taking *Cacopsylla* as example, the pleural sulcus turns downwards over the coxal condyle, becoming congruent with the elongated and internally ridged dividing suture of episternum and trochantin (Fig. 58). In *Togepsylla*, the metapleuron represents a halfway modification. The dividing suture of metepisternum and trochantin is absent, the trochantinal apodeme is shallow and in anterior position, as in mesothorax (Fig. 57).

Wax-secreting fields on abdominal sternites

Togepsylla possesses three pairs of fields of pores on sternites of abdominal segments 4–6, in both sexes. Wax secretions from these pores have been observed on *T. matsumurana* (Fig. 62). Similar structures, several pairs of wax plates composed of many small wax-secreting pores, is one of the defining characters of adult whiteflies: Whiteflies kick the wax secretions of these glands with the hind legs, and then spread the shattered wax particles over the entire body surface (Byrne and Bellows 1991). In females of Aleyrodinae, two pairs of wax plates are found, on segments 3–4, whereas in

Aleurodicinae, four, on segments 3–6; in males of Aleyrodinae, four pairs are present on segments 3–6, whereas three pairs appear on segments 3–5 in Aleurodicinae and Udamoselinae (Gill 1990; Martin 2007).

All the four members of Sternorrhyncha are known to secrete wax through integumental wax gland/pores. In scale insects whose wax glands are studied the most, these structures are highly variable in ultrastructure (shape and number of loculars of each pore) and distribution (all over the body or restricted to a certain region) (Foldi and Pearce 1985; Foldi and Lambdin 1995). Some aphid families/subfamilies possess wax gland plates, which also vary in shape and distribution, on body dorsum (Chen and Qiao 2012). These, however, are not so far known to reveal the same arrangement as Togeptyllinae and whiteflies, nor does the lack of detailed ultrastructural study of Togeptyllinae support their resemblance.

Psyllid immatures possess wax-secreting pores on their caudal plates. These pores are arranged in various patterns, mostly with a basic circum-anal ring (possibly homologous with the circum-anal ring of female adults), and on many occasions with extra pore fields (Brown and Hodlinson 1985). Extra pore fields can sometimes be succeeded by the adults, appearing on their more terminal (usually segments 7 and/or 8) abdominal tergites, e.g. *Agonosceca pegani* Loginova, 1960 and *A. sabulisa* Li, 1994 (in Li et al. 1994) (Luo 2016). Although it is not currently possible to accurately decide the homology between abdominal segments between immatures and adults, one can still roughly judge and count the separate segments of immatures by the dorsal and ventral setae rows. So far, the immature of not any species possess wax secreting pores on areas that are possibly homologous with abdominal sternites 4–6.

This is the first time that a psyllid adult is found with such fields of wax-secreting pores. Compared with those of whiteflies, wax pore fields of *Togeptylla* are strongly constricted, and the segment correspondence is different. It is uncertain whether these structures of *Togeptylla* and Aleyrodoidea are homologous or not.

Discussion

Togeptyllinae displays great differences with all the other psyllid taxa in external morphology. These include: frons completely fused with gena; gena firmly compact instead of being bisected; ‘conical sensoria’ absent from apex of labium; metapleuron distinctively arranged; metacoxa ventral aspect of metathorax as a compact sclerite; wax plates present on sternites of abdominal segments 4–6; male terminalia oriented caudally; male proctiger completely enveloped, instead of having a basal major part, which is sclerotized anteriorly and laterally, whereas membranous posteriorly, with a median suture; aedeagus one-segmented; sperm pump with only basal end plate, lacking the apical end plate; median valve of female terminalia simple, slender and placed more terminal, apex touching the subapex of ovipositor; fifth instar immatures without tarsal arolium, instead with pulvilli on claws. These traits make the current systematic position of Togeptyllinae doubtful.

Alternatively, *Togepssyllinae* share many similar characters with fossil pan-psyllids [extinct taxa included in *Psyllomorpha* by Bekker-Migdisova (1985), namely *Pincombeidae*, *Protopsyllidiidae*, *Liadopsyllidae*, *Malmopsyllidae* and *Neopsylloididae*] and whiteflies. With fossil pan-psyllids, the similarities include the half-modified jumping hind legs (compared with the none-jumping hind legs of *Liadopsyllidae* and *Malmopsyllidae*) (Ouvrard et al. 2010), the one-segmented aedeagus (particularly *Syncoptozus*, compared with *Postopsyllidium*) (Grimaldi 2003), frons fused with gena (compared with *Postopsyllidium*) (Grimaldi 2003). With whiteflies, the major similarities include the frons fused with gena, the pair of extra sclerites posterior to base of thoracic furcae (Fig. 61), presence of wax plates, one-segmented aedeagus, and absence of flag lobe on apex of valvula dorsalis of ovipositor. Similarities and differences among whiteflies, fossil pan-psyllids, *Togepssyllinae* and other modern psyllids, are listed in Table 2.

In the schematic phylogenetic tree (Burckhardt and Ouvrard 2012), *Rhinocolinae*, *Spondylaspidinae* and *Togepssyllinae* were treated as sister groups; and Drohojowska (2015), using thoracic characters, also produced a phylogeny that assigned *Togepssyllinae* and *Rhinocolinae* as sister groups. The supportive characters of Drohojowska include: anapleural cleft hardly visible; ventral view of anterior protruding of katepiternum small and oval; meracanthus absent or as very small tubercle. In *Rhinocolinae*, the most similar with *Togepssyllinae* was *Apsylla*, a genus (monotypic) with completely unmodified metacoxa (Ouvrard and Burckhardt 2010). Judging from the SEM photograph given by Drohojowska (2015: Fig. 13), hind legs of *Apsylla cistellata* (Buckton) follow the same model with *Togepssylla*, being on a plane nearly parallel with that of the middle legs. While according to the illustration in Mathur (1975), *A. cistellata* possesses no flag lobe on the apex of valvula dorsalis.

In addition to the obvious synapomorphies of *Aphalarinae* members, i.e., mesothoracic trochantal apodeme present on the anterior margin of the pleurite and metatibia with an open crown of apical spurs, *Togepssyllinae* and *Rhinocolinae* share other characters. They both have: a short clypeus; a pair of extra sclerites posterior to the base of thoracic furca; meracanthus absent or rather small; and the tubercle above the apical opening of metacoxa prominent. Most notable is the extra pair of sclerites posterior to the base of thoracic furcae. These shared characters may suggest a relatively close relationship between *Togepssyllinae* and *Aphalaridae-Rhinocolinae*.

Another species, *Atmetocranium myersi* (Ferris and Klyver) (*Calophyidae: Atmetocraniinae*), the sole member of the genus, is somewhat in resemblance with *Togepssyllinae*. Referring to a dry-mounted specimen and to the original description (Ferris and Klyver 1932: Fig. 15K), it was found that the species possesses the same type of hind legs as *Togepssyllinae*. This species also lacks the median suture on the vertex, flag lobes on valvulae dorsales of ovipositor, meracanthus on metacoxa, and metabasitarsal spurs. The immatures also possess two-segmented tarsi and lacks a tarsal arolium (Tuthill 1952). However, the male terminalia of *A. myersi* is of the common type, with proctiger and parameres oriented upward and the aedeagus two-segmented. Additionally, the gena is bisected as normal. Burckhardt and Ouvrard's (2012) assignment of

Table 2. Comparison of characters among whiteflies, fossil pan-psyllids, Togeapsyllinae, and other psyllids *sensu stricto*.

	Aleyrodoidea	Protoapsyllidae	Liadopsyllidae	Togeapsyllinae	Other Psylloidea sensu stricto
Median suture of vertex	Absent	Absent	Absent	Absent (<i>Togeapsylla</i>) or present in the anterior half of vertex (<i>Syncoptozus</i>)	Present (with a few exceptions such as <i>Pseudophacopteron</i> and <i>Armetocranium</i>)
Frons	Completely fused with gena	Completely fused with gena	Independent from gena	Completely fused with gena	Independent from gena
Clypeus	Fused with gena	Fused with gena	Attached to gena by a pair of sclerites	Attached to gena by a pair of sclerites	Attached to gena by a pair of sclerites
Labium	Long, originated before prosternum	Long, originated before ventrum of prothorax	Long, originated between procoxae	Shortened (two-segmented), originated between procoxae	Shortened (pseudo-three-segmented), originated between procoxae
Extra sclerites posterior to base of thoracic furca	Present	-	-	Present	Usually absent, but present in Rhinocolinae
Modification of metapleurite	-	-	-	Incomplete	Complete
Modification of metacoxa	Slight enlargement	Slight enlargement	Slight enlargement	Significant enlargement, slight backwards twist	Significant enlargement, backwards-twisted at 90°
Enlargement of trochanteral tendon	None	-	-	Slight	Significant
Reduction of tergite of abdominal segment I	Tergite complete	-	-	Consistent in the middle	Reduced to two separate small lateral sclerites
Wax plates	Present	-	-	Present	Absent
Aedeagus	One-segmented	One-segmented	-	One-segmented	Double-segmented
Male proctiger	Fused with subgenital plate	Fused with subgenital plate	-	Posterior aspect completely sclerotized and finely enveloped	Posterior aspect membranized
Valvulae dorsales of ovipositor	Without flag lobe	-	-	Without flag lobe	With flag lobe (except for <i>Apsylla</i>)
Ocular setae of last instar: immature	Absent	-	-	Present	Present or absent
Tarsal arolium of last instar: immature	Absent	-	-	Absent	Present

Atmetocranium into the higher Calophyidae was 'provisional', primarily based on the internal comb of apical spurs on metatibia and the one-segmented, asymmetrical antennal flagellum of immatures, but the family actually lacks defining synapomorphies (Burckhardt and Ouvrard 2012). Unfortunately, *Atmetocranium* is too scarce, and we did not have access to the slide-mounted specimens; thus, we do not know the details of its morphology, particularly those concerning the thorax. Therefore, currently, the relationship between Togepsyllinae and *Atmetocranium* remains uncertain.

Phylogeny of Togepsyllinae seems unsolvable in the current situation, given the clear fact that there are only two known genera which are distinct from each other in many traits, indicating the possible existence of further extinct members of the group. On a greater scale, the current definition of Aphalaridae needs a phylogeny-based revision, to resolve its internal relationships and to test if Togepsyllinae is an independent taxon.

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References

- Bekker-Migdisova EE (1971) On the evolution of the Homoptera-Psylomorpha. 13th International Congress of Entomology, Moscow, 231 pp.
- Bekker-Migdisova EE (1973) Sistema psillomorph (Psyllomorpha) i polozhenie gruppy v otrjade ravnokrylykh (Homoptera). In: Narchuk EP (Ed.) Doklady na dvadzat chetvertom ezhegodnom chtenii pamyati N. A. Kholodkovskogo 1–2 Aprelva 1971. Voprosy paleontologii nasekomykh, Nauka, Leningrad, 90–118.
- Bekker-Migdisova EE (1985) Iskopaemye nasekomye Psillomorfy. Trudy Paleontologicheskogo Instituta Akademiya Nauk SSSR 206: 1–94.
- Brown RG, Hodkinson ID (1988) Taxonomy and ecology of the jumping plant-lice of Panama (Homoptera: Psylloidea). E.J. Brill, Leiden, 304 pp.
- Buckton GB (1896) Notes on a new psyllid. Indian Museum Notes 3: 18–19.

- Burckhardt D, Ouvrard D (2012) A revised classification of the jumping plant-lice (Hemiptera: Psylloidea). *Zootaxa* 3509: 1–34. <http://dx.doi.org/10.11646/zootaxa.3509.1.1>
- Burrows M (2012) Jumping mechanisms in jumping plant lice (Hemiptera, Sternorrhyncha, Psyllidae). *Journal of Experimental Biology* 215: 3612–3621. <http://dx.doi.org/10.1242/jeb.074682>
- Byrne DN, Bellows TS Jr (1991) Whitefly biology. *Annual Review of Entomology* 36: 431–57. <https://doi.org/10.1146/annurev.en.36.010191.002243>
- Chen J, Qiao G (2012) Wax gland plates in Hormaphidinae (Hemiptera: Aphididae): morphological diversity and evolution. *Entomological News* 122: 27–44. <https://doi.org/10.3157/021.122.0104>
- Drohojowska J (2015) Thorax morphology and its importance in establishing relationships within Psylloidea (Hemiptera, Sternorrhyncha). *Wydawnictwo Uniwersytetu Śląskiego, Katowice*, 167 pp.
- Ferris GF, Klyver FD (1932) Report upon a Collection of Chermidae (Homoptera) from New Zealand. *Transactions of the New Zealand Institute* 63: 34–61.
- Foldi I, Lambdin P (1995) Ultrastructure and phylogenetical assessment of wax glands in pit scales (Hemiptera: Coccoidea). *International Journal of Insect Morphology and Embryology* 24: 35–49. [https://doi.org/10.1016/0020-7322\(94\)P3967-X](https://doi.org/10.1016/0020-7322(94)P3967-X)
- Foldi I, Pearce MJ (1985) Fine structure of wax glands, wax morphology and function in the female scale insect, *Pulvinaria regalis* Canard (Hemiptera: Coccidae). *International Journal of Insect Morphology and Embryology* 14: 259–271. [https://doi.org/10.1016/0020-7322\(85\)90041-8](https://doi.org/10.1016/0020-7322(85)90041-8)
- Gill RJ (1990) The morphology of whiteflies. In: Gerling D (Ed.) *Whiteflies, their Bionomics, Pest Status and Management*. Intercept, Andover, 13–46.
- Grimaldi DA (2003) First amber fossils of the extinct family Protopsyllidiidae, and their phylogenetic significance among Hemiptera. *Insect Systematics and Evolution* 34: 329–344. <https://doi.org/10.1163/187631203788964746>
- Hodkinson ID (1990) A new species of *Syncoptozus* Enderlein from Mexico with a redefinition of the subfamily Togeapsyllinae Bekker-Migdisova (Insecta: Homoptera: Psylloidea). *Journal of Natural History* 24: 711–717. <http://dx.doi.org/10.1080/00222939000770491>
- Hollis D, Broomfield PS (1989) Ficus-feeding psyllids (Homoptera), with special reference to the Homotomidae. *Bulletin of the British Museum (Natural History) Entomology* 58: 131–183.
- Kuwayama S (1931) A revision of the Psyllidae of Taiwan. *Insecta Matsumurana* 5: 117–133.
- Kuwayama S (1949) On a new species of the genus *Togeapsylla* from Japan. *Insecta Matsumurana* 17: 48–49.
- Li F (2011) *Psyllidomorpha of China* (Insecta: Hemiptera). Science Press, Beijing, 1976 pp.
- Li F, Yang C, Liu Y (1994) Two new species and a new record of *Agonosцена* Enderlein from China. *Acta Agriculturae Boreali-occidentalis Sinica* 3: 1–6.
- Liang X, Zhang C, Li Z, Xu L, Dai W (2013) Fine structure and sensory apparatus of the mouthparts of the pear psyllid, *Cacopsylla chinensis* (Yang et Li) (Hemiptera: Psyllidae). *Arthropod Structure & Development* 42: 495–506. <https://doi.org/10.1016/j.asd.2013.08.002>
- Logina MM (1960) New and little known leaf-hoppers (Homoptera, Psyllidae) of Middle Asia and Kazakhstan. *Trudy vsesoyuznogo entomologicheskogo obshchestva, Akademiya Nauk SSSR* 47: 53–93.

- Luo X (2016) Taxonomic study on the Aphalaridae and Liviidae from China. PhD thesis, China Agricultural University, Beijing, China.
- Martin JH (2007) Giant whiteflies (Sternorrhyncha, Aleyrodidae): a discussion of their taxonomic and evolutionary significance, with the description of a new species of *Udamoselis* Enderlein from Ecuador. *Tijdschrift voor Entomologie* 150: 13–29. <https://doi.org/10.1163/22119434-900000208>
- Mathur RN (1975) Psyllidae of the Indian Subcontinent. Indian Council of Agricultural Research, New Delhi, 429 pp.
- Matsuda R (1970) Morphology and evolution of the insect thorax. *Memoirs of the Entomological Society of Canada* 76: 1–431. <https://doi.org/10.4039/entm10276fv>
- Mifsud D, Burckhardt D (2002) Taxonomy and phylogeny of the Old World jumping plant-louse genus *Paurocephala* (Insecta, Hemiptera, Psylloidea). *Journal of Natural History* 36: 1887–1986. <http://dx.doi.org/10.1080/00222930110048909>
- Missouri Botanical Garden (2016) Tropicos.org. Available from: <http://www.tropicos.org/> [accessed 15 November 2016]
- Miyatake Y (1970) Some taxonomical and biological notes on *Togeipsylla matsumurana* Kuwayama, Jr. (Hemiptera: Psyllidae). *Bulletin of the Osaka Museum of Natural History* 23: 1–10.
- Miyatake Y (1981) Studies on Psyllidae of Nepal. I. Results of the survey in the Kathmandu Valley, 1979 part 1 (Hemiptera: Homoptera). *Bulletin of the Osaka Museum of Natural History* 34: 47–60.
- Ouvrard D, Bourgoïn T, Campbell BC (2002) Comparative morphological assessment of the psyllid pleuron (Insecta, Hemiptera, Sternorrhyncha). *Journal of Morphology* 252: 276–290. <http://dx.doi.org/10.1002/jmor.1105>
- Ouvrard D, Burckhardt D, Azar D, Grimaldi D (2010) Non-jumping plant-lice in Cretaceous amber (Hemiptera: Sternorrhyncha: Psylloidea). *Systematic Entomology* 35: 172–180. <http://dx.doi.org/10.1111/j.1365-3113.2009.00499.x>
- Takahashi R (1936) Food habits and new habitats of Formosan Psyllidae, with notes on the peculiar food habits of Formosan phytophagous insects. *Kontyû* 10: 291–296.
- The Angiosperm Phylogeny Group (2016) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnean Society* 181: 1–20. <https://doi.org/10.1111/boj.12385>
- Tuthill LD (1952) On the Psyllidae of New Zealand (Homoptera). *Pacific Science* 6: 83–125.
- Westwood JO (1856) The new *Aleyrodes* of the greenhouse. *Gardeners' Chronicle* 1856: 852.
- White IM, Hodkinson ID (1985) Nymphal taxonomy and systematics of the Psylloidea (Homoptera). *Bulletin of the British Museum (Natural History) Entomology* 50: 153–301.
- Yang C (1995) Homoptera: Hemipteripsyllidae. In: Wu H (Ed.) *Insects of Baishanzu Mountain, eastern China*. China Forestry Publishing House, Beijing, 109–111.
- Yang C, Li F (1981) On the new subfamily Hemipteripsyllinae (Homoptera Sternorrhyncha). *Entomotaxonomia* 3: 179–187.
- Yang CT (1984) Psyllidae of Taiwan. *Taiwan Museum Special Publication Series* 3: 1–305.
- Yang M, Burckhardt D, Fang S (2009) Psylloidea of Taiwan. Volume I. National Chung Hsing University, Taichung, 96 pp.

Three new species of the *Stenus cirrus* group from Guizhou, southwest China (Coleoptera, Staphylinidae)

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Abstract

Three new *Stenus* species of the *cirrus* group collected from Guizhou Province, southwest China, are described: *S. dashabeensis* sp. n., *S. zhangyuqingi* sp. n., and *S. liuyixiao* sp. n. The diagnostic characters of the new species are illustrated, and a key to species of the group from Guizhou Province is provided.

Keywords

China, Coleoptera, Guizhou, new species, Staphylinidae, *Stenus cirrus* group

Introduction

The *Stenus cirrus* group is a large group with 75 known species worldwide, 58 of which have been reported from China (Tang et al. 2008; Puthz 2009; Tang et al. 2016; Liu et al. 2017). The group was hitherto not recorded from Guizhou province, but three new species were collected recently and are described in this paper.

Materials and methods

The specimens examined in this paper were mainly collected at various locations in Guizhou, southwest China, by sifting leaf litter in broad-leaved forests. Specimens were euthanized with ethyl acetate and dried. For examination of the male and female genitalia, the apical three abdominal segments were detached from the body after softening in hot water. The aedeagi, together with other dissected parts, were mounted in Euparal (Chroma Gesellschaft Schmidt, Koengen, Germany) on plastic slides. Photographs of genitalia were taken with a Canon G9 camera attached to an Olympus CX31 microscope; habitus photos were taken with a Canon macro photo lens MP-E 65 mm attached to a Canon EOS7D camera and stacked with Zerene Stacker.

The type specimens treated in this study are deposited in the following public and private collections:

SHNU Department of Biology, Shanghai Normal University, P. R. China;

cPut Private collection V. Puthz, Schlitz, Germany.

The measurements of proportions are abbreviated as follows:

- BL** body length, measured from the anterior margin of the clypeus to the posterior margin of abdominal tergite X;
- FL** fore-body length, measured from the anterior margin of the clypeus to the apicolateral angle of elytra;
- HW** width of head including eyes;
- PW** width of pronotum;
- EW** width of elytra;
- PL** length of pronotum;
- EL** length of elytra, measured from humeral angle;
- SL** length of elytral suture.

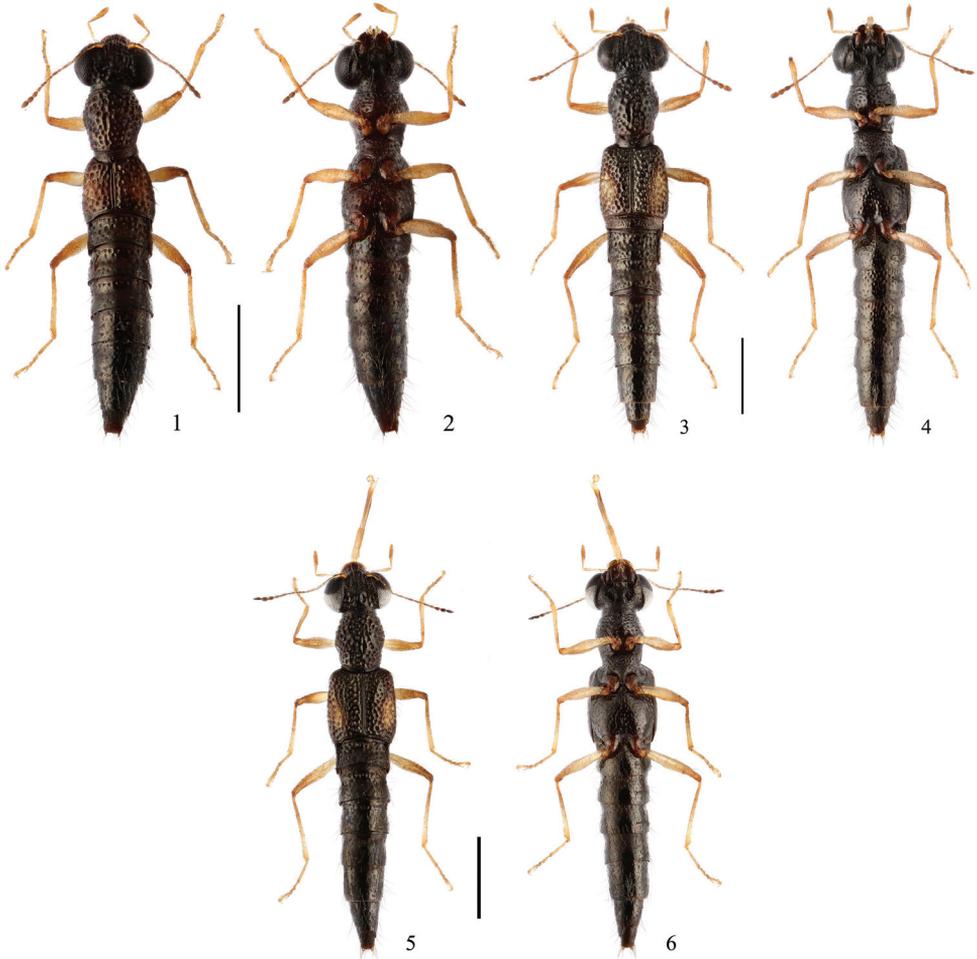
Taxonomy

Stenus dashaheensis sp. n.

<http://zoobank.org/F2CE4CFE-607D-40E0-A6AA-E31D7CAE65B1>

Figs 1, 2, 7–12

Material examined. CHINA: Guizhou: Holotype: ♂, glued on a card with labels as follows: “China: N. Guizhou, Daozhen Co., Dashahe, 29°10'12"N, 107°33'36"E, mixed leaf litter, sifted, 1730 m, 07.VII.2015, Jiang, Peng, Tu & Zhou leg.”. “Holotype / *Stenus dashaheensis* / Liu, Tang & Luo” [red handwritten label] (SHNU). **Paratypes:** 2♂♂3♀♀, same data as for the holotype. (SHNU, cPut).



Figures 1–6. Habitus. **1, 2** *Stenus dashabeensis* sp. n. **3, 4** *Stenus zhangyuyingqi* sp. n. **5, 6** *Stenus liuyixiao* sp. n. Scale bars: 1 mm.

Diagnosis. The new species can be distinguished from other related species by the following characters: body size smaller (BL < 4.2 mm), elytra distinctly shorter than wide (EL/EW = 0.84–0.90), the rather smooth surfaces of pronotum and elytra, and the larger and less confluent punctation of pronotum and elytra than abdomen.

Description. Brachypterous; body dark brown, each elytron with an orange spot near lateral margin. Antennae except the infuscate club, maxillary palpi, and legs yellowish brown. Labrum reddish brown. BL: 3.3–4.1 mm, FL: 1.7–2.0 mm. HW: 0.69–0.84 mm, PL: 0.55–0.65 mm, PW: 0.53–0.61 mm, EL: 0.57–0.68 mm, EW: 0.64–0.78 mm, SL: 0.43–0.49 mm.

Head 1.06–1.18 times as wide as elytra; interocular area with two deep longitudinal furrows, median portion convex, extending beneath the level of inner eye margins;

punctures round, slightly larger and sparser on median portion than those near inner margins of eyes, diameter of large punctures slightly wider than apical cross section of antennal segment II; interstices between punctures smooth, much narrower than half the diameter of punctures except those along the midline of the median portion, which may be slightly narrower than the diameter of punctures. Paraglossae oval.

Pronotum 0.98–1.05 times as long as wide; disk relatively smooth (without impressions) with median longitudinal furrow indistinct; punctures round and slightly confluent, variable in size, slightly larger than those of head; interstices smooth, much narrower than half the diameter of punctures except for few near the actual middle, which may be as wide as the diameter of punctures.

Elytra 0.84–0.90 times as long as wide; disk relatively smooth; punctures round to elliptical, moderately confluent, similar in size to those on pronotum; interstices smooth, distinctly smaller than half the diameter of punctures.

Legs with tarsomeres IV strongly bilobed.

Abdomen cylindrical; paratergites very narrow and almost impunctate, present only in segment III, tergites and sternites totally fused in segments IV–VI, posterior margin of tergite VII with an indistinct apical membranous fringe; punctuation of tergites III–VIII sparse and shallow, gradually becoming smaller posteriorly; interstices smooth, mostly wider than diameter of punctures except those on basal impressions of tergites III–V, which may be distinctly narrower than half the diameter of punctures.

Male. Sternite VIII (Fig. 7) with distinct triangular emargination at middle of posterior margin; sternite IX (Fig. 8) with long apicolateral projections, posterior margin serrated. Aedeagus (Figs 9–10) with apical sclerotized portion weakly prominent at apex; sclerotized expulsion clasps large, median ventral band long, narrow, dorsal bands short and relatively broad, lateral longitudinal bands short; copulatory tube stout; parameres longer than median lobe, each with 10–13 setae on apico-internal margins.

Female. Sternite VIII as in Fig. 11; sclerotized spermatheca (Fig. 12) consisting of basal duct, swollen spermathecal duct, and capsule.

Distribution. China (Guizhou).

Remarks. The new species is similar to *S. bullatus* Liu & Tang, 2017 from Guangxi, but can be easily distinguished from the latter by the less confluent punctuation of the pronotum and the elytra, and by shorter elytra (in *S. bullatus* EL/EW = 0.90–1.07).

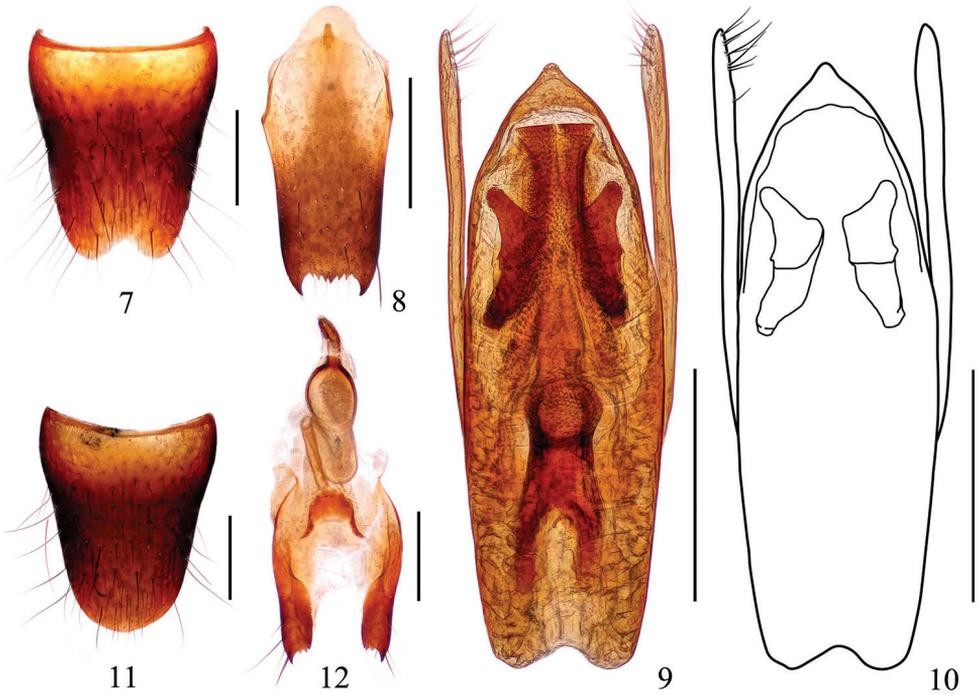
Etymology. The specific name is derived from the type locality of this species.

***Stenus zhangyuqingi* sp. n.**

<http://zoobank.org/44875E61-1CBA-4D9E-8A7E-8E47ABE1526F>

Figs 3, 4, 13–18

Material examined. CHINA: Guizhou: Holotype: ♂, glued on a card with labels as follows: “China: N. Guizhou, Libo County Maolan N.R., Dongdai, 25°17'13"N, 107°56'23"E, 792 m, 24.iv.2017, mixed leaf litter, sifted, Jiang, Jiang, Hu, Liu &



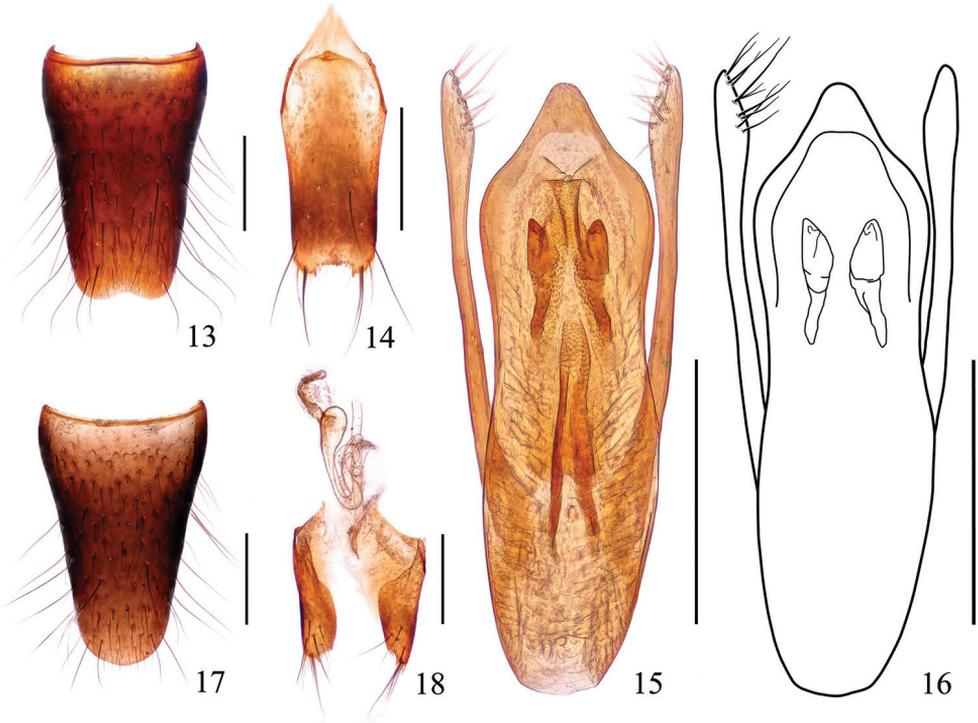
Figures 7–12. *Stenus dashabeensis* sp. n. **7** male sternite VIII **8** male sternite IX **9, 10** aedeagus. **11** female sternite VIII **12** valvifers and spermatheca. Scale bars: 0.25 mm.

Zhang leg.”. “Holotype / *Stenus zhangyuqingi* / Liu, Tang & Luo” [red handwritten label]. **Paratypes:** 4♂♂5♀♀, same data as for the holotype. (SHNU, cPt).

Diagnosis. The new species is the most characteristic of the group characterized by the largest body, longer than 4.2 mm, a broad head up to 0.83–0.96 mm, and a shallower and narrower median longitudinal furrow of the pronotum than the other two species in this paper.

Description. Macropterous; body blackish, each elytron with an elongated yellow spot near lateral margin. Antennae (except the infusate club), maxillary palpi, and legs yellowish brown. Labrum reddish brown. BL: 4.2–5.1 mm, FL: 2.1–2.5 mm. HW: 0.83–0.96 mm, PL: 0.64–0.79 mm, PW: 0.61–0.69 mm, EL: 0.84–1.00 mm, EW: 0.78–0.93 mm, SL: 0.68–0.79 mm.

Head 1.03–1.13 times as wide as elytra; interocular area with two deep longitudinal furrows, median portion convex, extending beneath the level of inner eye margins; punctures round and more or less confluent, larger and sparser on median portion than those near inner margins of eyes, diameter of large punctures larger than apical cross-section of antennal segment II; interstices between punctures smooth, much narrower than half the diameter of punctures except those along the midline of the median portion, which may be as wide as half the diameter of punctures. Paraglossae oval.



Figures 13–18. *Stenus zhangyuqingi* sp. n. **13** male sternite VIII **14** male sternite IX **15, 16** aedeagus **17** female sternite VIII **18** valvifers and spermatheca. Scale bars: 0.25 mm.

Pronotum 1.02–1.15 times as long as wide; disk with impressions, with a shallow and narrow median longitudinal furrow; punctures round and moderately confluent, variable in size, on average larger than those of head; interstices smooth, much narrower than half the diameter of punctures except for those along the middle of posterior half pronotum, which may be as wide as the diameter of punctures.

Elytra 1.07–1.16 times as long as wide; disk smooth; punctures round, moderately confluent, slightly larger than those on pronotum; interstices smooth, distinctly smaller than half the diameter of punctures.

Legs with tarsomeres IV strongly bilobed.

Abdomen cylindrical; paratergites very narrow and almost impunctate, visible only in segment III, tergites and sternites totally fused in segments IV–VI, posterior margin of tergite VII with apical membranous fringe; punctation of tergites III–VIII sparse and shallow, gradually becoming smaller posteriorly; interstices smooth, narrower than half the diameter of punctures on tergite III, narrower than half the diameter to diameter of punctures on tergites III and IV.

Male. Sternite VIII (Fig. 13) with shallow emargination at middle of posterior margin; sternite IX (Fig. 14) with long apicolateral projections, posterior margin ser-

rate. Aedeagus (Figs 15–16) with apical sclerotized portion triangular, convex at apex; internal structures: sclerotized expulsion clasps long, median ventral band long, narrow, dorsal bands long, lateral bands short; copulatory tube rather short, the main tube weakly curved near the middle; parameres longer than median lobe, slightly swollen in apical part, each with 10–12 setae on apicointernal margins.

Female. Sternite VIII as in Fig. 17; sclerotized spermatheca (Fig. 18) with spermathecal duct very coiled.

Distribution. China (Guizhou).

Remarks. The new species is closely related to *S. guangxiensis* Rougemont, 1984 from Zhejiang, Anhui, and Guangxi, as well as to *S. liuyixiaoi* sp. n., but can be easily distinguished from them by the narrower elytra (in the other two species, HW similar to or distinctly smaller than EW) and different sexual characters.

Etymology. This species is named in honor of Mr. Yu-Qing Zhang who collected some of the specimens of the new species.

***Stenus liuyixiaoi* sp. n.**

<http://zoobank.org/64D47988-137C-47E8-9786-1FF1A31BAD3E>

Figs 5, 6, 19–24

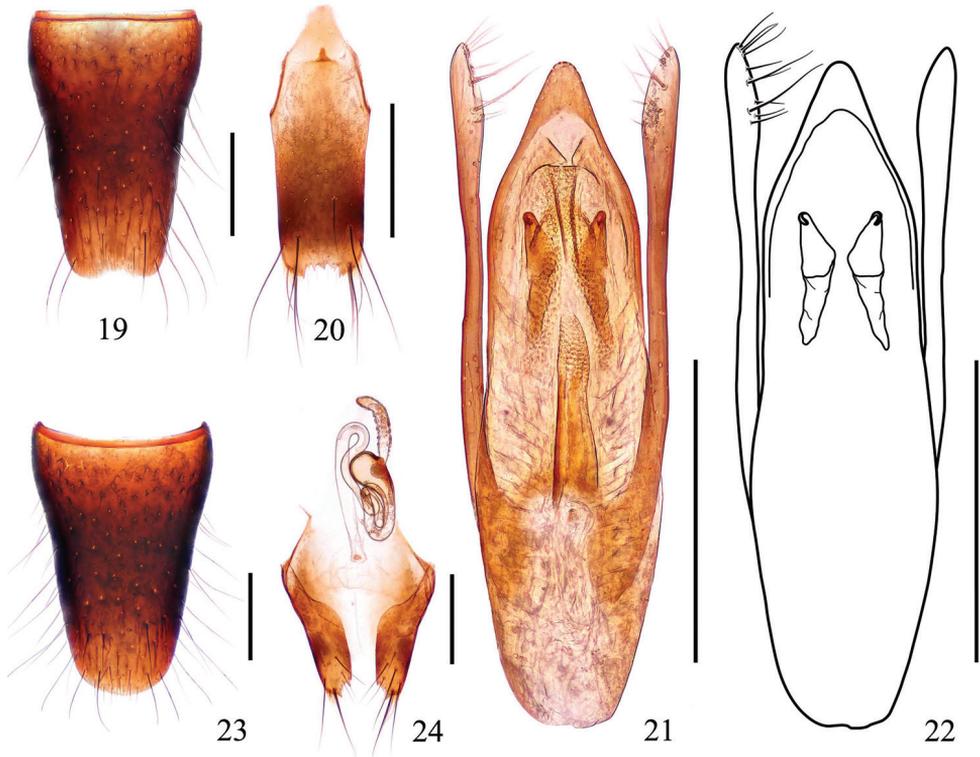
Material examined. CHINA: Guizhou: Holotype: ♂, glued on a card with labels as follows: “China: N. Guizhou, Libo County Maolan N.R., Bizuo, 25°16'59"N, 106°03'18"E, 587 m, 28.iv.2017, mixed leaf litter, sifted, Jiang, Jiang, Hu, Liu & Zhang leg.”. “Holotype / *Stenus liuyixiaoi* / Liu, Tang & Luo” [red handwritten label] (SHNU). **Paratypes:** 6♂♂9♀♀, same data as for the holotype (SHNU, cPut); 2♀♀, Maolan N.R., Dongdai, 25°17'51"N, 107°57'15"E, 808 m, 22.iv.2017, mixed leaf litter, sifted, Jiang, Jiang, Hu, Liu & Zhang leg. (SHNU); 4♂♂3♀♀, Maolan N.R., Dongdai, 25°17'58"N, 107°57'06"E, 874 m, 25.iv.2017, mixed leaf litter, sifted, Jiang, Jiang, Hu, Liu & Zhang leg. (SHNU); 1♂2♀♀, Dongdai, 25°17'13"N, 107°56'23"E, 792 m, 24.iv.2017, mixed leaf litter, sifted, Jiang, Jiang, Hu, Liu & Zhang leg. (SHNU).

Diagnosis. The new species is characterized by large body size (4.2–5.8 mm) and relatively sparse punctuation of the entire body, especially of the abdominal tergites.

Description. Macropterous; body blackish, each elytron with a large yellow spot near its lateral margin. Antennae (except the infusate club), maxillary palpi, and legs yellowish brown. Labrum reddish brown. BL: 4.2–5.8 mm, FL: 2.0–2.6 mm. HW: 0.77–0.96 mm, PL: 0.64–0.78 mm, PW: 0.61–0.72 mm, EL: 0.90–1.07 mm, EW: 0.82–1.01 mm, SL: 0.72–0.86 mm.

Head 0.93–1.03 times as wide as elytra, pronotum 1.06–1.13 times as long as wide, elytra 1.03–1.12 times as long as wide.

Other external characters as in *S. zhangyueqingi* sp. n., except that the punctuation of the pronotum and abdomen is slightly sparser.



Figures 19–24. *Stenus liuyixiaoi* sp. n. **19** male sternite VIII **20** male sternite IX **21, 22** aedeagus **23** female sternite VIII **24** valvifers and spermatheca. Scale bars: 0.25 mm.

Male. Sternite VIII (Fig. 19) with shallow emargination at middle of posterior margin; sternite IX (Fig. 20) with long apicolateral projections, posterior margin serrated. Aedeagus (Figs 21–22) with triangular apical sclerotized portion and convex apex; internal structures: sclerotized expulsion clasps large, median ventral band long, narrow, lateral bands short; copulatory tube long, weakly curved in the middle; parameres longer than median lobe, swollen at apical parts, each with 11–13 setae on apicointernal margins.

Female. Sternite VIII as in Fig. 23; spermatheca (Fig. 24) strongly sclerotized with spermathecal duct very coiled.

Distribution. China (Guizhou).

Remarks. The new species is closely related to *S. zhangyuqingi* sp. n., but may be distinguished from the latter by the relatively sparser punctation of pronotum and abdomen. It is also very similar to *S. guangxiensis* Rougemont, 1984, from which it is distinguished only based on the sexual characters.

Etymology. This species is named in honor of Mr. Yi-Xiao Liu who collected some specimens of the new species.

Key to species of the *Stenus cirrus* group of Guizhou

- 1 Brachypterous, elytra distinctly shorter than wide. Habitus: Figs 1, 2; sexual characters: Figs 7–12. BL: 3.3–4.1 mm..... ***S. dashabeensis* sp. n.**
- Macropterous, elytra distinctly longer than wide 2
- 2 Elytra broader with HW/EW = 0.93–1.03. Habitus: Figs 5, 6; sexual characters: Figs 19–24. BL: 4.2–5.8 mm..... ***S. liuyixiao* sp. n.**
- Elytra narrower with HW/EW = 1.03–1.13. Habitus: Figs 3, 4; sexual characters: Figs 13–18. BL: 4.2–5.1 mm ***S. zhangyueqing* sp. n.**

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References

- Rougemont G-M de (1984) Sur quelques *Stenus* récoltés en Chine méridionale (Col. Staphylinidae). Nouvelle Revue d'Entomologie 13(4): 351–355.
- Puthz V (1983) Beiträge zur Kenntnis der Steninen. CVC. Eine neue *Stenus*-Art aus dem südlichen China (Staphylinidae, Coleoptera). Philippia 5(2): 166–169.
- Puthz V (2009) The group of *Stenus cirrus* in Taiwan (Coleoptera: Staphylinidae) (3 10th contribution to the knowledge of Steninae). Entomological Review of Japan 64(2): 115–133.
- Tang L, Zhao Y-L, Puthz V (2008) Six new *Stenus* species of the *cirrus* group (Coleoptera, Staphylinidae) from China with a key to species of the group. Zootaxa 1745: 1–18.
- Tang L, Liu S-Y, Niu T (2016) A revision of the *Stenus flammeus* group (Coleoptera, Staphylinidae) with description of twelve new species. ZooKeys 595: 57–83. <https://doi.org/10.3897/zookeys.595.8752>
- Liu S-N, Tang L (2017) Seven new species of the *Stenus cirrus* group (Coleoptera, Staphylinidae) from Guangxi, South China. Zootaxa 4268(2): 238–254. <https://doi.org/10.11646/zootaxa.4268.2.4>
- Liu S-N, Tang L, Luo Y-T (2017) Notes on the *Stenus cirrus* group (Coleoptera, Staphylinidae) of Zhejiang, East China with descriptions of two new species (Coleoptera, Staphylinidae). ZooKeys 684: 75–84. <https://doi.org/10.3897/zookeys.684.13514>

A new species of *Zeraikia* Gil-Santana & Costa with taxonomic notes on *Zeraikia novafriburguensis* Gil-Santana & Costa (Hemiptera, Reduviidae, Peiratinae)

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Abstract

Zeraikia zeraikae sp. n. is described from the state of Rio de Janeiro, Brazil, based on one male and one female specimens. Some taxonomic notes on *Zeraikia* Gil-Santana & Costa, 2003 and *Zeraikia novafriburguensis* Gil-Santana & Costa, 2003 are provided. Detailed descriptions and several figures of the male genitalia of both species are furnished. A key for the species of *Zeraikia* is presented.

Keywords

corsairs, Heteroptera, male genitalia, Neotropics, taxonomy

Introduction

There are 11 genera of Peiratinae in the Neotropics (Maldonado 1990, Cai and Taylor 2006, Melo 2012). A summary of the taxonomic bibliography of this group in the Neotropical region and an updated key to the genera recorded there were furnished by Gil-Santana et al. (2015).

Zeraikia Gil-Santana & Costa, 2003 and *Zeraikia novafriburguensis* Gil-Santana & Costa, 2003 were described based on a single male that was collected in Nova Friburgo, a city located in a mountainous region of the state of Rio de Janeiro, Brazil (Gil-Santana and Costa 2003).

Following publication of this species, another male of *Z. novafriburguensis* was located in the Entomological Collection of the National Museum of the Federal University of Rio de Janeiro (MNRJ) and a female of the species was collected in the same locality in which the holotype was found. Through this opportunity, some additional details about this species are furnished, including a redescription of the male genitalia. Photographs of the holotype are also provided for the first time.

Zeraikia zeraikae sp. n. is described from Nova Friburgo, Brazil, based on one male and one female specimens.

A revised diagnosis and description of *Zeraikia* are presented.

Material and methods

The specimens described here are or will be deposited in the Entomological Collection of the “Museu Nacional da Universidade Federal do Rio de Janeiro”, Rio de Janeiro, Brazil (MNRJ). When citing the text on the labels of a pinned specimen, a slash (/) separates the lines and a double slash (//) different labels. All measurements are in millimeters (mm).

The photos of the male holotype of *Z. novafriburguensis* (Figs 1–2) were kindly provided by the team of the digitization project of the Entomological collection of MNRJ (“Projeto Informatização da Coleção Entomológica do Museu Nacional/UFRJ, SIBBR/CNPq proc. 405588/2015–1”). These photos were taken with a Leica DFC450 C camera attached to a Leica M205 C stereomicroscope. Multiple focal planes were merged using the auto-montage software Leica Application Suite version 4.8.0.

All remaining figures were produced by the author. The fixed adults, microscopic preparations, and genitalia were photographed using digital cameras (Nikon D5200 with a Nikon Macro Lens 105 mm and Sony DSC-W830). Drawings were made using a camera lucida. For clarity, the vestiture (setation) was completely or almost completely omitted in the ink drawings of Figs 4–5, 21–25, 41–42. Images were edited using Adobe Photoshop 7.0.

Observations were made using a Zeiss Stemi stereoscope microscope and a Leica CME compound microscope. Measurements were made using a micrometer eyepiece. The total length of the head was measured excluding the neck, for better uniformity of this measurement. Dissections of the male genitalia were made by first removing the pygophore from the abdomen with a pair of forceps and then clearing it in 20% NaOH solution for 24 hours. Following this procedure, the phallus of each species was firstly recorded without inflation (Figs 8–9, 31–32). The dissected structures were studied and photographed in glycerol. In the case of the holotype of *Z. zeraikae* sp. n., there was inadvertent breakage of the basal plate bridge of the articulatory apparatus and loss of one arm of it (Figs 32–33). The endosoma was then everted by carefully

pulling on the endosoma wall, using a pair of fine forceps, especially on the visible portion of the long tubular process, in order to release it completely from the surrounding tissues (Figs 10–14, 32, 34).

General morphological terminology mainly follows Schuh and Slater (1995). Currently, there is a lack of consensus about the terminology to be applied to female and male genitalia in Reduviidae (see Forero and Weirauch 2012). Therefore, in order to maintain uniformity with previous works (e.g. Cai and Taylor 2006), the terminology of the genitalia structures follows Lent and Wygodzinsky (1979). However, the “vesica”, as recognized by the latter authors, has been considered to be absent in reduviids. The assumed equivalent structure in reduviids is a somewhat sclerotized appendage of the phallosoma of the endosoma (Forero and Weirauch 2012) but not the homologous vesica of other heteropterans, such as Pentatomomorpha (Rédei and Tsai 2011). Thus, this term is not used here.

In general, the features already recorded in the description of *Zeraikia* are not repeated in the descriptions provided for its species.

Taxonomy

Subfamily Peiratinae

Zeraikia Gil-Santana & Costa, 2003

Zeraikia Gil-Santana & Costa, 2003: 4 [key; description], 7 [discussion]; Forero 2004: 155 [diagnosis], 155–156 [comments], 187 [key]; Cai and Taylor 2006: 51 [citation], 54 [Key]; Gil-Santana et al. 2015: 327 [key].

Type species. *Zeraikia novafriburguensis* Gil-Santana & Costa, 2003: 4–7, by monotypy.

Diagnosis. Head somewhat longer than fore lobe of pronotum; transverse sulcus distinct, shallowly impressed. Postocular region in dorsal view converging to neck from a point considerably posterior to eyes. Meso and metapleural sutures curved. Prosternal process ending short of apices of fore coxae. Space between mid coxae and hind coxae slightly smaller and wider than coxal diameter, respectively. Fore and mid tibia with spongy fossa. Spongy fossa of fore tibia occupying somewhat less than half length of the tibia, ventrally; spongy fossa of mid tibia about half size in comparison with that of fore tibiae, occupying approximately distal fourth of mid tibia, ventrally.

Description. Small sized (maximum length 10.7–12.8). *Structure:* integument mostly shiny. **Head:** integument mostly finely granulose and rugulose; on postocular region and lateral tubercles of neck there are larger granules; shorter than pronotum; somewhat longer than fore lobe of pronotum; anteocular portion longer than postocular and elongated. Transverse sulcus distinct, shallowly impressed with a small anterior median depression. Eyes of medium size, somewhat more than half as wide as interocular space in dorsal view, reaching near and far from outline of head dorsally

and ventrally, respectively; in lateral view, at level of midportion of labial segment III (second visible). Distance between ocelli approximately or somewhat more than twice diameter of ocellus. Area immediately posteroventral to eyes, somewhat prominent. Antennae inserted near eyes, elongated; segment I shortest and thickest, enlarged toward apex; remaining segments longer and progressively thinner. Labium robust, segment III (second visible) longest; segment IV thinnest, tapering; integument smooth on segments III–IV. Postocular region in dorsal view converging to neck from a point considerably posterior to eyes. Neck with a conspicuous pair of lateral tubercles, integument generally smooth and shiny. **Thorax:** integument mostly finely or coarsely granulose and rugulose; pronotal collar moderately developed, with prominent lateral lobes. Fore lobe of pronotum longer than hind lobe, lateral margins rounded in dorsal view; hind lobe enlarged toward posterior margin; lateral margins of fore and hind lobe carinate; humeral angles rounded and posterior margin convex; transverse furrow well-marked, curved, subparallel to posterior margin; fore lobe strongly longitudinally depressed in middle of posterior third, with shallow medial sulcus at anterior two-thirds and similar lateral sulci; integument finely granulose on the sulci and mostly shiny and smooth among sulci. Scutellum triangular; apical margin rounded. Prothoracic acetabula broad. Meso and metapleural sutures curved. Prosternal process elongated, tapering, ending short of apices of fore coxae, with stridulitrum occupying its midline, ventrally. Meso and metasternum finely punctuated. Mesosternum with a midlongitudinal shallow crest. Fore coxae thickened, somewhat thinner toward apices, elongated, implanted near each other; space between them smaller than width of each coxa and occupied by the prosternal process. Mid and hind coxae subglobular, progressively more widely separated from each other; space between mid coxae and hind coxae slightly smaller and wider than coxal diameter, respectively. Fore femora thickest, hind femora longest, mid femora somewhat thicker than hind femora. Fore and mid tibiae slightly shorter than respective femora and bearing spongy fossa. Fore tibiae conspicuously enlarged and somewhat curved upwards at approximately apical half; spongy fossa large, occupying somewhat less than half length of the tibia, ventrally, and surpassing its apex approximately to level of basal portion of second tarsomere. Mid tibiae somewhat enlarged at apical third to apical fourth; spongy fossa about half size in comparison with that of fore tibiae, occupying approximately distal fourth of the tibia, ventrally, and surpassing its apex approximately to the level of middle portion of first tarsomere. Hind tibiae slightly longer than femora, almost entirely straight, sometimes somewhat thickened or curved subapically. Hemelytra generally dull, not surpassing tip of abdomen in females but extending somewhat beyond it in males; on extreme base of dorsal surface, laterally, a small, somewhat elevated, translucent, rugulose area present. **Abdomen** suboval, larger in females; dorsal connexival segments also more prominent in females. Integument very finely rugulose and granulose. Sternite II (first visible) with dull and rugulose integument, granulose on median portion, sometimes also finely granulose on lateral portions. Sternites III–VII with shiny integument, variably rugulose; their median portion generally smoother, mainly in females, in which the segments are more enlarged; on sternite III a shallow median carina, sometimes in-

complete, not evident on posterior half of the segment. In males, only posterior margin of sternite VIII visible, in which there is a median posterior elongated subtriangular prolongation with the apex rounded; the remaining segment, i.e., the non-exposed part, less pigmented and less sclerotized; basal margin curved backwards on midportion ventrally. Integument somewhat rugulose on exposed portion of genital segments.

Male genitalia: asymmetrical. Exposed portion of pygophore subquadrate to subrectangular in ventral view; its non-exposed portion almost unpigmented and less sclerotized; basal margin curved backwards on midportion ventrally; median process large, elongated, strongly curved in ventral view, somewhat narrower at basal and apical portions; tip of apex blunt in ventral view and acute in lateral view. Parameres subtriangular, margins rounded; left paramere slightly longer than right paramere, with its apical portion more slender; a subapical process (**sp**) present on inner surface of both parameres, small on left paramere and larger on right paramere; just below this process, at one side, a longitudinal crest (**lc**) present on inner surface, somewhat shorter and more prominent on right paramere. Phallus suboval in shape when not inflated. Articulatory apparatus with moderately short basal plate arms (**bpa**); basal arms and basal plate bridge (**bpb**) forming a subtriangular set; basal plate bridge somewhat narrower than basal plate arms; pedicel (**pd**) moderately elongated, curved in lateral view. Dorsal phallosomal sclerite (**dps**) asymmetrical, twice curved in lateral and dorsal views, elongated; at its approximately median third there is a pair of asymmetrical rounded flat lateral expansions (**fle**); somewhat depressed at median portion, longitudinally, on dorsal surface of approximately distal half; apex rounded in dorsal view. Endosoma with three main processes: 1 – a globose to elongate subbasal larger process (**sbp**) formed by diffuse thickening; two processes formed by several to numerous variably sclerotized elements; 2 – an apical, elongated curved process (**ap**), formed by numerous sclerotized spined elements, in which the tip is surrounded by a globose expansion of endosoma (**ge**); and 3 – another process, which varies in shape, located basally or apically inside the subapical tubular projection of endosoma (**stp**). Endosoma wall longitudinally and transversely finely striated; finely rugose in some portions, especially on apical part; sometimes forming a globose small lateral lobe (**gl**); with a very long, conspicuous, subapical tubular projection (**stp**) which is apparent only after careful detachment and expansion of it apart from the surrounding tissues; in a resting position, most part of it remains embedded in phallosoma. Length of this tubular projection, when fully stretched, approximately as long as or somewhat longer than anteroposterior length of phallus.

Female genitalia: simple. Tergites IX and X obliquely directed backwards, clearly separated by a thin line; in posterior view, subtrapezoidal and subrectangular in shape, respectively.

Vestiture: integument generally covered by numerous, short, adpressed, pale to silvery setae, sometimes forming a pubescence; long to very long, darkened, stiff, straight or variably curved setae and stiff, darkened, straight or variably curved moderately short setae. **Head** covered with pale to silvery pubescence which is somewhat rarer ventrally and in postocular region, and also with scattered long oblique darkened stiff setae. Neck glabrous, except on lateral tubercles which are covered by pubescence. Eyes glabrous. Antenna: segment I less setose; pubescence and sparse, stiff, obliquely curved, short setae more numer-

ous toward apex, with a few, longer, stiff, somewhat curved to straight, darkened setae, one of them, implanted on approximately median portion of dorsal surface, is conspicuously thicker than the others. Segments II and III covered by dense pubescence formed by numerous thin, oblique, short pale setae, and scattered, longer, stiff, oblique, darkened setae. On segment II, some trichobothria present, which are variable in length, some of them very long; a conspicuous, subbasal, strong, stiff, straight, very long, darkened, dorsal seta and a subapical, dorsal, somewhat long, stiff, somewhat curved darkened seta. On segment IV, the setae forming the dense pubescence are even thinner and more adpressed, while the stiff oblique setae are somewhat longer, thinner and more numerous along the segment. Labium less setose, segments III and IV with some scattered stiff long straight setae only. **Thorax** with short, pale pubescence and variable long, stiff, straight or variably curved setae. Lateral lobes of pronotal collar with a single conspicuous, stiff, long, darkened seta. Integument glabrous on shiny and smooth areas among sulci of fore lobe of pronotum. Femora and tibiae with scattered, conspicuous, long to very long, straight, stiff, darkened setae, with variable areas also covered with pale pubescence. Pubescence on tibiae generally denser, mainly on ventral and dorsal surfaces of mid and hind tibiae; towards apical portion of the segment, tufts formed with very numerous, stiff, short, oblique, yellowish to golden-yellowish setae on ventral surface of fore tibiae, and dorsal and ventral surfaces of mid and hind tibiae. Tarsi densely covered with stiff, pale, yellowish to golden-yellowish, oblique to curved setae of variable lengths, somewhat shorter and more numerous on ventral surfaces of the segments. Hemelytra moderately setose on lateral portions of base and costal area of corium, sparsely on other portions, in which most if not all the setae are implanted on veins, with glabrous areas among them; membrane glabrous. **Abdomen:** each dorsal connexival segment with a single conspicuous long, stiff, darkened, somewhat curved to straight setae implanted just above posterolateral angle. Pubescence formed by very short and adpressed setae on connexivum and lateral portions of sternites; the latter with variable number of scattered long stiff darkened setae. In males, posterior margin of segment VII with some to several, very long, conspicuous, somewhat curved, stiff, darkened setae. **Genitalia** covered by short thin setae and longer stiff scattered setae on exposed portions. Parameres glabrous on basal portion; covered by numerous, moderately long, thin setae and a few, conspicuously longer, larger setae scattered on the exposed (outer) surface; inner surface mostly glabrous with a few rows of moderately long, thin setae basally to the inner crest and on the latter, in which the setae are more numerous and longer.

Zeraikia novafriburguensis Gil-Santana & Costa, 2003

Figures 1–18

Zeraikia novafriburguensis Gil-Santana & Costa, 2003: 4, 7 [description], 5–6 [figures 1–10]; Forero 2004: 155–156 [citation]; Gil-Santana et al. 2015: 326 [citation].

Material examined. *Zeraikia novafriburguensis*. **Type material.** BRAZIL, Rio de Janeiro, Nova Friburgo Municipality, Cascatina neighborhood (22°20'S, 42°33'W, ca. 1000 m



Figures 1–3. *Zeraikia novafriburguensis*, male. **1–2** holotype (courtesy of the team of the digitization project of the Entomological Collection of MNRJ and Luiz A. A. Costa) **1** dorsal view **2** lateral view **3** additional specimen, dorsal view. Scale bars: 5.0 mm (**1–2**); 2.0 mm (**3**).

a.s.l.), **Holotype** (male): Reduviidae / Peiratinae // Holotipo [red label] // *Zeraikia* / *novafriburguensis*. / Hécio Gil-Santana / & Luiz A. A. Costa, 2003 // 28-IX-2001 – Cascata – N. Fribur- / go – RJ – BRASIL // [QR CODE] / MNRJ-ENT3-142 (MNRJ).

Additional specimens. BRAZIL, Santa Catarina, Corupá Municipality, x. 1944, 01 male; Nova Friburgo, Cascatina neighborhood (22°20'S, 42°33'W, ca. 1000 m a.s.l.), 19.xii.2003, 01 female, (MNRJ).

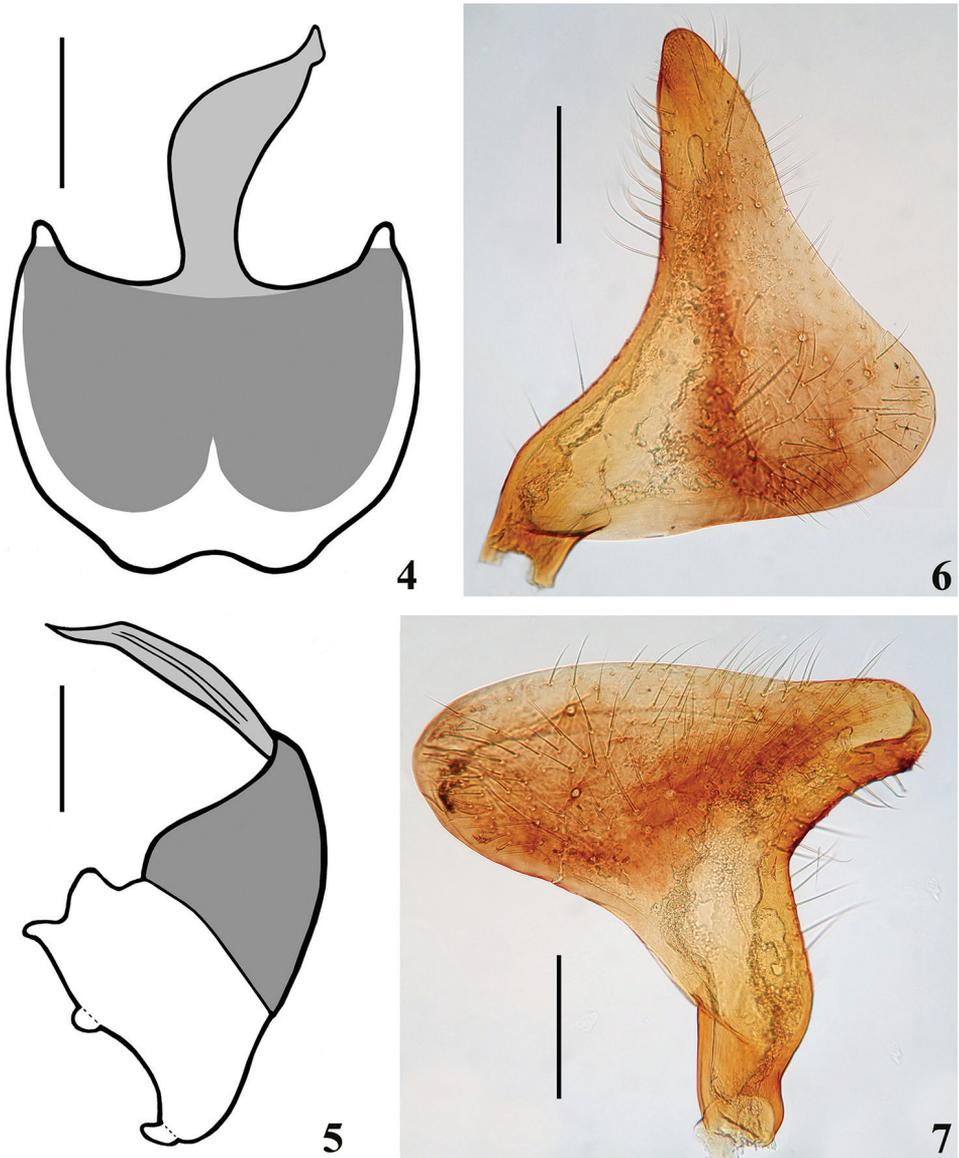
Diagnosis. General coloration blackish to brownish black, sometimes with subtle bluish luster, mainly on sternites. General coloration of corium, clavus and basal portion of membrane of hemelytra orange to reddish orange. Labial segments III and IV, coxae, trochanters, tibiae and tarsi distinctly or extensively marked with pale to yellowish pale markings. Pale markings of connexivum large, occupying approximately basal half of each segment. Several long stiff dark setae on ventral surface of femora, mainly on fore and mid femora, implanted in small rounded tubercles.

Addition to the original description. Male. Figures 1–17. Measurements (holotype /additional male): total length: to tip of hemelytra: 10.7 / 11.0; to tip of abdomen: 10.2 / 10.4; abdomen maximum width: 3.0 / 3.2.

Coloration: general coloration blackish to brownish black, sometimes with subtle bluish luster, mainly on sternites (Figs 1–3). Head with the following pale to pale yellowish parts: base and a submedian distal ring, somewhat variable in extent on antennal segment I; apex of antennal segment II; most of basal two-thirds of labial segment III (second visible), and apices of the labial segments III and IV. Posterior margin of hind lobe of pronotum somewhat paler in the additional male (Fig. 3). Apex of prosternal process paler. Coxae pale yellowish in approximately apical two-thirds. Trochanters pale yellow with apices darkened. Mid and hind femora with moderately large, subbasal, pale yellow rings. Fore femora with a small, almost imperceptible, paler, subapical spot, dorsally. Mid femora with a narrow, interrupted or incomplete, subdistal pale ring. Tibiae with a narrow, pale, subbasal ring. Fore and mid tibiae with apical half paler, of variable extent around the segment. Tarsi generally pale to pale yellow, with segments II and III darkened at base and apex. Hemelytra (Figs 1, 3): most of corium and clavus and basal portion of membrane orange to reddish orange; corium and clavus darkened to blackish in basal portion; most of membrane blackish with a median apical large pale yellow spot, somewhat enlarged towards apex, and somewhat larger in the additional male. Connexivum with approximately basal half of segments III–VII pale to pale yellow (Figs 1, 3).

Structure and vestiture: generally as in generic description. Tip of scutellum horizontal, directed backwards. Several long stiff dark setae on ventral surface of femora, mainly on fore and mid femora, implanted in small rounded tubercles. Hemelytra covered with numerous adpressed setae on costal area and numerous and longer stiff setae on veins of corium, surpassing abdomen by about half a millimeter.

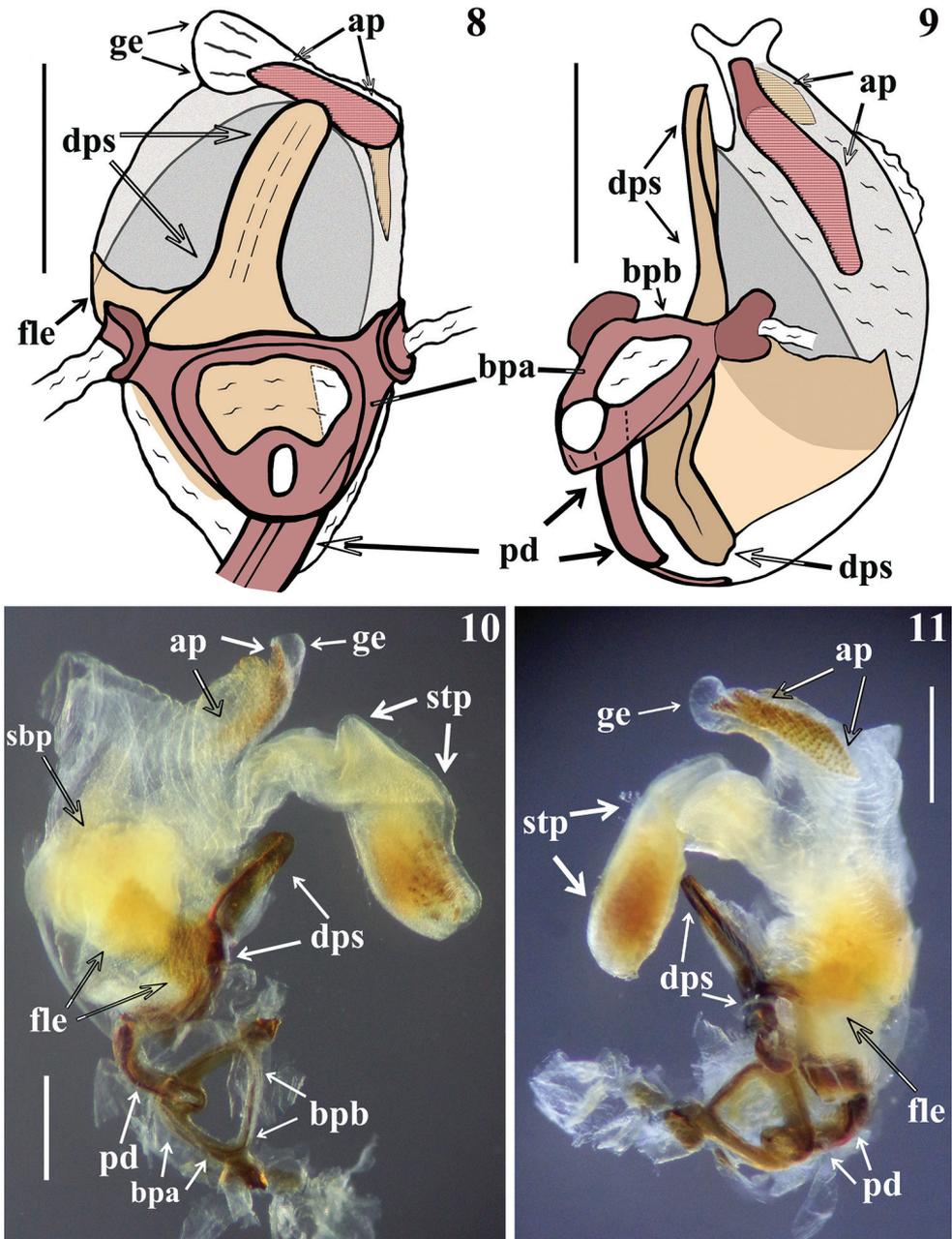
Male genitalia (in addition to generic characteristics described above) (Figs 4–17): both subapical processes of parameres spiniform. Dorsal phallosclerite (**dps**): very curved in lateral view at basal third (Figs 9–11); flat lateral expansions of the mid third (**fle**) prolonged laterally to approximately half the distance between dorsal and ventral surfaces (Figs 10–11, 14); left (in dorsal view) flat lateral expansion somewhat more than half the width of opposite flat lateral expansion (Figs 10–14); apical third of dorsal phallosclerite almost straight in lateral view (Figs 9, 11). Diameter of subapical tubular projection of endosoma wall (**stp**) roughly uniform,



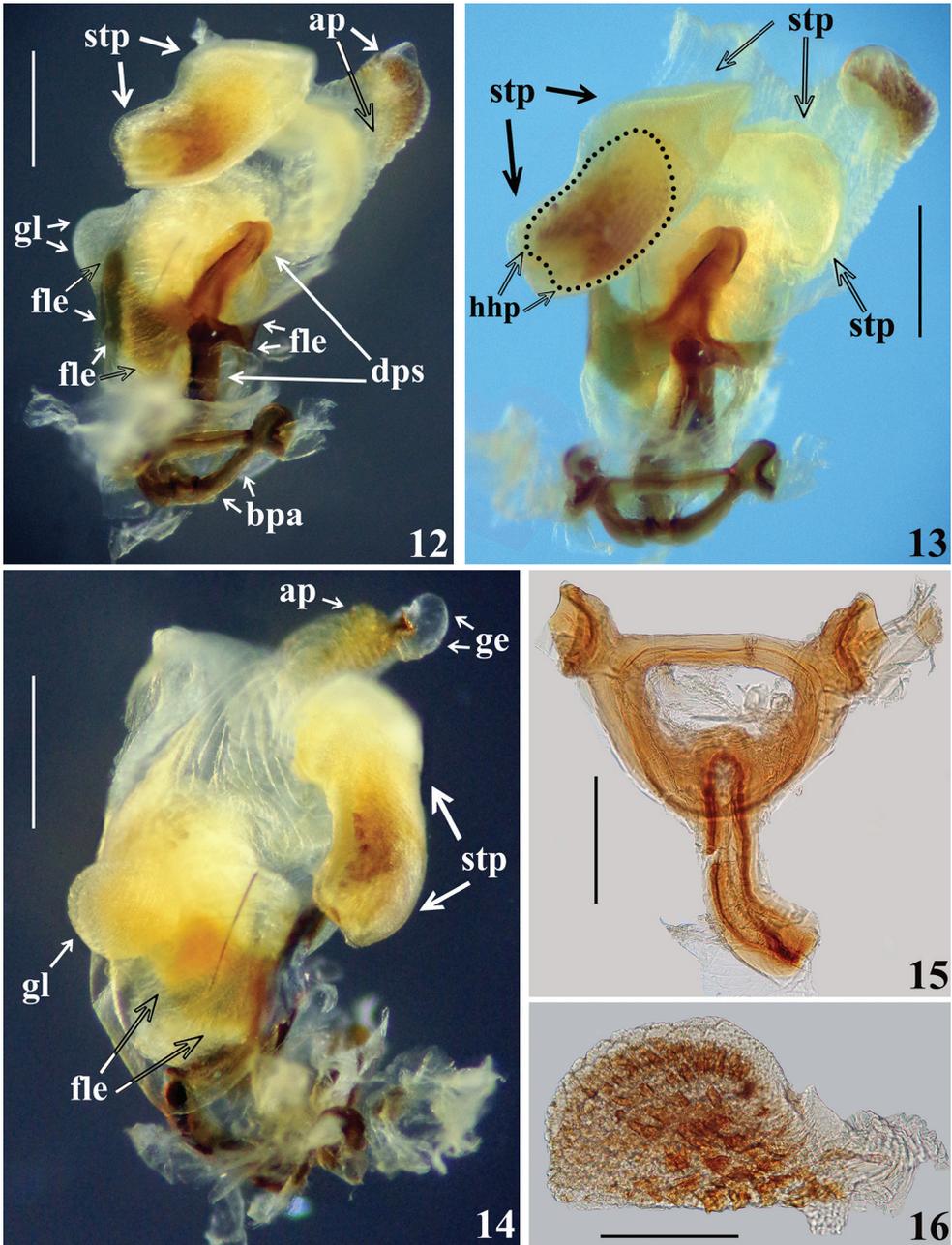
Figures 4–7. *Zeraikia novafriburguensis*, male genitalia. **4–5** pygophore without parameres **4** ventral view **5** lateral view **6** left paramere **7** right paramere. Scale bars: 0.5 mm (**4–5**); 0.3 mm (**6–7**).

with a half-hemispherical process (**hhp**) inside its apical portion (Figs 10–14), which is covered by several small sclerotized components, some of which are acutely spined (Fig. 16). Endosoma wall with a small rounded globose lobe laterally (**gl**), located just ventrally to apex of larger flat lateral expansion of dorsal phallosclerite (Figs 12, 14).

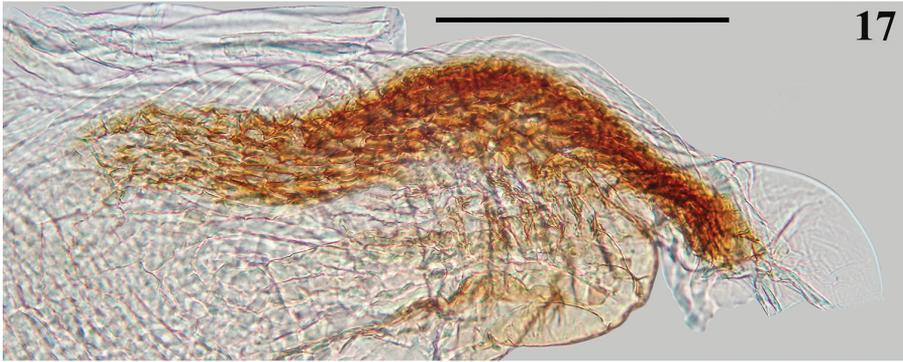
Female. Figure 18. Measurements: total length to tip of abdomen: 12.5; abdomen maximum width: 4.0. Similar to male. Hemelytra not surpassing abdomen, ending



Figures 8–11. *Zeratikia novafriburguensis*, male genitalia. **8–9** phallus not inflated **8** dorsal view **9** latero-dorsal view **10–11** phallus with endosoma inflated, lateral views. (**ap** apical process of endosoma; **bpa** basal plate arm; **bpb** basal plate bridge; **dps** dorsal phallosclerite; **fle** flat lateral expansion; **ge** globose expansion of endosoma; **pd** pedicel; **sbp** subbasal process of endosoma; **stp** subapical tubular projection of endosoma wall). Scale bars: 0.5 mm.



Figures 12–16. *Zeraikia novafriburguensis*, male genitalia. **12–14** phallus with endosoma inflated **12–13** dorsal view **14** lateral view **15** articular apparatus and pedicel **16** half-hemispherical process. (**ap** apical process of endosoma; **bpa** basal plate arm; **dps** dorsal phallothecal sclerite; **fle** flat lateral expansion; **ge** globose expansion of endosoma; **gl** small lateral globose lobe of endosoma wall; **hhp** half-hemispherical process; **stp** subapical tubular projection of endosoma wall). Scale bars: 0.5 mm (**12–14**); 0.3 mm (**15–16**).



17



18

Figures 17–18. *Zenaikia novafriburguensis*. **17** male genitalia, apical process of endosoma (**ap**) **18** female, dorsal view. Scale bars: 0.3 mm (**17**); 2.0 mm (**18**).

shortly after posterior margin of dorsal portion of segment VIII; pale yellow distal spot of the membrane somewhat larger at basal half, subrounded. Abdomen larger; dorsal connexival segments somewhat more evident.

Distribution. Brazil, in states of Rio de Janeiro and Santa Catarina.

***Zeraikia zeraikae* sp. n.**

<http://zoobank.org/A15DABA5-F9EA-4FDA-BE26-B6A48E61AAA2>

Figures 19–42

Type material. BRAZIL, Rio de Janeiro, Nova Friburgo Municipality (22°17'S, 42°29'W, ca. 1049 m a.s.l.), 05.xi.1997, **Holotype** (male); iii.1996, **Paratype** (female).

Diagnosis. General coloration black with bluish luster. General color of corium, clavus and basal half of membrane of hemelytra dull blackish. Labium, coxae, trochanters, tibiae and tarsi mostly or completely darkened, without conspicuous pale markings. Pale markings of connexivum relatively small, occupying approximately basolateral third and fifth of segments III–VI and VII, respectively. Long stiff dark setae on ventral surface of femora relatively smaller and not implanted in tubercles.

Description. Male. Figures 19–38. Measurements are given in Table 1.

Coloration: general coloration black with bluish luster, mostly very shiny, except on hemelytra, which are completely dull (Fig. 19). Extreme base of antennal segment I pale whitish. Apex of labial segment III (second visible) paler; apical half of labial segment IV reddish brown. Extreme base of trochanters somewhat paler; extreme apex of mid and hind trochanters pale. Mid and hind femora with a subbasal whitish marking that occupies the dorsal and lateral surfaces, but does not form a ring because it does not reach the ventral surface; larger on hind femora. Fore tarsomere I paler. Hemelytra: apical portion of clavus and adjacent portion of corium with a faintly smoky grayish marking just below level of apex of scutellum; an arcuate marking with similar coloration present just above mid portion of hemelytra, which crosses median third of upper closed cell, running as far as inner (posterior) margin; the latter somewhat paler to faintly smoky grayish from this arcuate marking to level of approximately mid portion of membrane (Figs 19–20). Membrane with a large subrounded yellowish orange spot at approximately distal half (Figs 19–20). Pale whitish spots on basolateral third and fifth of connexival segments III–VI and VII, respectively (Figs 19–20).

Structure and vestiture: generally as in generic description. Tip of scutellum directed obliquely upwards. Long stiff dark setae on ventral surface of femora relatively smaller and not implanted in tubercles. Hemelytra with thinner and less numerous setae in costal area and on veins of corium, surpassing abdomen by somewhat more than one millimeter.

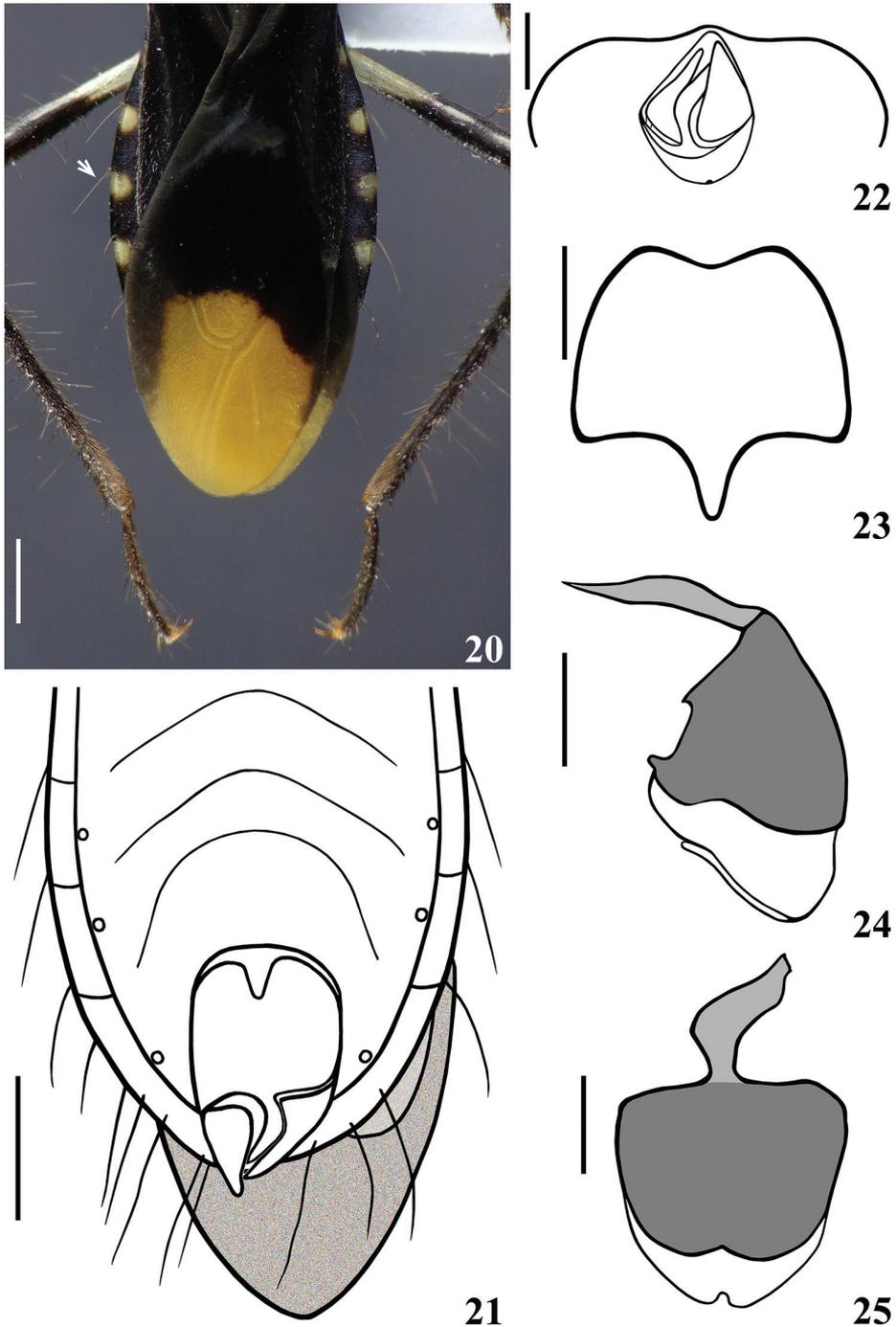
Male genitalia (in addition to generic characteristics described above) (Figs 21–38): subapical process (**sp**) of right paramere spiniform (Fig. 30); blunt on left paramere (Figs 27–28). Dorsal phallosclerite (**dps**) (Figs 31–34): less curved in lateral view at basal third; flat lateral expansions (**fle**) of mid third prolonged laterally approximate-

Table 1. Measurements of *Zeraikia zeraikae* sp. n.

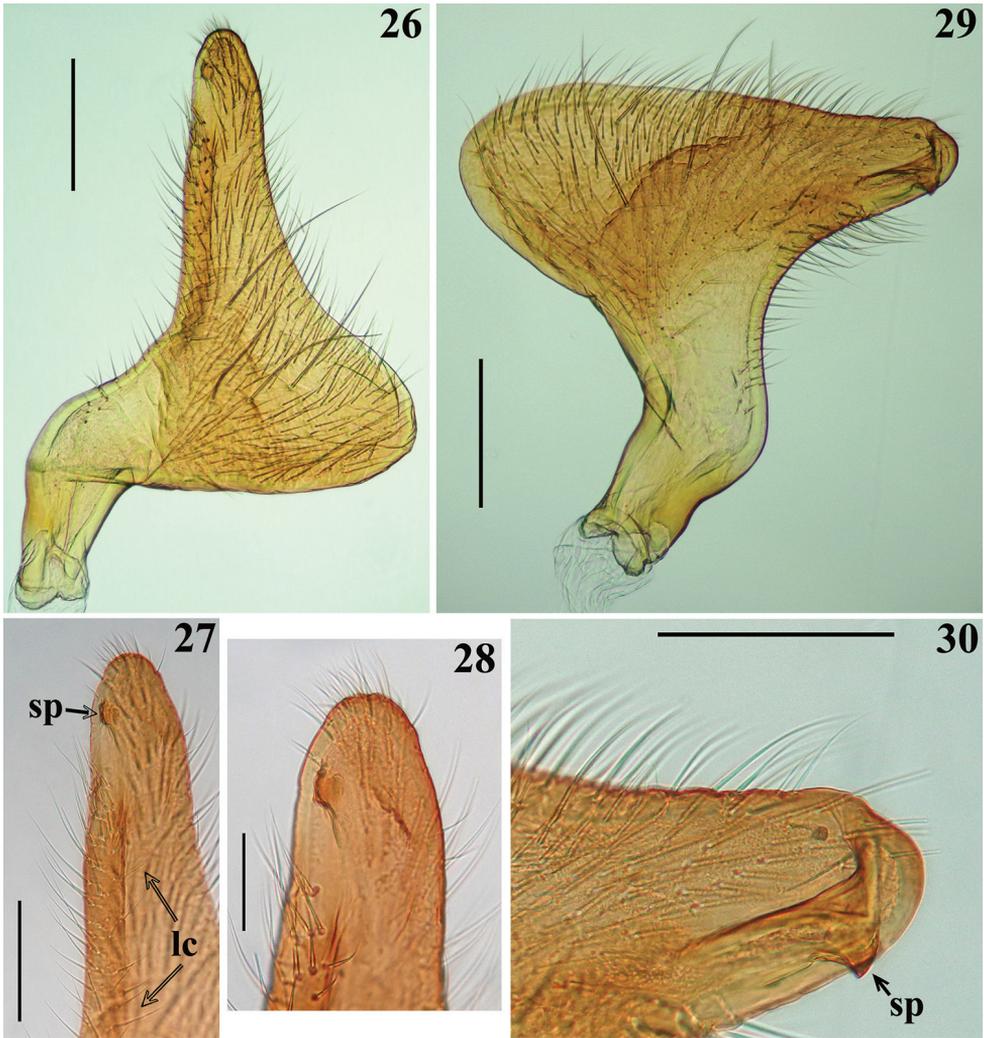
Measurements	Holotype male	Paratype female
Body length to tip of hemelytra	11.9	-
Body length to tip of abdomen	10.8	12.8
Head length (excluding neck)	2.0	2.0
Anteocular portion length	1.0	1.0
Postocular portion length	0.4	0.4
Head width across eyes	1.2	1.3
Interocular distance	0.5	0.6
Transverse width of eye	0.35	0.4
Antennal segment I length	0.7	0.7
Antennal segment II length	2.4	2.0
Antennal segment III length	1.8	1.5
Antennal segment IV length	2.0	1.8
Labial segment II length	0.6	0.6
Labial segment III length	1.0	1.0
Labial segment IV length	0.7	0.7
Ocellar tubercle width	0.5	0.5
Fore lobe of pronotum length	1.5	1.6
Fore lobe of pronotum max. width	1.8	2.0
Hind lobe of pronotum length	1.0	1.0
Hind lobe of pronotum max. width	2.8	3.0
Scutellum length	1.0	1.0
Scutellum maximum width	1.2	1.2
Fore coxa length	1.5	1.6
Fore femur length	2.7	2.8
Fore tibia length	2.3	2.5
Spongy fossa of fore tibia length	1.4	1.5
Spongy fossa of fore tibia max. width	0.5	0.5
Fore tarsus length	0.9	absent
Mid femur length	2.4	2.7
Mid tibia length	2.6	2.7
Spongy fossa of mid tibia length	0.7	0.7
Spongy fossa of mid tibia max. width	0.2	0.3
Mid tarsus length	1.2	1.2
Hind femur length	3.4	3.6
Hind tibia length	4.4	4.5
Hind tarsus length	1.6	1.7
Abdomen length	5.2	6.5
Abdomen maximum width	3.4	4.3



Figure 19. *Zeraikia zeraikae* sp. n., male holotype, dorsal view. Scale bar: 2.0 mm.

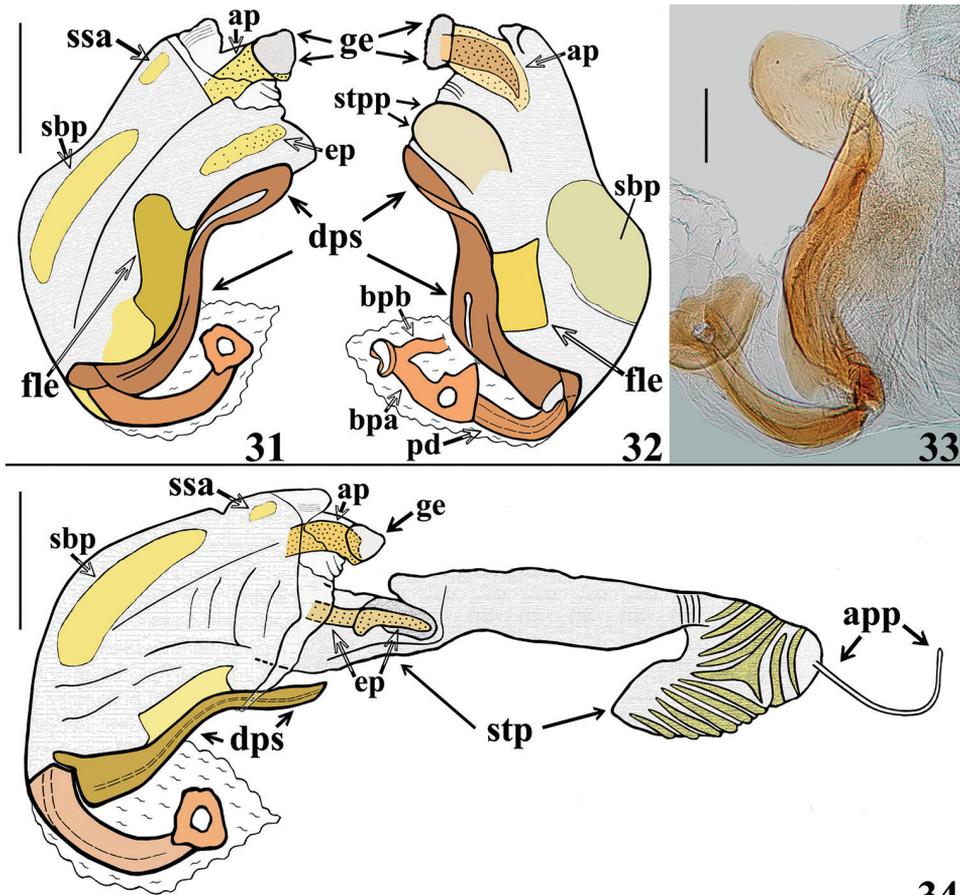


Figures 20–25. *Zeraikia zeraikae* sp. n., male holotype. **20** distal portion of hemelytra and connexivum, dorsal view (the arrow points to a single conspicuous long, stiff, darkened seta implanted just above posterolateral angle of a connexival segment) **21** distal portion of abdomen, ventral view **22** apical portion of abdomen, posterior view (hemelytra omitted) **23** sternite VIII, ventral view **24–25** pygophore without parameres **24** lateral view **25** ventral view. Scale bars: 1.0 mm (**20–21**); 0.5 mm (**22–25**).



Figures 26–30. *Zeraikia zeraikae* sp. n., male genitalia, parameres. **26–28** left paramere **27–28** apical portion **29–30** right paramere **30** apical portion. (**sp** subapical process; **lc** longitudinal crest). Scale bars: 0.3 mm (**26, 29**); 0.2 mm (**27, 30**); 0.1 mm (**28**).

ly only to a third of distance between dorsal and ventral surfaces; faintly sclerotized; left (in dorsal view) flat lateral expansion (**fle**) approximately a third larger than right flat lateral expansion; apical third of dorsal phallosclerite slightly curved in lateral view. Subapical tubular projection of endosoma wall (**stp**) conspicuously enlarged at apical portion, which is subtriangular in shape, with several low rugose crests and a very thin elongated appendix (**app**) at its tip, which is rounded (Figs 34, 37–38); inside its basal portion, an elongated, thin, slightly curved process (**ep**) formed by numerous, small, subtriangular to spined, somewhat sclerotized elements (Figs 34–35). An additional very small, rounded, somewhat sclerotized, subapical process (**ssa**) present just ventral to basal portion of the elongated curved apical process (**ap**) (Figs 31, 34, 36).

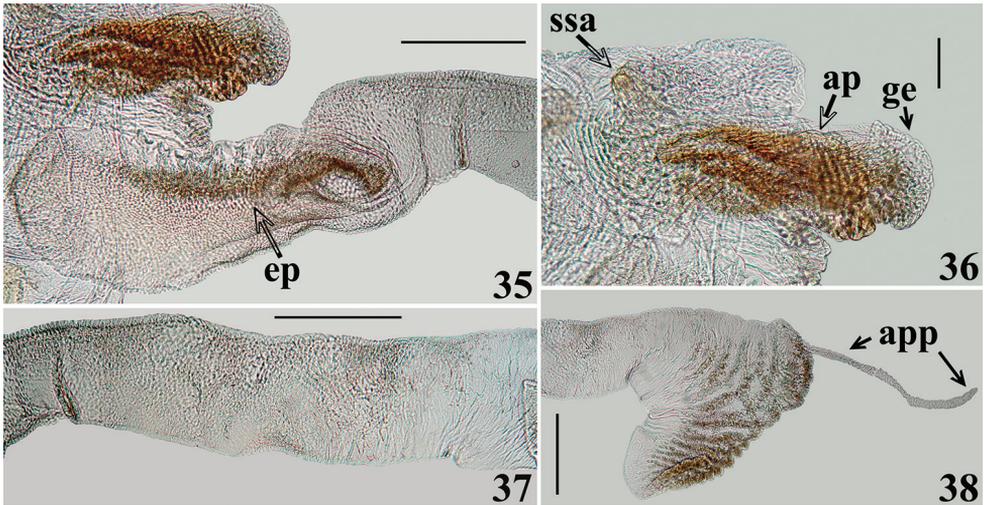


Figures 31–34. *Zeraikia zeraikae* sp. n., male genitalia, lateral views. **31–32** phallus not inflated **33** pedicel and dorsal phallotecal sclerite **34** phallus with endosoma inflated. (**ap** apical process of endosoma; **app** appendix; **bpa** basal plate arm; **bpb** basal plate bridge; **dps** dorsal phallothecal sclerite; **ep** elongated process inside basal portion of subapical projection of endosoma wall; **fle** flat lateral expansion; **ge** globose expansion of endosoma; **pd** pedicel; **sbp** subbasal process of endosoma; **ssa** small subapical process of endosoma; **stp** subapical tubular projection of endosoma wall; **stpp** visible portion of subapical tubular projection not extended). Scale bars: 0.5 mm (**31–32, 34**); 0.2 mm (**33**).

Female. Figures 39–42. Similar to male in general. Measurements presented in Table 1. Pale markings on femora and connexivum yellow to yellowish orange (Fig. 39). Hemelytra not surpassing abdomen, ending shortly before posterior margin of tergite VII; large yellowish orange spot at distal half of membrane smaller and more rounded in shape (Fig. 39). Tip of scutellum straight, directed upwards. Abdomen larger; dorsal connexival segments more evident (Fig. 39).

Etymology. The new species is named in honor of my beloved wife, Soraya Orichio Zeraik, who has always stimulated and helped me in my entomological studies.

Distribution. Brazil, in state of Rio de Janeiro.



Figures 35–38. *Zeraikia zeraikae* sp. n., male genitalia, lateral views. **35** apical process and basal portion of subapical tubular projection of endosoma wall. (**ep** elongated process inside basal portion of subapical tubular projection of endosoma wall) **36** small subapical and apical processes of endosoma. (**ap** apical process; **ge** globose expansion of endosoma **ssa** small subapical process) **37–38** endosoma wall projection portions **37** midportion **38** apical portion. (**app** appendix). Scale bars: 0.3 mm (**35, 37–38**); 0.1 mm (**36**).

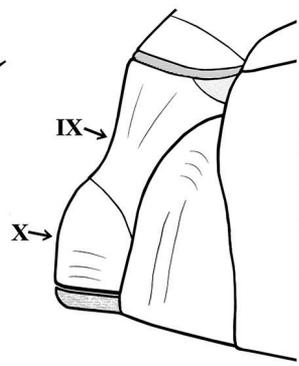
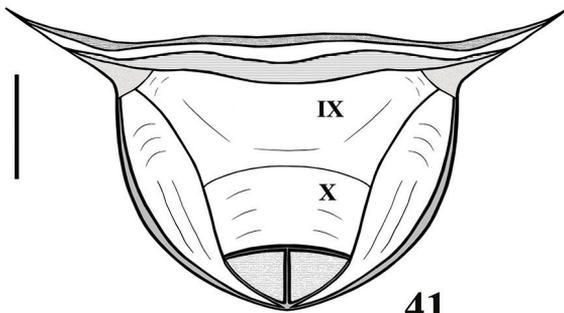
Discussion

The overall similarities in structure and vestiture between *Z. novafriburguensis* and *Z. zeraikae* sp. n. justify their placement in the same genus. The characteristics of *Z. zeraikae* sp. n. also corroborate placement of this species in *Zeraikia* in accordance with the definition of this genus by Gil-Santana and Costa (2003) and the diagnostic criteria of the keys furnished by Cai and Taylor (2006) and Gil-Santana et al. (2015).

On the other hand, *Z. novafriburguensis* and *Z. zeraikae* sp. n. can be unequivocally separated from each other based on several characteristics that are recorded in their respective diagnoses presented above. These and other additional differences, mentioned in their descriptions, are clear-cut enough to undoubtedly consider them to be distinct species.

In the male genitalia, the most striking differences were recorded between the characteristics of the long subapical tubular projection of the endosoma wall (**stp**) (Figs 10–14, 34–35, 37–38) and its associated process in each species (Figs 16, 35). In this regard, it is noteworthy that it was observed here that detachment and expansion of this long tubular projection of the endosoma wall from the surrounding tissues requires special attention. Because it does not seem to expand spontaneously, it might otherwise remain unnoticed and unrecorded. This structure not only showed features distinctive to the species studied here but also only after its release was it possible to study the rest of the endosoma and its processes in their entirety.

The general shape of the exposed portion of the eighth sternite, the pygophore, including its median process and parameres in these species of *Zeraikia* (Figs 4–7, 21–26, 29) are



Figures 39–42. *Zeraikia zeraikae* sp. n., female paratype. **39** dorsal view **40** thorax, ventral view **41–42** female genitalia **41** posterior view **42** lateral view. (IX tergite IX; X tergite X). Scale bars: 2.0 mm (**39**); 1.0 mm (**40**); 0.5 mm (**41–42**).

similar to several species belonging to other Neotropical genera of Peiratinae, such as *Eidmannia* Tauber, 1934, *Lentireduvius* Cai & Taylor, 2006 and *Rasabus* Amyot & Serville, 1843, as described in previous studies by Coscarón (1986), Cai and Taylor (2006) and Coscarón (1983), respectively. The shape and structure of the articulatory apparatus in *Zeraikia* (Figs 8–11, 13, 15, 32–33) is similar to that of several other Peiratinae e.g. *Rasabus*, *Lentireduvius*, *Sirthenea* Spinola, 1837 (Coscarón 1983, Cai and Taylor 2006, Willemse 1985) or even several other Reduviidae, e.g. Triatominae (Lent and Wygodzinsky 1979).

A similar long tubular expansion of the endosoma wall, like that of *Z. novafriburguensis* (with a roughly uniform diameter) (Figs 10–14), was recorded for *Lentireduvius brasiliensis* Cai & Taylor, 2006 by Cai and Taylor (2006), although they considered it to be part of the “vesica”, a term that is not used here. The dorsal phallothecal sclerite of *L. brasiliensis* seemed similar to that of *Z. zeraikae* sp. n., and a lobe similar to the globose small lateral lobe of the endosoma wall in *Z. novafriburguensis* (gl) (Figs 12, 14) was also recorded in *L. brasiliensis* (Cai and Taylor 2006).

On the other hand, because of the lack of more complete data about other structures of the endosome, including its processes, in previous works, further comparisons will require additional studies. In this regard, it is worth mentioning that, in almost all studies on Neotropical Peiratinae (see Gil-Santana et al. 2015 for an updated bibliography), the endosoma was not really or fully everted, which might have prevented a more detailed description of these structures.

Key for the species of *Zeraikia*

- 1 General coloration blackish to brownish black, sometimes with subtle bluish luster, mainly on sternites (Figs 1–3, 18). General coloration of corium, clavus and basal portion of membrane of hemelytra orange to reddish orange (Figs 1, 3, 18). Pale markings of connexivum large, occupying approximately the basal half of each segment (Figs 1–3, 18)..... ***novafriburguensis* Gil-Santana & Costa**
- General coloration black with bluish luster (Figs 19, 39). General color of corium, clavus and basal half of membrane of hemelytra dull blackish (Figs 19–20, 39). Pale markings of connexivum relatively small, occupying approximately the basolateral third and fifth of segments III–VI and VII, respectively (Figs 19–20, 39) ***zeraikae* sp. n.**

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I would like to thank Luiz A. A. Costa (MNRJ) along with the team of the digitization project of the Entomological collection of MNRJ, for the photos that they provided. I am also very grateful to Wanzhi Cai (China Agricultural University, China), Jocelia Grazia (Universidade Federal do Rio Grande do Sul, Brazil), Tadashi Ishikawa (Tokyo

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References

- Cai W, Taylor SJ (2006) *Lentireduvius*, a new genus of Peiratinae from Brazil, with a key to the New World genera (Hemiptera: Reduviidae). *Zootaxa* 1360: 51–60.
- Coscarón MC (1983) Revisión del género *Rasahus* (Insecta, Heteroptera, Reduviidae). *Revista del Museo de La Plata (Nueva Serie)* 13: 75–138.
- Coscarón MC (1986) Revisión del género *Eidmannia* Tauber, 1934 (Heteroptera, Reduviidae). *Revista Brasileira de Entomologia* 30: 311–322.
- Forero D (2004) Capítulo 5. Diagnósis de los géneros neotropicales de la familia Reduviidae (Hemiptera: Heteroptera), y su distribución em Colombia (excepto Harpactorinae). In: Fernández F, Andrade G, Amat G (Eds) *Insectos de Colombia Vol. 3*. Universidad Nacional de Colombia, Bogotá DC, 128–275.
- Forero D, Weirauch C (2012) Comparative genitalic morphology in the New World resin bugs Apiomerini (Hemiptera, Heteroptera, Reduviidae, Harpactorinae). *Deutsche Zeitschrift Entomologische* 59: 5–41.
- Gil-Santana HR, Costa LAA (2003) Um novo gênero e espécie de Peiratinae de Nova Friburgo, Rio de Janeiro, Brasil (Hemiptera, Heteroptera, Reduviidae). *Revista Brasileira de Zoologia* 20: 3–8. <http://dx.doi.org/10.1590/S0101-81752003000100002>
- Gil-Santana HR, Forero D, Weirauch C (2015) Assassin bugs (Reduviidae excluding Triatominae). In: Panizzi AR, Grazia J (Eds) *True bugs (Heteroptera) of the Neotropics*, *Entomology in Focus* 2. Springer Science + Business Media, Dordrecht, 307–351. https://doi.org/10.1007/978-94-017-9861-7_12
- Lent H, Wygodzinsky P (1979) Revision of the Triatominae (Hemiptera: Reduviidae) and their significance as vectors of Chagas' disease. *Bulletin of the American Museum of Natural History* 163: 123–520.
- Maldonado CJ (1990) Systematic catalogue of the Reduviidae of the World. *Caribbean Journal of Science*, Special publication No. 1, University of Puerto Rico, Mayagüez, 694 pp.
- Melo MC (2012) On the taxonomic placement of the genus *Sinnamarynus* (Hemiptera: Heteroptera: Reduviidae), and a new record of *S. rasabusoides* from Peru. *Check List* 8: 540–541. <http://dx.doi.org/10.15560/8.3.540>
- Rédei D, Tsai J-F (2011) The assassin bug subfamilies Centrocnemidinae and Holoptilinae in Taiwan (Hemiptera: Heteroptera: Reduviidae). *Acta Entomologica Musei Nationalis Pragae* 51: 411–442.
- Schuh RT, Slater JA (1995) *True Bugs of the World (Hemiptera: Heteroptera) – Classification and natural history*. Cornell University Press, Ithaca, 336 pp.
- Willemse L (1985) A taxonomic revision of the New World species of *Sirthenea* (Heteroptera: Reduviidae: Peiratinae). *Zoologische Verhandelingen* 215: 1–67.

A new large oregoniid spider crab of the genus *Pleistacantha* Miers, 1879, from the Bay of Bengal, India (Crustacea, Brachyura, Majoidea)

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Abstract

A new species of deep-water oregoniid spider crab of the genus *Pleistacantha* Miers, 1879, is described from the Indian Ocean. The species is distinct in possessing a prominently inflated carapace in which the median parts of the branchial regions almost meet. It can also be distinguished from its closest congeners, *P. moseleyi* (Miers, 1885), *P. pungens* (Wood-Mason, in Wood-Mason and Alcock 1891), and *P. ori* Ahyong & Ng, 2007, in its more elongate and less spinose chelipeds and ambulatory legs, shorter third maxilliped, trapezoidal male pleon and a male first gonopod which is relatively stout with a short subdistal dorsal papilla.

Keywords

deep-water, Indian Ocean, new species, Oregoniidae, *Pleistacantha*, taxonomy

Introduction

The majoid genus *Pleistacantha* Miers, 1879, currently contains 12 species (Ahyong and Lee 2006; Ahyong and Ng 2007; Ng et al. 2008). While many earlier authors treat *Pleistacanthoides* Yokoya, 1933, and *Parapleistacantha* Yokoya, 1933, as junior synonyms of *Pleistacantha* Miers, 1879 (Ng et al. 2008), these genera are now regarded as distinct genera (see Ng and Richer de Forges 2012; Richer de Forges et al. 2013, respectively). Although *Pleistacantha* has been traditionally classified with the Inachidae MacLeay, 1838 (see Ng et al. 2008), Marco-Herrero et al. (2013) used molecular, larval and morphological evidence to argue that this genus as well as *Bothromaia* Williams & Moffitt, 1991, *Ergasticus* A. Milne-Edwards, 1882, *Parapleistacantha* Yokoya, 1933, and *Pleistacanthoides* Yokoya, 1933, should be transferred to the Oregoniidae Garth, 1958, instead, and in its own subfamily, the Pleistacanthinae Števcíć, 2005. This classification is followed here.

The ports of south India with provisions for landing the bycatch of deep sea trawlers are proving to be a major source of rare systematic material for brachyuran studies, and several interesting taxa have been recorded in recent years (e.g., Ng and Kumar 2015, 2016; Mendoza and Suvarna Devi 2017; Ng et al. 2017; Prema et al. 2017). Among the material studied recently is a new species of *Pleistacantha* which is described here. While superficially resembling *P. moseleyi* (Miers, 1885), *P. pungens* (Wood-Mason, in Wood-Mason and Alcock 1891), and *P. ori* Ahyong & Ng, 2007, it has a markedly more inflated carapace, more elongate and less spinose chelipeds and ambulatory legs, a short third maxilliped and trapezoidal male pleonal shape as well as a diagnostic male first gonopod which is relatively stout with a short subdistal dorsal papilla.

Materials and methods

Specimens examined are deposited in the University of Kerala (**DABFUK**), India; Centre of Advanced study in Marine Biology, Annamalai University (**CASAU**), Parangipettai, Tamil Nadu, India; and the Zoological Reference Collection (**ZRC**) of the Lee Kong Chian Natural History Museum, National University of Singapore. The morphological terms used mostly follow Ahyong et al. (2005) with changes suggested by Davie et al. (2015).

The following abbreviations are used:

- cl** maximum carapace length (including rostrum);
- cw** carapace width (including spines);
- G1** male first pleopod;
- G2** male second pleopod;
- pcl** pre-rostral carapace length (maximum carapace length excluding rostrum).

All measurements are in millimetres. The ambulatory legs (pereopods 2–5) are abbreviated **P2–5**, respectively.

Systematics

Family Oregoniidae Garth, 1958

Genus *Pleistacantha* Miers, 1879

Type species. *Pleistacantha sanctijohannis* Miers, 1879, by original designation.

Pleistacantha kannu sp. n.

<http://zoobank.org/9FB362C1-38CF-4532-A1AE-ABCD3A2C5738>

Figs 1, 2, 4C, D, 5C, D, 6E, F, 7G–I, 8E, F, 9E, F, 10K–N, 11

?*Pleistacantha adenicus* Kazmi 1997: 82, figs 1, 2 (*nomen nudum*).

Material examined. Holotype: male (cl 106.2 mm, pcl 87.4 mm, cw 87.0 mm) (CASAU), Pazhayar, coll. S. Ravichandran et al., 2017. Paratypes: 1 female (cl 83.9 mm, pcl 78.7 mm, cw 72.9 mm) (rostrum broken) (CASAU), 1 ovigerous female (cl 84.4 mm, pcl 69.8 mm, cw 71.5 mm) (all ambulatory legs broken off), 1 female (cl 79.5 mm, pcl 65.21 mm, cw 66.9 mm) (each side two pairs of ambulatory legs broken) (CASAU), same data as holotype; 1 ovigerous female (cl 91.3 mm, pcl 81.2 mm, cw 75.5 mm), 2 females (cl 85.2 mm, pcl 75.0 mm, cw 70.4 mm; cl 87.3 mm, pcl 77.2 mm, cw 72.5 mm) (DABFUK), Tuticorin fishing port, India, coll. R. Ravinesh, March 2017; 1 female (cl 90.4 mm, pcl 80.2 mm, cw 73.9 mm) (DABFUK), Muttam Fishing Harbour, coll. A. B. Kumar, 14 October 2015. All localities from state of Tamil Nadu, India.

Comparative material. *Pleistacantha moseleyi* (Miers, 1885): 1 male (cl 82.5 mm, pcl 61.6 mm, cw 61.6 mm) (ZRC 2005.117), Maribohoc Bay, Panglao, Bohol, Philippines, 100–300 m, coll. T. J. Arbasto, November 2003–March 2004. *Pleistacantha pungens* (Wood-Mason, in Wood-Mason and Alcock 1891): 1 male (cl 94.0 mm, pcl 66.9 mm, cw 67.6 mm) (ZRC 2016.23), Ayeyarwady Delta, station 58, 14.3225°N, 93.7405°E, off Myanmar, Andaman Sea, 265–268.5 m, bottom trawl, coll. EAF-NANSEN Project (Myanmar Cruise), 9 May 2015; 1 female (cl 45.2 mm, pcl 30.8 mm, cw 29.8 mm) (ZRC 2016.24), Ayeyarwady Delta, station 68, 14.06216667°N, 94.31816667°E, off Myanmar, Andaman Sea, 455–457 m, bottom trawl, coll. EAF-NANSEN Project (Myanmar Cruise), 10 May 2015. *Pleistacantha ori* Ahyong & Ng, 2007: holotype male (cl 146.0 mm, pcl 129.1 mm, cw 106.3 mm) (ZRC 2006.158), off Durban, South Africa, coll. Oceanographic Research Institute, Durban, October 2004; paratypes: 1 male (cl 129.0 mm, pcl 115.0 mm, cw 92.7 mm), 1 ovigerous female (cl 120+ mm, pcl 106.6 mm, cw 83.9 mm), 1 spent female (cl 119.6 mm, pcl 104.9 mm, cw 84.5 mm) (ZRC 2006.0159), same data as holotype.

Etymology. Name after the late Professor T. Kannupandi, an influential crustacean worker from the Centre of Advanced Study in Marine Biology in Annamalai University. The name, a shortened version of his family name, is used as a noun in apposition.

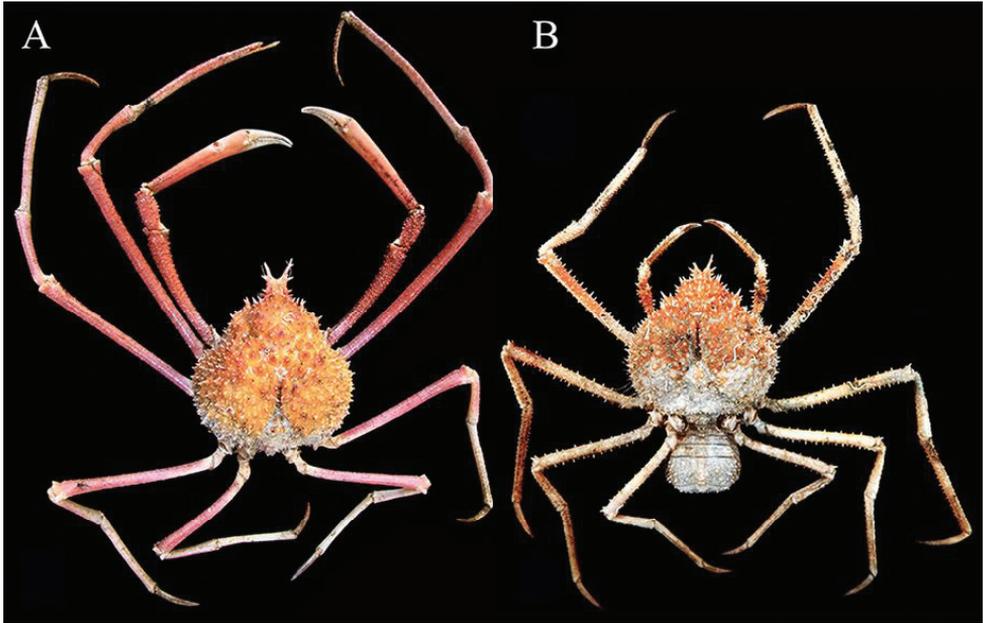


Figure 1. *Pleistacantha kannu* sp. n., colour in life. **A** holotype male (cl 106.2 mm, cw 87.0 mm) (CASAU), India **B** paratype ovigerous female (cl 84.4 mm, cw 71.5 mm) (CASAU), India.

Diagnosis. Carapace broadly pyriform, postrostral carapace length equal to or slightly longer than carapace width (ratio 1.0–1.1) (Figs 2A, B, 4C, D); dorsal carapace surface with short spines with relatively wider bases (Figs 2A, B, 4C, D, 5C, D); gastric regions strongly swollen (Figs 2A, B, 4C, D, 5C, D); branchial regions strongly swollen laterally and dorsally; medially separated by narrow space, area without spines, spines on margins of regions overlapping (Figs 2A, B, 4C, D, 5C, D); posterior carapace margin convex (Fig. 4C); rostrum relatively short; gently divergent, directly obliquely laterally, not curving upwards (Figs 2A, B, 4C, D, 5C, D, 6E); interantennular spine short, tip bifurcated with shallow concavity between short processes (Figs 6E, F); lateral margins of posterior margin of epistome strongly concave (Fig. 7G, H); ischium of third maxilliped short (Fig. 7I); adult male cheliped elongate, merus and chela slender (Figs 2A, 8F); surface of adult male chela mostly smooth, proximal part with short tubercles or granules, without long spines (Figs 2A, 8E, F); male anterior thoracic sternum relatively broad; surface with numerous blunt and sharp tubercles, never spines (Fig. 9E); male pleon transversely wide; distinctly trapezoidal; surface with numerous blunt and sharp tubercles, never spines (Fig. 9F); G1 relatively stout; distal part gently curved; subdistal dorsal papilla short (Fig. 10K–M).

Description of holotype male. Carapace broadly pyriform, postrostral carapace length almost equal to carapace width (Figs 2A, 4C). Rostral spines short, 0.2 times postrostral carapace length; basal half completely fused, medially gently divergent laterally, not curving upwards; dorsal surface with three small low dorsal spinules; lateral margin with one or two ventral (excluding basal) spines; with three equally spaced

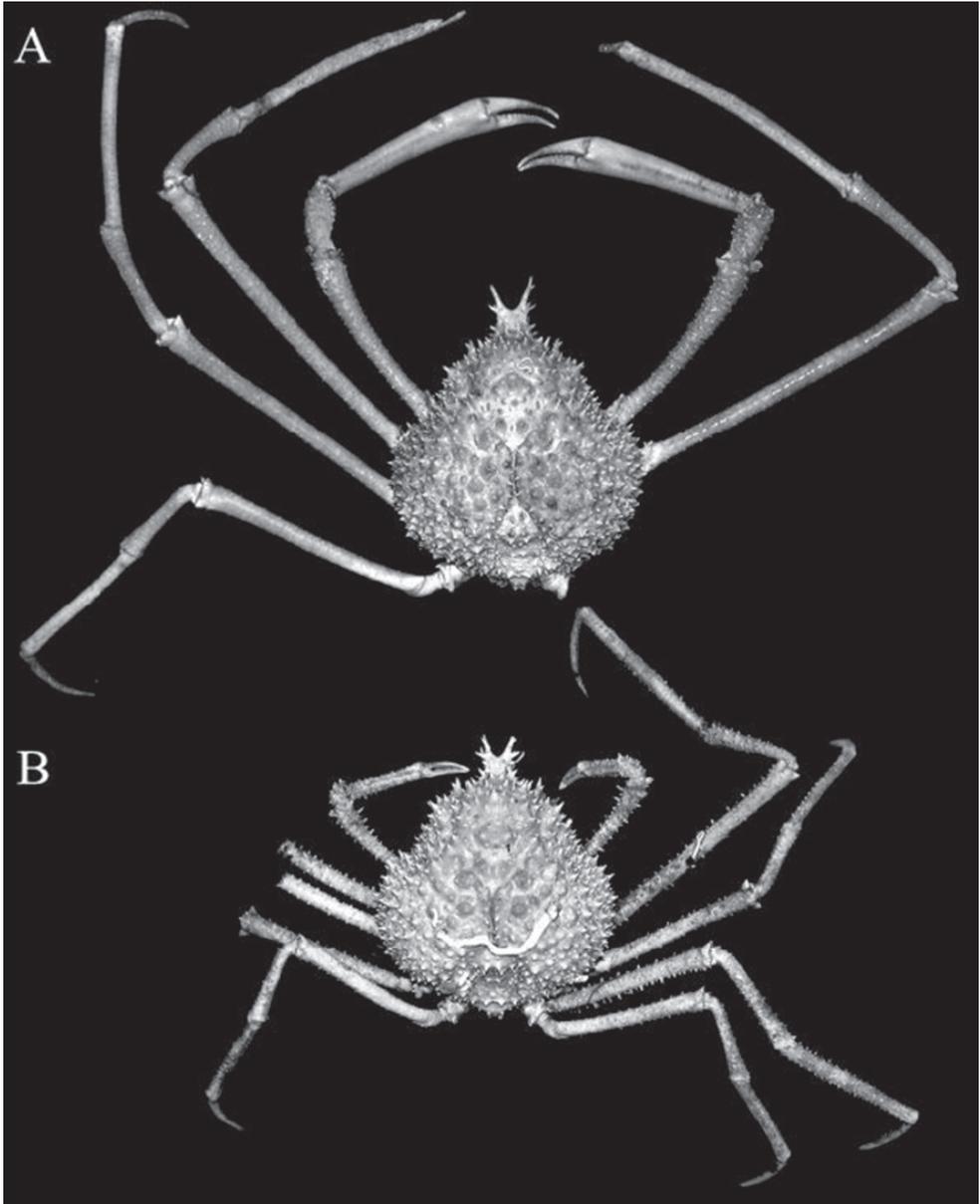


Figure 2. *Pleistacantha kannu* sp. n. **A** holotype male (cl 106.2 mm, cw 87.0 mm) (CASAU), India **B** paratype ovigerous female (cl 91.3 mm, cw 75.5 mm) (DABFUK), India.

lateral spines, median one largest, at junction of diverging spine (Fig. 3C). Interantennular spine strongly bent downwards, surface concave, bifurcated distally, depth of bifurcation shallow, processes short; distal margin of antennular sinus produced to form prominent ventrolaterally directed spine (Figs 6E, F, 7G). Orbital margin with three large spines increasing in size posteriorly, including intercalated and postorbital

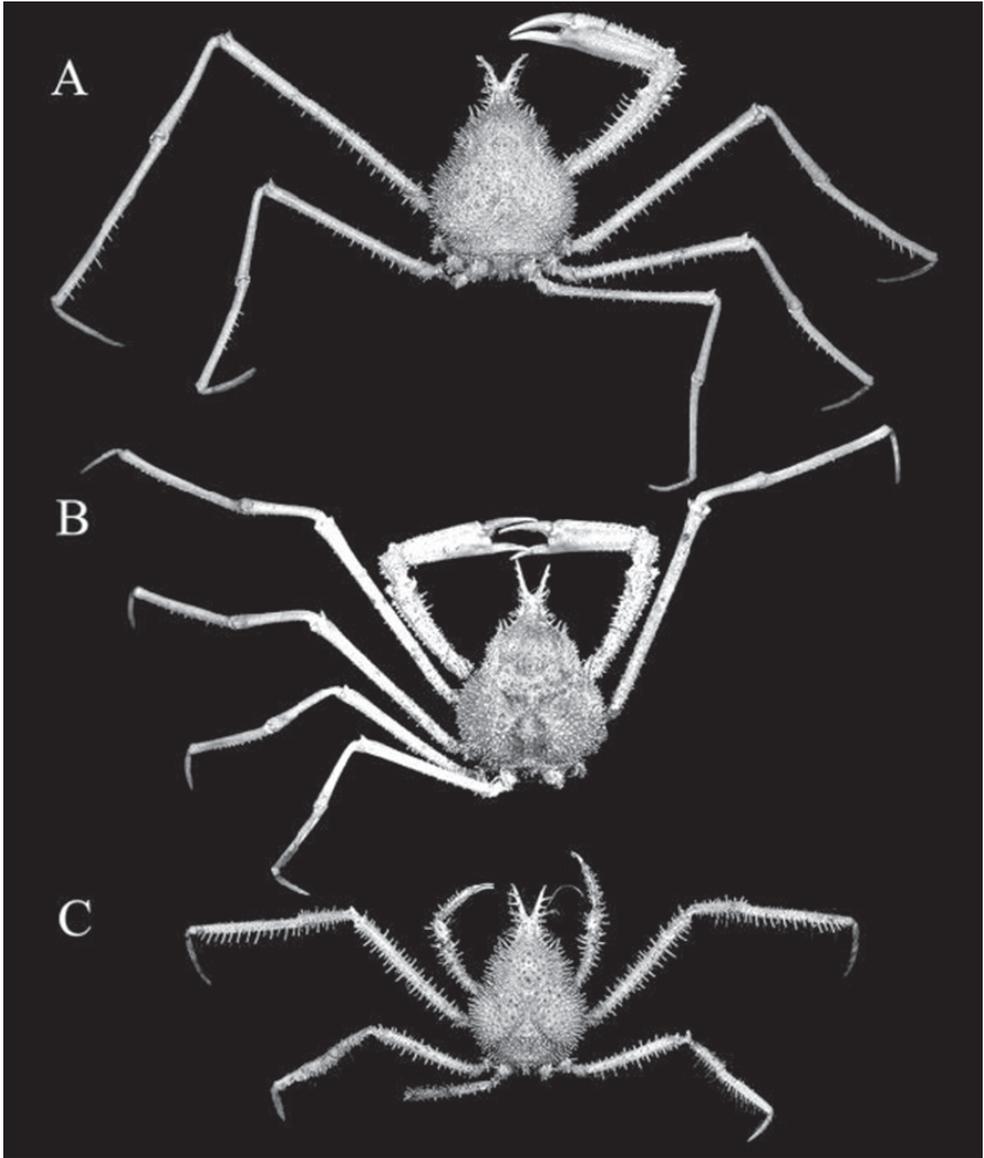


Figure 3. **A** *Pleistacantha moseleyi* (Miers, 1885), male (cl 82.5 mm, cw 61.6 mm) (ZRC 2005.117), Philippines **B** *Pleistacantha pungens* (Wood-Mason, in Wood-Mason and Alcock 1891), male (cl 94.0 mm, cw 67.6 mm) (ZRC 2016.23), Myanmar **C** *Pleistacantha pungens* (Wood-Mason, in Wood-Mason and Alcock 1891), female (cl 45.2 mm, cw 29.8 mm) (ZRC 2016.24), Myanmar.

spines (Fig. 4C). Hepatic spine large, anteriorly directed, with 2–4 small accessory spines (Fig. 4C). Dorsal surface covered with short conical spines with broad bases and acute tubercles (Figs 2A, 4C, 5C). Branchial regions markedly swollen dorsally and laterally, inner margins almost touching along carapace midline, with associated spines

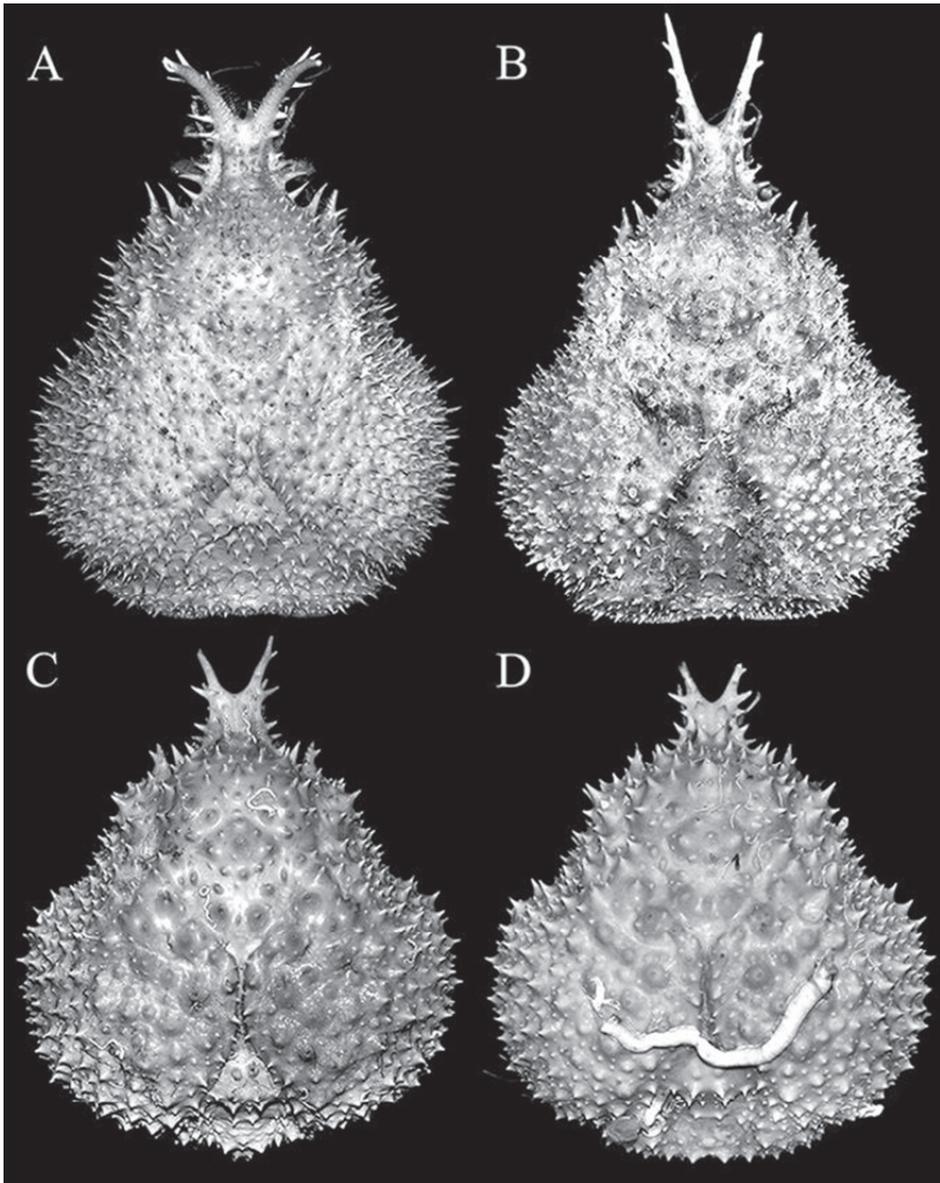


Figure 4. **A** *Pleistacantha moseleyi* (Miers, 1885), male (cl 82.5 mm, cw 61.6 mm) (ZRC 2005.117), Philippines **B** *Pleistacantha pungens* (Wood-Mason, in Wood-Mason and Alcock 1891), male (cl 94.0 mm, cw 67.6 mm) (ZRC 2016.23), Myanmar **C** *Pleistacantha pungens* (Wood-Mason, in Wood-Mason and Alcock 1891) **C** *Pleistacantha kannu* sp. n., holotype male (cl 106.2 mm, cw 87.0 mm) (CASAU), India **D** *Pleistacantha kannu* sp. n., paratype ovigerous female (cl 91.3 mm, cw 75.5 mm) (DABFUK), India.

overlapping opposite region, regions separated by narrow longitudinal channel; cardiac region not prominently swollen, with two rows of six short spines in total; intestinal region not well demarcated, region appears depressed (Figs 2A, 4C, 5C). Posterior

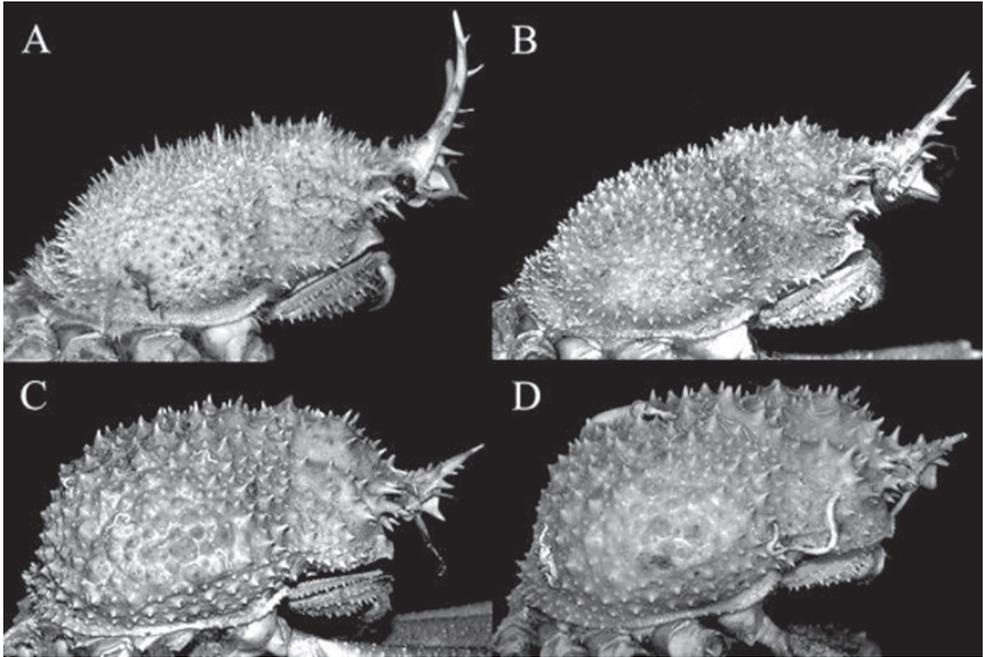


Figure 5. **A** *Pleistacantha moseleyi* (Miers, 1885), male (cl 82.5 mm, cw 61.6 mm) (ZRC 2005.117), Philippines **B** *Pleistacantha pungens* (Wood-Mason, in Wood-Mason and Alcock 1891), male (cl 94.0 mm, cw 67.6 mm) (ZRC 2016.23), Myanmar **C** *Pleistacantha kannu* sp. n., holotype male (cl 106.2 mm, cw 87.0 mm) (CASAU), India **D** *Pleistacantha kannu* sp. n., paratype ovigerous female (cl 91.3 mm, cw 75.5 mm) (DABFUK), India.

carapace margin convex (Fig. 4C). Sub-branchial region covered with short, stout spinules; pteryogostomial region with scattered sharp tubercles (Fig. 5C).

Proepistome with ventrally directed, laterally flattened tooth, tip rounded; margin lateral to antennal gland aperture (infraorbital margin) with 2 long spines; anterolateral angle of buccal cavity flared, lobiform, margin with two or three low teeth (Fig. 7G, H). Eye short, when folded back into ‘orbit’, not reaching antennal gland aperture; ocular peduncle short, with 2 granules on subdistal surface adjacent to cornea. Basal antennular article with two short spines. Basal antennal article elongate, rectangular, outer margin with two short spines, mesial margin with two short spines; next article elongate, with two sharp tubercles (Fig. 7G). Epistome wide; posterior margin with lateral margins strongly concave; median lobe subtruncate, separated by deep median fissure, separated from lateral margin by V-shaped cleft (Fig. 7G, H).

Third maxilliped merus almost as wide as ischium; meral surface spinose, with long slender spines on either side of carpal articulation, anterolateral angle triangular, produced, with spinose margins; ischium short, with dentate margins, surface with two longitudinal rows of tubercles separated by shallow median sulcus; exopod relatively slender, outer surface and outer margin each with row of short spines (Fig. 7I).

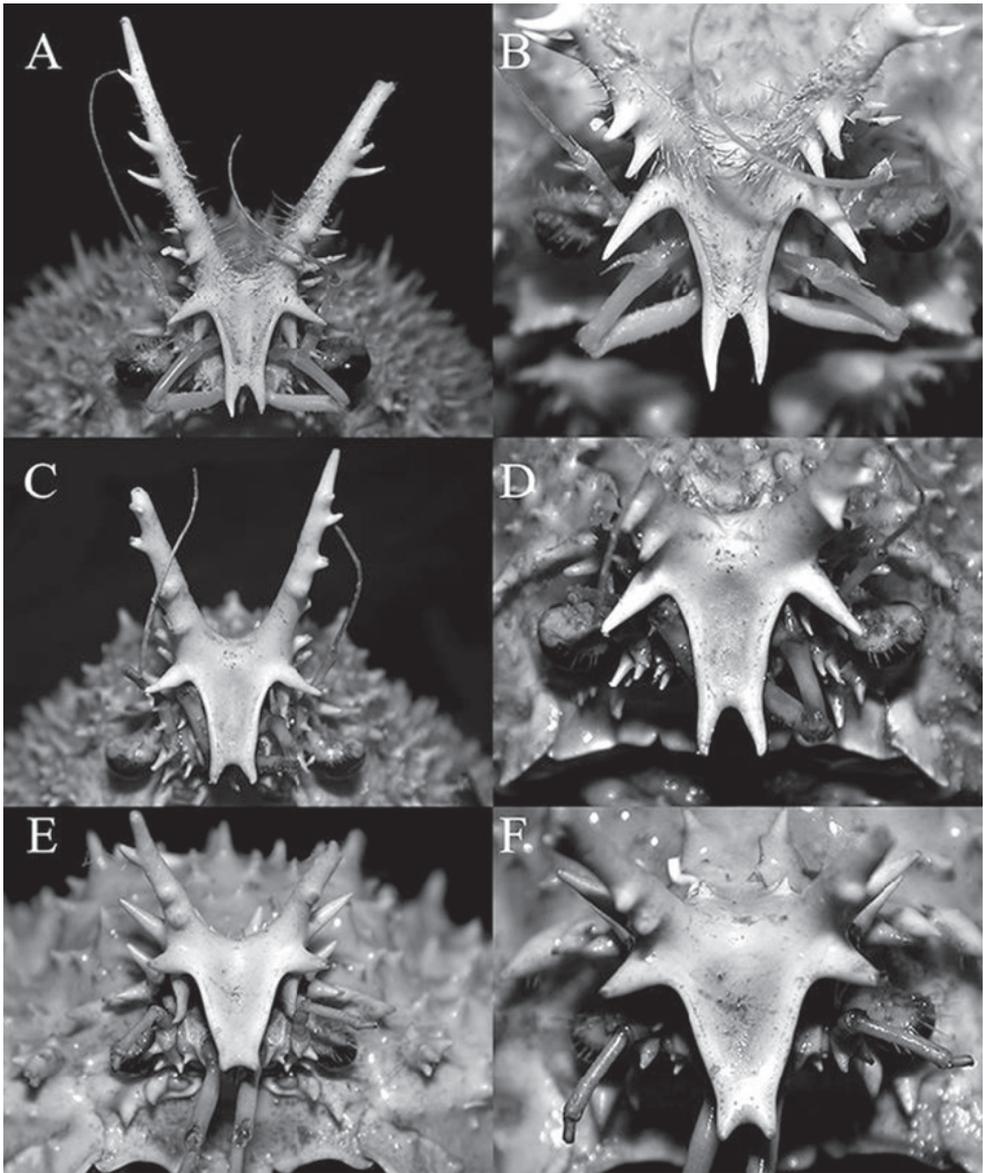


Figure 6. **A, B** *Pleistacantha moseleyi* (Miers, 1885), male (cl 82.5 mm, cw 61.6 mm) (ZRC 2005.117), Philippines **C, D** *Pleistacantha pungens* (Wood-Mason, in Wood-Mason and Alcock 1891), male (cl 94.0 mm, cw 67.6 mm) (ZRC 2016.23), Myanmar **E, F** *Pleistacantha kannu* sp. n., holotype male (cl 106.2 mm, cw 87.0 mm) (CASAU), India.

Male cheliped elongate, slender, symmetrical (Fig. 2A). Male chela elongated, stout, not distinctly inflated; distal two-thirds relatively smooth, proximal third with tubercles and low spines; occlusal margins of dactylus and pollex with blunt, obtuse teeth, not forming distinct gape when closed; carpus and merus with numerous sharp

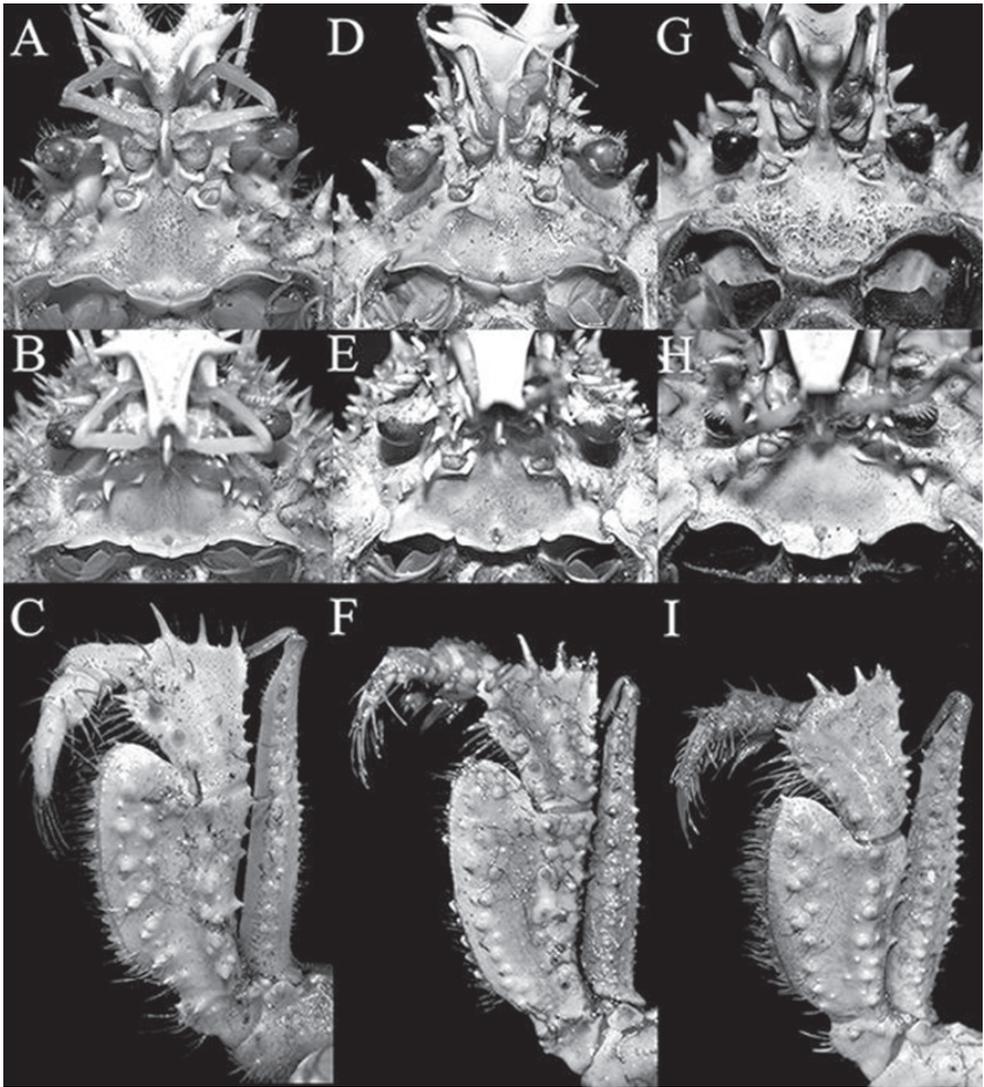


Figure 7. **A–C** *Pleistacantha moseleyi* (Miers, 1885), male (cl 82.5 mm, cw 61.6 mm) (ZRC 2005.117), Philippines **D–F** *Pleistacantha pungens* (Wood-Mason, in Wood-Mason and Alcock 1891), male (cl 94.0 mm, cw 67.6 mm) (ZRC 2016.23), Myanmar **G–I** *Pleistacantha kannu* sp. n., holotype male (cl 106.2 mm, cw 87.0 mm) (CASAU), India. **A, D, G** epistome, antennae and antennules; **B, E, H** epistome; **C, F, I** left third maxilliped.

tubercles and granules along margins and surfaces; merus elongate, slender with distal half wider than proximal part (Figs 2A, 8E, F). Ambulatory legs (P2–5) long, slender, decreasing in length posteriorly (Fig. 2A). Surfaces of propodus, carpus and merus of P2–4 granular, with short tubercles or granules, not spinose; dactylus covered with dense soft setae and corneous tip (Fig. 2A).

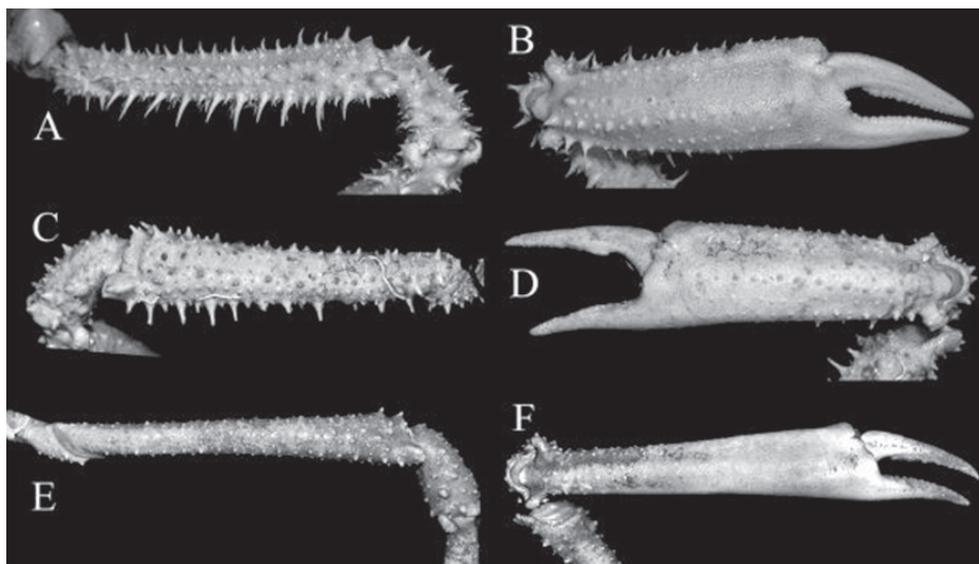


Figure 8. **A, B** *Pleistacantha moseleyi* (Miers, 1885), male (cl 82.5 mm, cw 61.6 mm) (ZRC 2005.117), Philippines **C, D** *Pleistacantha pungens* (Wood-Mason, in Wood-Mason and Alcock 1891), male (cl 94.0 mm, cw 67.6 mm) (ZRC 2016.23), Myanmar **E, F** *Pleistacantha kannu* sp. n., holotype male (cl 106.2 mm, cw 87.0 mm) (CASAU), India. **A, C, E** outer view of merus of cheliped; **B, D, F** outer view of chela.

Anterior thoracic sternum relatively wide transversely (Fig. 9E). Thoracic sternites 1 and 2 fused, forming acutely triangular process; separated from sternite 3 by prominent ridge with concave surface; sternites 3 and 4 fused, anterior part constricted at junction of sternites; sternite 4 with low obliquely transverse ridge lined with tubercles, anterior surface with more prominent tubercles; surfaces of sternites 5–7 with scattered tubercles, some relatively sharp; sternopleonal cavity reaching to suture between sternites 4 and 5 (Fig. 9E, F). Male pleon with six free somites and telson; somites 4–6 trapezoidal, wide; widest at somites 2 and 3; surface tuberculate but not spinose (Fig. 9E, F).

G1 gently curving outwards, relatively shorter, with distal tenth more distinctly curved; subdistal papilla on inner margin short, triangular, shorter than length between papilla base and tip (Fig. 10K–M). G2 short, with basal part dilated; distal part approximately bifurcate, short (Fig. 10N).

Females. The adult females differ from the holotype male in possessing a proportionately shorter rostrum and chelipeds (Figs 1B, 2B, 11A). In addition, the surfaces of the chelipeds and ambulatory legs are covered with more prominent spines and sharper tubercles, with these structures all appearing distinctly spinose (Figs 1B, 2B, 11A, B). The spines and tubercles on the carapace of females (Fig. 4D, 5D) also tend to be relatively more acute compared to those on the male (Fig. 4C, 5C). *Pleistacantha* species are typically sexually dimorphic in these respects (see Grindley 1961; Ah Yong and Ng 2007). The female pleon is very broad, and while all the somites and telson appear to be free, they are quite rigid due to their strongly convex shape, forming a

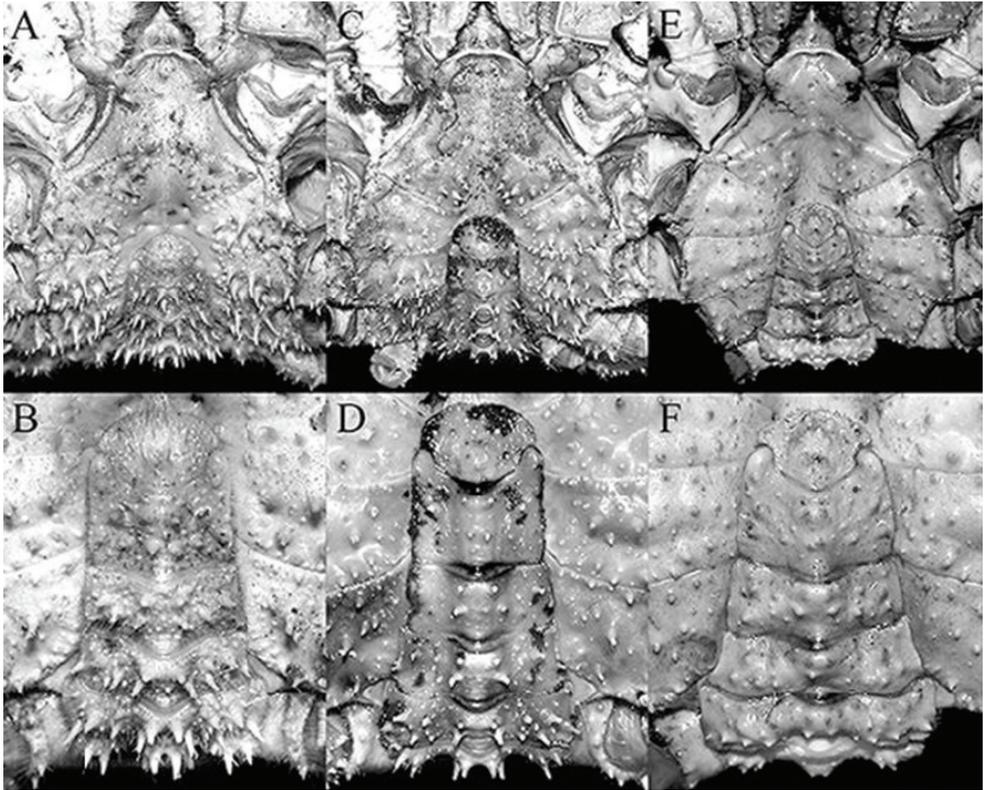


Figure 9. **A, B** *Pleistacantha moseleyi* (Miers, 1885), male (cl 82.5 mm, cw 61.6 mm) (ZRC 2005.117), Philippines **C, D** *Pleistacantha pungens* (Wood-Mason, in Wood-Mason and Alcock 1891), male (cl 94.0 mm, cw 67.6 mm) (ZRC 2016.23), Myanmar **E, F** *Pleistacantha kannu* sp. n., holotype male (cl 106.2 mm, cw 87.0 mm) (CASAU), India. **A, C, E** anterior thoracic sternum and pleon; **B, D, F** male pleon.

dome-like structure (Fig. 11D). The vulvae are large, subovate and positioned on the anterior surface of sternite 6 (Fig. 11D).

Colour. Most of dorsal carapace surface of carapace orange to orange-red (Fig. 1); male chelipeds and ambulatory legs reddish-brown on dorsal surface except for white fingers (Fig. 1A); female chelipeds and ambulatory legs orange and white (Fig. 1B); ventral surfaces dirty white.

Remarks. Ah Yong and Ng (2007: 72) recognized a group of three large species of *Pleistacantha* readily distinguished from congeners by possessing a “relatively uniform dorsal carapace spination, in which the dorsal spines are of similar length rather than having several gastric and branchial spines markedly longer than the remainder, in combination with divergent rather than medially appressed rostral spines, and a deeply bifurcate interantennular spine.” *Pleistacantha moseleyi* (Miers, 1885) is known from the Philippines in the western Pacific (Guinot and Richer de Forges 1982, 1986; Ah Yong and Lee 2006) while *P. pungens* (Wood-Mason, in Wood-Mason and Alcock 1891) and *P. ori* Ah Yong & Ng, 2007, are known from the eastern and western

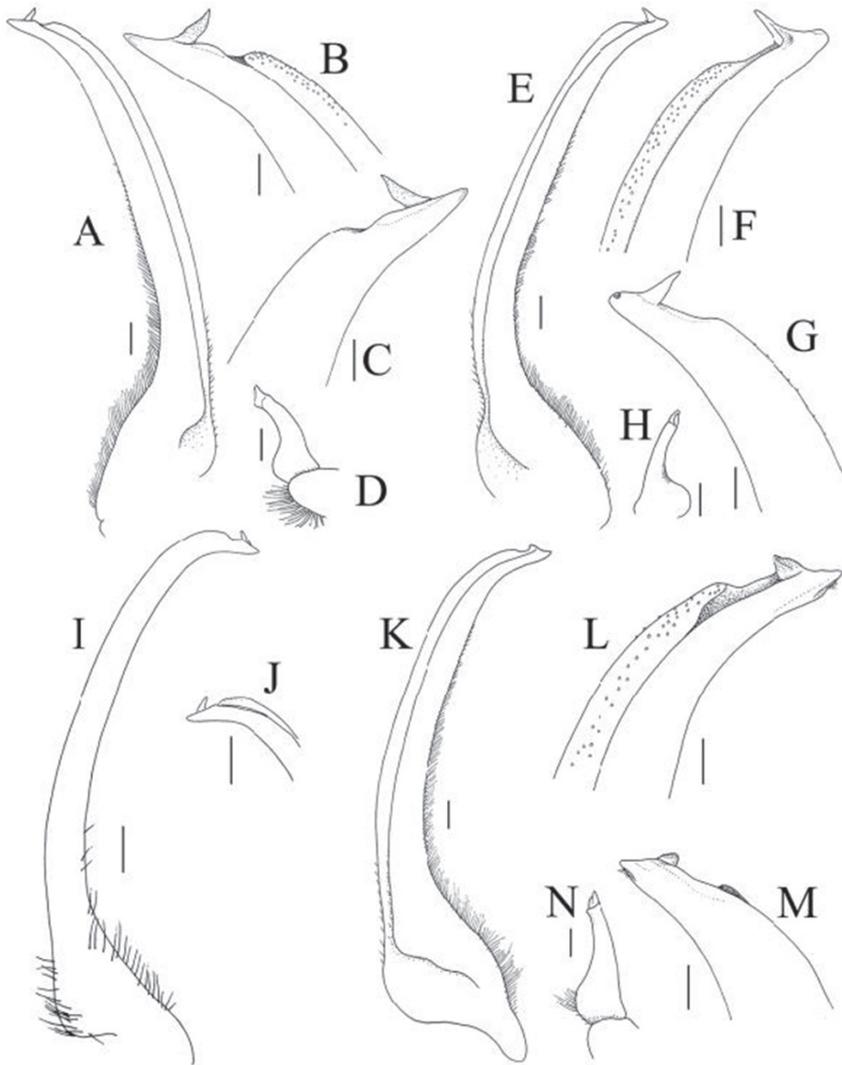


Figure 10. **A–D** *Pleistacantha moseleyi* (Miers, 1885), male (cl 82.5 mm, cw 61.6 mm) (ZRC 2005.117), Philippines **E–H** *Pleistacantha pungens* (Wood-Mason, in Wood-Mason and Alcock 1891), male (cl 94.0 mm, cw 67.6 mm) (ZRC 2016.23), Myanmar **I, J** *Pleistacantha ori* Ah Yong & Ng, 2007, holotype male (cl 146.0 mm, cw 106.3 mm) (ZRC 2006.0158), South Africa (after Ah Yong and Ng 2007: fig. 4) **K–N** *Pleistacantha kannu* sp. n., holotype male (cl 106.2 mm, cw 87.0 mm) (CASAU), India. **A–C, I, J** right G1; **D** right G2; **E–G, K–M** left G1; **H, N** left G2. Scales: **A, D, E, H, K, N** 1.0 mm; **B, C, F, G, L, M** 0.5 mm; **I, J** 2.0 mm.

Indian Ocean basins, respectively (Guinot and Richer de Forges 1982, 1986; Ah Yong and Ng 2006, 2007). Although most extant literature cite the *Challenger* material as “Miers, 1886”, a number of names like *Pleistacantha* were actually validated by the same author a year earlier (see Frogliola and Clark 2011).

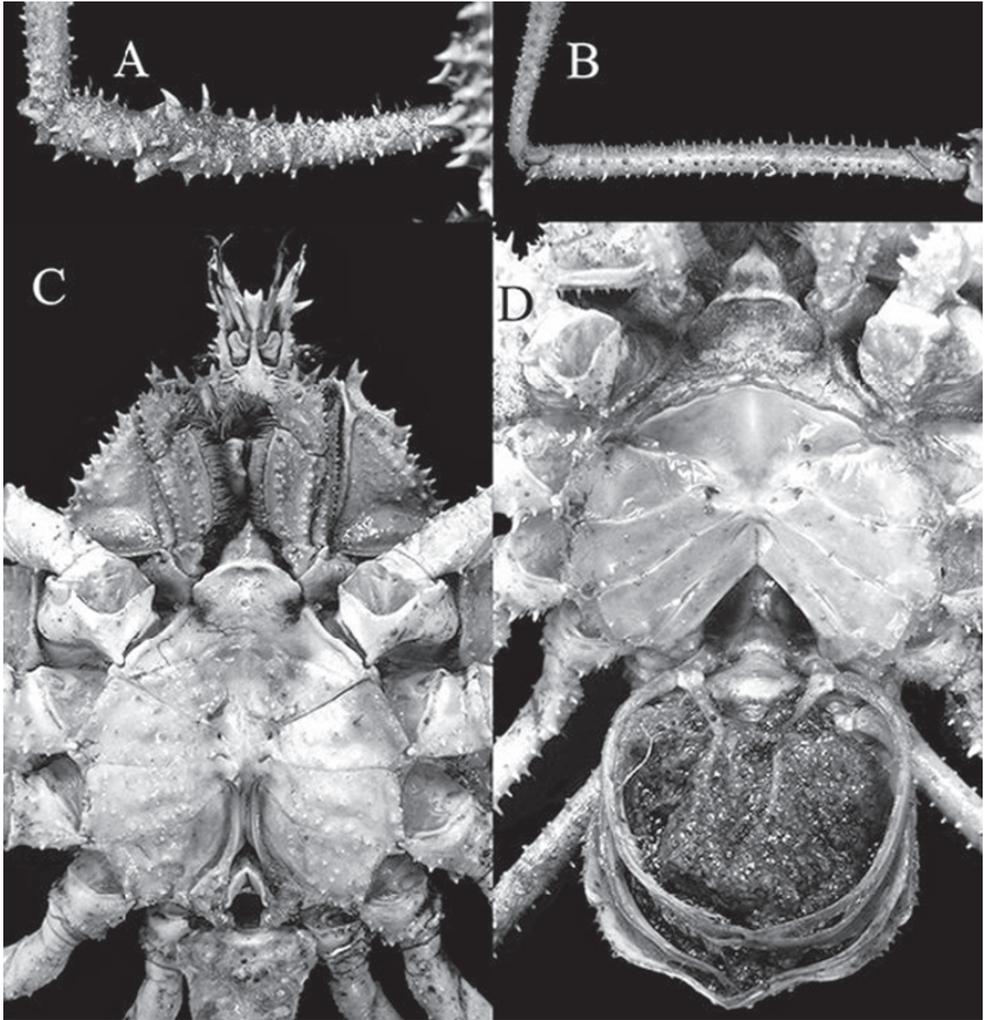


Figure 11. *Pleistacantha kannu* sp. n. **A, B** paratype ovigerous female (cl 91.3 mm, cw 75.5 mm) (DABFUK), India **C** holotype male (cl 106.2 mm, cw 87.0 mm) (CASAU), India **D** paratype ovigerous female (cl 84.4 mm, cw 71.5 mm) (CASAU), India.

The present new species most closely resembles *P. moseleyi* and *P. pungens* in having the branchial regions relatively more swollen, such that the inner margins are close to each other in the midline of the carapace with the gastric and cardiac regions forming an approximate “hour-glass” shape (cf. Ah Yong and Ng 2007: 73). In *P. kannu* sp. n., however, the branchial regions are more prominently swollen laterally and dorsally, so much so that the inner margins are now almost adjacent to each other, forming a narrow channel between them (Fig. 4C, D). The margins are so close that the adjacent spines overlap each other (Fig. 4C, D). As the specimens are all comparable in size, the difference in carapace inflation is not size-related. In addition, *P. kannu* can be distin-

guished from these three congeners in its relatively broader carapace (Figs 2A, B, 4C, D), the spines on the carapace are relatively broader and shorter even in large specimens (Figs 2A, B, 4C, D, 5C, D), the posterior carapace margin is distinctly convex (Fig. 4C), the lateral margins of the posterior margin of the epistome are prominently more concave (Fig. 7G, H), the ischium of the third maxilliped is proportionately shorter (Fig. 7I), the rostral spines are proportionately shorter, gently divergent, not curving upwards (Figs 2A, B, 4C, D, 5C, D, 6E), the interantennular spine is short and while the tip is bifurcated, the processes are short (Figs 6E, F), the male anterior thoracic sternum is proportionately broader (Fig. 9E), the adult male chelipeds are proportionately more slender and longer, with the chela elongate rather than distinctly inflated and mostly smooth (Figs 2A, 8F), the male pleon is broader and more trapezoidal in shape (Fig. 9F), and G1 is not elongate with the distal part not sharply curved and the subdistal dorsal papilla is short (Fig. 10K–M) (Table 1).

Pleistacantha kannu may be conspecific with a taxon discussed in Kazmi (1997) and identified as "*Pleistacantha adenicus*". In a review of Pakistani spider crabs, Kazmi (1997) discussed the identity of a berried female of *Pleistacantha* measuring 68 mm in carapace length collected from the mouth of the Gulf of Aden in her collection. In her abstract, she noted that "The occurrence of the genus *Pleistacantha* in the Arabian Sea and its adjacent gulfs is discussed in detail due to presence of a unique female which was taken by *Fridtjof Nansen* Cruise in 1977. This seems to be an undescribed species. At the moment the female is just given as *Pleistacantha* sp1 till more specimens obtained determine its position." (Kazmi 1997: 79). Later in the paper, the heading for her discussion was written as "DESCRIPTION OF UNDESCRIBED *PLEISTACANTHA*. *Pleistacantha* sp. 1" and she commented that "My specimen is still unnamed and is given here as *P. sp. 1*" (Kazmi 1997: 82). She described and compared the specimen with related congeners at length but she clearly opted not to name the taxon due to a lack of additional material. In her caption for her second figure, she wrote "Fig.2. *Pleistacantha* sp.1, cl.68mm" (Kazmi 1997: 84) while in her table of species discussed, she listed the taxon as "*Pleistacantha* sp.1" (Kazmi 1997: 86). However, in her caption for the first figure of this species, she wrote "Fig.1. *Pleistacantha adenicus* n. sp., holotype, cl.68 mm" (Kazmi 1997: 83). In the context of her comments, "*Pleistacantha adenicus*" cannot be regarded as an available name. The use of this new name is clearly an accident as her published intentions in the paper are clear. She probably originally wanted to name the new species but decided against this later on before publication, but forgot to remove the name from the first caption. Under the terms of reference for Article 15.1 which states that names regarded as conditionally published after 1960 are not available (ICZN 1999), "*Pleistacantha adenicus* Kazmi, 1997" must therefore be regarded as a nomen nudum.

Pleistacantha kannu is probably the same species as Kazmi's "*P. adenicus*". Both taxa share the character of the highly inflated branchial regions with the inner margins almost meeting along the midline of the carapace (Kazmi 1997: fig. 1), and their rostral, epistomal, and third maxilliped features (Kazmi 1997: fig. 2A–C) also agree. However, in lieu of examining specimens, and given that her specimen was from the Arabian Sea (the present material is all from southern India), we cannot be certain.

Table 1. Differences between *Pleistacantha moseleyi* (Miers, 1885), *P. pungens* (Wood-Mason and Alcock 1891), *P. ori* Ahlyong & Ng, 2007, and *P. kannu* sp. n.

	<i>Pleistacantha moseleyi</i>	<i>Pleistacantha pungens</i>	<i>Pleistacantha ori</i>	<i>Pleistacantha kannu</i>
Carapace	Pyriiform (Figs 3A, 4A)	Pyriiform (Figs 3B, C, 4B)	Pyriiform (cf. Ahlyong and Ng 2007: fig. 1A, B)	Broadly pyriiform (Figs 2A, B, 4C, D)
Spines on dorsal surface of carapace	Acute (Figs 3A, 4A, 5A)	Acute (Figs 3B, C, 4B, 5B)	Relatively acute but short (cf. Ahlyong and Ng 2007: fig. 1A, B)	Relatively more obtuse basally (Figs 2A, B, 4C, D, 5C, D)
Gastric regions	Gently swollen (Figs 4A, 5A)	Gently swollen (Figs 4B, 5B)	Gently swollen (cf. Ahlyong and Ng 2007: fig. 1A, B)	Strongly swollen (Figs 2A, B, 4C, D, 5C, D)
Branchial regions	Gently swollen laterally and dorsally; medially separated by distinct space and several large short, vertical spines; spines on margins of regions not overlapping (Figs 4A, 5A)	Gently swollen laterally and dorsally; medially separated by distinct space, area without spines; spines on margins of regions not overlapping (Figs 4B, 5B)	Gently swollen laterally and dorsally; medially separated by wide space, area with short spines; spines on margins of regions not overlapping (cf. Ahlyong and Ng 2007: fig. 1A, B)	Strongly swollen laterally and dorsally; medially separated by narrow space, area without spines; spines on margins of regions overlapping (Figs 2A, B, 4C, D, 5C, D)
Posterior carapace margin	Gently concave (Fig. 4A)	Gently concave (Fig. 4B)	Distinctly convex (cf. Ahlyong and Ng 2007: fig. 1B)	Distinctly convex (Fig. 4C, D).
Rostral spines	Relatively long; strongly divergent; distinctly curving upwards (Figs 3A, 4A, 5A, 6A)	Relatively long; gently divergent; directed obliquely laterally, not curving upwards (Figs 3B, C, 4B, 5B, 6C)	Relatively long; gently divergent; directed obliquely laterally, not curving upwards (cf. Ahlyong and Ng 2007: figs 1C, 2B)	Relatively short; gently divergent; directly obliquely laterally, not curving upwards (Figs 2A, B, 4C, D, 5C, D, 6E)
Interantennular spine	Long, slender; tip deeply bifurcated forming 2 long processes (Figs 6A, B)	Long; tip deeply bifurcated forming 2 long processes (Figs 6C, D)	Long; tip deeply bifurcated forming 2 long processes (cf. Ahlyong and Ng 2007: fig. 2D)	Short; tip bifurcated with shallow concavity between short processes (Figs 6E, F)
Posterior margin of epistome	Lateral margins gently concave (Fig. 7A, B)	Lateral margins gently concave (Fig. 7D, E)	Lateral margins gently concave (cf. Ahlyong and Ng 2007: fig. 2A)	Lateral margins strongly concave (Fig. 7G, H)
Third maxilliped	Ischium elongate (Fig. 7C)	Ischium elongate (Fig. 7F)	Ischium elongate (cf. Ahlyong and Ng 2007: fig. 3C)	Ischium short (Fig. 7I)
Outer surfaces of male chelipeds	With numerous long sharp spines (Figs 3A, 8A, B)	With numerous long sharp spines (Figs 3B, 8E, F)	Mostly smooth, proximal part with short tubercles or granules, without long spines (cf. Ahlyong and Ng 2007: fig. 1E)	Mostly smooth, proximal part with short tubercles or granules, without long spines (Figs 2A, 8E, F)
Male merus	Relatively short, stout (Figs 3A, 8A)	Relatively short, stout (Figs 3B, 8C)	Relatively short, stout (cf. Ahlyong and Ng 2007: 1A)	Elongate, slender (Figs 2A, 8E)

	<i>Pleistacantha moseleyi</i>	<i>Pleistacantha pungens</i>	<i>Pleistacantha ori</i>	<i>Pleistacantha kannu</i>
Male chela	Relatively short, stout (Figs 3A, 8B)	Relatively short, stout (Figs 3B, 8D)	Relatively short, stout (cf. Ah Yong and Ng 2007: fig. 1E)	Elongate, slender (Figs 2A, 8F)
Male anterior thoracic sternum	Relatively narrow; surface with numerous sharp posteriorly directed spines (Fig. 9A)	Relatively narrow; surface with sharp posteriorly directed spines and tubercles (Fig. 9C)	Relatively broad; surface with numerous sharp tubercles and short spines (cf. Ah Yong and Ng 2007: 2C)	Relatively broad; surface with numerous blunt and sharp tubercles, never spines (Fig. 9E)
Male pleon (somites 4–6)	Relatively narrow transversely; almost rectangular in shape; surface with numerous sharp posteriorly directed spines (Fig. 9B)	Relatively narrow transversely; almost rectangular in shape; surface with sharp posteriorly directed spines and tubercles (Fig. 9D)	Relatively narrow transversely; almost rectangular in shape; surface with sharp posteriorly directed spines and tubercles (cf. Ah Yong and Ng 2007: fig. 2C)	Transversely wide; distinctly trapezoidal; surface with numerous blunt and sharp tubercles, never spines (Fig. 9F)
G1	Relatively stout; distal part gently curved; subdistal dorsal papilla long (Fig. 10A–C)	Relatively slender; distal part gently curved; subdistal dorsal papilla long (Fig. 10E–G)	Relatively long, slender; distal part sharply curved; subdistal dorsal papilla long (Fig. 10I, J; Ah Yong and Ng 2007: fig. 4)	Relatively stout; distal part gently curved; subdistal dorsal papilla short (Fig. 10K–M)

The prominently swollen branchial regions of *Pleistacantha kannu* are noteworthy, and may suggest that they also live in low oxygen deep-sea habitats, an area known as the “oxygen minimum zone” in the Indian Ocean (see Creasey et al. 1997). This is the habitat apparently favoured by the inachid *Encephaloides armstrongi* Wood-Mason, in Wood-Mason and Alcock 1891, which has even more disproportionately swollen branchial regions, presumably to aid in respiration in such zones (see also Kazmi and Moazzam 2014; Dash et al. 2017). This may also be true of a recently described deep-water homolid, *Moloha tumida* Ng & Kumar, 2015, described also from the western Indian Ocean (Ng and Kumar 2015).

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References

- Ahyong ST, Chen H, Ng PKL (2005) *Pleistacantha stilipes*, a new species of spider crab from the South China Sea (Decapoda: Brachyura: Majidae). *Zootaxa* 822: 1–10. <https://doi.org/10.11646/zootaxa.822.1.1>
- Ahyong ST, Lee T (2006) Two new species of *Pleistacantha* Miers, 1879 from the Indo-West Pacific region (Crustacea, Decapoda, Majidae). *Zootaxa* 1378: 1–17.
- Ahyong ST, Ng PKL (2007) *Pleistacantha ori*, a new species of deep-water spider crab (Crustacea: Decapoda: Brachyura: Majidae) from the western Indian Ocean. *Raffles Bulletin of Zoology, Supplement* 16: 67–74.
- Creasey S, Rogers AD, Tyler P, Young C, Gage J (1997) The population biology and genetics of the deep-sea spider crab, *Encephaloides armstrongi* Wood-Mason 1891 (Decapoda: Majidae). *Philosophical Transactions of the Royal Society of London, Series B*, 352: 365–379. <https://doi.org/10.1098/rstb.1997.0027>
- Dash G, Koya MK, Makwana NP (2017) First report of a deep sea spider crab, *Encephaloides armstrongi* Wood-Mason and Alcock, 1891 from Gujarat waters of India. *Indian Journal of GeoMarine Sciences* 46(5): 982–985.
- Davie PJF, Guinot D, Ng PKL (2015) Anatomy and functional morphology of Brachyura. In: Castro P, Davie PJF, Guinot D, Schram FR, von Vaupel Klein JC (Eds) *Treatise on Zoology – Anatomy, Taxonomy, Biology. The Crustacea. Volume 9C-I. Decapoda: Brachyura (Part 1)*, 11–163. https://doi.org/10.1163/9789004190832_004

- Froggia C, Clark PF (2011) The forgotten Narrative of *H.M.S. Challenger* and the implications for decapod nomenclature. *Zootaxa* 2788: 45–56.
- Grindley JR (1961) On some crabs trawled off the Natal coast. *Durban Museum Novitates* 6(10): 127–134.
- Guinot D, Richer de Forges B (1982) Nouvelles récoltes des genres *Cyrtomaia* Miers et *Pleistacantha* Miers (Crustacea, Decapoda, Brachyura). *Bulletin du Muséum National d'Histoire Naturelle, Paris, series 4, 3, section A (4)*: 1087–1125. [Dated 1981, published 1982.]
- Guinot D, Richer de Forges B (1986) Crustacés Décapodes: Majidae (genres *Platymaia*, *Cyrtomaia*, *Pleistacantha*, *Sphenocarcinus* et *Naxioides*). In: Résultats des Campagnes MUSEORSTOM I et II -Philippines (1976, 1980). Tome 2. Mémoires du Muséum national d'Histoire naturelle, Paris, A (Zoologie) 133: 83–179. [figs 1–21, pls 1–9]
- ICZN, International Commission on Zoological Nomenclature (1999) *International Code of Zoological Nomenclature*. International Commission of Zoological Nomenclature. Fourth Edition. Adopted by the XXI General Assembly of the International Union of Biological Sciences. International Trust for Zoological Nomenclature, in association with the British Museum (Natural History), London, 338 pp.
- Kazmi QB (1997) A review of spider majid crabs of the northern Arabian Sea, with particular reference to Pakistani species, and with description of an undescribed *Pleistacantha*. *Pakistan Journal of Marine Sciences* 6 (1/2): 79–91.
- Kazmi QB, Moazzam M (2014) Additional report on Armstrongs' Spider Crab, *Encephaloides armstrongi* Wood-Mason & Alcock, 1891 (Crustacea, Decapoda, Brachyura, Majidae) from Pakistanis waters. *FUUAST Journal of Biology, Federal Urdu University of Arts, Science & Technology, Pakistan* 4(2): 265–267.
- Marco-Herrero E, Torres AP, Cuesta JA, Guerao G, Palero F, Abelló P (2013) The systematic position of *Ergasticus* (Decapoda, Brachyura) and allied genera, a molecular and morphological approach. *Zoologica Scripta* 42(4): 427–439. <https://doi.org/10.1111/zsc.12012>
- Mendoza JCE, Suvarna Devi S (2017) A new species of the swimming crab genus, *Laleonectes* Manning & Chace, 1990 (Crustacea: Brachyura: Portunidae), from the western Indian Ocean. *Zootaxa* 4323(2): 219–228. <https://doi.org/10.11646/zootaxa.4323.2.5>
- Miers EJ (1885) The Brachyura. In: Tizard TH, Moseley HN, Buchanan JY, Murray J (Eds) Narrative of the cruise of H.M.S. Challenger with a general account of the scientific results of the expedition. Report on the Scientific Results of the Voyage of H.M.S. Challenger during the years 1873–1876 under the command of Captain George S. Nares, R.N., F.R.S. and the late Captain Frank Tourle Thomson, R.N. prepared under the Superintendence of the late Sir C. Wyville Thomson, Knt., F.R.S. &c. Regius Professor of Natural History in the University of Edinburgh Director of the civilian scientific staff on board and now of John Murray, one of the naturalists of the Expedition. Order of Her Majesty's Government, London, Edinburgh and Dublin, Her Majesty Stationery Office. Narrative 1(2): 585–592.
- Miers EJ (1886) Part II. Report on the Brachyura collected by H.M.S. *Challenger* during the years 1873–76. In: Report on the Scientific Results of the Voyage of H.M.S. Challenger during the years 1873–1876 under the command of Captain George S. Nares, N.R., F.R.S. and the late Captain Frank Tourle Thomson, R.N. prepared under the Superintendence of

- the late Sir C. Wyville Thomson, Knt., F.R.S. &c. Regius Professor of Natural history in the University of Edinburgh of the civilian scientific staff on board and now of John Murray one of the naturalists of the Expedition. Zoology, Published by Order of Her Majesty's Government. London, Edinburgh and Dublin, HMSO 17: 1–362. [pls 1–29]
- Ng PKL, Guinot D, Davie PJF (2008) Systema Brachyurorum: Part I. An annotated checklist of extant brachyuran crabs of the world. Raffles Bulletin of Zoology, Supplement 17: 1–286.
- Ng PKL, Kumar AB (2015) The species of *Moloha* Barnard, 1946, from the western Indian Ocean, with the description of a new species from India (Crustacea: Brachyura: Homolidae). European Journal of Taxonomy 166: 1–25. <https://doi.org/10.5852/ejt.2015.166>
- Ng PKL, Kumar AB (2016) *Carcinoplax fasciata*, a new species of deep-water goneplacid crab from southwestern India (Crustacea: Decapoda: Brachyura: Goneplacoidea). Zootaxa 4147(2): 192–200. <https://doi.org/10.11646/zootaxa.4147.2.6>
- Ng PKL, Prema M, Tan SH, Ravichandran S (2017) The taxonomy of two poorly known species of elbow crabs, *Daldorfia spinosissima* (A. Milne-Edwards, 1862), and *D. triangularis* Sakai, 1974 (Brachyura, Parthenopidae). Crustaceana 90(14): 1779–1791. <https://doi.org/10.1163/15685403-00003721>
- Ng PKL, Richer de Forges B (2012) *Pleisticanthoides* Yokoya, 1933, a valid genus of deep-sea inachid spider crab (Crustacea: Decapoda: Brachyura: Majoidea), with descriptions of two new species from the Philippines, Papua-New Guinea and Vanuatu. Zootaxa 3551: 65–81.
- Prema M, Ravichandran S, Ng PKL (2017) Redescription of *Parilia alcocki* (Wood-Mason, in Wood-Mason & Alcock, 1891) (Decapoda, Brachyura, Leucosiidae) from Pazhayar, southeast coast, India. Zootaxa.
- Richer de Forges B, Ng PKL, Ahyong ST (2013) *Parapleisticantha* Yokoya, 1933, a valid genus of deep-sea inachid spider crab from Japan and the Philippines (Crustacea: Decapoda: Brachyura: Majoidea), with the description of a new species. Zootaxa 3635(1): 15–26. <https://doi.org/10.11646/zootaxa.3635.1.2>
- Wood-Mason J, Alcock A (1891) Natural history notes from H. M. Marine Survey Steamer 'Investigator,' Commander R. F. Hoskyn, R.N., late commanding. No. 21. Note on the results of the last season's deep-sea dredging. Annals and Magazine of Natural History, series 6, 7: 258–272.