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Research Article

Dimorphostylis pilocorpus sp. nov. (Crustacea, Cumacea, Diastylidae), a new cumacean from Korean waters

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Abstract

A new species of Cumacea belonging to the genus *Dimorphostylis* Zimmer was collected from the Dokdo and Ulleung Islands in the East Sea of Korea. The new species, *Dimorphostylis pilocorpus* **sp. nov.**, can be distinguished from all other *Dimorphostylis* species by the combination of the body surface covered with numerous slender simple setae; carapace with one transverse, a pair of frontal, and three pairs of oblique ridges; three pairs of oblique ridges connected on a submedian carina; telson of the female with 1 pair of short simple and 1 short, stout simple seta centrally; 1 pair of stout simple and 3 pairs of short simple setae on the post-anal section; pleonite 5 of male with 1 spiniform seta on the ventral margin; post-anal section with 2 pairs of stout simple setae bearing a single subterminal setule on both sides; terminal margin with 3 stout simple setae; and a central seta slightly longer than the outer pair of setae. Full illustrations of the new species, including the mouthparts, are given in this paper. A key to the Korean species of *Dimorphostylis* is also provided.

Key words: Cumacea, Diastylidae, *Dimorphostylis*, identification key, morphology, new species, taxonomy

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Introduction

The family Diastylidae Bate, 1856 is currently composed of 25 genera and approximately 355 species worldwide (WoRMS 2023). Among the 25 genera, *Dimorphostylis* Zimmer, 1921 is the fourth most speciose genus, following *Diastylis* Say, 1818, *Makrokylindrus* Stebbing, 1912 and *Leptostylis* G.O. Sars, 1869. The genus *Dimorphostylis* was established by Zimmer (1921) for *Dimorphostylis asiatica* from Japanese waters, and 33 species have been reported. *Dimorphostylis* is distributed in the Indo-West Pacific and the coast of Australia (Akiyama 2011; Gerken 2014). All known *Dimorphostylis* are shallow water inhabitants, with the deepest previous record of 918 m in *Dimorphostylis brevicarpus* Akiyama, 2011. Up to now, nine *Dimorphostylis* species have been recorded from Korean waters: *Dimorphostylis acroplicata* Harada, 1960, *D. asiatica* Zimmer, 1921, *D. breviplicata* Lee & Lee, 2012, *D. echinata* Gamô 1962, *D. hirsuta* Gamô 1960, *D. longicauda* Gamô 1962, *D. manazuruensis* Gamô 1960, *D. namhaedoensis* Lee & Lee, 2000 and *D. valida* Harada, 1960 (Kang and Lee 1995; Hong et al. 1998; Lee and Lee 2002, 2007, 2012; Lee et al. 2003). In this study, we describe and illustrate a new species of *Dimorphostylis* from Korean waters. A key to the Korean species of the genus *Dimorphostylis* is also provided.

Material and methods

The specimens were collected using a light trap (Holmes and O'Connor 1988; Kim 1992) from the Dokdo and Ulleung Islands (East Sea), Korea. The collected specimens were fixed in 80% ethanol, moved to the laboratory, and stored in 95% ethanol. The specimens were identified with a stereomicroscope (Model SZX12; Olympus, Japan). Photographs of the whole body were taken with a microscope equipped with a digital camera (eXcope T500; DIXI Science, Korea) and complemented by Helicon Focus v. 7.7.5 (Helicon Soft Ltd., Kharkiv, Ukraine). The body length was measured from the anterior tip of the carapace to the posterior end of pleonite 6. The lengths of the appendages were measured along the mid-line of each appendage. The whole body was drawn using a stereomicroscope (Olympus SZX12) with a drawing tube. Later, the samples were transferred to glycerin for dissection under a stereomicroscope (Olympus SZX12). Drawing of the appendages was performed using a light microscope (Model BX51; Olympus, Japan) with a drawing tube. Type specimens were deposited at the National Institute of Biological Resources (NIBR), Incheon, Korea.

Taxonomy

Genus *Dimorphostylis* Zimmer, 1921

Type species. *Dimorphostylis asiatica* Zimmer, 1921.

Diagnosis. ***Female and subadult male*.** Maxilliped 3 with exopod. Pereopods 3–4 without exopods in female and with exopods in subadult male. ***Adult male*.** Bases of pereopods 2–4 expanded, with exopod.

Species composition. *Dimorphostylis acroplicata* Harada, 1960, *D. asiatica* Zimmer, 1908, *D. australis* Foxon, 1932, *D. bathyelegans* Akiyama, 2011, *D. brevicarpus* Akiyama, 2011, *D. brevicaudata* (Zimmer, 1903), *D. breviplicata* Lee & Lee, 2012, *D. colefaxi* Hale, 1945, *D. cornigera* Harada, 1960, *D. coronata* Gamô, 1960, *D. cottoni* Hale, 1936, *D. echinata* Gamô, 1962, *D. elegans* Gamô, 1960, *D. gibbosa* Harada, 1960, *D. hirsuta* Gamô, 1960, *D. horai* Kurian, 1956, *D. inauspicata* Hale, 1945, *D. latifrons* Harada, 1960, *D. longicauda* Gamô, 1962, *D. longitelson* Kurian, 1963, *D. maledivensis* Mühlenhardt-Siegel, 1996, *D. manazuruensis* Gamô, 1960, *D. namhaedoensis* Lee & Lee, 2002, *D. nordaustraliana* Gerken, 2014, *D. quadriplicata* Gamô, 1960, *D. roccatagliatai* Gerken, 2014, *D. sculpturensis* Vassilenko & Tzareva, 1990, *D. subaculeata* Hale, 1945, *D. tasmanica* Hale, 1945, *D. tribulis* Hale, 1945, *D. triplicata* Gerken, 2014, *D. valida* Harada, 1960 and *D. vieta* (Hale, 1936).

Dimorphostylis pilocorpus **sp. nov.**
https://zoobank.org/1A9BEBD2-3F28-4966-8A30-8AFF7EFD89A6
Figs 1–7
Korean name: Ju-reum-teol-bo-i-hyeong-ol-chaeng-i-sae-u, new

Type material. ***Holotype***, ovigerous female, 3.51 mm, cat no. NIBRIV0000901416, Sadong Port, Sadong-ri, Ulleung-eup, Ulleung-gun, Gyeongsangbuk-do, Korea, 37°27'37.1"N, 130°52'35.3"E, 3 July 2022, S.H. Kim collected by light trap. ***Paratypes***, 1 ovigerous female, cat no. NIBRIV0000911249 and 2 adult males, cat no. NIBRIV0000911248, NIBRIV0000911250, data same as holotype (1♂ 1♀ dissected); the remaining paratypes 80♂♂ 12♀♀, cat no. NIBRIV0000911251, data same as holotype.

Additional material examined. 1♂, NIBRIV0000901413, Namyang Port, Namyang-ri, Seo-myeon, Ulleung-gun, Gyeongsangbuk-do, Korea, 37°28'00.8"N, 130°49'59.5"E, 28 April 2022, S.H. Kim collected by light trap; 1♂ 1♀, NIBRIV0000901414, Namyang Port, Namyang-ri, Seo-myeon, Ulleung-gun, Gyeongsangbuk-do, Korea, 37°28'00.8"N, 130°49'59.5"E, 3 July 2022, S.H. Kim collected by light trap; 49♂♂, NIBRIV0000901415, Sadong Port, Sadong-ri, Ulleung-eup, Ulleung-gun, Gyeongsangbuk-do, Korea, 37°27'37.1"N, 130°52'35.3"E, 28, April, 2022, S.H. Kim collected by light trap; 9♂♂, NIBRIV0000901417, Dokdo-ri, Ulleung-eup, Ulleung-gun, Gyeongsangbuk-do, Korea, 37°14'38.0"N, 131°51'41.0"E, 30 April 2022, S.H. Kim collected by light trap; 1♂, NIBRIV0000901418, Dokdo-ri, Ulleung-eup, Ulleung-gun, Gyeongsangbuk-do, Korea, 37°14'23.1"N, 131°52'03.5"E, 30 April 2022, S.H. Kim collected by light trap; 5♂♂, NIBRIV0000901419, Dokdo-ri, Ulleung-eup, Ulleung-gun, Gyeongsangbuk-do, Korea, 37°14'17.8"N, 131°52'08.8"E, 6 July 2022, S.H. Kim collected by light trap; 3♂♂ 6♀♀, NIBRIV0000901420, Dokdo-ri, Ulleung-eup, Ulleung-gun, Gyeongsangbuk-do, Korea, 37°14'26.3"N, 131°52'16.6"E, 7 July 2022, S.H. Kim collected by light trap; 2♀♀, NIBRIV0000901421, Cheonbu Port, Cheonbu-ri, Buk-myeon, Ulleung-gun, Gyeongsangbuk-do, Korea, 37°32'27.1"N, 130°52'22.3"E, 4 July 2022, S.H. Kim collected by light trap.

Diagnosis. Body surface covered with numerous slender simple setae, carapace with 1 transverse, 1 pair of frontal, and 3 pairs of oblique ridges. ***Adult female*.** Carapace with 1 pair of small spines respectively on pseudorostral lobe and ocular lobe, 2 small spines on median region of frontal lobe, telson with 1 pair of short simple and 1 short stout simple seta centrally, 1 pair of stout simple and 3 pairs of short simple setae on post-anal section, 2 stout simple setae terminally. ***Adult male*.** Pleonite 5 with 1 spiniform seta on ventral margin, post-anal section with 2 pairs of stout simple setae bearing single subterminal setule on both sides, terminal margin with 3 stout simple setae, central seta slightly longer than outer pair of setae.

Description. Paratype, ovigerous female, cat no. NIBRIV0000911249. Body (Fig. 2A) length 4.42 mm. Body surface covered with numerous slender, simple setae (Figs 2B, 5B). Carapace (Fig. 2A, C) 0.3 times as long as body, 1.2 times as long as width, 1.4 times as long as depth, frontal lobe with 1 transverse ridge; both sides of carapace with 1 pair of frontal ridges and 3 pairs of oblique ridges (anterior, middle, and posterior); frontal ridges serrated, connecting to a transverse ridge; anterior oblique ridge beginning near pseudorostrum, running upward and not connecting to dorso-median portion of carapace, front

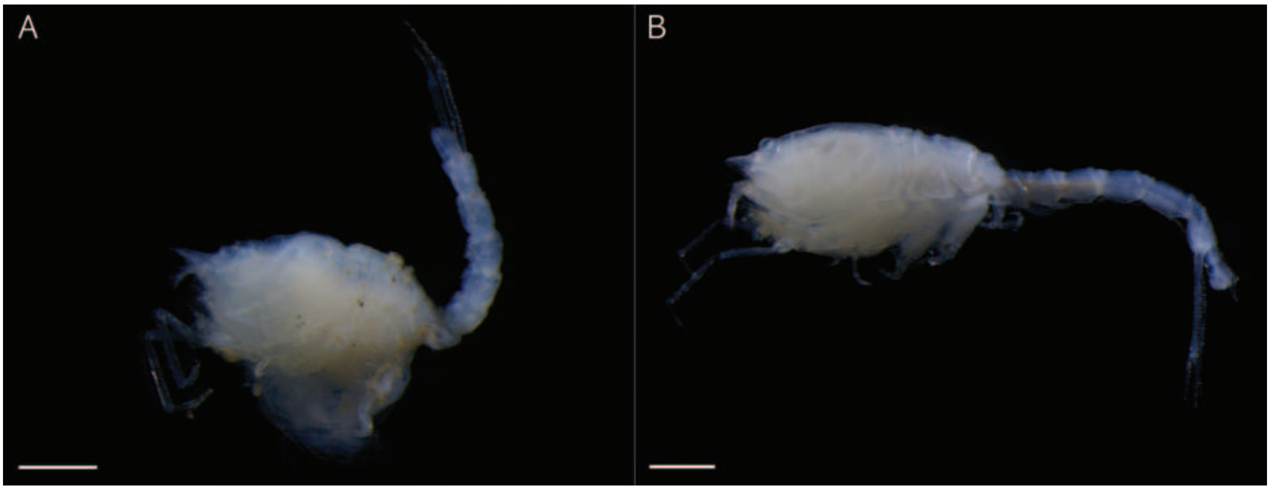

Figure 1. *Dimorphostylis pilocorpus* sp. nov. **A** holotype, ovigerous female, 3.51 mm, cat no. NIBRIV0000901416, lateral view **B** paratype, adult male, 4.62 mm, cat no. NIBRIV0000911248, lateral view. Scale bars: 0.5 mm (**A, B**).

part serrated; middle oblique ridge beginning near ventral margin of carapace, almost parallel with anterior oblique ridge, running upward and turning abruptly forward to merge with anterior oblique ridge; posterior oblique ridge running upward to 6/7 point of carapace, connecting with middle ridge; pseudorostral lobe and ocular lobe with 1 pair of small spines respectively, 2 small spines on median region of frontal lobe, lens of ocular lobe invisible; dorsal groove formed on posteromedian surface of carapace; antennal notch and antero-lateral angle prominent, antero-lateral and anterior half of lower margins serrated. Pereon (Fig. 2A, C) 0.7 times as long as carapace. Pleon (Fig. 2A) 0.8 times as long as carapace and pereon together.

Antenna 1 (Fig. 2D) peduncle 3-articulate; article 1 subequal in length to remaining articles combined, with several hair-like and 1 bent simple setae laterally, 7 slender simple setae on surface, numerous hair-like setae on surface and medial margin, 1 long plumose seta mediodistally; article 2 0.4 times as long as article 1, with several hair-like setae on both margins, 1 slender simple seta on surface, 2 simple, 1 long simple, and 2 plumose setae medially; article 3 1.7 times as long as article 2, with 2 long simple setae laterodistally, 2 slender simple setae on surface, 4 simple setae medially, 2 complex pedunculate setae mediodistally. Main flagellum 3-articulate; article 1 unarmed; article 2 with 1 aesthetasc distally; article 3 with 1 aesthetac, 3 short simple, 1 complex pedunculate, and 1 long annulate setae terminally. Accessory flagellum 3-articulate; article 1 with 1 short simple seta medially; article 2 with 1 complex pedunculate seta distally; 3 simple and 1 complex pedunculate setae terminally.

Left mandible (Fig. 2E) with row of 11 lifting setae; incisor with 2 teeth; lacinia mobilis with 3 teeth.

Right mandible (Fig. 2F) with row of 12 lifting setae; incisor with 2 teeth.

Maxilla 1 (Fig. 2G) outer endite with 1 plumose seta laterally, several hair-like setae medially, 7 stout simple, 3 stout microserrate, and several hair-like setae terminally; inner endite with several hair-like setae lateral and medial margins, 1 simple, 2 stout simple, 1 stout tricuspid, and 1 stout microserrate setae terminally; palp with 2 setae.

Maxilla 2 (Fig. 2H) broad endite with few hair-like setae laterally, several hair-like, 21 simple, and 2 microserrate setae medially, several hair-like, 1 stout

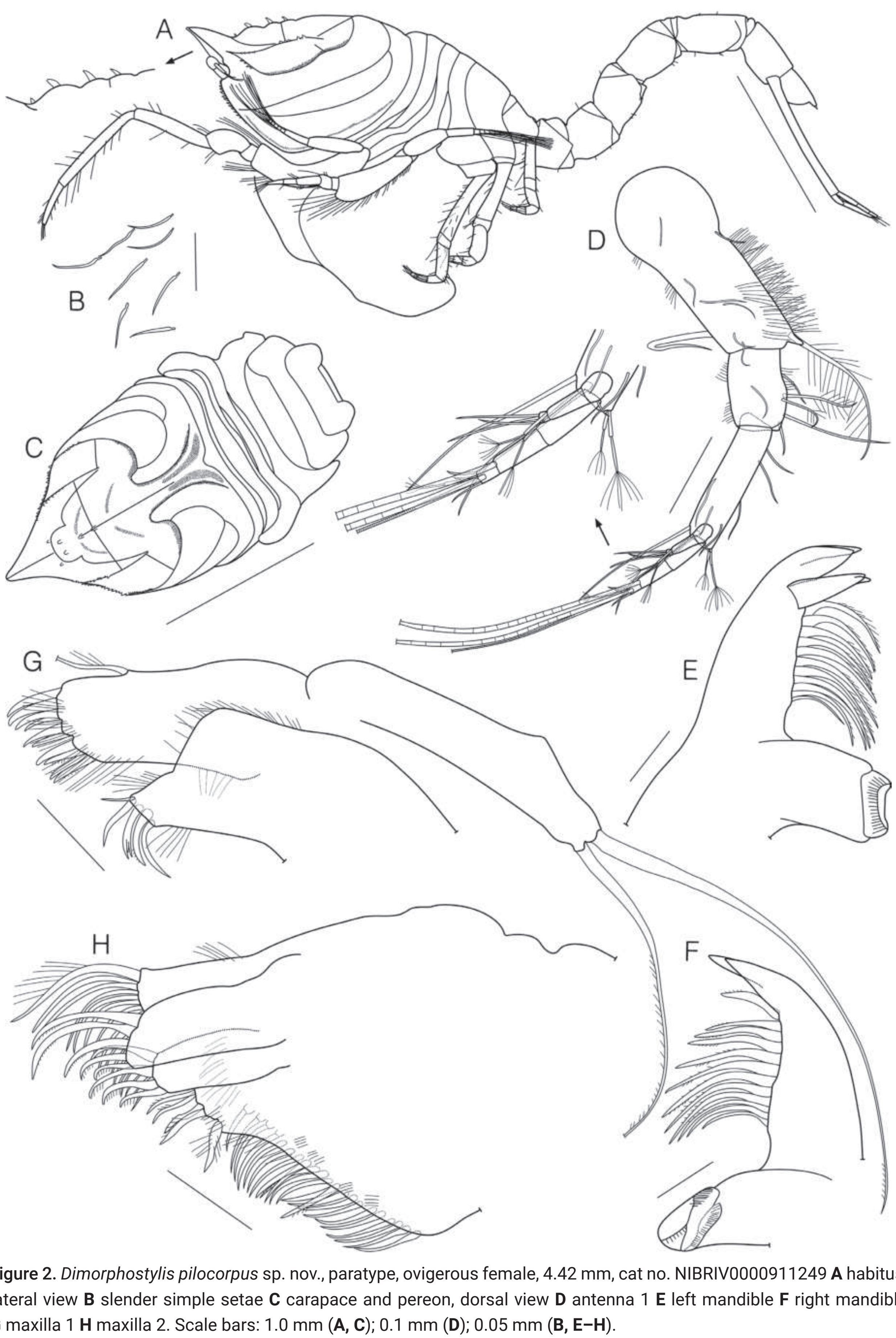

Figure 2. *Dimorphostylis pilocorpus* sp. nov., paratype, ovigerous female, 4.42 mm, cat no. NIBRIV0000911249 **A** habitus, lateral view **B** slender simple setae **C** carapace and pereon, dorsal view **D** antenna 1 **E** left mandible **F** right mandible **G** maxilla 1 **H** maxilla 2. Scale bars: 1.0 mm (**A, C**); 0.1 mm (**D**); 0.05 mm (**B, E–H**).

pappose, 3 microserrate, 1 plumose, and 13 simple setae terminally; outer endite with 5 stout microserrate setae terminally; inner endite with 4 stout microserrate setae terminally.

Maxilliped 1 (Fig. 3A) basis with numerous hair-like and 3 short simple setae on lateral surface, 1 plumose seta mediodistally, medial lobe with 5 plumo-microserrate, 3 plumose, and 2 hook setae medially, 1 plumose, 2 stout simple, 1 simple, and 1 stout bicuspid setae terminally; ischium not present; merus with few hair-like setae laterally, several hair-like and 1 plumose setae on lateral surface, 2 plumose setae distally; carpus with few hair-like and 1 long plumose setae laterally, several hair-like and 7 plumose setae on lateral surface, 4 comb-like setae medially, 4 plumose setae subdistally; propodus with 5 plumose, 2 long plumose, 1 stout microserrate, and 1 stout serrate setae distally; dactylus with few hair-like setae laterally, 4 simple setae terminally.

Maxilliped 2 (Fig. 3B) basis subequal in length to remaining articles combined, with several hair-like setae on lateral and medial margins, 3 short simple setae on medial surface, 4 long plumose setae distally; ischium short, unarmed; merus with 2 plumose setae distally; carpus with several hair-like and 5 plumose setae medially, 3 plumose setae distally; propodus with 2 plumose and 2 plumo-serrate setae medially, 2 plumose setae on medial surface, 1 plumose and 1 long plumose setae distally; dactylus with 4 simple, 2 stout simple, and 1 microserrate setae terminally.

Maxilliped 3 (Fig. 3C) basis 1.4 times as long as remaining articles combined, with 12 slender simple setae on lateral surface, numerous hair-like setae on surface and both margins, 1 short simple, 1 plumose, and 4 long plumose setae laterodistally, several spines, 1 stout spiniform and 7 plumose setae medially; ischium with 4 slender simple setae on lateral surface, 1 stout spiniform, several hair-like, and 1 plumose setae medially; merus 1.3 times as long as ischium, with 1 long plumose seta laterally, 1 stout spiniform, several hair-like and 2 plumose setae medially; carpus 1.3 times as long as merus, with 1 plumose seta laterally, 2 long simple and 3 plumose setae medially; propodus 0.8 times as long as carpus, with 1 plumose seta laterally, 4 plumose setae medially; dactylus 0.7 times as long as propodus, with 2 long simple setae laterodistally, 2 microserrate setae mediodistally, and 1 simple, 1 long stout simple, and 1 long microserrate seta terminally; exopod shorter than basis length.

Pereopod 1 (Fig. 3D) basis 0.4 times as long as remaining articles combined, with 9 slender simple setae on surface, 9 plumose setae on lateral surface and margin, 1 complex pedunculate and numerous hair-like setae on lateral surface, several spines, 4 short simple, 13 simple, and 10 plumose setae medially, 2 short simple and 4 long plumose setae distally; ischium 0.1 times as long as basis, with few hair-like and 1 short simple setae medially; merus 2.6 times as long as ischium, with several hair-like, 1 short simple, and 2 plumose setae laterally, 3 slender simple and 1 plumose setae on surface, 1 short simple and 2 simple setae medially; carpus 2.3 times as long as merus, with 1 short simple and 2 simple setae laterally, 12 slender simple setae on lateral surface, numerous hair-like and 2 simple setae medially; propodus 1.2 times as long as carpus, with 7 simple setae laterally, 12 slender simple setae on surface, numerous hair-like, 4 simple, and 4 long simple setae medially; dactylus 0.4 times as long as propodus, with 2 short simple and 4 simple setae laterally, few hair-like, 1 short simple, and 7 simple setae medially, 2 simple and 2 stout simple

Figure 3. *Dimorphostylis pilocorpus* sp. nov., paratype, ovigerous female, 4.42 mm, cat no. NIBRIV0000911249 **A** maxilliped 1 **B** maxilliped 2 **C** maxilliped 3 **D** pereopod 1. Scale bars: 0.2 mm (**C, D**); 0.1 mm (**B**); 0.05 mm (**A**).

setae terminally; exopod shorter than basis length, basal article with several hair-like and 1 short simple setae laterally.

Pereopod 2 (Fig. 4A) basis subequal in length to remaining articles combined, with 12 slender simple and 1 complex pedunculate setae on lateral surface, 9 short simple setae on lateral surface and margin, 4 spines, 17 simple, 4 plumose, and 8 long plumose setae medially; ischium 0.1 times as long as basis, with few hair-like setae laterally, few hair-like and 1 short simple setae medially; merus 2.0 times as long as ischium, with few hair-like, 1 slender simple, 2 short simple, and 1 plumose setae laterally, few hair-like, 1 short simple, and 1 simple setae medially, 1 plumose seta distally; carpus 1.3 times as long as merus, with few hair-like, 1 slender simple, 1 short simple and 1 simple setae laterally, 3 short simple and 2 simple setae medially; propodus 0.6 times as long as carpus, with few hair-like setae laterally, 1 complex pedunculate, 2 short simple and 1 long simple setae distally; dactylus subequal in length to propodus, with few hair-like, 1 short simple, and 1 simple setae laterally, few hair-like, 3 simple, and 1 annulate setae medially, 1 short simple and 4 annulate setae terminally; exopod longer than basis length, basal article with several hair-like and 6 short simple setae laterally.

Pereopod 3 (Fig. 4B) basis 1.2 times as long as remaining articles combined, with 5 slender simple setae on lateral surface, 6 simple and 1 complex pedunculate setae laterally, 1 simple, 2 plumose, and 3 long plumose setae on medial surface, 1 simple and 1 complex pedunculate setae medially; ischium 0.1 times as long as basis, with 1 simple seta laterally, 1 simple seta medially, 1 simple and 2 annulate setae mediodistally; merus 2.9 times as long as ischium, with 2 slender simple setae on lateral surface, 3 simple setae laterally, 3 simple setae medially, 2 simple setae on surface; carpus 0.5 times as long as merus, with 1 simple, 1 annulate, and 1 stout annulate setae distally; propodus 0.9 times as long as carpus, with 1 spine laterally, 1 complex pedunculate seta medially, 1 stout annulate seta distally; dactylus 0.5 times as long as propodus, with 1 simple seta medially, 1 simple and 1 stout simple setae terminally.

Pereopod 4 (Fig. 4C) basis 0.8 times as long as remaining articles combined, with 2 slender simple setae on surface, 2 simple setae laterally, 1 simple and 2 annulate setae laterodistally, 3 simple and 2 complex pedunculate setae medially; ischium 0.2 times as long as basis, with 1 simple and 1 annulate setae laterally; merus 3.1 times as long as ischium, with 1 slender simple seta on surface, 2 simple and 1 annulate setae laterally; carpus 0.3 times as long as merus, with 1 annulate seta laterally, 3 annulate setae medially, 1 simple seta distally; propodus 0.9 times as long as carpus, with 1 annulate seta on lateral surface, 1 complex pedunculate seta mediodistally; dactylus 0.6 times as long as propodus, with 1 simple seta medially, 1 simple and 1 stout simple setae terminally.

Pereopod 5 (Fig. 4D) basis 0.7 times as long as remaining articles combined, with 1 slender simple, 1 simple, 1 annulate, and 1 complex pedunculate setae on lateral surface, 2 simple and 1 annulate setae laterally, 1 simple seta mediodistally, 1 annulate seta distally; ischium 0.2 times as long as basis, with 1 simple seta medially, 2 annulate setae distally; merus 3.7 times as long as ischium, with 2 annulate and 1 simple setae laterally, 1 simple seta medially; carpus 0.6 times as long as merus, with 2 annulate setae laterally, 3 annulate setae on lateral surface, 1 simple seta medially; propodus 0.6 times as long as carpus, with 1 complex pedunculate and 1 annulate setae distally; dactylus 0.8 times as long as propodus, with 1 simple seta medially, 1 simple and 1 stout simple setae terminally.

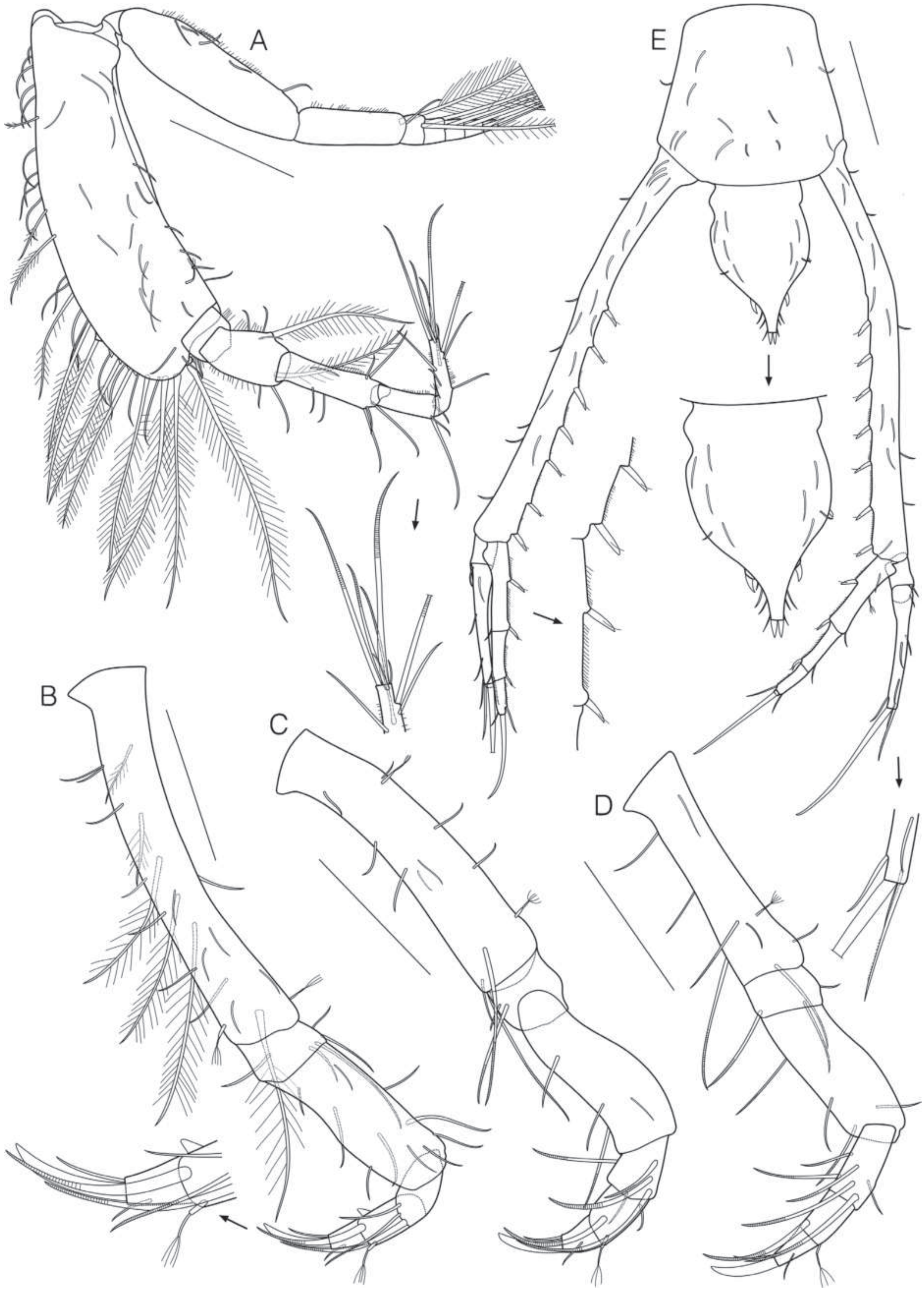

Figure 4. *Dimorphostylis pilocorpus* sp. nov., paratype, ovigerous female, 4.42 mm, cat no. NIBRIV0000911249 **A** pereopod 2 **B** pereopod 3 **C** pereopod 4 **D** pereopod 5 **E** telson and uropods. Scale bars: 0.2 mm (**A–E**).

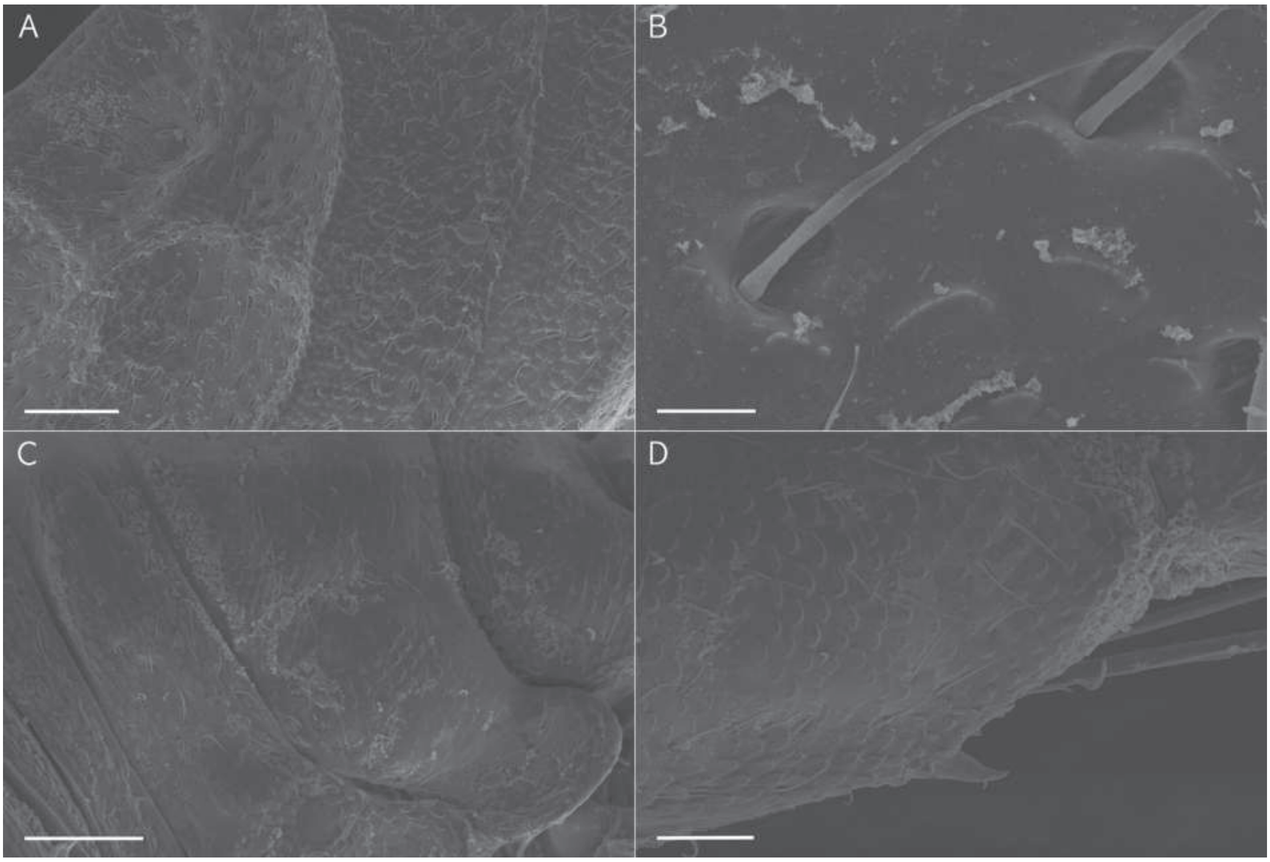

Figure 5. *Dimorphostylis pilocorpus* sp. nov., paratype, adult male, 4.46 mm **A** carapace **B** slender simple setae **C** pereon **D** pleonite 5. Scale bars: 100 µm (**A, C**); 50 µm (**D**); 10 µm (**B**).

Telson (Fig. 4E) 0.8 times as long as pleonite 6, with 7 slender simple setae on surface, 1 pair of short simple and 1 short stout simple seta centrally, 1 pair of stout simple and 3 pairs of short simple setae on post-anal section, 2 stout simple setae terminally.

Uropod (Fig. 4E) peduncle 2.8 times as long as telson, 2.4 times as long as pleonite 6, with 10–13 slender, simple setae on surface, 5–6 short simple setae laterally, 7 simple setae bearing single subterminal setule and numerous hair-like setae medially. Uropod endopod 3-articulate, 0.4 times as long as peduncle; article 1 subequal in length to remaining articles combined, with 2 simple setae bearing single subterminal setule and several hair-like setae medially, 1 slender simple seta on surface, 1 short simple and 1 complex pedunculate setae laterally; article 2 with 1 simple seta bearing single subterminal setule and several hair-like setae medially, 1 short simple seta laterally; article 3 with 1 simple and several hair-like setae medially, 1 short simple seta laterally, 1 long stout simple seta terminally. Uropod exopod 2-articulate, 0.9 times as long as endopod; article 1 short, with 1–2 short, simple setae laterally; article 2 with 1 simple seta mediodistally, 3–4 short simple setae laterally, 1 microserrate and 1 long stout simple seta terminally.

Paratype, adult male, cat no. NIBRIV0000911250. Body (Fig. 6A) length 4.45 mm. Body surface (Fig. 5) covered with numerous slender, simple setae. Carapace (Fig. 6A, C) 0.3 times as long as body, 1.5 times as long as width, 1.9 times as long as depth, ridge pattern similar to females, ridges not serrated; pseudorostral lobe and ocular lobe without spines; ocular lobe with 3 distinct

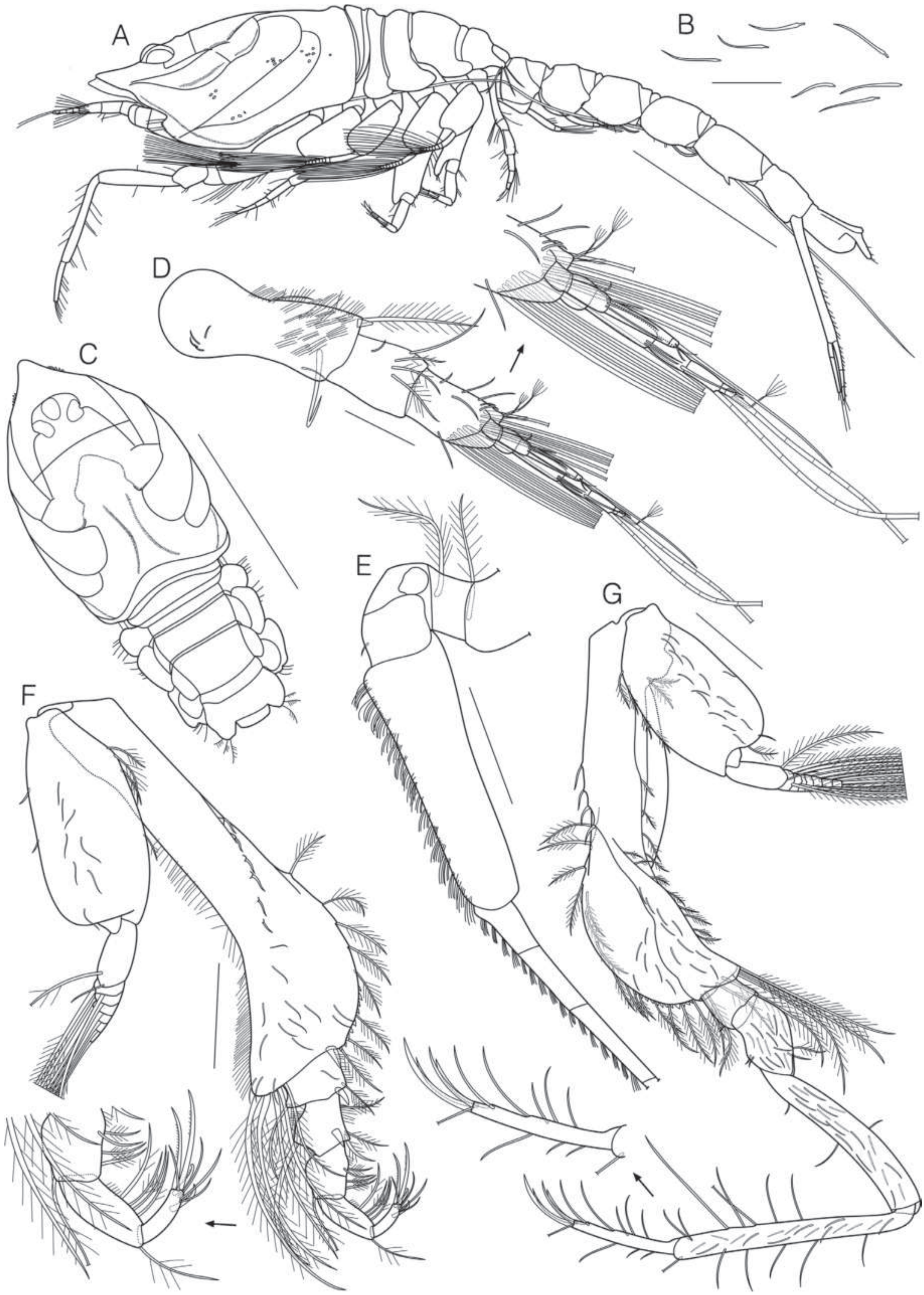

Figure 6. *Dimorphostylis pilocorpus* sp. nov., paratype, adult male, 4.45 mm, cat no. NIBRIV0000911250 **A** habitus, lateral view **B** slender simple setae **C** carapace and pereon, dorsal view **D** antenna 1 **E** antenna 2 **F** maxilliped 3 **G** pereopod 1. Scale bars: 1.0 mm (**A, C**); 0.2 mm (**E–G**); 0.1 mm (**D**); 0.05 mm (**B**).

lenses; antennal notch and antero-lateral angle prominent, antero-lateral margin serrated. Pereon (Fig. 6A, C) 0.6 times as long as carapace. Pleon (Fig. 6A) 0.8 times as long as carapace and pereon together; pleonite 5 with 1 spiniform seta on ventral margin.

Antenna 1 (Fig. 6D) peduncle 3-articulate; article 1 slightly longer than remaining articles combined, with numerous hair-like, 1 slender simple, and 4 short simple setae on surface, 1 bent simple seta on medial surface, numerous hair-like and 1 simple seta medially, 1 spiniform and 1 plumose seta mediodistally; article 2 0.4 times as long as article 1, with 1 short simple and 3 plumose setae on surface, 1 long simple seta medially; article 3 1.1 times as long as article 2, with 1 simple seta laterally, 3 short simple, 3 simple, and 3 complex pedunculate setae medially, brush of setae subterminally. Main flagellum 5-articulate; article 1 unarmed; article 2 with 2 simple setae distally; article 3 with 1 simple seta distally; article 4 with 1 aesthetasc distally; article 5 with 1 aesthetasc, 2 short simple and 1 complex pedunculate setae terminally. Accessory flagellum 4-articulate; article 1 unarmed; article 2 with 1 short simple seta medially, 3 simple setae distally, article 3 unarmed; article 4 with 2 short simple and 1 long simple seta terminally.

Antenna 2 (Fig. 6E) elongated, extending beyond end of telson; peduncle 5-articulated, article 1 and article 2 with 1 plumose seta each, article 4 with 1 short simple seta, article 5 with ranks of simple setae; each article of flagellum with several simple setae.

Maxilliped 3 (Fig. 6F) basis 1.9 times as long as remaining articles combined, with numerous hair-like setae laterally, 1 plumose and 4 long plumose setae laterodistally, 14 slender simple and 6 short simple setae on lateral surface, 9 spines, 1 stout spiniform, and 8 plumose setae medially; ischium with 1 slender simple seta on lateral surface, 1 plumose seta laterally, 1 stout spiniform, few hair-like, and 1 plumose setae medially; merus 1.4 times as long as ischium, with few hair-like and 1 long plumose setae laterally, 1 stout spiniform, few hair-like, and 3 plumose setae medially; carpus 0.9 times as long as merus, with 1 plumose seta laterodistally, few hair-like, 1 simple, and 3 plumose setae medially; propodus 1.4 times as long as carpus, with 1 plumose seta laterodistally, few hair-like and 4 plumose setae medially; dactylus 0.6 times as long as propodus, with 1 microserrate and 2 simple setae laterodistally, 1 microserrate, 2 simple, and 2 long microserrate setae terminally; exopod shorter than basis length, basal article with 2 short simple setae laterally, 8 slender simple setae on lateral surface, 4 plumose setae medially.

Pereopod 1 (Fig. 6G) basis 0.6 times as long as remaining articles combined, with 17 slender simple setae on lateral surface, 14 plumose setae on lateral surface and margin, 3 long plumose setae laterodistally, 12 spines, 4 simple and 15 plumose medially, 3 plumose and 1 long plumose setae distally; ischium 0.1 times as long as basis, with 1 short simple seta medially; merus 1.8 times as long as ischium, with 8 slender simple setae on lateral surface, 6 slender simple setae on medial surface, 1 simple and 1 plumose seta laterally, 2 short simple setae medially; carpus 2.5 times as long as merus, with 11 slender simple setae on lateral surface, 8 slender simple setae on medial surface, 1 short simple seta laterally, 1 short simple and 1 simple setae medially; propodus 1.2 times as long as carpus, with 7 slender simple setae on lateral surface, 8 slender simple setae on medial surface, 6 simple setae laterally, 6 simple and 1 long simple setae medially; dactylus 0.4 times as long as propodus, with 2 short simple and 1 simple setae laterally, 6 simple setae medially, 1 simple and 3 stout simple setae terminally; exopod shorter than basis length, basal article with 15 slender simple setae on lateral surface, 1 short simple and 1 plumose setae laterodistally, 4 plumose setae medially.

Pereopod 2 (Fig. 7A) basis 1.4 times as long as remaining articles combined, with 6 plumose setae laterally, 15 slender simple, 1 simple, and 5 plumose setae on surface, 2 simple and 5 plumose setae medially; distal corner very inflated, reaching to the middle of carpus, with 10 plumose setae; ischium short, unarmed; merus 2.1 times as long as ischium, with 1 short simple and 1 plumose seta laterodistally, 1 slender simple seta on lateral surface, 1 short simple and 1 plumose setae mediodistally; carpus 1.4 times as long as merus, with 2 short simple setae laterally, 1 slender simple seta on lateral surface, 1 short simple and 3 simple setae medially; propodus 0.6 times as long as carpus, with 1 slender simple seta on lateral surface, 1 complex pedunculate, 2 short simple, and 1 long simple setae distally; dactylus 1.3 times as long as propodus, with 1 short simple and 1 simple seta laterally, 2 short simple, 2 simple, and 1 long simple setae medially, 1 short simple, 2 simple, and 1 long simple setae terminally; exopod longer than basis length, basal article with 2 short simple setae laterally, 9 slender simple setae on lateral surface, 2 simple setae distally, 2 plumose setae medially.

Pereopod 3 (Fig. 7B) basis 1.3 times as long as remaining articles combined, with 7 slender simple, 1 complex pedunculate, 1 short simple, 2 short plumose, and 3 plumose setae on lateral surface, 4 plumose setae on medial surface, 1 simple and 3 plumose setae medially; distal corner very inflated, reaching to the one-third of merus, with 3 plumose setae; ischium 0.1 times as long as basis, with 2 simple and 1 annulate setae; merus 3.9 times as long as ischium, with 3 simple setae laterally, 1 simple seta on medial surface, 1 short simple seta medially; carpus 0.5 times as long as merus, with 2 annulate setae laterally, 1 simple and 2 annulate setae on lateral surface, 1 simple seta on medial surface, 1 simple seta mediodistally; propodus 0.7 times as long as carpus, with 1 annulate and 1 complex pedunculate setae distally; dactylus 0.7 times as long as propodus, with 1 simple and 1 stout simple seta terminally; exopod slightly shorter than basis length, basal article with 1 simple seta laterally, 1 plumose seta laterodistally, 10 slender simple setae on lateral surface, 1 short simple and 1 plumose seta medially.

Pereopod 4 (Fig. 7C) basis 1.3 times as long as remaining articles combined, with 18 slender simple, 7 plumose, 4 complex pedunculate, and 1 short simple seta on surface, several hair-like setae medially; distal corner very inflated, reaching to the one-third of merus, with 1 short simple, 2 simple, and 5 plumose setae; ischium 0.1 times as long as basis, with 1 simple and 1 annulate seta medially; merus 3.5 times as long as ischium, with 2 slender simple setae on lateral surface, 4 short simple setae laterally, 3 simple setae medially; carpus 0.4 times as long as merus, with 1 slender simple seta on lateral surface, 2 annulate setae laterally, 1 short simple and 2 simple setae medially, 2 annulate setae distally; propodus subequal in length to carpus, with 1 annulate seta laterodistally, 1 complex pedunculate seta mediodistally; dactylus 0.5 times as long as propodus, with 1 short simple seta medially, 1 simple and 1 stout simple setae terminally; exopod longer than basis length, basal article with 2 short simple and 4 simple setae laterally.

Figure 7. *Dimorphostylis pilocorpus* sp. nov., paratype, adult male, 4.45 mm, cat no. NIBRIV0000911250 **A** pereopod 2 **B** pereopod 3 **C** pereopod 4 **D** pereopod 5 **E** pleopod 1 **F** pleopod 2 **G** telson and uropods. Scale bars: 0.2 mm (**A–D, G**); 0.1 mm (**E, F**).

Pereopod 5 (Fig. 7D) basis 0.6 times as long as remaining articles combined, with few hair-like setae laterally, 1 complex pedunculate and 3 annulate setae laterodistally, 6 slender simple and 1 plumose setae on lateral surface, 1 annulate and 1 plumose seta medially; ischium 0.2 times as long as basis, with 1 short simple and 3 annulate setae laterally; merus 2.9 times as long as ischium, with 1 simple and 1 annulate seta laterally, 1 annulate seta on lateral surface, 1 short simple seta medially; carpus 0.7 times as long as merus, with 1 simple and 2 annulate setae laterally, 1 simple and 3 annulate setae medially; propodus 0.6 times as long as carpus, with 1 complex pedunculate and 1 annulate seta distally; dactylus 0.7 times as long as propodus, with 1 short simple seta medially, 1 simple and 1 stout simple setae terminally.

Pleopod 1 (Fig. 7E) basis with 3 microserrate and 3 plumose setae medially, 5 simple setae on lateral surface and margin; outer ramus with 4 long plumose setae terminally; inner ramus with 3 plumose setae medially, 4 long plumose setae terminally.

Pleopod 2 (Fig. 7F) basis with 3 microserrate setae medially; outer ramus 2-articulated, article 2 with 1 stout simple seta laterally, 3 long plumose setae terminally; inner ramus unarticulated, with 4 long plumose setae terminally.

Telson (Fig. 7G) 1.3 times as long as pleonite 6; pre-anal section with 6 slender simple and 4 short simple setae on surface, 24 complex pedunculate setae on U-shaped dorsal ridge; post-anal section with 2 pairs of stout simple setae bearing single subterminal setule on both sides, terminal margin with 3 stout simple setae, central seta slightly longer than outer pair of setae.

Uropod (Fig. 7G) peduncle 2.0 times as long as telson, 2.6 times as long as pleonite 6, with 14–27 slender simple setae on lateral surface and margin, 5 short simple setae laterally, numerous hair-like, 2 short simple setae, and 17–19 stout microserrate setae bearing single subterminal setule medially; Uropod endopod 3-articulate, 0.4 times as long as peduncle; article 1 1.2 times as long as remaining articles combined, with 2 complex pedunculate and 1 shot simple setae laterally, numerous hair-like setae and 6 stout microserrate setae bearing single subterminal setule medially; article 2 with 1 short simple seta laterally, several hair-like setae and 2 stout microserrate setae bearing single subterminal setule medially; article 3 with several hair-like and 1 stout microserrate seta bearing single subterminal setule medially; 1 short simple, 1 simple, and 1 long simple seta terminally. Uropod exopod 2-articulate, 0.9 times as long as endopod; article 1 short, with 1 short simple seta laterally, 2 simple setae laterally, 3 simple and 1 long simple seta terminally.

Remarks. The most similar species is *Dimorphostylis asiatica* Zimmer, 1921, which has transverse, a pair of frontal and three pairs of oblique ridges on the carapace. However, the new species is obviously distinguished from *D. asiatica* by a combination of the following features (*D. asiatica* condition in parentheses): 1) body surface covered with numerous slender simple setae (vs. without slender simple setae); 2) carapace, posterior oblique ridge running upward to 6/7 point of carapace, connecting with the middle ridge (vs. posterior oblique ridge running upward and turning abruptly forward to merge with dorsal submedian carina); and 3) telson of female with 1 pair of short simple setae centrally, 1 pair of stout simple setae on post-anal section (vs. without a stout simple seta).

Etymology. The new species name, *pilocorpus*, is from the combination of the Latin words *pilósus*, meaning 'hairy or shaggy' and *corpus*, meaning 'body', alluding to the body surface covered with numerous slender simple setae.

Habitat. The new species was collected in Dokdo and Ulleung Islands (East Sea), Korea, which has a sandy substrate.

Depth. 5–20 m.

Distribution. Korea (Dokdo and Ulleung Islands).

Key to the species of *Dimorphostylis* from Korean waters (female of *D. hirsuta* unknown)

1	Carapace, frontal lobe with transverse ridge	**2**
–	Carapace, frontal lobe without transverse ridge	**6**
2	Telson of male, post-anal section with more than a pair of short stout setae on both sides	**3**
–	Telson of male, post-anal section without short stout setae on both sides	**5**
3	Body surface covered with numerous slender simple setae	***D. pilocorpus* sp. nov.**
–	Body not covered with slender simple seta	**4**
4	Telson of female almost 0.7 times as long as pleonite 6, post-anal section with 3 pairs of lateral bristles, telson of male with 3 terminal setae of which middle seta longest	***D. asiatica***
–	Telson of female about 0.8 times as long as pleonite 6, post-anal section with 2–3 pairs of hairy setae near middle portion, 1–3 pairs of bristles, telson of male with 3 terminal setae of which middle seta very small	***D. namhaedoensis***
5	Uropod peduncle of male less than 2.5 times as long as telson, with 14–18 setae on medial margin	***D. hirsuta***
–	Uropod peduncle of male about 2.7 times as long as telson, with 13 setae on medial margin	***D. valida***
6	Carapace without frontal ridge	***D. manazuruensis***
–	Carapace with 1 pair of frontal ridges	**7**
7	Carapace, middle oblique ridge short, not connecting with anterior oblique ridge	***D. breviplicata***
–	Carapace, middle oblique ridge long, running upward and connecting with anterior oblique ridge	**8**
8	Uropod peduncle less than 2.0 times as long as telson	***D. longicauda***
–	Uropod peduncle more than 2.1 times as long as telson	**9**
9	Carapace, anterior oblique ridge W-shaped and not parallel with middle oblique ridge; propodus of pereopod 1 with 1 long and 9 short simple setae in female (with 1 long and 8 short simple setae in male)	***D. acroplicata***
–	Carapace, anterior oblique ridge curved and almost parallel with middle oblique ridge; propodus of pereopod 1 with 8 long and 12 short simple setae in female (with 8 long and 10 short simple setae in male)	***D. echinata***

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Identification, Investigation, Methodology, Writing – original draft: SHK. Funding acquisition, Supervision, Project administration: TL. Writing – review and editing: SHK and TL.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Research Article

Description of a new species of *Parens* Fibiger, 2011 (Lepidoptera, Erebidae, Hypenodinae) from Korea

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Abstract

The genus *Parens* comprises small moths, with a wingspan of 9–13 mm, belonging to the family Erebidae. Until now, only four species have been described worldwide. In Korea, only one species, *P. occi* (Fibiger & Kononenko, 2008) has been known to date. In this study, a new species from Korea, *P. fibigerina* Lee & Byun, **sp. nov.**, is described. As a result, two *Parens* species are now known from Korea. Figures of adults, male and female genitalia, and a key to the species of *Parens* in Korea are provided.

Key words: Checklist, identification key, Micronoctuini, new species, taxonomy

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Introduction

The genus *Parens* Fibiger, 2011 belongs to the tribe Micronoctuini, subfamily Hypenodinae of the family Erebidae. Early authors considered *Parens* as a member of the family Micronoctuidae based the simple male genitalia without a uncus and the two-veined hindwing (Kononenko and Han 2007; Fibiger and Kononenko 2008; Fibiger et al. 2011; Fibiger 2011). More recently, Zahiri et al. (2012) proposed a new taxonomy of the Erebidae based on molecular phylogenetics. The family Micronoctuidae was downgraded to a tribe within the subfamily Hypenodinae, with its subfamilies given the rank of subtribes. This genus was established by Fibiger (2011) with *Parens paraocci* Fibiger, 2011 as the type species. *Parens* is a relatively small genus with only four recognized species worldwide. In Korea, only one species, *P. occi* (Fibiger & Kononenko, 2008) is known, which was first reported by Kononenko and Han (2007) as *Micronoctua* sp. In the present study, a new species, *P. fibigerina* Lee & Byun, sp. nov., is described from Korea.

Materials and methods

Terminology

We follow the general terminology proposed by Fibiger (2011).

Collection and preparation of specimens

The specimens were mainly collected using a bucket light trap with a 20 W black-light lamp and a LepiLED, standard model (WIF, Dr Gunnar Brehm, Sonnenblumenweg, Germany) and a 200 V / 400 W mercury-vapor lamp (220 V / 400 W).

All specimens were photographed before the dissection of their genitalia. Images of the adults were taken using a Canon EOS 600D digital camera (Canon Inc., Ota, Tokyo, Japan). Male and female genitalia were dissected and mounted in Euparal solution, following the procedure described in Holloway et al. (1987). The genitalia slides were photographed using a digital camera attached to a Leica M205C microscope (Leica Microsystems, Wetzlar, Germany) and refined with Photoshop CS5 (Adobe Systems Inc., San Jose, CA, USA).

Most specimens examined in this study were deposited in the Systematic Entomology Laboratory, Hannam University, Daejeon, Korea (**HNSUEL**). Additional specimens examined are from the Korea National Insect Collection, Korea National Arboretum, Korea (**KNA**). Abbreviations for localities in Korea are as follows: **GG** (Gyeonggi-do), **GW** (Gangwon-do), **CB** (Chungcheongbuk-do), **DJ** (Daejeon), **GB** (Gyeongsangbuk-do), **GN** (Gyeongsangnam-do), **JN** (Jeollanam-do), and **JJ** (Jeju-do). Other abbreviations are **TL** (type locality) and **TD** (type depository).

Systematic accounts

Family Erebidae Leech, [1815]
Subfamily Hypenodinae Forbes, 1954

Genus *Parens* Fibiger, 2011

Type species. *Parens paraocci* Fibiger, 2011.

Key to *Parens* species in Korea

1	In female genitalia, ductus bursae coiled at terminal margin ....***Parens occi***
–	In female genitalia, ductus bursae not coiled at terminal margin .... ***Parens fibigerina***

***Parens fibigerina* sp. nov.**
https://zoobank.org/60C683F2-89B4-49D0-BBDA-FA1E8C3C1F84
Figs 1A, 2A, B

Type material. ***Holotype*** Female, Korea, Donghae-si, GW, 12.viii.2021 (BK Byun), gen. slide no. HNUSEL-6442-coll. HNUSEL.

Diagnosis. This species is distinguished from *P. occi* by the shape of the signum in the corpus bursae. In *P. occi*, the cross-shaped signum in the corpus bursae, while *P. fibigerina* has a triangular signum. Additionally, the *P. fibigerina* has the forewing with a more rounded apex, a whitish-beige ground color, and a terminal margin covered with more blackish scales. The hindwing is grayish with mixed black scales. Also, the new species is distinguished from *P. chekiangi* Fibiger, 1911 by characters of the 8th abdominal segment and

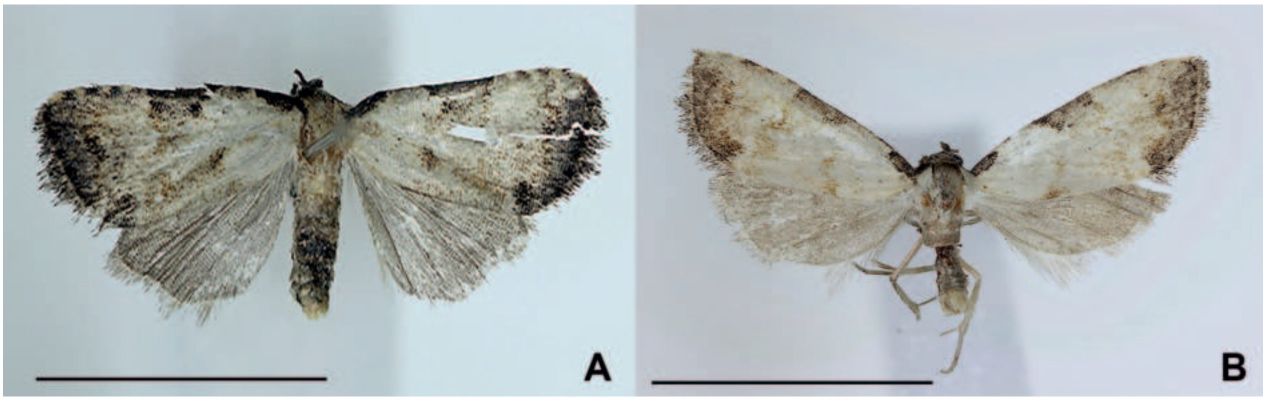

Figure 1. Adults of *Parens* **A** *P. fibigerina* sp. nov. (gen. slide no. HNUSEL_6442) **B** *P. occi* (gen. slide no. HNUSEL_5931) Scale bars: 0.5 mm.

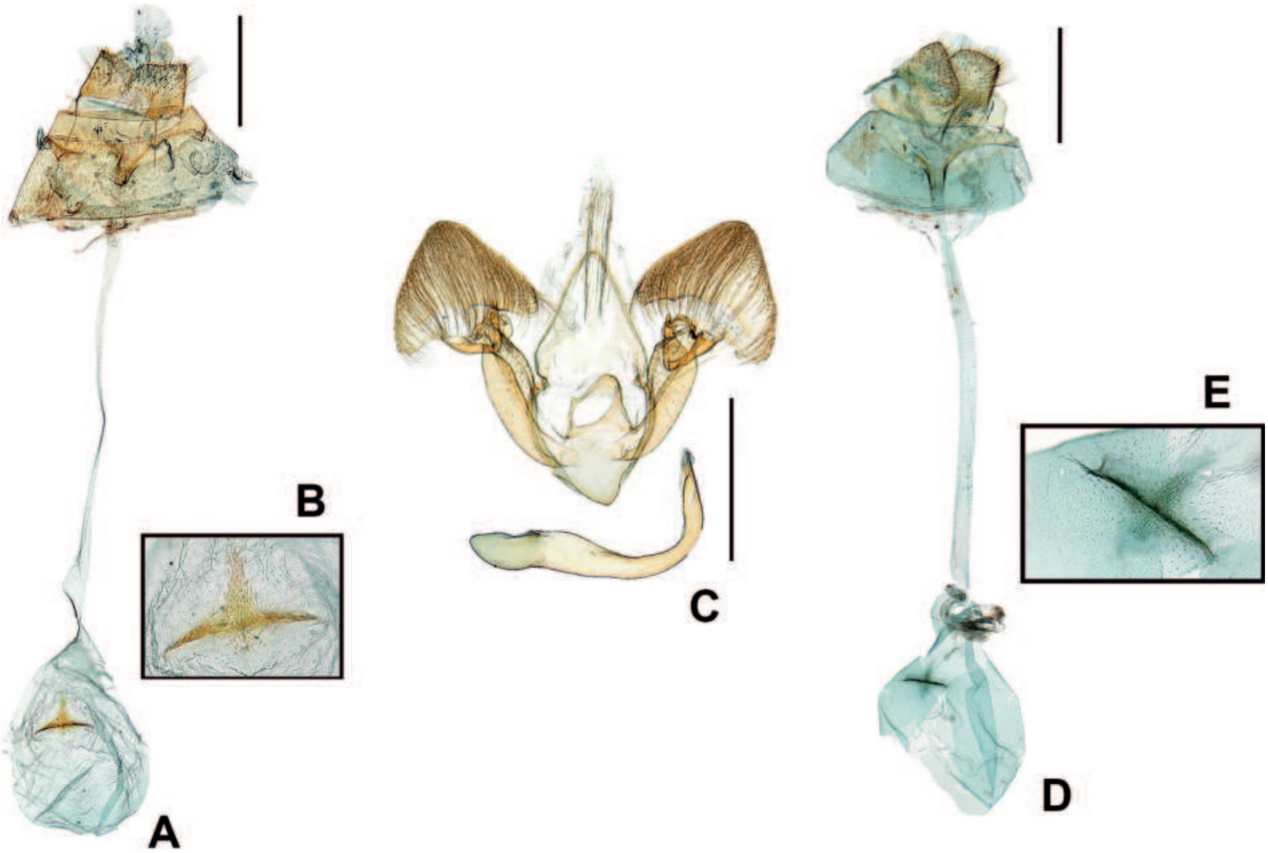

Figure 2. Male and female genitalia of Korean *Parens* species **A** ♀, *P. fibigerina* sp. nov., holotype (gen. slide no. HNUSEL_6442) **B** ditto, signum **C** ♂, *P. occi* (gen. slide no. HNUSEL_5931, 5937) **D** ♀, *P. occi* (gen. slide no. HNUSEL_6958) **E** ditto, signum. Scale bars: 0.1 mm.

the shape of the signum. The new species has the 8th abdominal segment is 2/3 length of the posterior apophyses and is well sclerotized. The antrum is strongly sclerotized. The new species has a triangular signum in the corpus bursae, while in *P. chekiangi* has a cross-shaped signum.

Description. Adult (Fig. 1A). Wingspan 11 mm. Head bend down, black; antenna filiform, black; frons rounded; labial palps porrect. Thorax and abdomen with sparse scales, beige; A8–10 dark brown. Forewing ground color whitish beige, with black line from base to costal margin; base with half-round, blackish patch; apex rounded and with four yellowish blotches; antemedial and post-medial lines parallel, wavy, dark brown; spot reniform with whitish inner area and light brown outline. Hindwing ground color grayish brown, mixed black, and outline slightly curved to inner side with many cilia.

***Male genitalia*.** Unknown.

Female genitalia (Fig. 2A, B). Papillae anales normal shape, rounded apex, with many short hairs, and well sclerotized. Posterior apophyses length equal to papillae anales ; anterior apophyses extremely short. Ostium bursae placed in the median of abdomen. Antrum short, strongly sclerotized. Ductus bursae long, almost straight, narrow, membranous, and dilated at junction to corpus bursae (ca twice as broad as main tube). Corpus bursae globular and membranous, with triangular signum positioned slightly to left. Signum strongly sclerotized at base; upper side rather weakly sclerotized.

Distribution. Korea (endemic).

Etymology. This new species is dedicated to the memory of Michael Fibiger, a Danish entomologist, who was a renowned researcher of the tribe Micronoctuini.

***Parens occi* (Fibiger & Kononenko, 2008)**
Figs 1B, 2C–E

Micronoctua occi Fibiger & Kononenko, 2008: 52. TL: Russia, Primorye territory, Gornotaezhnoe.
Micronoctua sp.: Kononenko and Han 2007: 29.
Parens occi: Fibiger 2011: 19.
Parens occi: Lee and Byun 2022: 612.

Description. Adult (Fig. 1B). Wingspan 10–12 mm. See Lee and Byun (2022).

Male genitalia (Fig. 2C). See Lee and Byun (2022).

Female genitalia (Fig. 2D, E). See Lee and Byun (2022).

Materials examined. [GG] 1♂, Mt. Bongmisan, 03.xi.2008 (BW Lee, SY Park, DH Kwon), genitalia slide no. HNUSEL-5936-coll. KNAE; [GW] 1♂, Girin-myeon, 27.vi.2013 (BK Byun), genitalia slide no. HNUSEL-5931-coll. HNUSEL; 1♂, Yeong-wol-gun, 26.viii.2021 (BK Byun), genitalia slide no. HNUSEL-6438-coll. HNUSEL; [CB] 2♂, Boeun-gun, 17.ix.2021 (BK Byun), genitalia slide no. HNUSEL-6309-coll. HNUSEL; Chungju-si, 10.vii.2020 (BK Byun), genitalia slide no. HNUSEL-6437-coll. HNUSEL; [DJ] 1♀, Masan-dong, 9.viii.2022 (BK Byun), genitalia slide no. HNUSEL-6958-coll. HNUSEL; [JN] 3♂, Isl. Jindo, 4.vi.2022 (BK Byun), genitalia slide no. HNUSEL-6763, 6913, 6914-coll. HNUSEL; [JJ] 1♂, Sanghyo-dong, 01.viii.2018 (BK Byun), genitalia slide no. HNUSEL-5937-coll. HNUSEL.

Distribution. Korea, China, Japan, Russia (Russian Far East).

Remarks. This species was reported first time from Korea by Kononenko and Han (2007).

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Conceptualization: BKB. Data curation: JYL. Investigation: JYL. Visualization: JYL. Writing - original draft: JYL. Writing - review and editing: BKB.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Research Article

Magnifying the hotspot: descriptions of nine new species of many-plumed moths (Lepidoptera, Alucitidae), with an identification key to all species known from Cameroon

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Abstract

This study confirms Mount Cameroon as an unprecedented hotspot for the diversity of many-plumed moths, with the discovery and description of nine new species: *Alucita fako* Ustjuzhanin & Kovtunovich, **sp. nov.**, *Alucita pyrczi* Ustjuzhanin & Kovtunovich, **sp. nov.**, *Alucita sroczki* Ustjuzhanin & Kovtunovich, **sp. nov.**, *Alucita potockyi* Ustjuzhanin & Kovtunovich, **sp. nov.**, *Alucita sedlaceki* Ustjuzhanin & Kovtunovich, **sp. nov.**, *Alucita tonda* Ustjuzhanin & Kovtunovich, **sp. nov.**, *Alucita erzayi* Ustjuzhanin & Kovtunovich, **sp. nov.**, *Alucita sokolovi* Ustjuzhanin & Kovtunovich, **sp. nov.**, and *Alucita hirsuta* Ustjuzhanin & Kovtunovich, **sp. nov**. Additionally, four additional species are reported from the Mount Cameroon area as new for the country: *Alucita agassizi*, *Alucita dohertyi*, *Alucita plumigera*, and *Alucita rhaptica*. Of the 89 Alucitidae known from the Afrotropics, the studied area hosts 36 species, most of which are endemic to the area. This unprecedented level of diversity and endemism within this lepidopteran family highlights Mount Cameroon's significance as a stronghold for specialised insect taxa. Efficient conservation efforts are necessary to protect these ecosystems and their associated unique microlepidopteran diversity.

Key words: Afrotropics, *Alucita*, biodiversity, Cameroon, endemic, microlepidoptera, taxonomy, tropical rainforest

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Introduction

Mount Cameroon represents a well-documented hotspot of diversity for many-plumed moths (Lepidoptera, Alucitidae), a group of moths distinguished by the division of their wings into six lobes. In our previous studies (Kovtunovich and Ustjuzhanin 2016; Ustjuzhanin et al. 2018a, 2020a), we described 17 new species of many-plumed moths and reported additional six species within the Mount Cameroon area. By these numbers, Mount Cameroon was revealed as a key hotspot for the group diversity as it hosts a considerable proportion of the 80 species of Alucitidae known from the Afrotropical region prior to this study (De Prins and De Prins 2023).

In this study, we report the remaining material of Alucitidae gathered during our extensive sampling in the Mount Cameroon area between 2014 and 2017 as part of a large ecological project (e.g., Maicher et al. 2020a, b). Nine species of *Alucita* are described as new for science, and four additional species are reported as new for Cameroon. Furthermore, we furnish an identification key for the majority of species (excluding four species with unknown males) reported from Cameroon.

Materials and methods

Our sampling of Alucitidae was performed in nine rainforest localities situated on the south-western and southern slopes of Mount Cameroon, spanning from November 2014 to October 2017. The sampled elevations ranged from 30 to 2200 m a.s.l. These diverse localities provided a comprehensive range of regionally available rainforest habitats. All reported specimens were attracted to light. A comprehensive sampling protocol was previously outlined in Ustjuzhanin et al. (2018a) and Maicher et al. (2020a).

Holotypes will be housed in the Nature Education Centre, Jagiellonian University, Kraków, Poland (NECJU), while paratypes and other specimens will be divided between NECJU and the personal collections of P. Ustjuzhanin and V. Kovtunovich, located in Novosibirsk and Moscow, Russia (CUK).

For identification, we dissected and examined genitalia of most specimens, adhering to the established protocol described in Ustjuzhanin et al. (2018a). Each permanent preparation received a unique code that allows for convenient retrieval and cross-referencing in the collections where they are stored. The relevant codes are provided in the captions of the genitalia figures.

The sampling localities are listed below in an alphabetic order:

Bamboo Camp. Bamboo Camp (350 m a.s.l.), Mount Cameroon (SW slope), 4.0879°N, 9.0505°E; a lowland rainforest with historical disturbances from selective logging.

Bimbia-Bonadikombo. Mexico Camp (30 m a.s.l.), Bimbia-Bonadikombo Community Forest, 3.9818°N, 9.2625°E; a littoral forest in the part of the community forest that is officially disturbance-free, but with extensive current logging (Ferenc et al., 2018).

Crater Lake. Crater Lake camp (1450 m a.s.l.), Mount Cameroon (SW slope), 4.1443°N, 9.0717°E; a submontane rainforest locally disturbed by forest elephants.

Drink Gari. Drink Gari camp (650 m a.s.l.; also known as “Drinking Gari” or “Drink Garri”), Mount Cameroon (SW slope), 4.1014°N, 9.0610°E; a lowland rainforest with a dense canopy layer.

Ekonjo. Ekonjo camp (1150 m a.s.l.), Mount Cameroon (S slope), 4.0881°N, 9.1168°E; an upland closed-canopy rainforest.

Elephant Camp. Elephant Camp (1850 m a.s.l.), Mount Cameroon (SW slope), 4.1170°N, 9.0729°E; a montane forest with a sparse canopy layer as a consequence of natural disturbances by forest elephants.

Mann's Spring. Mann's Spring camp (2200 m a.s.l.), Mount Cameroon (SW slope), 4.1428°N, 9.1225°E; a montane forest at the natural timberline.

Mapanja. Mapanja camp (1850 m a.s.l.), Mount Cameroon (S slope), 4.1157°N, 9.1315°E; a montane forest with mostly closed canopy layer.

PlanteCam. PlanteCam camp (1100 m a.s.l.; also misspelled as "Planticamp"), Mount Cameroon (SW slope), 4.1175°N, E9.0709°E; an upland rainforest in the transition between the lowland and montane zones, with a sparse canopy layer as a consequence of natural disturbance by forest elephants (Maicher et al. 2020b).

Results

Descriptions of the new species

***Alucita pyrczi* Ustjuzhanin & Kovtunovich, sp. nov.**
https://zoobank.org/46B56C3C-9FD0-4C42-B2A3-D3B6FB64F72A
Figs 1, 2

Type material. ***Holotype*** • ♀, (NECJU 230701), Cameroon, Bamboo Camp, 350 m a.s.l., Mount Cameroon, 4.0879°N, 9.0505°E, 12–20.XII.2014, lgt. V. Maicher, Sz. Sáfián, Š. Janeček, R. Tropek.

Differential diagnosis. Externally, *Alucita pyrczi* closely resembles *Alucita lidiya* Ustjuzhanin & Kovtunovich, 2018 (known so far only from the male, also collected at Bamboo Camp) but can be distinguished by the presence of a pale orange medial band on its hind wings, the orange band on its fore wings being half as wide, and a larger wingspan. In terms of female genitalia, *A. pyrczi* shares similarities in the structure of antrum and the shape of papillae anales and apophyses with *Alucita molliflua* (Meyrick, 1927) (Figs 24, 25). However, these species are clearly differentiated by the structure of the ductus, the position of the ductus seminalis, and the absence of signa in the bursa copulatrix.

External characters. The head and thorax are covered with appressed dark-grey scales, while the tegulae appear white. Labial palpi are dark grey on the outside, with white scales on the inner side, and are twice as long as the longitudinal eye diameter. The third segment is short and white, with scattered tiny brown scales. The antenna is yellowish white. The wingspan measures 18 mm. The fore wing is brown with a distinct orange medium band and is lightened with yellowish white scales at the base. The hind wings are noticeably paler than the forewings and feature a pale orange medial band. The lobes of the hind wings have dark-brown and orange spots of scales submarginally. The fringes on the hind wings are whitish apart from sections of dark-brown hairs around the medial band and submarginal spots, and the distal half of the costa of the first lobe of the hindwing is dark brown. The hind legs are pale-yellow.

Female genitalia. The papillae anales are narrow and elongated. The posterior apophyses are shorter than the anterior apophyses. The antrum is wide and goblet-like, sclerotised. The ductus between the ductus seminalis and antrum

Figures 1, 2. *Alucita pyrczi* Ustjuzhanin & Kovtunovich, sp. nov. **1** adult female, holotype, NECJU **2** female genitalia, holotype, NECJU, preparation slide no. 230701. Scale bar: 5 mm.

is narrow and short. The ductus widens significantly at the junction with the ductus seminalis and narrows at its entrance to the bursa copulatrix. The bursa copulatrix is rounded, and no signa are present.

Distribution. The species was found in Cameroon only.

Flight period. The species was collected in December.

Etymology. The species is named in honour of the Polish lepidopterist Tomasz Wilhelm Pyrcz, who contributed significantly to the collection and study of butterflies and moths in many parts of the world, including Cameroon.

Alucita sroczki **Ustjuzhanin & Kovtunovich, sp. nov.**
https://zoobank.org/294E0CD2-7B73-41F5-B048-CCB7D09CC210
Figs 3–5

Type material. ***Holotype*** • ♂, (NECJU 230702), Cameroon, Bamboo Camp, 350 m a.s.l., Mount Cameroon, 4.0879°N, 9.0505°E, 17–23.IV.2015, lgt. V. Maicher, Sz. Sáfián, Š. Janeček, R. Tropek. ***Paratypes*** • 4 ex., (NECJU, CUK) same data as holotype • 3 ex., (NECJU, CUK), 11–23.IV.2015, same data as holotype • 5 ex., (NECJU, CUK), Cameroon, PlanteCam, 1100 m a.s.l., Mount Cameroon, 4.1175°N, 9.0709°E, 09–14.IV.2015, lgt. V. Maicher, Sz. Sáfián, Š. Janeček, R. Tropek • 7 ex., (NECJU, CUK), Cameroon, Crater Lake, 1500 m a.s.l., Mount Cameroon, 4.1443°N, 9.0717°E, 23–29.IV.2017, lgt. V. Maicher, P. Potocký, S. Delabye • 8 ex., (NECJU, CUK), 17–25.II.2017, lgt. P. Potocký, Sz. Sáfián, J. Mertens, Š. Janeček, R. Tropek • 1 ♂, (CUK), Cameroon, Mapanja, 1850 m a.s.l., Mount Cameroon, 4.1157°N, 9.1315°E, 23–28.X.2017, lgt. V. Maicher, S. Delabye.

Differential diagnosis. *Alucita sroczki* shares a mottled greyish brown wing colouration with *Alucita seychellensis* (T.B. Fletcher 1910) (illustrated in Ustjuzhanin and Kovtunovich 2016) and *Alucita megaphimus* (Hering, 1917) (Figs 6–8). However, it can be distinguished from these species by the darkened terminal

3 4 5

Figures 3–5. *Alucita sroczki* Ustjuzhanin & Kovtunovich, sp. nov. **3** adult male, holotype, NECJU **4** male genitalia, holotype, NEJCU, preparation slide no. 230702 **5** female genitalia, paratype, NEJCU, preparation slide no. 230703. Scale bar: 5 mm.

6 7 8

Figures 6–8. *Alucita megaphimus* (Hering, 1917), stat. rev. **6** adult female **7** male genitalia **8** female genitalia. Scale bar: 5 mm.

band present on all wings and by its larger size. The most reliable distinguishing feature lies in the male genital structure. While the general structure of the male genitalia is reminiscent of *A. seychellensis*, *A. sroczki* has narrower valves, a shorter gnathos, and a set of complex sacculus structures with serrated spiky forms, as well as a narrower aedeagus. In the female genitalia, the new species differs from *A. seychellensis* and *A. megaphimus* in the deep V-shaped notch on the outer edge of the antrum.

External characters. The head, thorax, and tegulae are covered with clinging grey-brown hairs. Labial palpi are dark-grey and measure 2.5–3 × the longitudinal eye diameter. The third segment is thin, long, and belted basally and apically with narrow white scales. The antennae are dark brown. The wingspan ranges from 16 to 20 mm (holotype 18 mm). All wings exhibit a greyish brown colouration, with four and six distinct pale transverse zigzag bands on the fore wing and hind wing, respectively. The wings are noticeably darkened distally.

The fringe on the lobes of all wings features alternating portions of pale yellow and dark brown hairs. The hind legs are pale yellow.

Male genitalia. The uncus is simple, long, and medially narrowing, with a widened distal end that bears a small notch. The gnathos is slightly shorter than the uncus and narrow, tapering to an acute apex. The gnathos arms are short and wide. The valves are simple and short, measuring half the length of the uncus. The distal portion of the sacculus is expanded as a forked structure. The outer portion of this fork is narrower, internally serrated and terminating in an acute and slightly inwardly bent apex. The inner portion of the fork is wider and finger-like, also serrated on the inside. The basal portion of the sacculus is wide, with a globular sclerotised formation covered with tiny sharp needles. The anellus arms are long, equal in length to the gnathos, and wide at the base, gradually narrowing. The saccus is slightly elongated and caudally rounded. The aedeagus is straight, basally widened, and 1.5 × longer than the uncus. The cornutus is needle-like, distinctive, and occupies most of the aedeagus.

Female genitalia. The papillae anales are narrow and elongated. The posterior apophyses are long and thin, approximately equal in length to the anterior apophyses. The antrum is tubulate and sclerotised, with a narrow V-shaped notch on the outer edge. The ductus is very short, slightly shorter than the antrum, and the ductus seminalis passes from the confluence of the ductus into the bursa. The bursa is oval and very large, featuring two narrow ribbon-like signa.

Distribution. The species was found in Cameroon only.

Flight period. The species was sampled in April and October.

Etymology. The species name is a noun in apposition. It is named in honour of the curators from NECJU, Ewelina Sroka and Karolina Sroka, who crucially contributed to the processing of the abundant moth material collected on Mount Cameroon and several other Afrotropical localities. The name 'sroczki' refers to the nickname commonly used for the twin sisters.

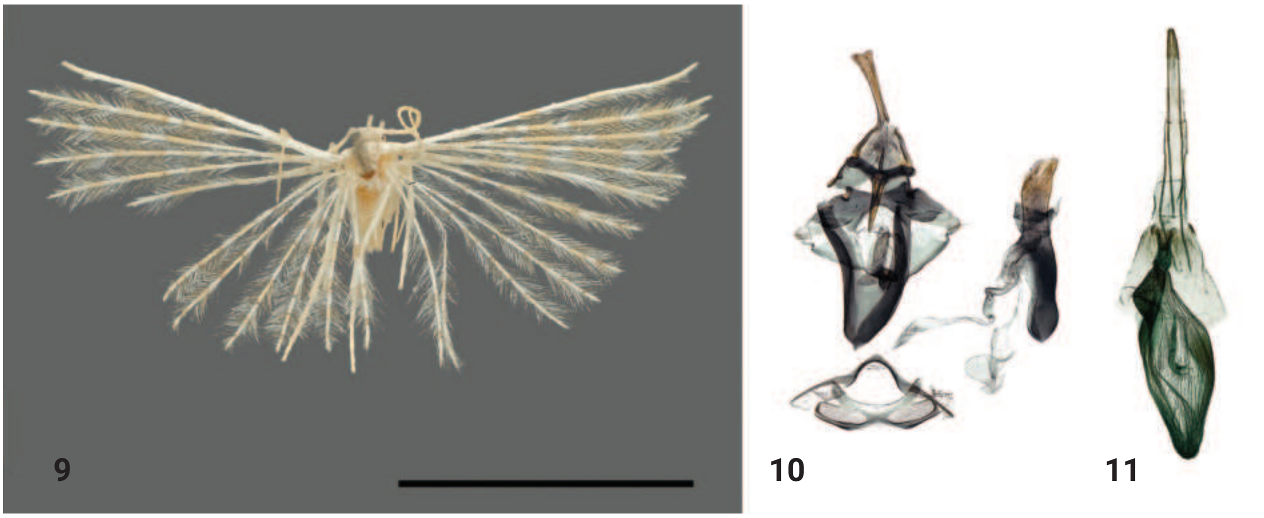
Note. Previously, Ustjuzhanin and Kovtunovich (2017) erroneously synonymised *A. megaphimus* with *A. seychellensis*. Later, PU and VK re-examined their characters in more detail, and therefore we consider *Alucita megaphimus* (Hering, 1917), stat. rev., as a separate species.

Alucita fako **Ustjuzhanin & Kovtunovich, sp. nov.**

https://zoobank.org/EF4D5685-1041-4833-B6A4-965EABD0DF69
Figs 9–11

Type material. ***Holotype*** • ♂, (NECJU 230704), Cameroon, Ekonjo, 1150 m a.s.l., Mount Cameroon, 4.0881°N, 9.1168°E, 25.X.2017, lgt. V. Maicher, S. Delabye. ***Paratypes*** • 1 ♀, (NECJU 230705), Cameroon, Bamboo Camp, 350 m a.s.l., Mount Cameroon, 4.0879°N, 9.0505°E, 12 –20.XII.2014, lgt. V. Maicher, Sz. Sáfián, Š. Janeček, R. Tropek.

• 1 ♀, (NECJU), same data as holotype • 3 ♀, (NECJU, CUK), Cameroon, PlanteCam, 1100 m a.s.l., Mount Cameroon, 4.1175°N, 9.0709°E, 11–18.XII.2014, lgt. V. Maicher, Sz. Sáfián, Š. Janeček, R. Tropek • 4 ♀, (NECJU, CUK), Cameroon, Elephant Camp, 1850 m a.s.l., Mount Cameroon, 4.1170°N, 9.0729°E, 19–24. XI.2014, lgt. V. Maicher, Sz. Sáfián, Š. Janeček, R. Tropek • 1 ♀, (NECJU), Ekonjo, 1150 m a.s.l., Mount Cameroon, 4.0881°N, 9.1168°E, 24.X.2017, lgt. V. Maicher,



Figures 9–11. *Alucita fako* Ustjuzhanin & Kovtunovich, sp. nov. **9** adult male, holotype, NECJU **10** male genitalia and structures of the segment VIII of the male abdomen, holotype, NEJCU, preparation slide no. 230704 **11** female genitalia, paratype. Scale bar: 5 mm.

S. Delabye • 1 ♀, (CUK), Crater Lake, 1500 m a.s.l., Mount Cameroon, 4.1443°N, 9.0717°E, 23–29.IV.2017, lgt. V. Maicher, S. Delabye.

Differential diagnosis. In the male genitalia, the new species exhibits great similarity to *Alucita escobari* Ustjuzhanin & Kovtunovich, 2018, from which it differs in the more reduced notch in the top of the uncus and in the caudally acute saccus. In contrast, in *A. escobari* the notch on the top of the uncus is clearly expressed, triangular, and the saccus is caudally smooth, oval, and not acute. Additionally, these two moth species are clearly distinct externally. In the female genitalia, the new species closely resembles *Alucita besongi* Ustjuzhanin & Kovtunovich, 2018 and *Alucita janeceki* Ustjuzhanin & Kovtunovich, 2018. From the former, it differs in the oval, elongated bursa copulatrix and the absence of small signa in it, while in *A. besongi* the bursa copulatrix is pear-like, its surface covered with tiny signa. From the latter, the new species differs in the shape of the bursa copulatrix and the antrum, in the new species the bursa copulatrix narrows caudally, while in *A. janeceki*, it has a rounded base. The antrum in the new species has a narrow V-shaped notch on the outer edge, while in *A. janeceki* the notch is wide. From both species, the new species differs in the very long posterior apophyses, in *A. besongi* and *A. janeceki* the anterior and posterior apophyses are equal in the length. Furthermore, the male genitalia of the new species are clearly different from those of *A. besongi* and *A. janeceki*.

External characters. The head, thorax, and tegulae are white. Labial palpi are pale-yellow and measure twice the longitudinal eye diameter. The antennae are yellowish white. The wingspan ranges from 9 to 12 mm (holotype 11 mm). The wings are pale yellow, mottled, with alternating white and yellowish brown portions of scales. All lobes of the wings have small dark spots of scales on tips. The fringe on all lobes of the wings has alternating white and pale brown portions of hairs. The hind legs are white.

Male genitalia. The uncus is long, distally extended, and apically with a poorly visible notch. The gnathos is slightly shorter than the uncus and apically acute. The gnathos arms are wide and slightly shorter than the gnathos itself. The valves are wing-like and apically have a bundle of thin needle-like setae.

The anellus arms are wide, straight, and equal in length to the gnathos. The saccus is elongated and forms a narrow triangle, with an acute tip. The aedeagus is almost straight, obliquely cut apically, and without cornuti.

Female genitalia. The papillae anales are narrow and elongated. The posterior apophyses are very long and thin. The antrum is sclerotised, with a narrow V-shaped notch on the outer edge. The ductus is very short, slightly shorter than the antrum, and the ductus seminalis extends distally inside the bursa copulatrix. The bursa copulatrix is oval, elongated, and noticeably narrows at the end, with numerous longitudinal long ribs inside.

Distribution. The species was found in Cameroon.

Flight period. The species was collected in May and from October to December.

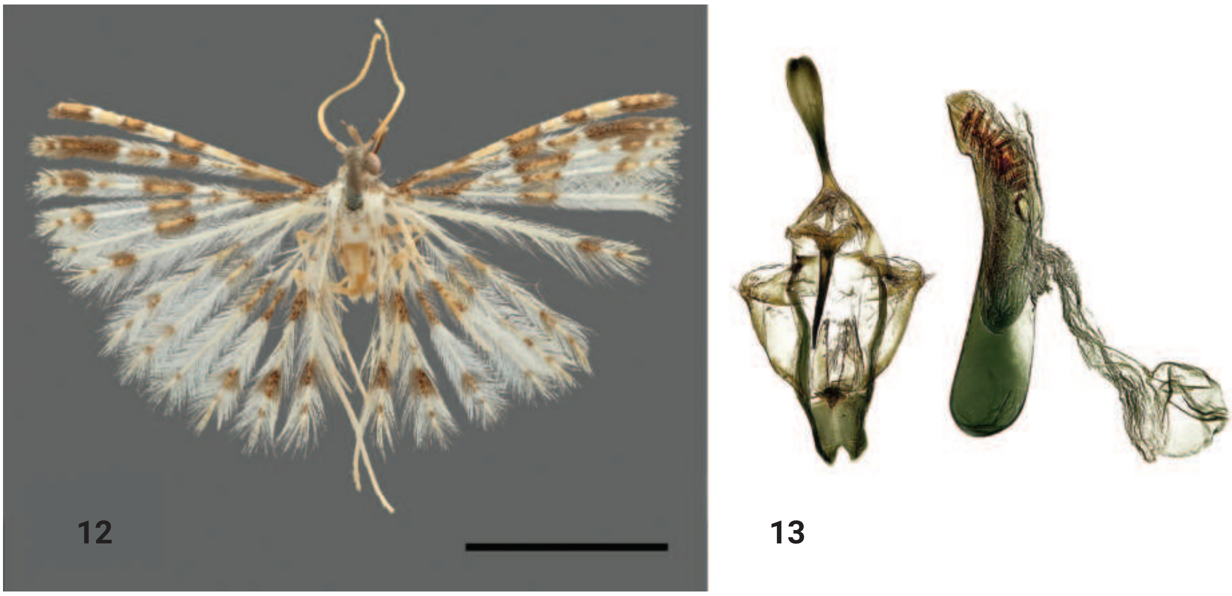
Etymology. The species is named after Fako, the local name of Mount Cameroon, which is the type locality of the species. The name aims to emphasise the importance of the area and encourage the protection of the species' habitats.

Alucita sedlaceki **Ustjuzhanin & Kovtunovich, sp. nov.**
https://zoobank.org/9C428B4E-9960-4EC0-8C86-32BB3FB1DA6F
Figs 12, 13

Type material. ***Holotype*** • ♂, (NECJU 230706), Cameroon, PlanteCam, 1100 m a.s.l., Mount Cameroon, 4.1175°N, 9.0709°E, 09–14.IV.2015. V. Maicher, Sz. Sáfián, Š. Janeček, R. Tropek. ***Paratypes*** • 1 ♂, (CUK), Cameroon, Mount Cameroon, Ekonjo, 1150 m a.s.l., 4.0881°N, 9.1168°E, 25.X.2017, lgt. V. Maicher, S. Delabye • 1 ♂, (CUK), Cameroon, Bamboo Camp, 350 m a.s.l., Mount Cameroon, 4.0879°N, 9.0505°E, 14–23.II.2016, lgt. V. Maicher, Sz. Sáfián, R. Tropek.

Differential diagnosis. In terms of wing colouration, the species somewhat resembles *Alucita mischenini* Ustjuzhanin & Kovtunovich, 2018, but it differs in the length of the apical dark-brown portion of scales on the first and second lobes of the fore wing. In the new species, the portion on the second lobe is twice as long as that on the first lobe, while in *A. mischenini* it is equal to or even shorter than that on the first lobe. In the male genitalia, there is also a similarity to *A. mischenini*, but in the new species, the saccus has a distinct triangular notch caudally, and the aedeagus has an ordered arrangement of needle-like cornuti distally. In contrast, in *A. mischenini* the notch is absent on the saccus, and the cornuti in the aedeagus are tiny and chaotically disorganised.

External characters. The head and thorax are brown, and the tegulae are white. The labial palpi are brown and measure 2.5 × longer than the longitudinal eye diameter. The third segment is short, isolated, and directed upwards. The antennae are yellowish brown and serrated. The wings are white, with black and brown portions of scales. The medial band is well-developed. The wingspan ranges from 12 to 16 mm (holotype 16 mm). The first lobe on the fore wing has alternating brown and yellow rectangular portions. The apical dark brown portion on the first lobe is half as long as the apical portion on the second lobe. The fore wings are basally darkened with dark-brown scales. Medially, they have a wide brown band, which is missing on the sixth lobe. On the hind wings, this band is positioned closer to the base of the wing. All wings have a dark brown subterminal band that is broken in the fifth lobe of the forewing and the third lobe of the hindwing, with the small dark spots of scales subapically



Figures 12, 13. *Alucita sedlaceki* Ustjuzhanin & Kovtunovich, sp. nov. **12** adult male, holotype, NECJU **13** male genitalia, holotype, NEJCU, preparation slide no. 230706. Scale bar: 5 mm.

on all lobes of all wings. The fringe on the wings is pale, with only the banded portions being brown. The hind legs are yellowish white.

Male genitalia. The uncus is long, basally and medially narrow, and distally widened, with a small notch at the apex. The gnathos is narrow, apically acute, and equal in length to the uncus. The gnathos arms are short and wide. The valves are short, wide, and wing-like. The anellus arms are long, slightly shorter than the gnathos, but significantly wider than it, being basally wide and apically narrowing. The saccus is equal in length to the anellus arms, with a clearly expressed triangular notch caudally. The aedeagus is slightly concave medially and almost equal in length to the entire genital structure (excluding the uncus). The aedeagus large needle-like cornuti distally arranged in an orderly array.

Distribution. The species was found in Cameroon only.

Flight period. The species was collected in February, April, and October.

Etymology. The species is named in honour to Ondřej Sedláček, a recognised ornithologist and entomologist with experience from many African countries. On Mount Cameroon, he established several ongoing ecological research projects and was instrumental in helping local communities to understand how to protect the unique local ecosystems in which they live.

Alucita tonda **Ustjuzhanin & Kovtunovich, sp. nov.**

https://zoobank.org/B1D0EEEE-1911-44F8-85E5-9A611A80A993

Figs 14, 15

Type material. ***Holotype*** • ♀, (NECJU 230707), Cameroon, Drink Gari, 650 m a.s.l., Mount Cameroon, 4.1014°N, 9.0610°E, 06–15.II.2016, lgt. V. Maicher, Sz. Sáfián, Š. Janeček, R. Tropek.

Differential diagnosis. The dark colour of the wings in this species shows some similarity to *Alucita acalyptra* Meyrick, 1913, but the new species lacks the zigzag bands on the wings' distal parts. In terms of the female genitalia, the

Figures 14, 15. *Alucita tonda* Ustjuzhanin & Kovtunovich, sp. nov. **14** adult male, holotype, NECJU **15** male genitalia, holotype, NEJCU, preparation slide no. 230707. Scale bar: 5 mm.

new species stands out with its unusual asymmetric structure of the antrum, which has no analogues among known species.

External characters. The head, thorax, and tegulae are dark brown. The labial palpi are short, straight, and slightly longer than the longitudinal eye diameter. The antennae are brown. The wingspan is 16 mm, and the wings are dark brown. Narrow pale longitudinal bands are present on the lobes of all wings. The fringe on the lobes of all wings is greyish brown. The hind legs are pale yellow.

Female genitalia. The papillae anales are wide. The posterior apophyses are short, thick, and slightly shorter than the anterior apophyses. The antrum is asymmetric, sclerotised, and distally tubulate, with a small triangular notch in the middle. The medium portion of the antrum is very wide, with the right half distinctively protruding to the side, creating a structural asymmetry. The lower portion of the antrum is membranous and bears two round sclerotised plaques. The ductus is short, almost invisible, and passes into a narrow membranous bursa copulatrix, with no signa observed.

Distribution. The species was found in Cameroon only.

Flight period. The species was collected in February.

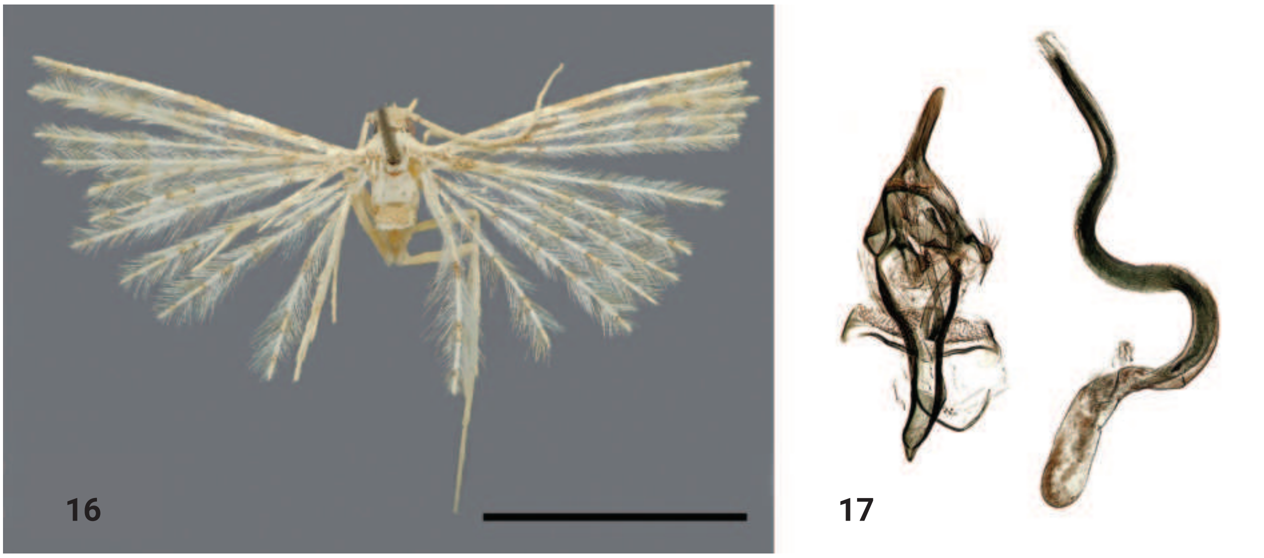
Etymology. The species name is a noun in apposition, given in honour of Antonín “Tonda” Tropek, who is RT’s father.

Alucita erzayi Ustjuzhanin & Kovtunovich, sp. nov.

https://zoobank.org/4527A604-C418-43BD-9CFF-9EF96A06A7C3

Figs 16, 17

Type material. ***Holotype*** • ♂, (NECJU 230708), Cameroon, PlanteCam, 1100 m a.s.l., Mount Cameroon, 4.1175°N, 9.0709°E, 11–23.IV. 2014, lgt. V. Maicher, Sz. Sáfián, Š. Janeček, R. Tropek.



Figures 16, 17. *Alucita erzayi* Ustjuzhanin & Kovtunovich, sp. nov. **16** adult male, holotype, NECJU **17** male genitalia and structures of the segment VIII of the male abdomen, holotype, NEJCU, preparation slide no. 230708. Scale bar: 5 mm.

Differential diagnosis. The male genital structures of this new species resemble those of *Alucita longipenis* Ustjuzhanin & Kovtunovich, 2018. As in *A. longipenis*, the aedeagus of the new species is very long, but it is slightly shorter, has fewer curves, and is straight for the distal portion. Additionally, the saccus of *A. erzayi* is gently curved distally and apically acute, while in *A. longipenis* the saccus is bent and apically acute. The wingspan of the new species is 14 mm, whereas it is 18–23 mm for *A. longipenis*.

External characters. The head, thorax, and tegulae are yellowish white. The labial palpi are thin, straight, and twice as long as the longitudinal eye diameter. The antennae are pale yellow. The wingspan is 14 mm, and the wings are pale yellow, interspersed with brown strokes and spots. Two small dark brown patches are present in the basal portion of the costa of the first lobe of the fore wing. Indistinct pale brown regions of scales are present in the medial and distal portions of the first two lobes. The fringe on the wings is pale yellow, and the hind legs are pale yellow.

Male genitalia. The uncus is relatively long and evenly wide throughout its length, with a rounded apex. The gnathos is long and narrow. The valves are reduced. The anellus arms are long and evenly narrow throughout their length. The saccus is long, elongated, and smoothly bent caudally, with a clearly acute apex. The aedeagus is very long, ~ 4 × longer than the entire genital structure, forming two arched curves in the medium part. No cornuti are present.

Distribution. The species was found in Cameroon only.

Flight period. The species was collected in April.

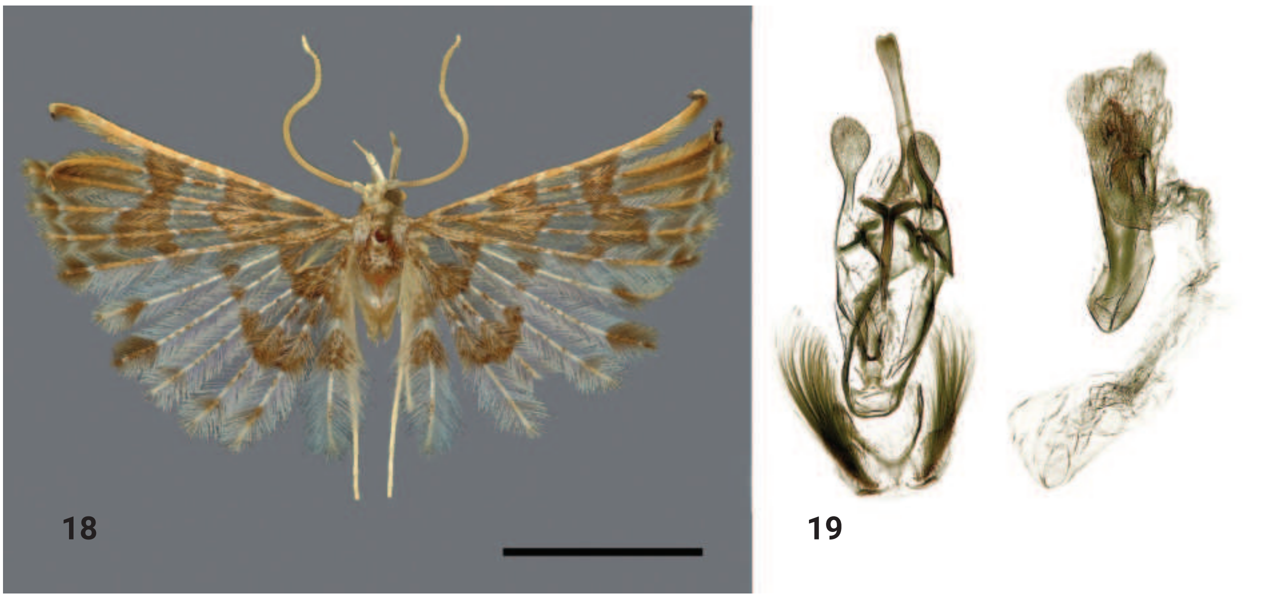
Etymology. The species is a noun in apposition. 'Erzayi' is a word in the Bakweri language, which is the dominant local language in the Mount Cameroon region, and it translates to "feather". This corresponds with the appearance of many-plumed moths' feather-like characteristic wing lobes.

Alucita sokolovi **Ustjuzhanin & Kovtunovich, sp. nov.**
https://zoobank.org/3D9F4858-D646-4A23-9620-E3C883642BD0
Figs 18, 19

Type material. ***Holotype*** • ♂, (NECJU 230709), Cameroon, Mann's Spring, 2200 m a.s.l., Mount Cameroon, 4.1428°N, 9.1225°E, 16–21. IV. 2017, lgt. V. Maicher, P. Potocký, S. Delabye. ***Paratypes*** • 2 ♂, (NECJU, CUK), Cameroon, Crater Lake, 1500 m a.s.l., Mount Cameroon, 4.1443°N, 9.0717°E, 17–25. II. 2017, lgt. P. Potocký, Sz. Sáfián, R. Tropek, J. Mertens, Š. Janeček • 1 ♂, (CUK), Cameroon, Mapanja, 1850 m a.s.l., Mount Cameroon, 4.1157°N, 9.1315°E, 13.V.2017, lgt. V. Maicher, P. Potocký, S. Delabye.

Differential diagnosis. The wing colour of this species slightly resembles *Alucita jana* Ustjuzhanin & Kovtunovich, 2020, but it can be distinguished by the widened distal band on the fore wing, whereas in *A. jana* it narrows at the fourth-fifth lobe. Additionally, *A. sokolovi* has a band in the medial portion of the wing, which is absent in *A. jana*. The labial palpi of the new species are 3 × longer than the longitudinal eye diameter, compared to only 1.5 × in *A. jana*. In the male genitalia, the structure of the aedeagus and the shape of the gnathos of *A. sokolovi* slightly resemble *Alucita bokwango* Ustjuzhanin & Kovtunovich, 2020. However, *A. sokolovi* can be differentiated by its uncus, which is widened on the top, and the wide oval apical portions of the valves, while in *A. bokwango* the uncus is narrow throughout its length, and the valves' apices are less widened.

External characters. The head has white shiny scales. The thorax and tegulae are covered with pale brown clinging scales. The labial palpi are wide, long, ~ 3 × as long as the longitudinal eye diameter, white inside and brown outside. The third segment is isolated and apically acute. The antennae are yellowish brown, and the scape is wide and flattened. The wingspan is 17–18 mm (holotype 17 mm), and the wings are pale brown. There are two clearly expressed wide brown bands on the fore wings, distally and basally. The fore wings are



Figures 18, 19. *Alucita sokolovi* Ustjuzhanin & Kovtunovich, sp. nov. **18** adult male, holotype, NECJU **19** male genitalia and structures of the segment VIII of the male abdomen, holotype, NEJCU, preparation slide no. 230709. Scale bar: 5 mm.

apically framed with a white subapical zigzag. The hind wings are noticeably paler than the fore wings, with a brown band widening towards the last three lobes. There are bundles of brown hairs on the lobes, both distally and basally, with white fringes between them. The hind legs are pale yellow.

Male genitalia. The uncus is long, noticeably exceeding the gnathos in length, and is distally slightly widened with a small apical notch. The gnathos is narrow and apically acute. The valves are long and membranous, apically smoothly forming a wide oval shape. The anellus arms are thin and straight. The saccus is caudally oval. The aedeagus is short, almost straight, and has two spiky cornuti.

Distribution. The species was found in Cameroon only.

Flight period. The species was collected in February, April, and May.

Etymology. The new species is named after Vasily Igorevich Sokolov (Moscow, Russia), the famous Russian ichthyologist and bioresource recovery specialist.

Alucita hirsuta **Ustjuzhanin & Kovtunovich, sp. nov.**
https://zoobank.org/0B0E031A-7DE7-49CE-8CA7-A36DEF703D7D
Figs 20, 21

Type material. ***Holotype*** • ♀, (NECJU 230710), Cameroon, Mapanja, 1850 m a.s.l., Mount Cameroon, 4.1157°N, 9.1315°E, 23.X.2017, lgt. V. Maicher, S. Delabye.

Differential diagnosis. The mushroom-like antrum and elongated crest-like signum of this species bear similarity to *Alucita ectomesa* (Hering, 1917) (illustrated in Ustjuzhanin and Kovtunovich 2016), but it can be distinguished by the wider ductus, the round bursa copulatrix, and numerous tiny spiky signa present in it. Additionally, the unique colouration of the wings sets *A. hirsuta* apart from all other African Alucitidae species.

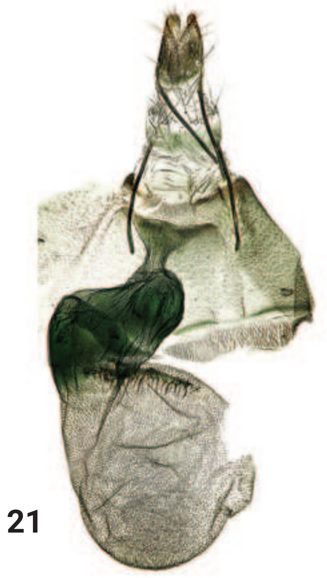
External characters. The head, thorax, and tegulae are dark brown. The labial palpi are short, slightly longer than the longitudinal eye diameter. The antennae are brown. The wingspan is 14 mm, and the wings have a reddish brown appearance. The lobes of all wings bear protruding tousled dark-brown hairs, especially dense on the first two lobes of the fore wings, creating the appearance of a shaggy moth. There are narrow, poorly visible pale longitudinal bands on all wings. The fringe on all wings ranges from pale to dark brown. The hind legs are yellow.

Female genitalia. The papillae anales are narrowly triangular in shape. Both the posterior and anterior apophyses are of equal length, thick, and straight. The antrum is wide and mushroom-like. The ductus is wide, corrugated, and strewn with narrow strands. The ductus seminalis passes from the middle of the ductus. The bursa copulatrix is round, with a robust crest-like signum located in the upper part of the bursa, near the confluence of the ductus. Numerous tiny spiky signa densely cover the entire surface of the bursa.

Distribution. The species was found in Cameroon only.

Flight period. The species was collected in October.

Etymology. The species name is derived from Latin 'hirsute' (shaggy, bristly, hairy). It refers to the appearance of the adult moth, with tousled protruding dark-brown hairs on the wings, reminiscent of a hairy and shaggy moth.



Figures 20, 21. *Alucita hirsuta* Ustjuzhanin & Kovtunovich, sp. nov. **20** adult female, holotype, NECJU **21** female genitalia, holotype, NEJCU, preparation slide no. 230710. Scale bar: 5 mm.

Alucita potockyi **Ustjuzhanin & Kovtunovich, sp. nov.**
https://zoobank.org/F8D2F968-7B4B-4ED1-9861-105B9BBF9972
Figs 22, 23

Type material. ***Holotype*** • ♂, (NECJU 230711), Cameroon, Mexico Camp, 30 m a.s.l., Bimbia-Bonadikombo, 3.9818°N, 9.2625°E, 10.X.2017, lgt. V. Maicher, S. Delabye.

Differential diagnosis. The yellow wing colour of this species resembles *Alucita compsoxantha* Meyrick, 1924, but it can be distinguished by the differences in the position of the bands. In the male genitalia, *A. potockyi* shares similarities with *Alucita tesserata* (Meyrick, 1918) in the short uncus widening towards the apex and in the saccus shape, but it clearly differs in the apically tapered gnathos, long narrow valves and the long aedeagus that exceeds the genital structure in its length. In comparison, *A. tesserata* has a gnathos that strongly widens apically, short and wide valves, and a noticeably smaller aedeagus relative to the genital structure (see Ustjuzhanin et al. 2020a for the genitalia illustration).

External characters. The forehead is covered with white clinging scales, while the nape bears protruding yellow-brown hairs. The thorax and tegulae are yellowish brown. The labial palpi are short, ~ 1.5 × as long as the longitudinal eye diameter, with the third segment acute and framed with brown scales. The antennae are yellow, with only the basal area above the scape adorned with dark-brown scales. The wingspan measures 14 mm, and the wings have a yellowish brown colouration. There is a narrow white band medially on the fore wings (potentially even more bands can be present, but it is difficult to distinguish them clearly on the single available specimen of a mediocre quality), and alternating brown and yellowish portions of scales are present in the distal half of the fore wings. The wings' basal areas are covered with brown scales. The hind wings are slightly paler than the fore wings, with alternating brown and yellow portions of scales along all lobes. The fringe on all wings is yellow, and the hind wings appear pale-yellow.

Figures 22, 23. *Alucita potockyi* Ustjuzhanin & Kovtunovich, sp. nov. **22** adult male, holotype, NECJU **23** male genitalia and structures of the segment VIII of the male abdomen, holotype, NEJCU, preparation slide no. 230711. Scale bar: 5 mm.

Male genitalia. The uncus is short, widening apically. The gnathos is robust, sharply narrowing apically. The valves are narrow, long, and poorly sclerotised. The gnathos arms are short and narrow-triangular. The anellus arms are thin, long, straight, and apically form axe-shaped extensions. The saccus is caudally oval. The aedeagus is long, slightly longer than the genital structure, and bears a series of tiny transverse spiky cornuti distally, along with two big needle-like cornuti positioned along the aedeagus medially.

Distribution. The species was found in Cameroon only.

Flight period. The species was collected in October.

Etymology. The species is named after the Czech lepidopterist Pavel Potocký Sr., in appreciation of his long-term support with moth preparation and identification in various projects of RT's research group.

Other species newly recorded on Mount Cameroon

Alucita agassizi **Ustjuzhanin & Kovtunovich, 2018**

Alucita agassizi Ustjuzhanin & Kovtunovich, 2018: 169. Type locality: Tanga, E Usambara, Tanzania.

Type material examined. ***Holotype*** • ♀, Natural History Museum of United Kingdom, London, UK (NHMUK), examined by the authors (illustrated in Ustjuzhanin et al. 2018b).

Other material examined. 1 ♂ (CUK), 1 ♀ (NECJU), Cameroon, Bamboo Camp, 350 m a.s.l., Mount Cameroon, 4.0879°N, 9.0505°E, 19.XII.2014 • 2 ♂ (NECJU), 12–20.XII.2014; 2 ♂ (CUK), 17–23.IV.2015, lgt. V. Maicher, Sz. Sáfián, S. Janeček, R. Tropek • 1 ♀ (CUK), Cameroon, PlanteCam Camp, 1100 m a.s.l., Mount Cameroon, 4.1175°N, 9.0709°E, 09–14.IV.2015, lgt. V. Maicher, Sz. Sáfián, S. Janeček, R. Tropek.

Distribution. The species was found in Tanzania and Cameroon.

Note. New species for Cameroon.

Figures 24, 25. *Alucita molliflua* (Meyrick, 1927) **24** adult female, holotype **25** female genitalia, holotype. Scale bar: 5 mm.

Alucita dohertyi (Walsingham, 1909)

Orneodes dohertyi Walsingham, 1909: 174. Type locality: Ibea, Kikuyu, Escarpment, E Africa, [Kenya].
Orneodes decaryella Viette, 1956: 89. Type locality: Madagascar.

Type material examined. ***Holotype*** • ♂, NHMUK, examined by the authors.

Other material examined. 5 ex. (NECJU, CUK), Cameroon, Mount Cameroon, Mapanja, 1850 m a.s.l., 4.1157°N, 9.1315°E, 28.X.2017, lgt. V. Maicher, S. Delabye.

Distribution. The species is known from Tanzania, Uganda, Kenya, Madagascar, Republic of South Africa (De Prins and De Prins 2023), and Cameroon.

Note. New species for Cameroon.

Alucita plumigera (Strand, 1913)

Orneodes plumigera Strand, 1913: 63. Type locality: Alén, Equatorial Guinea.

Type material examined. ***Holotype*** • ♂, Museum für Naturkunde, Berlin, Germany (MfN), examined by the authors.

Other material examined. (NECJU, CUK) 2 ♂, Cameroon, PlanteCam Camp, 1100 m a.s.l., Mount Cameroon, 4.1175°N, 9.0709°E, 11–18.XII.2014, lgt. V. Maicher, Sz. Sáfián, Š. Janeček, R. Tropek • 6 ex., Cameroon, Bamboo Camp, 350 m a.s.l., Mount Cameroon, 4.0879°N, 9.0505°E, 17–23.IV.2015, lgt. V. Maicher, Sz. Sáfián, Š. Janeček, R. Tropek • 2 ex., Cameroon, Mount Cameroon, Bamboo Camp, 350 m a.s.l., 29.I.–07. II.2016, lgt. Sz. Sáfián, R. Tropek, V. Maicher • 1 ♂, Cameroon, PlanteCam Camp, 1100 m a.s.l., Mount Cameroon, 4.1175°N, 9.0709°E, 09–14.IV.2015, lgt. V. Maicher, Sz.Sáfián, S. Janeček, R. Tropek • 5 ex., Cameroon, Bamboo Camp, 350 m a.s.l., Mount Cameroon, 4.0879°N, 9.0505°E, 12–20.XII.2014, lgt. V. Maicher, Sz. Sáfián, S. Janeček, R. Tropek • 1 ♂, 2 ♀s, Cameroon, Mount Cameroon, Mapanja, 1850 m a.s.l., 4.1157°N, 9.1315°E, 23–28.X.2017, lgt. V. Maicher, S. Delabye • 1 ♀, Cameroon, Mount Cameroon, Ekonjo, 1150 m a.s.l., 4.0881°N, 9.1168°E, 21.X.2017, lgt. V. Maicher, S. Delabye • 1 ♀, Cameroon, Mount Cameroon, Drink Gari, 650 m a.s.l., 4.1014°N, 9.0610°E, 06–15.II.2016, lgt. Sz. Sáfián, R. Tropek, V. Maicher.

Distribution. The species occurs in Equatorial Guinea and Cameroon.

Note. New species for Cameroon.

Alucita rhaptica (Meyrick, 1920)

Orneodes rhaptica Meyrick, 1920: 82. Type locality: Kwale County, [Kenya].

Type material examined. ***Holotype*** • ♀, Museum National d'Histoire Naturelle, Paris, France (MNHN), examined by the authors.

Other material examined. 1 ♀ (NECJU), Cameroon, Bamboo Camp, 350 m a.s.l., Mount Cameroon, 4.0879°N, 9.0505°E, 17–23.IV.2015, lgt. V. Maicher, Sz. Sáfián, S. Janeček, R. Tropek. • 1 ♀, 20.XII.2014, same data as the previous specimen.

Distribution. The species occurs in Tanzania, Malawi, Republic of South Africa (De Prins and De Prins 2023), and Cameroon.

Note. New species for Cameroon. Female genitalia of this species were illustrated in Ustjuzhanin et al. (2020a).

Key to identify *Alucita* species in the Mount Cameroon area (males only)

In addition to the 36 species of *Alucita* previously reported from the Mount Cameroon area in Ustjuzhanin et al. (2018a, 2020a), Ustjuzhanin and Kovtunovich (2016), and in this study, the identification key also includes the only other species known from Cameroon, *Alucita illuminatrix* (Meyrick, 1929) described from Bitje, South Region, Cameroon (DePrins and DePrins 2023). Although this species has not been recorded in the Mount Cameroon area, we have included it in the identification key. On the other hand, *Alucita tatjana* Ustjuzhanin & Kovtunovich, 2020, *A. pyrczi*, *A. tonda*, and *A. hirsuta* are not included in the identification key despite their occurrence on Mount Cameroon, because only females are known for these species.

1 Wingspan ≥ 20 mm **2**
– Wingspan < 20 mm **5**
2 Wingspan ≥ 30 mm **3**
– Wingspan < 30 mm **4**
3 Hind wings basally whitish with blackish grey bars distally. A postmedian transverse narrow brown band in hind wings. Hind wings distally framed in a wide dark brown band. In female genitalia, antrum oval, large, wide, almost equal to bursa copulatrix; ductus narrow, short .... ***A. illuminatrix***
– Hind wings basally brown. Several transverse lightened bands running down in the middle of hind wings. Hind wings distally framed by a narrow brown band. In female genitalia, antrum cup-like; ductus wide, short .... ***A. dohertyi***
4 Wings predominantly yellowish orange .... ***A. coffeina***
– Wings without yellow or orange colouration **5**

5 Wings mostly dark brown and black. Wings dark, brown. In male genitalia, aedeagus straight, shorter than the entire genital apparatus ..... ***A. bokwango***
– Wings pale, almost white. In male genitalia, aedeagus strongly curved, 5 × longer than the entire genital apparatus .... ***A. longipenis***
6 Male genitalia with reduced valves **7**
– Male genitalia with developed valves **11**
7 Aedeagus 4 × longer than the entire genital structure, with 2 arched curves in its medium part. Wingspan 14 mm... ***A. erzayi***
– Aedeagus equal, slightly longer or slightly shorter than the entire genital structure, straight or slightly curved.. **8**
8 Saccus long, elongated, caudally acute **9**
– Saccus short, caudally rounded **10**
9 Uncus finger-like, of equal width throughout its length. Aedeagus with 2 small horn-like cornuti. Anellus arms short, narrow, arched, apically acute. Wings mottled brown and white. Wingspan 12 mm .... ***A. zuza***
– Uncus distally extended, apically with a small notch in the middle. Aedeagus with 1 long needle-like cornutus, exceeding the length of aedeagus. Anellus arms very short, with wide lobes, equally in length to gnathos. Wings yellowish brown, with 3 transverse white bands. Wingspan 12–13 mm .... ***A. fokami***
10 Saccus with a small notch caudally. Aedeagus with long needle-like cornuti. Gnathos short, wide. Well expressed white belts on abdominal tergites. Wings dark brown with portions of white scales. Wingspan 13–15 mm .... ***A. deja***
– Saccus caudally without a notch. Aedeagus with a cluster of tiny cornuti. Gnathos not expressed. Abdomen without any white belts. Wings greyish white, basally darkened with brown scales. Wingspan 10–12 mm .... ***A. janeceki***
11 Uncus apically expanded **12**
– Uncus equally wide throughout its length, apex not expanded **25**
12 Valves wing-like, wide **13**
– Valves not wing-like: finger-like, narrow or wide, short or long **19**
13 Saccus short... **14**
– Saccus noticeably elongated.. **15**
14 Valves apically with long needle-like setae. Uncus long, paddle-like, apically with a smooth edge. Aedeagus relatively short, almost straight, distally with a cluster of tiny needle-like cornuti. Wing pattern uniquely greyish white with pale grey-brown basal regions, wide brown medial bands, and distal portion of forewings outlined in dark brown. Wingspan 16–18 mm ... . ***A. ludmila***
– Valves apically without needle-like setae. Uncus long, basally narrow, distally extended, apically with a weak notch. Saccus wide, caudally with a small notch. Aedeagus short, slightly bent in the middle, distally with a cluster of tiny spiky cornuti. Wings mottled, with a clearly expressed medial band, hind wings basally lightened. Wingspan 12–15 mm .... ***A. mischenini***
15 Saccus not solid, caudally not closed, discontinuous. Anellus arms long, slightly bent inwards. Aedeagus distally and apically with tiny needle-like cornuti. Wings white, with wide dark brown bands. Wingspan 18 mm .... ***A. zinovievi***
– Saccus solid, caudally closed, not discontinuous.................................... **16**

16 Saccus with a triangle notch caudally. Anellus arms slightly shorter than gnathos. Aedeagus distally with orderly arranged big needle-like cornuti. Wings white, with black and brown portions of scales, a medial band well developed. Wingspan 12–16 mm .... ***A. sedlaceki***

– Saccus without a notch caudally... **17**

17 Saccus distinctly acute caudally. Gnathos slightly shorter than uncus, apically acute, with wide arms. Anellus arms wide, straight, equal to gnathos in its length. Aedeagus almost straight, obliquely cut apically, without cornuti. Wings pale yellow, mottled, with alternating white and yellowish brown portions of scales. Wingspan 9–12 mm .... ***A. fako***

– Saccus caudally rounded, not acute **18**

18 Gnathos wide, slightly shorter than uncus. Aedeagus apically without protruding spikes. Anellus arms relatively wide, slightly shorter than the gnathos, slightly bent inwards, apically narrowing. Wings yellowish brown, medially with a clearly expressed transverse brown arched band on all wings. Wingspan 14–16 mm.. ***A. escobari***

– Gnathos narrow, equally long as uncus. Aedeagus apically with sharp thin spikes protruding outwards. Anellus arms wide, short. Wings yellowish brown, with 4 transverse white bands.Wingspan 18 mm .... ***A. bakweri***

19 Valves wide, short, not extending beyond base of uncus......................... **20**

– Valves narrow, long, extending beyond base of uncus **22**

20 Saccus elongated, gnathos narrow. Sacculus of complicated structure, anellus arms long, distally narrowing. Cornutus needle-like, occupying most of aedeagus. Wings elongated, greyish brown, mottled, with 4 clearly expressed transverse zigzag pale bands on all wings. Wingspan 16–20 mm .... ***A. sroczki***

– Saccus not elongated, caudally rounded, gnathos wide........................... **21**

21 Anellus arms wide, gnathos arms short. Aedeagus with a cluster of tiny needle-like cornuti medially. Uncus apically with a small notch. Wingspan 16–20 mm .... ***A. plumigera***

– Anellus arms narrow, gnathos arms long, arched. Aedeagus with a cluster of needle-like cornuti distally. Uncus with 2 small notches apically. Wingspan 15 mm... ***A. jana***

22 Uncus long, noticeably exceeding length of gnathos. Valves smoothly forming extended ovals apically. Aedeagus short, almost straight, with 2 spiky cornuti. Anellus arms thin, straight. Saccus caudally oval. Wings pale brown. Fore wings apically framed in a white zigzag rim, basally and distally with 2 distinct wide brown bands on fore wings. Hind wings noticeably paler than fore wings, medially with a brown band extending to the last 3 lobes. Wingspan 17–18 mm .... ***A. sokolovi***

– Uncus short, equal to gnathos in length. Valves not extended apically..... **23**

23 Uncus with a small notch apically. Gnathos arms short, shaped as narrow triangles. Anellus arms thin, long, apically forming hatchet-like extensions. Valves narrow, weakly sclerotised. Wings yellowish brown, medially with a narrow white band and alternating portions of brown and yellowish scales on fore wings. Hind wings slightly paler than fore wings. Wingspan 14 mm .... ***A. potockyi***

– Uncus with two uncinate processes apically. Gnathos arms long, narrow, tapered to apices... **24**

24 Gnathos wide, slightly narrowing distally. Valves slightly narrowing apically. Aedeagus narrow, elongated, longer than the entire genital structure, with 1 distinct long cornutus and a cluster of tiny needle-like cornuti distally. Wings mottled, yellowish brown. First lobe of fore wings with clearly expressed elongated orange spots alternating with elongated dark brown spots and separated by white bands. Wingspan 10–11 mm........... ***A. olga***

– Gnathos narrow, apically strongly extended. Apices of valves rounded. Aedeagus narrow, shorter the entire genital structure. Wings mottled, grey, with alternating dark and pale portions and a clearly expressed dark medial band. All wing lobes apically ending with a small dark brown spot. Wingspan 12–15 mm.. ***A. spicifera***

25 Saccus elongated.. **26**

– Saccus not elongated **28**

26 Valves apically clearly extended, rounded. Gnathos narrow, apically acute. Anellus arms narrow, straight. Aedeagus 1.5 × shorter than the entire genital structure, without cornuti. Wings pale brown, with a clearly expressed medial white band. Wingspan 13–16 mm................................ ***A. chloracta***

– Valves simple, apically not extended or only slightly extended **27**

27 Aedeagus long, almost 2 × as long as the entire genital structure. Uncus long, distally extended, apically slightly acute. Gnathos narrow, relatively long, apically acute. Valves wider at base. Anellus arms straight, long. Saccus elongated, oval. Wings pale brown, with white crossing lines and conspicuous elongated white patches separated by pale brown portions on the first lobe. Wingspan 8–10 mm... ***A. besongi***

– Aedeagus short, 1.5 × shorter than the entire genital structure, with a distinct large spiky cornutus in its middle part. Valves narrow, membranous, slightly extended apically. Gnathos narrow, equal to uncus in its length. Anellus arms long, straight. Wings elongated, mottled, dark grey, with clearly expressed pale transverse zigzag bands. Wingspan 13–14 mm........... ***A. megaphimus***

28 Saccus caudally saddle-shaped **29**

– Saccus caudally rounded... **30**

29 Uncus apically acute. Aedeagus short, wide, with a cluster of tiny cornuti distally. Valves narrow, longer than gnathos. Wings mottled, dark grey to almost black, distally with pale thin transverse zigzag bands. Wingspan 12–15 mm .... ***A. acalyptra***

– Uncus apically rounded bluntly. Aedeagus long, narrow, without cornuti. Valves short, wide, equally long as gnathos. Wings mottled, dark grey, with portions of whitish scales, with a pale zigzag band along an outer edge of all wings. Each lobe apically ending with a small spot of dark scales. Wingspan 10–12 mm.. ***A. agassizi***

30 Valves apically narrow. Anellus arms undulated, long, reaching the centre of gnathos. Gnathos apically acute. Wings mottled, yellowish grey, with a poorly expressed yellowish brown band medially. Alternating grey and white portions of wing scales shaped as elongated spots, dots, and strokes on the lobes of all wings. Wingspan 12–15 mm .... ***A. bakingili***

– Valves apically rounded. Anellus arms straight, not reaching the centre of gnathos **31**

31 Anellus arms wide, distally much wider. Gnathos 3 × narrower than the width of anellus arms. Aedeagus without cornuti. Wings yellowish brown,

with alternating elongated yellow-orange and dark brown spots on the first lobe of fore wing. Hind wings basally with an inclusion of dark spots of scales. Wingspan 12–14 mm ....***A. rhaptica***

– Anellus arms only slightly extended distally. Gnathos equal to anellus arms in width. Aedeagus with a cluster of needle-like cornuti distally. Wings greyish brown, basally darkened with dark-brown scales, medially with a wide pale yellow band, and distally with a wide dark brown band. Wingspan 14–15 mm.. ***A. lidiya***

Discussion

The Mount Cameroon area hosts a remarkable diversity of Alucitidae. This paper adds nine newly described species and four other newly reported species, bringing the total count to 36 species. This comprises 40% of all 89 Alucitidae species known from the Afrotropical region, including 80 species listed in the Afromoths database (De Prins and De Prins 2023) and nine species described in this study. The extent of local diversity in this moth group is unprecedented, as only a few species of this group are known from any other locality in the region (Ustjuzhanin et al. 2018a, 2020a; De Prins and De Prins 2023).

Mount Cameroon is known to harbour high diversity in many taxa, including other Lepidoptera groups (e.g., Ballesteros-Mejia et al. 2013; Maicher et al. 2016; Przybyłowicz et al. 2019; Delabye et al. 2020, Mertens et al. 2021). The region's exceptional species richness is often attributed to its location at the confluence of the Guinean and Congolian biogeographic regions, and a presence of diverse habitats along its elevational and precipitation gradients (Cable and Cheek 1998; Bergl et al. 2007; Hořák et al. 2019; Maicher et al. 2020a; Delabye et al. 2021; Doležal et al. 2022). Additionally, the area's relatively high isolation further contributes to the unique ecological conditions (Ustjuzhanin et al. 2018a). However, the sheer magnitude of many-plumed moth species richness on Mount Cameroon surpasses expectations based on combinations of these exceptional factors in other Afrotropical localities. Despite this unique combination of conditions, it remains challenging to fully account for why Mount Cameroon exhibits such a substantial predominance of many-plumed moths compared to all other known sites in the Afrotropical region.

Notably, 24 of these species have been described solely from the Mount Cameroon area (as *A. ludmila* was already known from Nigeria and Ghana when it was described; Ustjuzhanin et al. 2018a), and the majority of them (except for *A. mischenini* and *A. zinovievi* recently reported from Liberia and Ghana, respectively; Ustjuzhanin et al. 2020b) are considered endemic to Cameroon and have not been recorded elsewhere. This level of endemism among the Alucitidae underscores the importance of Mount Cameroon as a vital refuge for specialised and unique insect taxa. While the region is already renowned for its rich endemic diversity of moths and butterflies (e.g., Larsen 2005; Sáfián and Tropek 2016; Przybyłowicz et al. 2019; Sáfián et al. 2019), as well as its endemic plant (Cable and Cheek 1998) and vertebrate (Fjeldså and Lovett 1997; Bergl et al. 2007) species, the unparalleled level of endemism of Alucitidae further highlights the area's significance as a centre of microlepidopteran diversity in the Afrotropics.

The discovery of such a diverse and endemic locality on Mount Cameroon has exceeded expectations, despite the limited knowledge of Afrotropical microlepidoptera. The implications of this exceptional diversity extend beyond taxonomy, prompting future research into the evolutionary and ecological processes that have facilitated the development of this diverse moth community. The unique diversity and endemism of many-plumed moths in the Mount Cameroon area underscore the urgent need for efficient conservation of ecosystems and habitats in the region, especially considering previous conservation efforts that faced challenges in some parts (Ferenc et al. 2018). Collaborative efforts among researchers, conservationists, and local communities are crucial in preserving this treasure trove of biodiversity and securing the future not only for many-plumed moths.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

RT conceived the study ideas and supervised the project; RT, SD, VM, and SzS sampled the material; PU, VK, and AS identified and compared the material; PU and VK prepared the species description and identification key; PU and RT wrote the first draft; all authors contributed to writing and approved the final text.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Research Article

A new genus and three newly recorded species of Encyrtidae (Hymenoptera, Chalcidoidea) from China

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Abstract

A new genus and species of Encyrtidae (Hymenoptera: Chalcidoidea), *Apteronotus* Kang, Hu & Luo, **gen. nov.** (type species *A. indigus* Kang, Hu & Luo, **sp. nov.**), associated with insects inhabiting *Oxytropis* spp., and three newly recorded species for China, *Copidosoma clavatum*, *Ericydnus aeneus* and *Tetracnemus kozlovi*, are described from the Altun Mountain Nature Reserve, Xinjiang. Detailed illustrations of all species were included to support the identification and further study.

Key words: Alpine steppes, *Apteronotus indigus*, encyrtids, new genus, taxonomy, wingless

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Introduction

Encyrtidae, a large family in Chalcidoidea (Hymenoptera), is characterized by their extensive diversity and cosmopolitan distribution, encompassing over 500 genera and 4700 species worldwide, among them, 128 genera and 483 species recorded from China. Encyrtidae are predominantly parasitoids, targeting a wide range of host taxa primarily within Hemiptera, but also extending to Lepidoptera, Coleoptera, Diptera, and other insect groups, as well as other arthropods, including ticks (Noyes 2019). The majority of Encyrtidae species are endoparasitoids, and a few of them are hyperparasitoids (Trjapitzin 1989). Many species of this family have been utilized in the biological control of crop pests, underscoring the family's ecological and biogeographical significance.

A critical milestone in the study of Chinese Encyrtidae was achieved by Zhang and Huang (2004), who provided an extensive key to 123 genera. Despite this, knowledge of the biological resources of Encyrtidae in vast areas of China is still limited. The Altun Mountain National Nature Reserve, located in Xinjiang, China, is one of China's four uninhabited areas, which is characterized by unique extreme environmental conditions such as low temperature, strong winds, and high ultraviolet radiation, as well as complex and diverse habitats like widespread sandy and gravel deserts, wetlands and alpine steppes. Under such environmental conditions, the poorly known species of Encyrtidae need to be investigated comprehensively and urgently to reveal its biodiversity and enrich available data on the family for further study on its adaptation to the extreme environment.

In this context, our study focused on encyrtids collected from 2019 to 2021 in the dominant alpine steppes' habitats within the Altun Mountain Nature Reserve. This research contributes to the taxonomic understanding of the family by documenting four species across four genera. Notably, it includes one new genus, *Apteronotus* Kang, Hu & Luo, gen. nov., and one new species, *Apteronotus indigus* Kang, Hu & Luo, sp. nov. Additionally, we report three species, *Copidosoma clavatum*, *Ericydnus aeneus* and *Tetracnemus kozlovi*, as new distributional records for China. This work represents a significant step in unraveling the taxonomic and ecological complexities of Encyrtidae in an alpine region that has been historically underrepresented in entomological research.

Materials and methods

All the examined specimens were collected by using sweeping nets, yellow pan traps as well as malaise traps in July from 2019 to 2021; yellow pans were left from 8 to 24 hours at each site, and alcohol in the malaise traps was changed every 10 (±5) days to 1 month. The specimens were sorted and immediately preserved in absolute ethanol and stored at -20 °C. Selected specimens of both sexes were slide-mounted and labeled or air-dried and card mounted, and examined under a Nikon SMZ745T stereomicroscope using the available keys (Trjapitzin 1989; Zhang and Huang 2004). Habitus photographs were taken with a Nikon D7000 digital camera connected to a Nikon SMZ25 stereomicroscope. Detailed features of the new species were photographed with a LEO-1430VP scanning electron microscope (SEM), and plates were compiled using Adobe Illustrator CC 2017 software. All specimens were deposited in the Insect Collection of the College of Life Science and Technology, Xinjiang University, Urumqi, Xinjiang, China (**ICXU**).

The taxonomic terminology and abbreviations follow Trjapitzin (1989). The following abbreviations are used in the text: **F1–6**, funicle segment number; **POL**, distance between the posterior ocelli; **OOL**, distance between the eye margin and the adjacent posterior ocellus; **OCL**, distance between the posterior ocellus and the occipital margin; and **T1–7**, tergite segment number.

Results

Genus *Apteronotus* Kang, Hu & Luo, gen. nov.
https://zoobank.org/1D48FE0E-4167-426D-87EF-192D33A4A6C1
Figs 1, 2

Type species. *Apteronotus indigus* Kang, Hu & Luo, sp. nov.

Etymology. Female, "Apteron" refers to lack of wings in this genus, and "notus" is a suffix often used in insect taxonomy.

Diagnosis. This genus exhibits distinct morphological divergences when compared to the two subfamilies (Encyrtinae and Tetracneminae) in Encyrtidae. The new genus can be differentiated from other related genera by a combination of the following characteristics: Body length 0.65–0.75 mm, short and

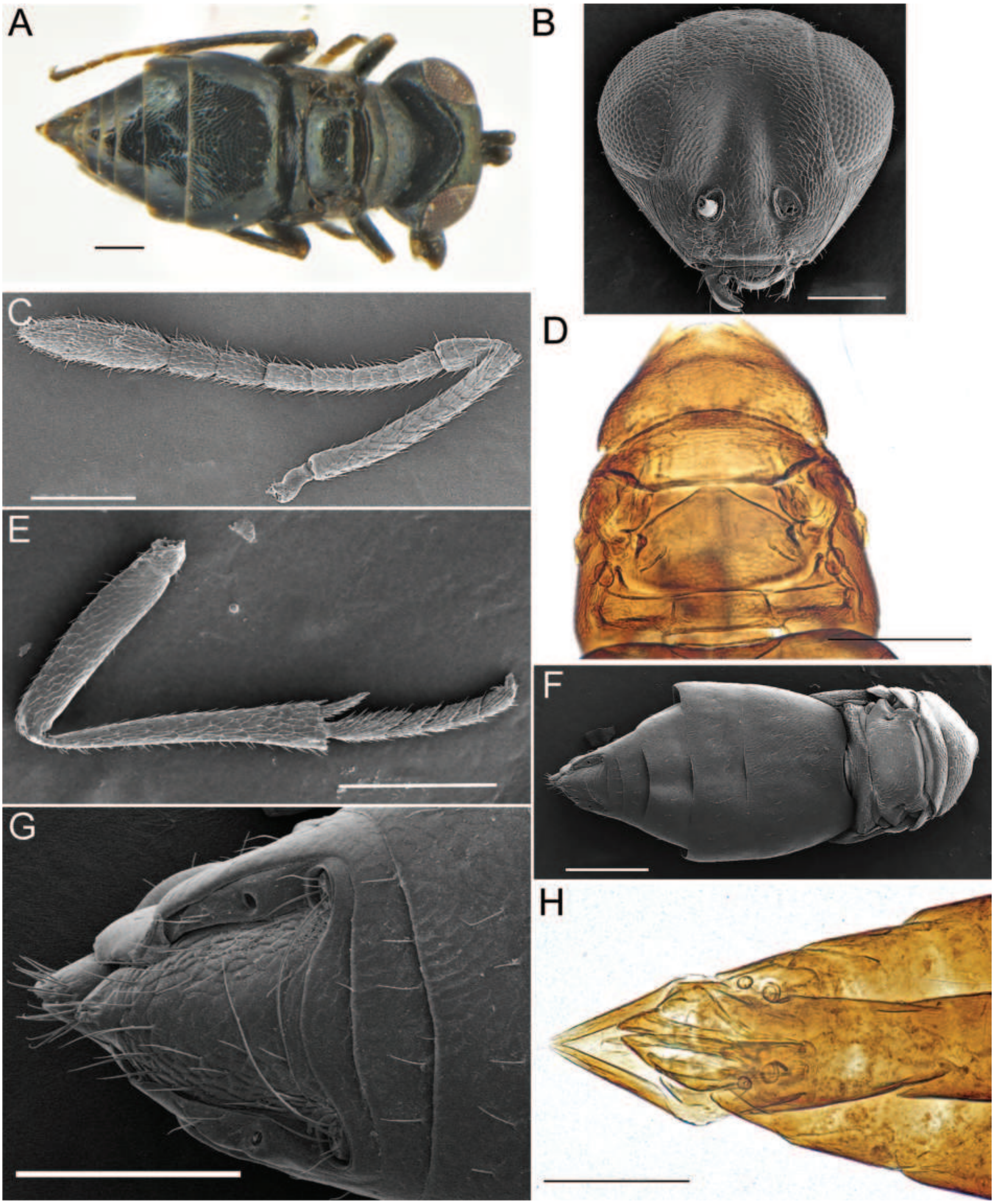


Figure 1. *Apteronotus indigus* Kang, Hu & Luo, sp. nov., female **A** habitus, dorsal view **B** head, frontal view **C** antenna **D** mesoscutum, dorsal view **E** mid leg **F** body, dorsal view **G, H** tip of gaster. Scale bars: 100 μm.

robust, body indigo blue, eyes and ocelli dark red, mandible yellow, tibia and trochanter yellow, basitarsus, and apical tibiae yellow. Head in dorsal view without occipital margin; antenna slender, slightly longer than head width, clava 3-segmented; mesoscutum slightly shorter than head width, with faint reticulation and sparse setose; notaular lines absent, axillae separate apically; propodeum shorter than 1/2 scutellum medially; wings absent in both sexes; mid tibial spur shorter than basitarsus; gaster ovate, posterior margin of T1 medially incised in some individuals, ovipositor sheath not exserted, paratergite not present.

Distribution. China (Xinjiang).

Hosts. Unknown.

Comments. The genus does not run to any genus in the keys (Trjapitzin 1989; Noyes et al. 1997). Extensive morphological comparisons were made with several brachypterous genera (Trjapitzin and Gordh 1979); however, *Globulencyrtus* Hoffer, 1976 differs in the following characteristics: head with sharp occipital margin, clava shorter than funicle, forewing rudiments, and reaching to about apex of scutellum posteriorly (Hayat et al. 2013); *Austrochoreia* Girault, 1929 is distinguished by the elongate pronotum that almost covers the mesoscutum, lack of notaular lines and abbreviated wings (Noyes and Hayat 1984); it can be distinguished from *Aglyptus* (Tetracneminae) by several key characteristics: body chocolate-brown-yellow, with light green shine, female body length 1.9–2.0 mm, forewing not developed and with dark transverse band in the apical third; similarly, the related genus *Bactritopus* with large and deep depression on face, clypeal margin forming a spatulate protrusion, antennal toruli located at the edge of mouth, mandible tridentate, with a long middle tooth, mesoscutum with complete notauli, wings not shortened (Trjapitzin 1978). The specimens also share some characteristics with the genus *Choreia* (Encyrtinae), but they differ notably in having a large punctation on the vertex and frons, occipital margin sharp, mesoscutum usually 3× as broad as long, scutellum roundish in back view, axillae meeting, and female body length at least 1 mm (Westwood 1833; Förster 1856). We also found some characteristic differences within the new species, the hind margin of T1 slightly incised medially in some individuals.

Apteronotus indigus **Kang, Hu & Luo, sp. nov.**

https://zoobank.org/8D8E6AD7-86B6-4DE9-ADB6-758CEAA683EF

Figs 1A–H, 2A–F

Type material. ***Holotype***, ♀, card mounted, China, Xinjiang, Ruoqiang County, Altun Mountain Nature Reserve, 36°58'10"N, 90°14'45"E, Altitude: 4021.95 m, 14.VII.2020, Coll. Shun-Gang Luo, Ning Kang, Hong-Ying Hu by yellow pan trapping. ***Paratypes***. 1♀, 1♂, on slide, same data as holotype except 18.VII.2020; 3♀♀, 5♂♂, card mounted, 21.VII.2020. Coll. Shun-Gang Luo, Ning Kang, Hong-Ying Hu (all deposited in ICXU).

Description. Female. Length 0.7 mm. Body black with dark bluish metallic sheen (Fig. 1A). Antenna, femora, and tibiae dark brown, head in dorsal view with bronze shine at some angle. Mesosoma black. Legs with all coxae black; trochanter and their apices deep yellow, tarsal segments 1–3 yellow, fourth and fifth tarsi dark brown (Fig. 2C). Gaster black except T6–7 dark brown.

Head in frontal view 1.2× as broad as high (385:330) (Fig. 1B), 1.9× as broad as mesosoma, with fine reticulate sculpture, covered with sparse and short setae; frontovertex width 0.5× head width (117:385), antenna located below the lower eye margin and separated from clypeus margin by 1.4× height of the torulus, inner edge of eyes diverged at the lower part, malar sulcus distinct and straight, malar space 0.65× as long as eye height (120:185), mandible bidentate.

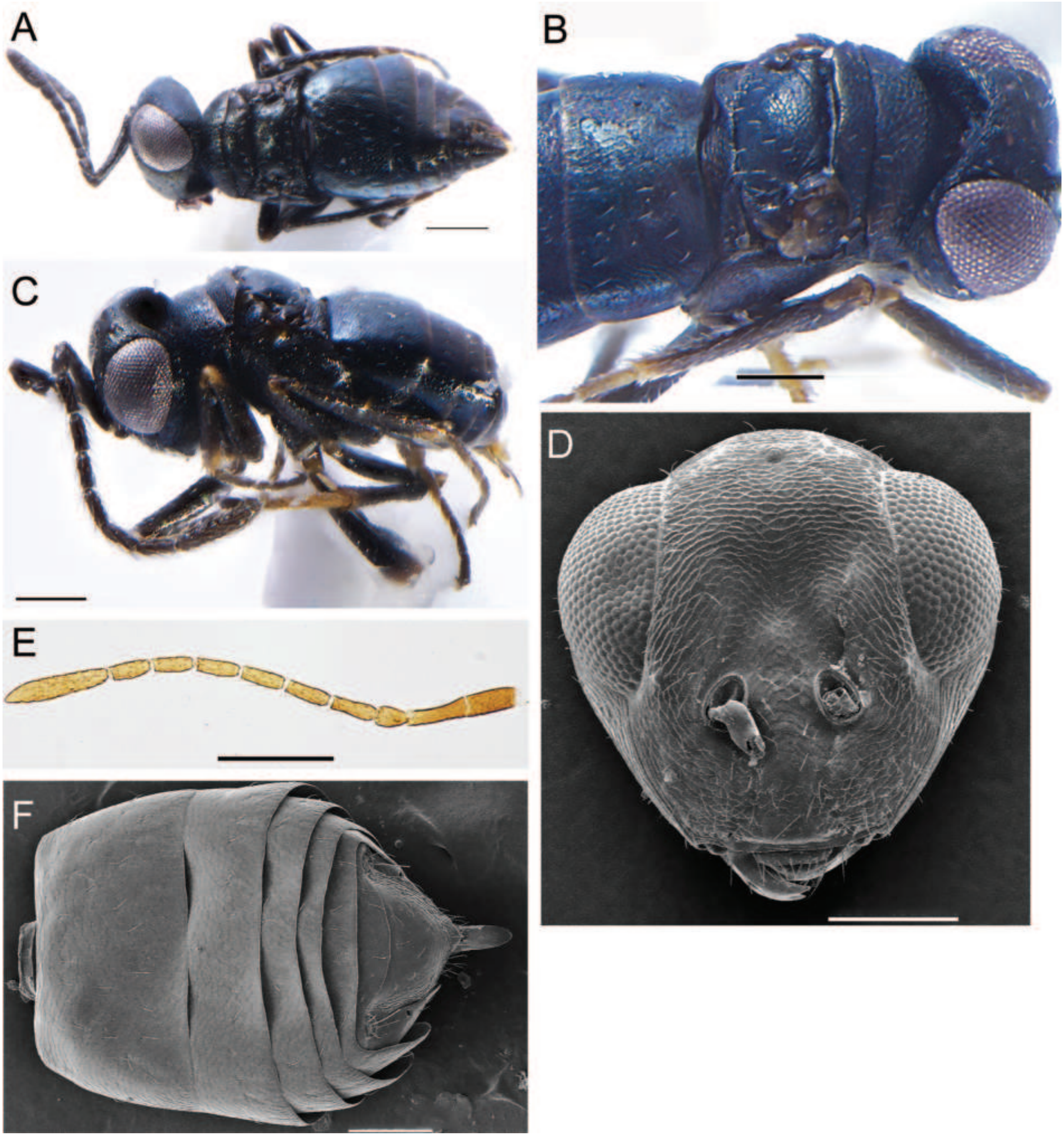


Figure 2. *Apteronotus indigus* Kang, Hu & Luo, sp. nov., male **A** habitus, dorsal view **B** mesoscutum, lateral view **C** habitus, lateral view **D** head, frontal view **E** antenna **F** gaster. Scale bars: 100 μm.

Head in dorsal view 2.1× as broad as long (347:168), ocelli forming an obtuse angle (110°), POL 1.8× as long as OOL (55:30), posterior edge of eye adjacent to posterior margin of head. Antenna with scape cylindrical and covered with short setae, 9× as long as wide (260:28), pedicel 2× as long as wide (60:30); all funicular segments longer than wide (Fig. 1C), each funicular with three rows of irregular longitudinal sensilla, F1 and F3 2× as long as broad respectively (40:20), obviously shorter than pedicel and other segments, F4–F6 subequal in length, 1.5× as long as broad (45:30); clava 3-segmented, 3.6× as long as broad (145:40), longer than the combined length of F5–F6, with obscure boundaries and apically rounded, the collective length of pedicel and flagellum 1.22× as long as head width (470:385).

Mesosoma much shorter than metasoma and reticulate sculpture larger than that on head. Pronotum 1.8× as long as mesoscutum length (90:50) and 2.78× as broad as long (250:90); mesoscutum 5.2× as wide as long (260:50) (Fig. 1D), notaular lines absent, tegula large and semicircular; scutellum slightly convex and 2.2× as wide as long (250:117), scattered with some short white setae irregularly arranged on its posterior part, axillae very small and apically separated; propodeum medially longer than 1/3 of the scutellum (40:117), with sinuated inverted U-shaped ridges (Fig. 1F). Mesotibial spur strong, 0.6× as long as basitarsus (63:104) (Fig. 1E). Wings absent.

Gaster 1.6× as long as broad (694:426), longer than the combined length of head and mesosoma, T1 distinctly longer than other tergites individually (250:444), occupying about two-fifths of the total length, covered with 3–4 rows of setae, T2–T6 each with a single row of setae, T7 with 2–3 rows of short setae, and with 5 long cercal bristles at each side. Paratergites absent. Hypopygium slightly extends to the apex of gaster (Fig. 1G, H).

Male. Length 0.57–0.64 mm (0.6±0.042 mm, *N* = 5) (Fig. 2A–C), similar to female in body color and sculpture, but differs as follows. Frontovertex slightly arched (Fig. 2D); each funicular segment clearly elongated, 3× as long as broad, with at least 2 rows of long black whorled setae (Fig. 2E); pedicel distinctly shorter than F1, 0.67× as its length; clava 4.25× as long as broad; the combined length of pedicel and flagellum 1.6× as long as head width. Gaster 1.3× as long as broad, posterior margin of each tergite straight (Fig. 2F).

Hosts. Unknown.

Etymology. “*indigus*” means indigo blue, signifying the body color of the female species.

Genus *Copidosoma* Ratzeburg, 1844

Note. The genus is widely distributed worldwide, with 204 valid species, 22 of which have been recorded from China (Zhang and Huang 2007). Most species of the genus are parasitic on lepidopteran insects, especially endoparasitic in eggs and larvae (Noyes 2019), which provide good prevention and control effects on agriculture and forestry pest populations.

Copidosoma clavatum Myartseva, 1982

Fig. 3A–G

Copidosoma clavatum Myartseva, 1982: 26.

Material examined. China: 3♀♀, card mounted, Xinjiang, Ruoqiang, Altun Mountain Nature Reserve, 37°58'30.15"N, 88°58'25.15"E, Altitude: 3489 m, 14.VII.2020. Coll. Shun-Gang Luo; 2♀♀, 36°58'10.89"N, 90°14'44.19"E, Altitude: 4021.95 m, 21.VII.2020. Coll. Shun-Gang Luo, by yellow pan trapping (all deposited in ICXU).

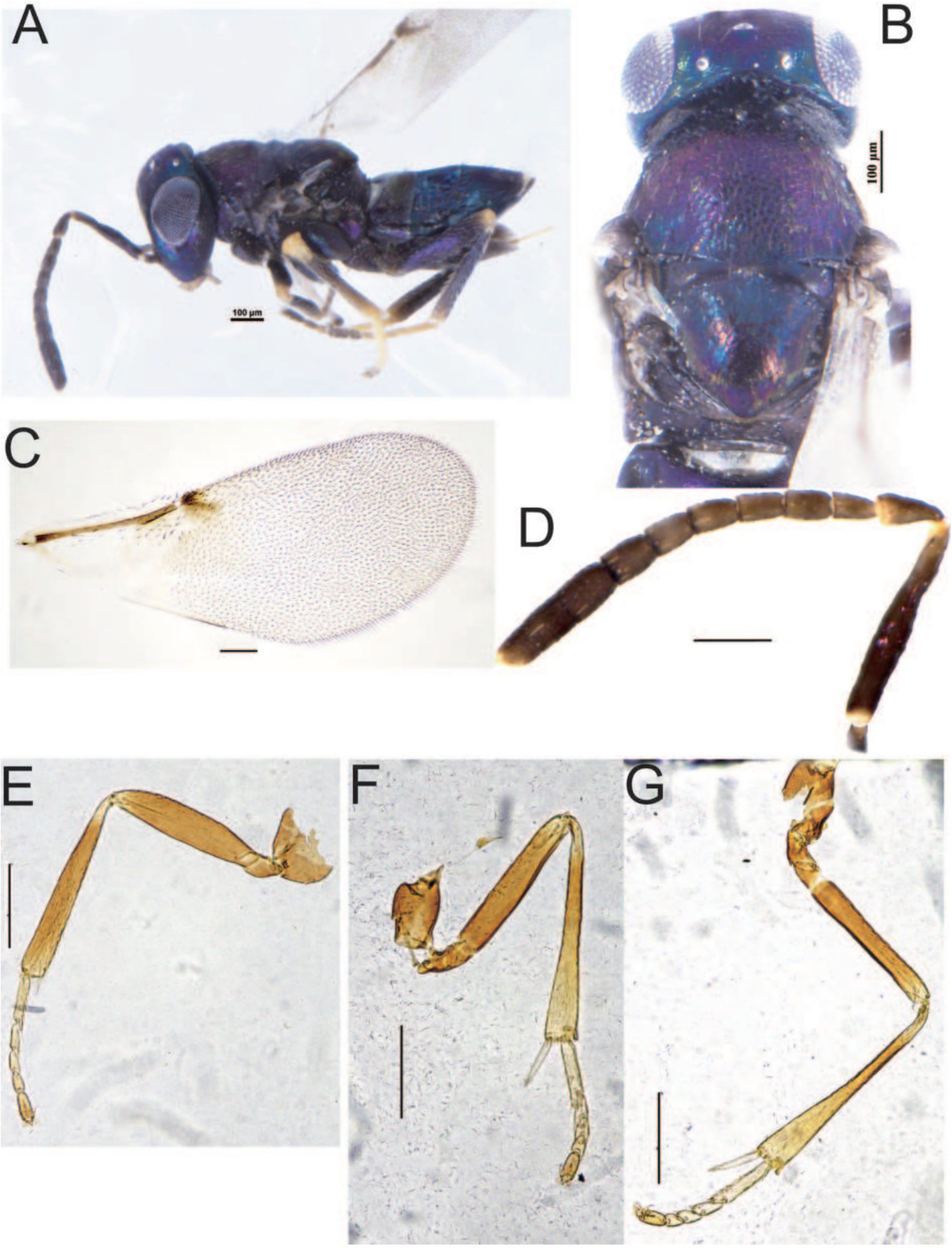


Figure 3. *Copidosoma clavatum* Myartseva, female **A** habitus, lateral view **B** head and mesoscutum, dorsal view **C** fore-wing **D** antenna **E** fore leg **F** mid leg **G** hind leg. Scale bars: 100 μm.

Diagnosis. Female. Length 1.12–1.45 mm (Fig. 3A), body ink blue, with blue-purple metallic luster; ocelli silver, eyes argenteous; antenna and leg dark brown; tibiae concolorous with body, trochanter, distal tibiae and tarsi yellow (Fig. 3E–G); forewing hyaline, venation dark brown. Head width equal to its height, ocelli forming an obtuse angle range from 96–105°, OOL about 1.55× OCL, torulus below the ventral margin of eye, F1–F6 equal in length, gradually widen towards the end, scape less than 6× as long as width, clava 3-segmented, with slight oblique truncation (Fig. 3D); mandible tridentate, with median tooth longest. Mesoscutum with honeycomb reticulate, axillae separated apically (Fig. 3B); linea calva complete, postmarginal vein punctate (Fig. 3C); mesotibial spur 0.87× basitarsus (Fig. 3F). The exerted ovipositor obviously shorter than mesotarsus.

Male. Unknown.

Hosts. Unknown.

Distribution. China (Xinjiang) new record; India (Andhra Pradesh, Kerala, Odisha, Tamil Nadu, West Bengal) (Kazmi and Hayat 2012), Turkmenistan (Trjapitzin 1989).

Comments. The similar species *C. aretas* can be separated from this species by the body color dark green, funicle elongated distally, scape more than 6× as long as width, clava without oblique truncation, and forewing linea calva interrupted posteriorly (Trjapitzin 1989).

Genus *Ericydnus* Haliday, 1832

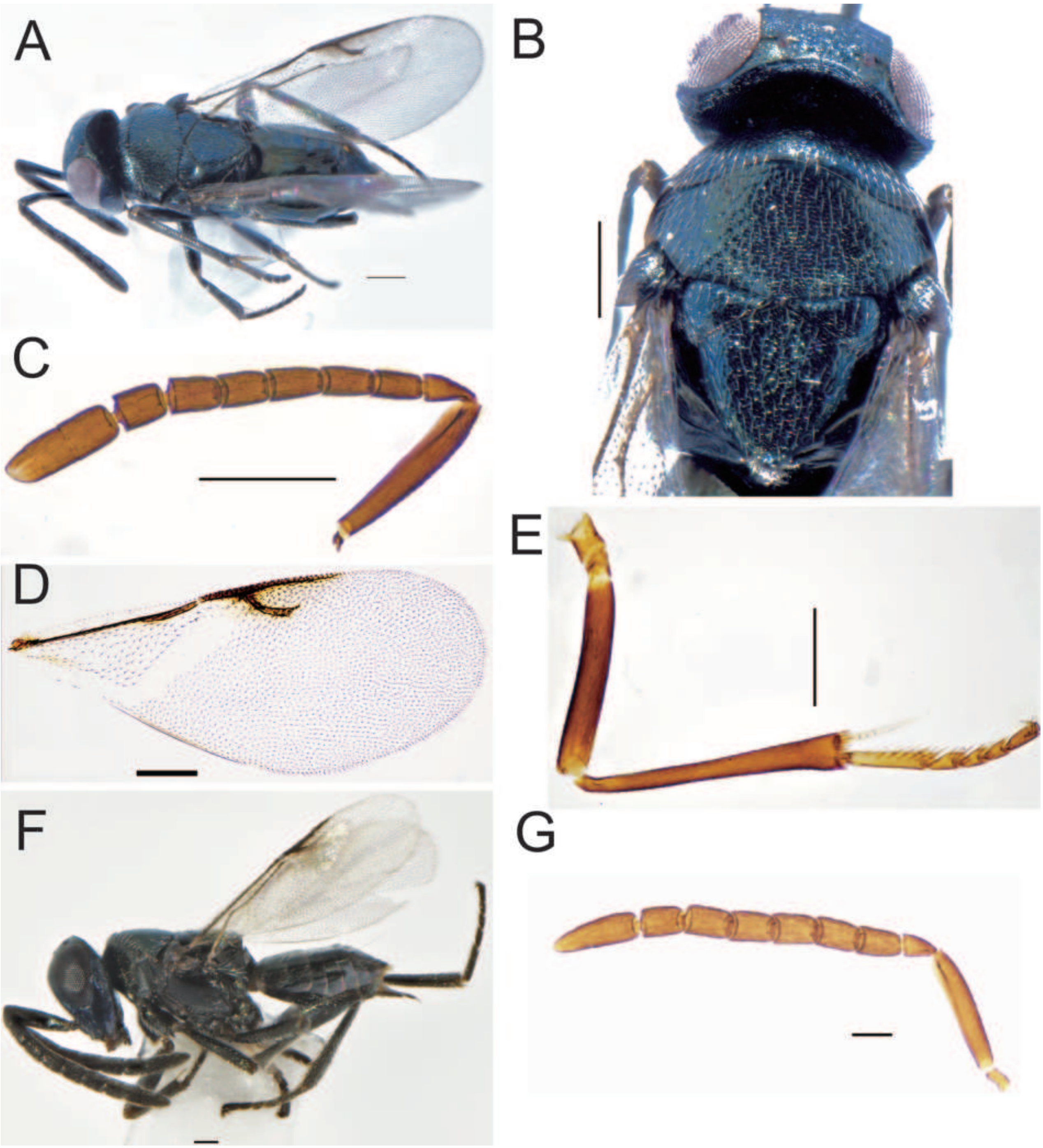
Note. The genus has 33 valid species in the world, mostly distributed in the Palearctic region with 11 species from China. The distinct characteristics of this genus are mandible bidentate, all funicles longer than wide; mesoscutum covered with white setae, scutellum with membranous sharp flange apically, and overhanding propodeum; forewing infuscate, linea calva complete, veins long, stigmal with long uncus.

Ericydnus aeneus Nikolskaya, 1952
Fig. 4A–G

Ericydnus aeneus Nikolskaya, 1952: 357.
Ericydnus (*Aeneus*) *robustior* Nikolskaya, 1952: 96. Synonymized by Trjapitzin 1989.

Material examined. 5♀♀8♂♂, China: Xinjiang, Ruoqiang, Altun Mountain Nature Reserve, 36°58'10.89"N, 90°14'44.19"E, Altitude: 4021.95 m, 14–21.VII.2020. Coll. Shun-Gang Luo, by malaise trap; 4♀♀3♂♂, 37°51'49.39"N, 89°36'31.77"E, Altitude: 3782 m, 13.VII.2020. Coll. Shun-Gang Luo, by yellow pan trapping (all deposited in ICXU).

Diagnosis. Female. Length 1.65–1.95 mm (Fig. 4A); body dark aeneous, head and mesoscutum covered with distinct white setae, antenna and legs black, eyes and ocelli dark red; forewing hyaline, with infuscate around postmarginal and stigmal vein, venation yellow-brown (Fig. 4D); tarsi dark brown. Head width around 1.09× head length in frontal view, with light reticulate, ocelli forming an obtuse



Figures 4. *Ericydnus aeneus* Nikolskaya, female **A** habitus, dorsal view **B** mesoscutum, dorsal view **C** antenna **D** forewing **E** mid leg. Male: **F** habitus, dorsal view **G** antenna. Scale bars: 100 μm.

angle (103–107°), OCL 0.82× OOL; torulus below the level of lower eye margin, F1–F6 shortened towards the end, clava 3-segmented, apex with oblique truncation (Fig. 4C), mandible bidentate. Mesoscutum flat, axillae touching (Fig. 4B); forewing hyaline, with infuscate mark under postmarginal and stigmal vein, linea calva entire; mid tibia slightly shorter than exerted ovipositor, its spur slightly longer than basitarsus (Fig. 4E). The exerted hypopygium 0.14× as long as gaster.

Male. Length 1.35–1.52 mm (Fig. 4F), clava unsegmented (Fig. 4G), apical rounded, other characters same as female.

Hosts. Pseudococcidae, *Trionymus perrisii* and *Trionymus multivorus* (Japoshvili and Hansen 2013).

Distribution. China (Xinjiang) new record; Azerbaijan, Europe, Norway, Portugal, Romania, Spain, Turkey, Uzbekistan.

Comments. *Ericydnus danatensis* is similar to *E. aeneus* but differs in the following characters: head 1.5× as wide as long, torulus at the level of lower eye margin, forewing with distinct dark bands (Myartseva 1980; Sharkov 1986).

Genus *Tetracnemus* Westwood, 1837

Note. The most important characteristics of the genus are the wide and flat flagellum, clava only one segment, and mandible bidentate. The genus encompasses 36 species worldwide, with three species recorded in China. These species are widely distributed throughout the world and their dominant hosts belong to Pseudococcidae (Noyes 2019).

Tetracnemus kozlovi Sharkov, 1984

Fig. 5A–G

Tetracnemus kozlovi Sharkov, 1984: 90–91.

Material examined. 10♀♀28♂♂, China, Xinjiang, Ruoqiang, Altun Mountain Nature Reserve, 36°56'25.85"N, 90°16'48.23"E, Altitude: 4023 m, 21.VII.2020. Coll. Shun-Gang Luo, by yellow pan trapping. 8♀7♂, 36°58'10.89"N, 90°14'44.19"E, Altitude: 4021.95 m, 21.VII.2021. Coll. Ning Kang, by sweeping (all deposited in ICXU).

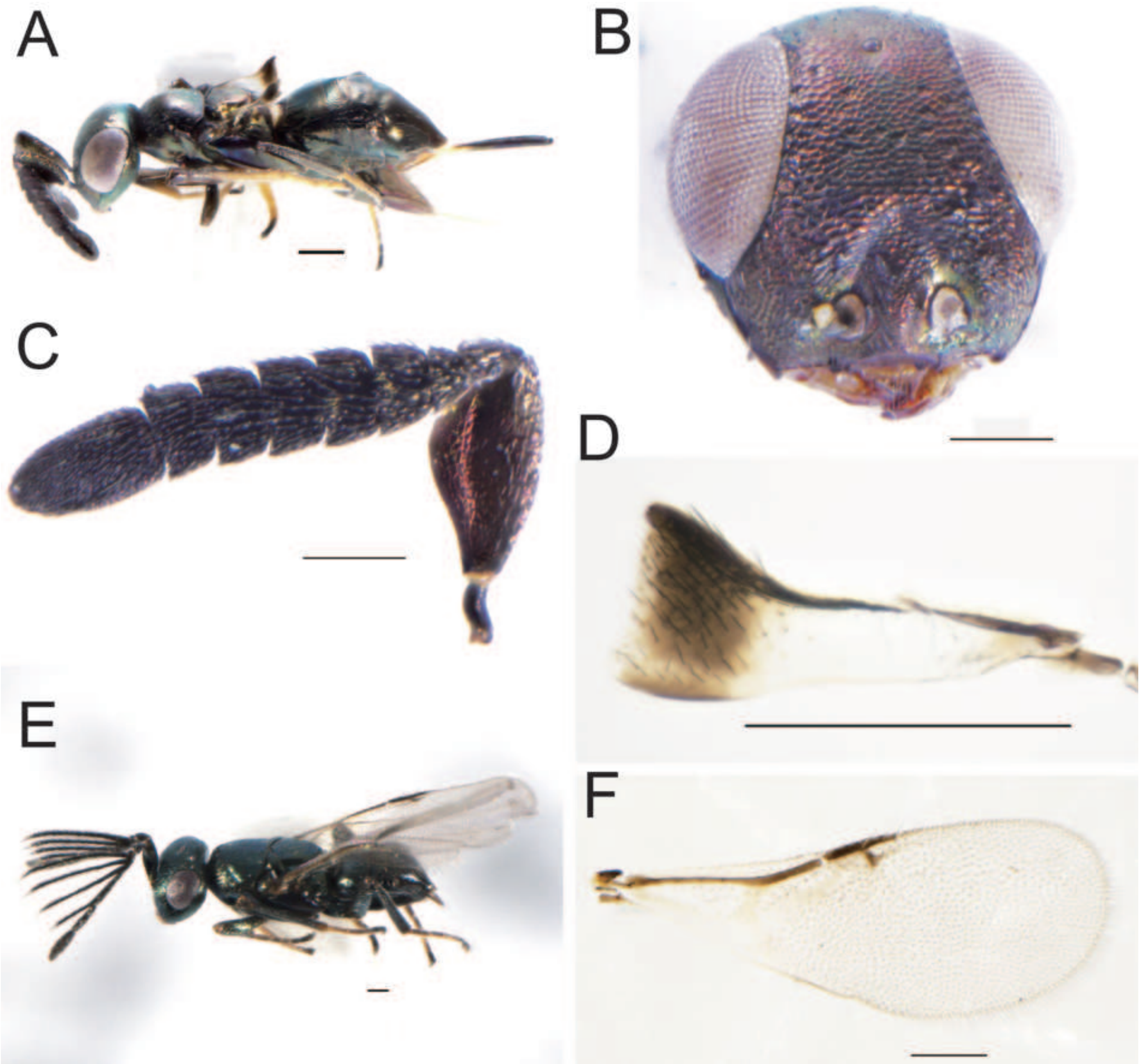
Diagnosis. Female. Length 1.5–2 mm, body deep green with purple metallic luster at mesoscutum (Fig. 5A); eyes dark red, mandible yellowish-brown; antenna and legs dark brown, scape with metallic reflection; wings with basal 2/3 hyaline and tip 1/3 with dark band; the distal 1/2 of tibiae and tarsi yellow. Torulus below the ventral edge of eyes (Fig. 5B); scape distinctly enlarged ventrally, flagellum obviously widened (Fig. 5C), ocelli forming an acute angle (75–85°), OCL 2.15× OOL; scape about 2× as long as broad, and ventral side enlarged obviously, all the funicles transverse, clava unsegmented. Mesoscutum with shallow reticulate engraving, axillae separated medially, wings degenerated, not exceeding the propodeum and truncated distally (Fig. 5D). The exserted part of ovipositor 0.6× gaster length.

Male. Length 1.2–1.3 mm (Fig. 5E), antennal funicle with long branches, clava unsegmented; forewing not degenerated and length exceeding beyond the end of gaster (Fig. 5F), wings infuscate, venation brown, linea calva interrupted with four lines of seta, post marginal vein shorter than marginal vein, longer than stigmal vein.

Hosts. Unknown.

Distribution. China (Xinjiang) new record; Russia.

Comments. For the similar short-winged species within the genus, there are obvious morphological differences compared to this species. For example, the antennal scape of *T. subapterus* is not broadened or flattened, each funicle segment is longer than wide, and the ovipositor sheaths are very short. The base of



Figures 5. *Tetracnemus kozlovi* Sharkov, female **A** habitus, lateral view **B** head, frontal view **C** antenna **D** forewing. Male: **E** habitus, dorsal view **F** forewing. Scale bars: 100 μm.

the antennal scape in *T. hofferi* is noticeably shortened, ovipositor sheaths are about 2/3 length of gaster, and the head has a deep microcellular sculpture. The antennal scape of *T. heydeni* is smoothly rounded ventrally, ocelli form an equilateral triangle, and the outer edges of the scrobes are acute (Trjapitzin 2012).

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Conceptualization: NK. Data curation: SG, SL, NK. Formal analysis: HH. Funding acquisition: HH. Investigation: SG, NK, HH, SL. Methodology: HH, SL, NK. Project administration: HH. Writing - original draft: NK.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Research Article

Two new species of the order Monhysterida (Nematoda) from the sea of China

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Abstract

Two new marine nematode species belonging to the order Monhysterida are described from the sea of China. *Halomonhystera zhangi* **sp. nov.** is characterized by its relatively small body size; short anterior sensory setae; small, circular amphidial fovea located at the level of buccal cavity base; funnel-shaped buccal cavity; an excretory-secretory system with a large ventral gland and opening as a very narrow canal just posterior to the level of cephalic setae; slightly curved slender spicules with cephalated proximal end and tapered distal end; rod-like gubernaculum without apophysis; two papilliform precloacal supplements just in front of the cloaca; conico-cylindrical tail with two ventral papillae, each with a seta; and distance between the vulva and anus slightly longer than the tail length. This is the first new species of epiphytic nematode reported in China. The second new species, *Stylotheristus flagellicaudatus* **sp. nov.**, has a relatively shorter body and longer tail; striated cuticle; The anterior sensilla arranged in two circles, the first circle consisting of six inner labial setiform papillae (3–4 μm) and the second circle consisting of 16 long setae (12–19 μm); a transversely oval amphideal fovea; a well-developed muscle around the funnel-shaped buccal cavity; short spicules and a gubernaculum composed of a single piece; and precloacal supplements absent. An updated key to all species of *Halomonhystera* and pictorial key to all species of *Stylotheristus* are also given.

Key words: Biodiversity, epiphytic, free-living marine nematode, *Halomonhystera zhangi* sp. nov., *Stylotheristus flagellicaudatus* sp. nov., taxonomy

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Introduction

To investigate the diversity of epiphytic nematodes growing in seaweed in the intertidal zone along the coast of the Yellow Sea, six species of common seaweeds were collected from 11 sites in 2021. The mean abundance of epiphytic nematodes in the seaweeds (e.g. *Ulva lactuca*, *Gracilaria tenuistipitata*, and *Sargassum thunbergii*) was 3502 ind./g algae (dry weight). Forty species belonging to 29 genera, 16 families, and seven orders were identified. The main species were *Neochromadora poecilosomoides* (Filipjev, 1918) Micoletzky, 1924, *Chromadorina germanica* (Bütschli, 1874) Wieser, 1954, *Oncholaimus sinensis* Zhang & Platt, 1983, and *Thalassomonhystera siamensis* Kito & Aryuthaka, 1998. Among these materials collected was an unknown species, which is identified as new to science; it is described here as *Halomonhystera zhangi* sp. nov.

The genus *Halomonhystera* was proposed by Andrássy (2006) to accommodate marine species previously included within the genus *Geomonhystera*. Tchesunov et al. (2015) reviewed the genus and gave an annotated list of 21 morphospecies. According to NeMys database (Nemys Eds 2024), 19 *Halomonhystera* species are accepted as valid. *Halomonhystera ambiguoides* (Bütschli, 1874) is considered a *taxon inquirenda*. *Halomonhystera paradisjuncta* (De Coninck, 1943) is accepted as *H. disjuncta* (Bastian, 1865) Andrássy, 2006. *Halomonhystera zhangi* sp. nov. is the first species of the genus found in the Yellow Sea of China.

To research the diversity of free-living marine nematodes in the northern South China Sea, sediment samples were taken at many sites in the intertidal zone. Results showed that the average abundance of free-living nematodes were 1596 ind·10 cm^{-2} in the study area. The most dominant genera were *Daptonema*, *Theristus*, and *Oncholaimus*. Among them, an unrecorded species belonging to family Xyalidae was discovered, and it is described here as *Stylotheristus flagellicaudatus* sp. nov. At present, more than 300 nematode species have been identified in a study of the biodiversity of free-living marine nematodes in the South China Sea (Huang et al. 2021; Lu et al. 2022).

The genus *Stylotheristus* was established by Lorenzen in 1977 and, until now, included only two species, namely *S. mutilus* (Lorenzen, 1973) Lorenzen, 1977 and *S. multipapillatus* Pinto & Neres, 2020. *Stylotheristus flagellicaudatus* sp. nov. is also the first species recorded within the genus in the South China Sea.

Materials and methods

Samples of *Sargassum thunbergii* (seaweed) containing specimens of *Halomonhystera* were collected using a shovel from the intertidal rocky reef of Qingdao along the Yellow China sea (36°37.43'N, 120°18.9'E) in May 2021. The whole algal samples were scooped off at the roots, then fixed with equivalent 10% formalin in seawater for long-term preservation. In the laboratory, algal samples were poured into a beaker with filtered water, shaken, and washed. Then washing liquid was poured into two layers of sieves (500 and 42 μm mesh sizes, respectively), and washed with tap water to remove silt and to separate macrofauna from meiofauna. Heavier sediment particles were removed using centrifugation in Ludox-TM (50% colloidal silica, suspension in water; product of Sigma Aldrich Co., USA) with a specific gravity of 1.15 g/ml (de Jonge and Bouwman 1977). Each sample was washed into a Petri dish with distilled water, and the meiofauna was sorted under a stereoscopic microscope. Nematodes were transferred into a cavity block containing a solution of 5% glycerol, 5% pure ethanol, and 90% freshwater by volume (McIntyre and Warwick 1984). After ethanol was slowly evaporated, the specimens were mounted in glycerin on permanent slides. The descriptions were made using a differential interference contrast microscope (Leica DM 2500). Line drawings were made with the aid of a camera lucida. All measurements were obtained using Leica LAS X v. 3.3.3, and all curved structures were measured along the arc or median line.

Sediment samples containing specimens of *Stylotheristus* were collected at an intertidal muddy beach of Sangengzhi along Hainan Island in the South China Sea (19°26'55"N, 108°37'38"E) in March 2017. The samples were taken from the 0–8 cm sediment layer using a 2.9 cm diameter sawn-off syringe, then fixed with 10% formalin in filtered seawater for long-term preservation. In the laboratory, the samples were stained with 0.1% rose Bengal, poured into two layers of sieves (500 and 42 μm mesh sizes), and washed with tap water to remove silt and separate macrofauna from meiofauna. The following experimental procedure was as mentioned above.

Abbreviations are as follows: a, the ratio of body length to maximum body diameter; abd, body diameter at cloaca or anus; b, ratio of body length to pharynx length; c, ratio of body length to tail length; cbd, corresponding body diameter; c', ratio of tail length to cloacal or anus body diameter; V%, position of vulva from anterior end expressed as a percentage of total body length.

Results and discussion

Taxonomy

Order Monhysterida Filipjev, 1929
Family Monhysteridae de Man, 1876

Genus *Halomonhystera* Andrássy, 2006

Diagnosis. Cuticle thin, smooth with few somatic setae; labial region not or only slightly off-set; outer labial and cephalic setae short, usually no longer than one-quarter of labial width; buccal cavity cuticularized, cup-shaped or funnel-shaped; amphidial fovea circular, located one to three head diameters from anterior end; pharynx relatively short, without basal bulb; secretory–excretory system well developed with large ventral gland and opening in anterior third of pharynx; females with single anterior ovary to the right of intestine; vulva usually close to anus; males with single outstretched testis; spicules thin, arcuate, with or without a capitulum; gubernaculum short, often with caudal apophysis; one or two ventral precloacal papillae and two or three pairs of smaller caudal papillae; rectum short and thin; tail conical, usually shorter in males than females; three or two caudal glands; spinneret surrounded by tube-like structure (modified from Leduc 2014).

***Halomonhystera zhangi* sp. nov.**
https://zoobank.org/F20E976D-2B9F-48D2-9C8F-58E0656741F2
Figs 1–3, Table 1

Diagnosis. *Halomonhystera zhangi* sp. nov. is characterized by relatively small body size, anterior sensory setae 3 μm long; small circular amphidial fovea located at the level of buccal cavity base; buccal cavity funnel-shaped; excretory-secretory system with large ventral gland and opening close to the level of cephalic setae by a very thin canal; slender spicules curved slightly with cephalated proximal end and tapered distal end; gubernaculum rod-like, without apophysis; two papilliform precloacal supplements just in front of cloaca; tail conico-cylindrical with two ventral papillae and each with a seta; testis outstretched with folded anterior portion, situated at the right side of the intestine; distance between the vulva and anus longer than the tail length.

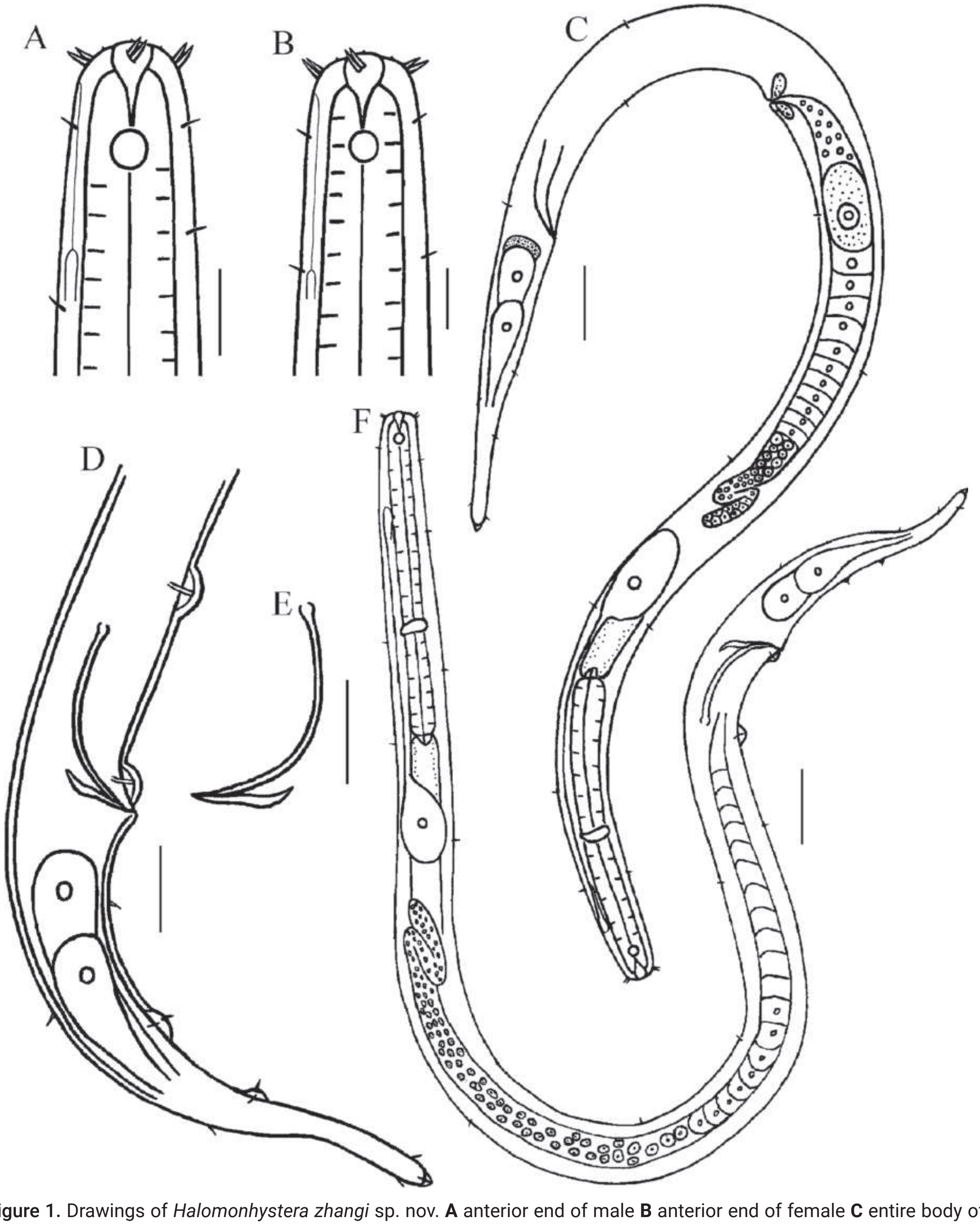

Figure 1. Drawings of *Halomonhystera zhangi* sp. nov. **A** anterior end of male **B** anterior end of female **C** entire body of female **D** posterior end of male **E** spicules and gubernaculum **F** entire body of male. Scale bars:10 µm (**A, B**); 30 µm (**C, F**); 20 µm (**D, E**).

Material examined. Four males and two females were obtained. ***Holotype***: ♂#1 on slide QDZQ-16JL-89; ***paratypes***: ♂#2 on slide QDZQ-11SC-148, ♂#3 on slide QDZQ-11SC-157, ♂#4 on slide QDZQ-16JL-93, ♀#1 on slide QDZQ-16JL-97, and ♀#2 on slide QDZQ-16JL-98. Type specimens were deposited in the Marine Biological Museum of the Chinese Academy of Sciences, Qingdao.

Table 1. Measurements of *Halomonhystera zhangi* sp. nov. (in μm except for ratios).

Characters	Holotype	Paratypes	
	male	males (*n* = 3)	females (*n* = 2)
Total body length	820	732.3 ± 68.5 (654–781)	677.0 ± 67.9 (629–725)
Maximum body diameter	28	25.3 ± 1.2 (24–26)	27.0 ± 2.8 (25–29)
Head diameter	11	10.7 ± 0.6 (10–11)	13.5 ± 0.7 (13–14)
Length of cephalic setae	3	3.0 ± 0.0 (3)	4.3 ± 0.4 (4–4.5)
Depth of buccal cavity	7	6.3 ± 0.6 (6–7)	6.0 ± 0 (6–6)
Width of buccal cavity	4	4.3 ± 0.6 (4–5)	3.5 ± 0.7 (3–4)
Amphidial fovea diameter	4	4.0 ± 0.0 (4)	3.0 ± 0 (3–3)
Amphidial fovea from anterior end	7	7.7 ± 0.6 (7–8)	7.0 ± 0 (7–7)
Body diameter at amphidial fovea level	14	13.3 ± 0.6 (13–14)	14.5 ± 0.7 (14–15)
Nerve ring from anterior end	89	81.7 ± 5.5 (78–88)	68.5 ± 9.2 (62–75)
Body diameter at nerve ring level	22	20.0 ± 1.0 (19–21)	22.0 ± 1.4 (21–23)
Pharynx length	134	128.7 ± 5.5 (123–134)	116.5 ± 12.0 (108–125)
Body diameter at base of pharynx	23	21.3 ± 1.5 (20–23)	23.0 ± 1.4 (22–24)
Spicules length along arc	47	43.3 ± 2.1 (41–45)	–
Length of gubernaculum	20	17.0 ± 1.0 (16–18)	–
Body diameter at cloaca or anus	29	26.0 ± 2.6 (23–28)	22.0 ± 2.8 (20–24)
Tail length	136	118.3 ± 14.6 (102–130)	114.5 ± 10.6 (107–122)
Vulva from anterior end	–	–	393.5 ± 37.5 (367–420)
Body diameter at vulva	–	–	28.5 ± 3.5 (26–31)
V%	–	–	58.1 ± 0.3 (57.9–58.3)
a	29.3	28.9 ± 1.4 (27.3–30.0)	25.1 ± 0.1 (25.0–25.2)
b	6.1	5.7 ± 0.6 (5.3–6.4)	5.8 ± 0 (5.8–5.8)
c	6.0	6.2 ± 0.2 (6.0–6.4)	5.9 ± 0 (5.9–5.9)
c'	4.7	4.5 ± 0.2 (4.4–4.8)	5.3 ± 0.2 (5.1–5.4)

Type locality and habitat. Holotype and all the additional specimens were found from *Sargassum thunbergii* (seaweed) growing on the intertidal rocky reef of Qingdao Trestle, China (36°37.43'N, 120°18.9'E).

Etymology. The specific epithet “zhangi” is in honor of Professor Zhinan Zhang, a Chinese nematologist, in recognition of his contributions to nematode taxonomy.

Measurements. All measurement data are given in Table 1.

Description. Males. Body slender, tapering towards both extremities. Cuticle smooth without transversely striated. Four longitudinal rows of short somatic setae sparsely distributed throughout the body, 3–4 μm long. Head diameter representing 39–42% of the maximum body diameter. Inner labial sensilla papilliform. Outer labial sensilla setiform. Outer labial setae and cephalic setae united in one circle with a total of 12 setae, each 3 μm long, i.e. 27–30% of head diameter, situated at the level of middle of the buccal cavity. Amphidial fovea circular with a diameter of 4 μm, which is occupying 29–31% of the corresponding body diameter, located at the level of buccal cavity base, i.e.7–8 μm from the anterior end. Buccal cavity funnel-shaped, without teeth. Pharynx cylindrical with a swollen base, not forming a real terminal bulb. Cardia conical, 6–9 μm long.

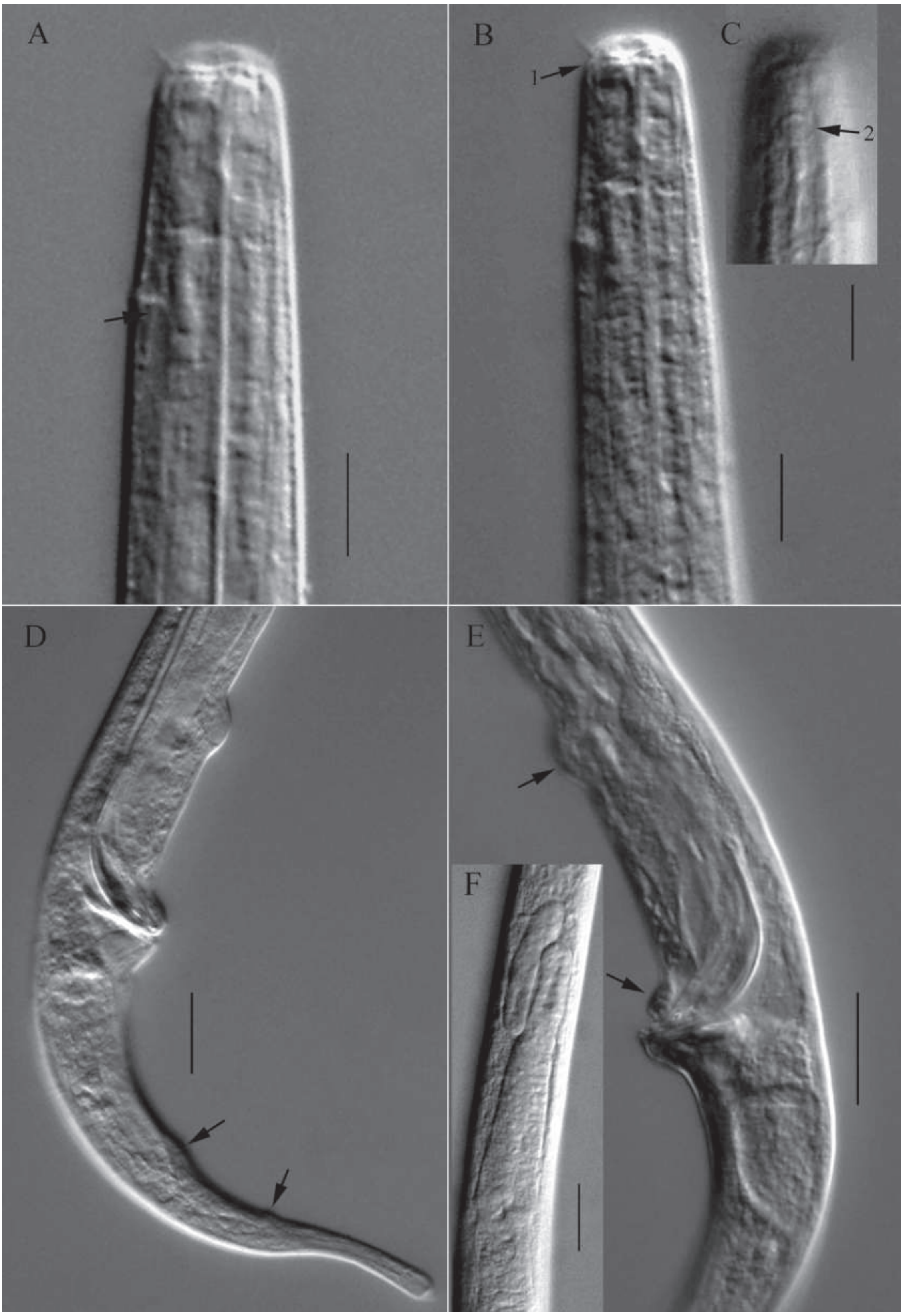

Figure 2. Microscopic images of *Halomonhystera zhangi* sp. nov. **A** anterior end of holotype, showing anterior setae, renette ampulla (arrow) **B, C** anterior end of holotype, showing buccal cavity, cephalic setae, excretory pore (arrow 1) and amphidial fovea (arrow 2) **D** posterior end of holotype, showing gubernaculum and caudal papillae (arrows) **E** cloacal region of paratype 1, showing spicule and precloacal papillae (arrows) **F** anterior portion of testis of holotype. Scale bars: 10 μm (**A**–**E**); 20 μm (**F**).

Nerve ring situated posterior to the middle of pharynx. Excretory–secretory system with a large ventral cell, situated near anterior section of intestine; ampulla situated posterior to amphidial fovea, about 25 μm from the anterior end of body; a very thin canal extended forwards from the ampulla, and opening just posterior to the level of outer labial and cephalic setae crown. Tail conical with posterior third cylindrical, equal to 4.4–4.8 cloacal body diameter long. Tail tip slightly swollen with a conical hyaline spinneret (Fig. 2D). Terminal setae absent. A few short caudal setae sparsely distributed throughout the tail. Two prominent caudal gland cells confined entirely to the tail.

Reproductive system monorchic with an outstretched testis with folded anterior portion, situated at the right side of the intestine. (Fig. 2F). Spicules slender, arcuated, proximally cephalated and distally pointed, 1.52–1.96 times of cloacal body diameter. Gubernaculum rod-like, slightly curved proximally, without apophysis. Two papilliform precloacal supplements, one just anterior to cloaca, another one 30–50 μm anterior to cloaca. Two ventral caudal papillae in the middle region of tail, each with a short seta. The anterior one located at 43–52 μm posterior from cloaca, and the other at 63–72 μm posterior from cloaca.

Females. Similar to males in most morphological characteristics except cephalic setae slightly longer and amphidial fovea relatively smaller. Reproductive system monodelphic with an anterior outstretched ovary, located at the right side of intestine. Mature egg large, oval. Uterus a wide tube. Vulva located posterior to mid-body (i.e. 57.9–58.3% of body length from the anterior end). Distance between the vulva and anus (155–183 μm) longer than the tail length (107–122 μm). Spermatheca not seen.

Differential diagnosis and discussion. *Halomonhystera zhangi* sp. nov. agrees well with the primary diagnostic characters of the genus, especially in having well developed excretory–secretory system with large ventral gland and opening at anterior pharyngeal region, spinneret with hyaline structure, males having papillary precloacal supplements and caudal papillae. The inconsistent characters to diagnosis of *Halomonhystera* are cephalic setae paired and vulva not very close to anus.

The present species is similar to *H. chitwoodi* (Steiner, 1958) Andrássy, 2006 in the position of amphidial fovea (closing to anterior end of body), the distance between vulva and anus (not shorter than the tail length) and they all growing on Sargassum, but it differs from the latter species by slightly smaller body size (vs longer than 1 mm), two papilliform precloacal supplements (vs only one precloacal supplement), and conico-cylindrical tail with two ventral bristled papillae (vs conical tail without bristled papilla). In having relatively long distance between the vulva and anus, the new species resembles *H. glaciei* (Blome & Riemann, 1999) Andrássy, 2006, but differs from it by the much shorter and stouter body (vs 2 mm or more, a = 60 or more), the amphidial fovea closing to the anterior body end (vs two labial diameters from anterior end) and by the shorter tail (vs c'= 7). The new species can easily be distinguished from other known species within this genus by relatively small body size, position of amphidial fovea near to anterior end of body, two papilliform precloacal supplements, conico-cylindrical tail with two ventral bristled papillae. The difference between *H. zhangi* sp. nov. and other known species within the genus can be inferred from the key below.

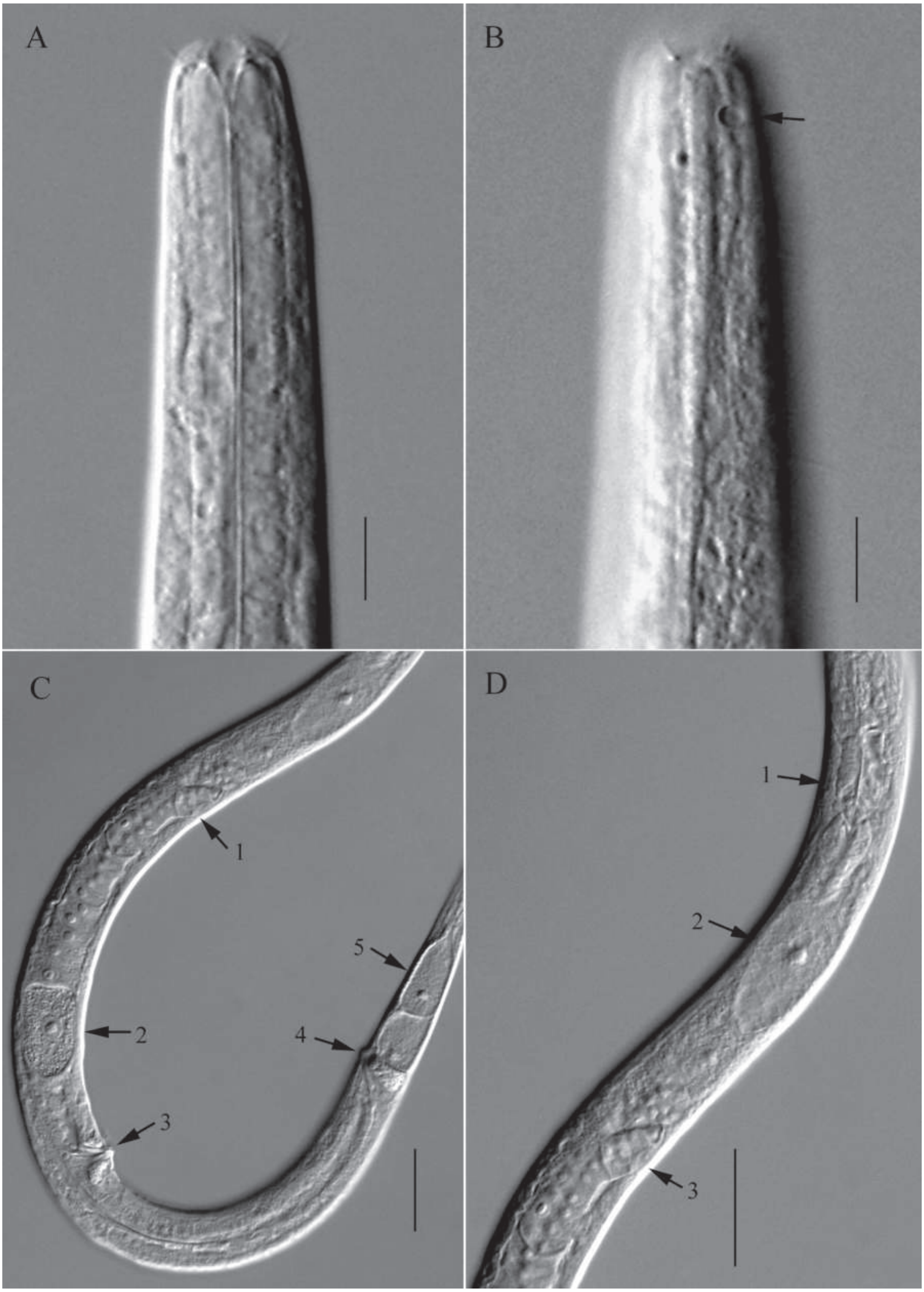

Figure 3. Microscopic images of *Halomonhystera zhangi* sp. nov. **A** anterior end of female 1, showing buccal cavity and anterior setae **B** anterior end of female 2, showing cephalic setae and amphidial fovea (arrow) **C** middle region of female, showing ovary (arrow 1), egg (arrow 2), vulva (arrow 3), anus (arrow 4) and caudal glands (arrow 5) **D** anterior region of female intestine, showing pharyngeal base (arrow 1), ventral gland (arrow 2) and ovary (arrow 3). Scale bars: 10 μm (**A, B**); 30 μm (**C, D**).

Updated key to all species of *Halomonhystera* (based on Leduc 2014; Tchesunov et al. 2015)

1	Distance from vulva to anus 4–12 abd, equal or longer than tail length	**2**
–	Distance from vulva to anus 1–3 abd, much shorter than tail length	**8**
2	Body longer than 2 mm, extremely slender (a = 60–91)	***H. glaciei* (Blome & Riemann, 1999)**
–	Body shorter than 1.5 mm, moderately slender (a = 20–38)	**3**
3	Body very short, 357–400 µm, spicules 14–19 µm	***H. islandica* (De Coninck, 1943)**
–	Body longer than 600 µm, spicules longer than 22 µm	**4**
4	Spicules longer than 40 µm	**5**
–	Spicules equal or shorter than 30 µm	**6**
5	Tail conico-cylindrical with two ventral bristled papillae	***H. zhangi* sp. nov.**
–	Tail conical without bristled papilla	***H. chitwoodi* (Steiner, 1958)**
6	Tail elongated, both males and females longer than 5.5 abd, spicules 22 µm long	***H. bathislandica* (Riemann, 1995)**
–	Tail length medium, spicules 23–30 µm long	**7**
7	Width of amphidial fovea equal to 50% cbd, females ovoviviparous	***H. fisheri* (Zekely, Sorensen & Bright, 2006)**
–	Width of amphidial fovea equal to 40% cbd, females oviparous	***H. vandoverae* (Zekely, Sorensen & Bright, 2006)**
8	Body longer than 1.8 mm, a = 40–50, tail with three successive pairs of subventral papillae in males, spicules 46–96 µm long	***H. socialis* (Bütschli, 1874)**
–	Body shorter than 1.6 mm, a = 20–43, spicules 23–53 µm long	**9**
9	Body small (440–460 µm long) with relatively longer tail (c' = 6.5)	***H. uniformis* (Cobb, 1914)**
–	Body size medium, with relatively shorter tail	**10**
10	Distance from amphidial fovea to anterior body end 2–3 cbd, spicules 38 µm long	***H. cameroni* (Steiner, 1958)**
–	Distance from amphidial fovea to anterior body end less than 2 cbd	**11**
11	Width of amphidial fovea equal to 33–50% cbd	**12**
–	Width of amphidial fovea less than 32% cbd	**14**
12	Spicules 34–40 µm long	***H. antarctica* (Cobb, 1914)**
–	Spicules 25–30 µm long	**13**
13	Body plump, 420–580 µm long, a = 20–24	***H. continentalis* Andrássy, 2006**
–	Body slender, 605–780 µm long, a = 28–34	***H. hickeyi* Zekely, Sorensen & Bright, 2006**
14	Females ovoviviparous	**15**
–	Females oviparous	**17**
15	Amphid located 1.5–1.9 labial diameters from the anterior body end, gubernaculum without or with inconspicuous apophysis	***H. disjuncta* (Bastian, 1865)**
–	Amphid located more anteriorly (0.7–1.4 labial diameters), gubernaculum with conspicuous apophysis	**16**

16 Tail with three successive pairs of subventral papillae in males .... ***H. hermesi* Tchesunov, Portnova & van Campenhout, 2015**
– Tail with only one pair of subventral papillae close to the tail tip in males ... . ***H. halophila* Andrássy, 2006**
17 Distance from vulva to anus 4.2 abd, equal to 85% tail length.................... .... ***H. rotundicapitata* (Filipjev, 1922)**
– Distance from vulva to anus less than 2 abd, shorter than 35% tail length **18**
18 Gubernaculum with caudal apophyses, tail with four pairs post-cloacal papillae in males.. ***H. tangaroa* Leduc, 2014**
– Gubernaculum without caudal apophyses, tail without or with two pairs post-cloacal papillae in males **19**
19 Buccal cavity with denticles, spicules 41–44 μm long .... ***H. parasitica* Poinar, Duarte & Santos Maria, 2009**
– Buccal cavity without denticles, spicules 23–30 μm .... ***H. taurica* (Tsalolikhin, 2007)**

Family Xyalidae Chitwood, 1951

Genus *Stylotheristus* Lorenzen, 1977

Diagnosis. Anterior sensilla arranged in two crowns with the number of setae in the second crown depending on the sex and life stage, 6+4 in females and juveniles and 6+10 in males, inner labial sensilla conical; buccal cavity conical; pharyngeal muscles well-developed around the buccal cavity; amphidial fovea transversely oval; spicules short; spermatheca present on the right side of intestine; three caudal glands opening at separate pores; tail conico-cylindrical with three terminal setae (Pinto and Neres 2020).

***Stylotheristus flagellicaudatus* sp. nov.**
https://zoobank.org/3875D927-471F-4BEF-AF20-41B8F80B3380
Figs 4, 5, Table 2

Diagnosis. *Stylotheristus flagellicaudatus* sp. nov. is characterized by relatively shorter body and longer tail than that of two species already described in this genus; cuticle striated; anterior sensilla arranged in two circles: the first circle consisting of six inner labial setiform papillae (3–4 μm), the second circle consisting of 16 long setae (12–19 μm); amphideal fovea transversely oval; well-developed muscle around funnel-shaped buccal cavity; spicules short, gubernaculum composed of a single piece, precloacal supplements absent; tail elongated, filiform.

Type material. Four males were collected. ***Holotype*:** ♂#1 on slide Sangengzhi 87-4. ***Paratypes*:** ♂#2 on slide Sangengzhi 81-10, ♂#3 on slide Sangengzhi 81-11 and ♂#4 on slide Sangengzhi 37-3.

Type locality and habitat. Holotype and other specimens were collected in the muddy sediment from the intertidal zone of Sangengzhi, Hainan Province (19°26'55"N, 108°37'38"E).

Etymology. The species epithet “flagellicaudatus” refers to its long and filiform tail.

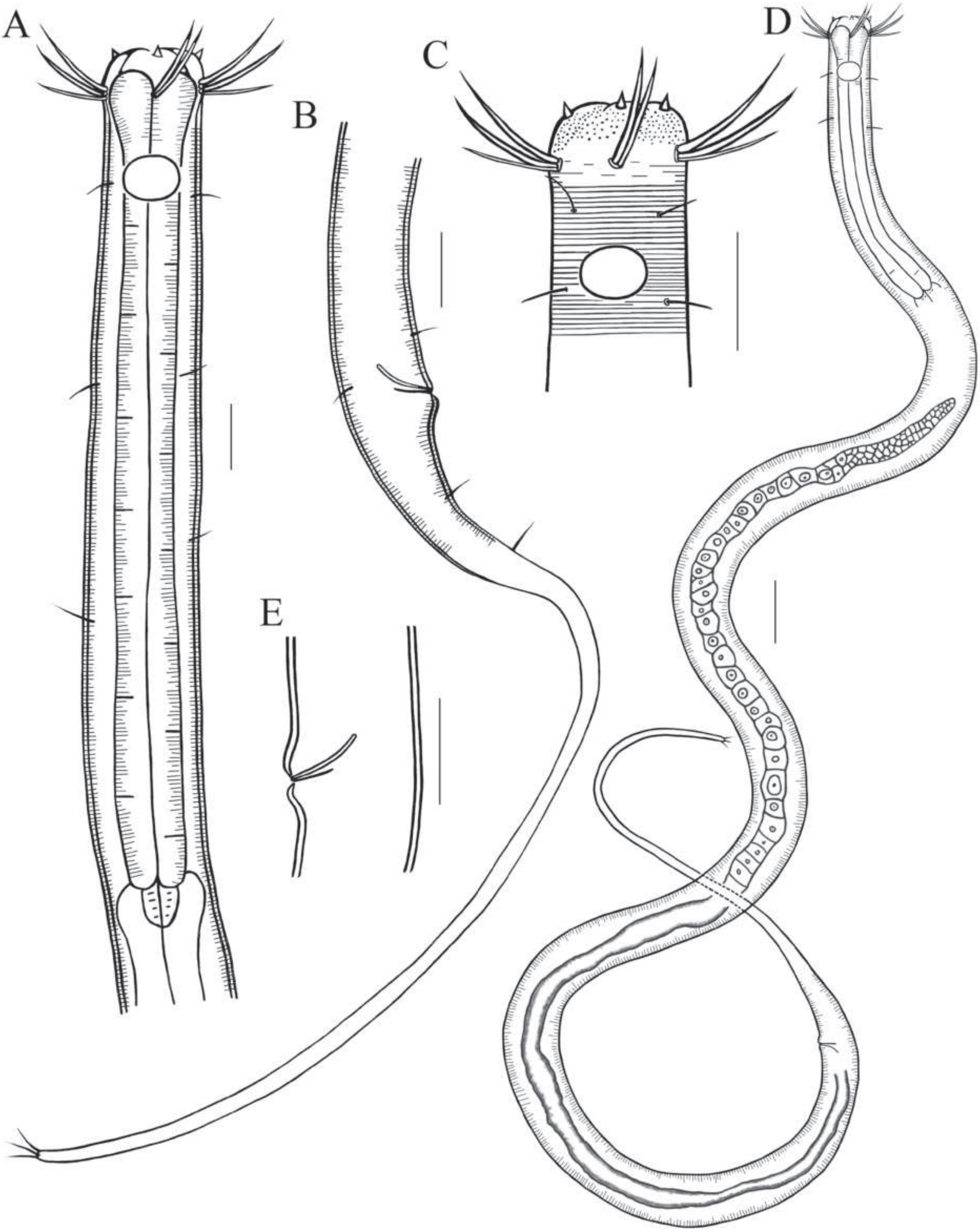

Figure 4. Drawings of *Stylotheristus flagellicaudatus* sp. nov. **A** lateral view of pharyngeal region of holotype **B** lateral view of posterior portion, showing long conico-cylindrical tail **C** lateral view of anterior portion of holotype, showing the two circles of anterior setaes and oval amphideal fovea **D** entire view of male **E** cloacal region of holotype, showing spicule and gubernaculum. Scale bars: 20 μm (**A**–**C, E**), 30 μm (**D**).

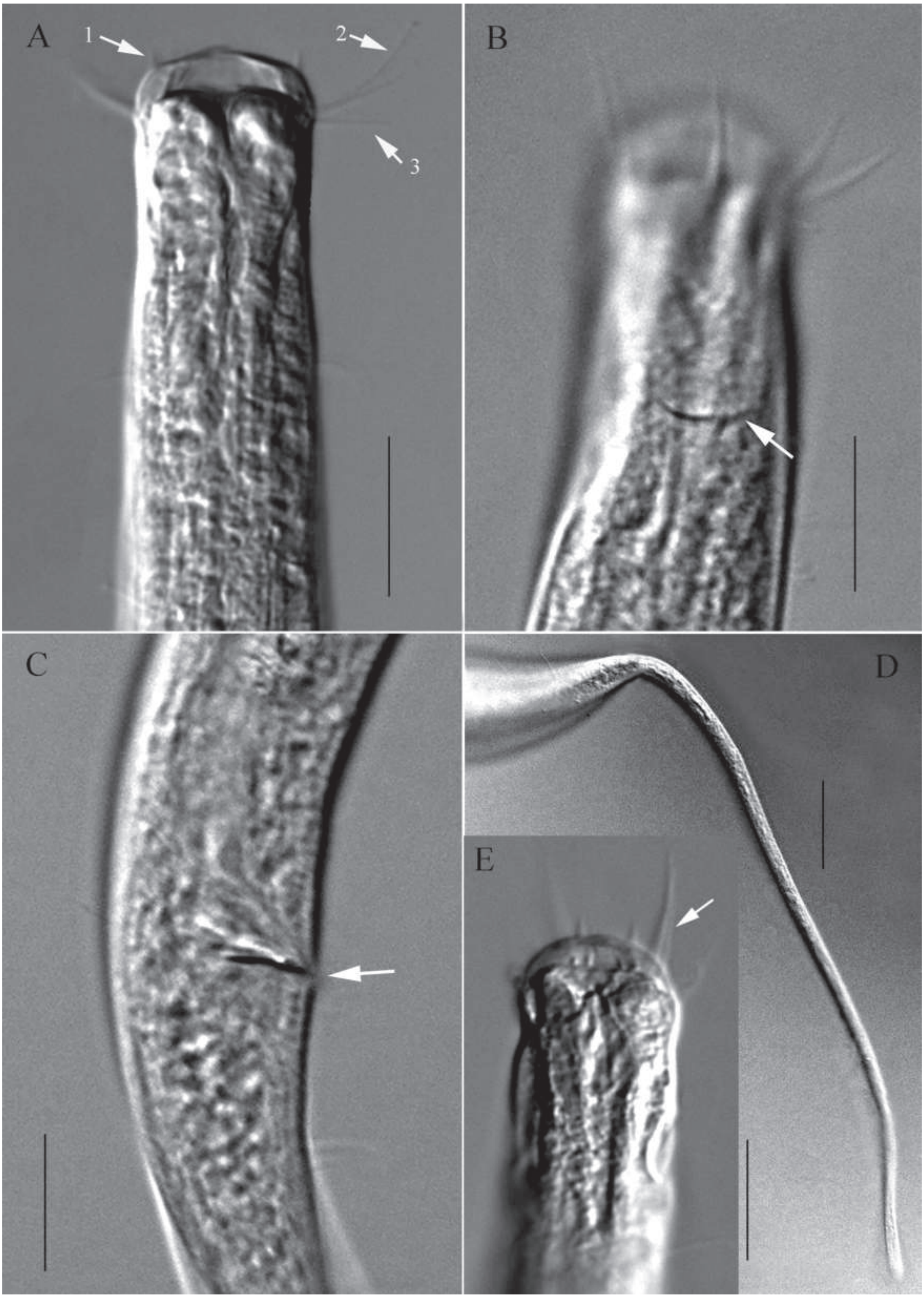

Figure 5. Microscopic images of *Stylotheristus flagellicaudatus* sp. nov. **A** lateral view of anterior portion of holotype, showing conical inner labial setae (arrow 1), outer labial setae (arrow 2), subcephalic setae (arrow 3) and buccal cavity **B** lateral view of anterior portion of holotype, showing cephalic setae and amphideal fovea (arrow) **C** lateral view of cloacal region of holotype, showing spicule and gubernaculum (arrow) **D** lateral view of posterior portion of paratype 1, showing filiform tail and caudal setae **E** dorsal view of anterior portion of paratype 3, showing cephalic setae (arrow). Scale bars: 20 μm.

Table 2. Measurements of the *Stylotheristus flagellicaudatus* sp. nov. (in μm except for ratios).

Characters	Holotype	Paratypes
	male	males (n = 3)
Total body length	1683	1570.7 ± 39.3 (1526–1600)
Maximum body diameter	30	31.7 ± 2.1 (31–34)
Head diameter	23	23.7 ± 1.2 (23–25)
Length of inner labial setae	4	3.0 ± 0 (3)
Length of outer labial setae	18	19.3 ± 1.2 (18–20)
Length of cephalic setae	18	19.3 ± 1.2 (18–20)
Amphideal fovea as percentage of corresponding body diameter	45	45.0 ± 5.0 (40–50)
Amphideal fovea from anterior end	24	25.0 ± 0 (25)
Pharynx length	201	191.7 ± 5.7 (187–198)
Body diameter at pharyngeal base	36	29.3 ± 1.2 (28–30)
Length of spicules	15	14.0 ± 2.6 (11–16)
Cloacal body diameter	25	24.7 ± 0.6 (24–25)
Tail length	310	299.7 ± 0.6 (299–300)
a	56.1	49.5 ± 4.4 (44.9–53.3)
b	8.4	8.2 ± 0.1 (8.1–8.3)
c	5.4	5.2 ± 0.2 (5.1–5.5)
c’	12.4	12.1 ± 0.3 (12.0–12.5)

Measurements. Measurements are given in Table 2.

Description. Males. Body slender, cylindrical, and gradually tapering towards tail end. Cuticle striated. Six longitudinal lines of short somatic setae sparsely distributed throughout the body, 4–6 μm long. Anterior sensilla arranged in two circles: the first circle consisting of six inner labial setiform papillae, conical, 3–4 μm long; the second circle consisting of six outer labial setae (18–19 μm), four cephalic setae (16–17 μm) and six subcephalic setae (12–13 μm), situated at the level of buccal cavity base. Buccal cavity funnel-shaped, with well-developed pharyngeal muscles around it. Pharynx cylindrical, not expanded at posterior end. Amphideal fovea transversely oval, 8 μm high and 11–12 μm wide, occupying 40–50% of corresponding body diameter, located at the position of 24–25 μm from the anterior end. Nerve ring located at the middle of pharynx. Secretory–excretory pore not observed. Tail elongated, conico-cylindrical, posterior three-quarters filiform. Three terminal setae 10 μm long, three caudal glands present.

Reproductive system monorchid, an anterior testis outstretched, to the left side of intestine. Spicules short and thin, almost straight, 46–64% of cloacal body diameter long. Gubernaculum simple, short, and laminar, about 70% of spicules length. Precloacal supplements absent.

Females not found.

Differential diagnosis and discussion

The characteristics of the new species match well with the main diagnostic of *Stylotheristus* (Fonseca and Bezerra 2014). The genus only has contained only two species until now, i.e. *S. mutilus* (Lorenzen, 1973) Lorenzen, 1977 and *S. multipapillatus* Pinto & Neres, 2020. The new species is distinguished from *S. multipapillatus* by the absence of precloacal supplements, relatively larger amphidial fovea, and a longer filiform tail. The latter species possess 11–15 papilliform precloacal supplements and a smaller amphidial fovea (32–38% of corresponding body diameter). The new species differs from *S. mutilus* by absence of inerratic circle of long cervical setae, relatively larger amphidial fovea (vs 37% of corresponding body diameter), shorter spicules not cephalated proximally (vs 18–20 μm with cephalated proximal ends) and the different structure of gubernaculum (only a piece). In *S. mutilus*, the gubernaculum is formed by two pieces, it has a circle of long cervical setae. Besides that, the body size of new species is smaller than of the two known species but the tail in the new species is relatively longer (Fig. 6).

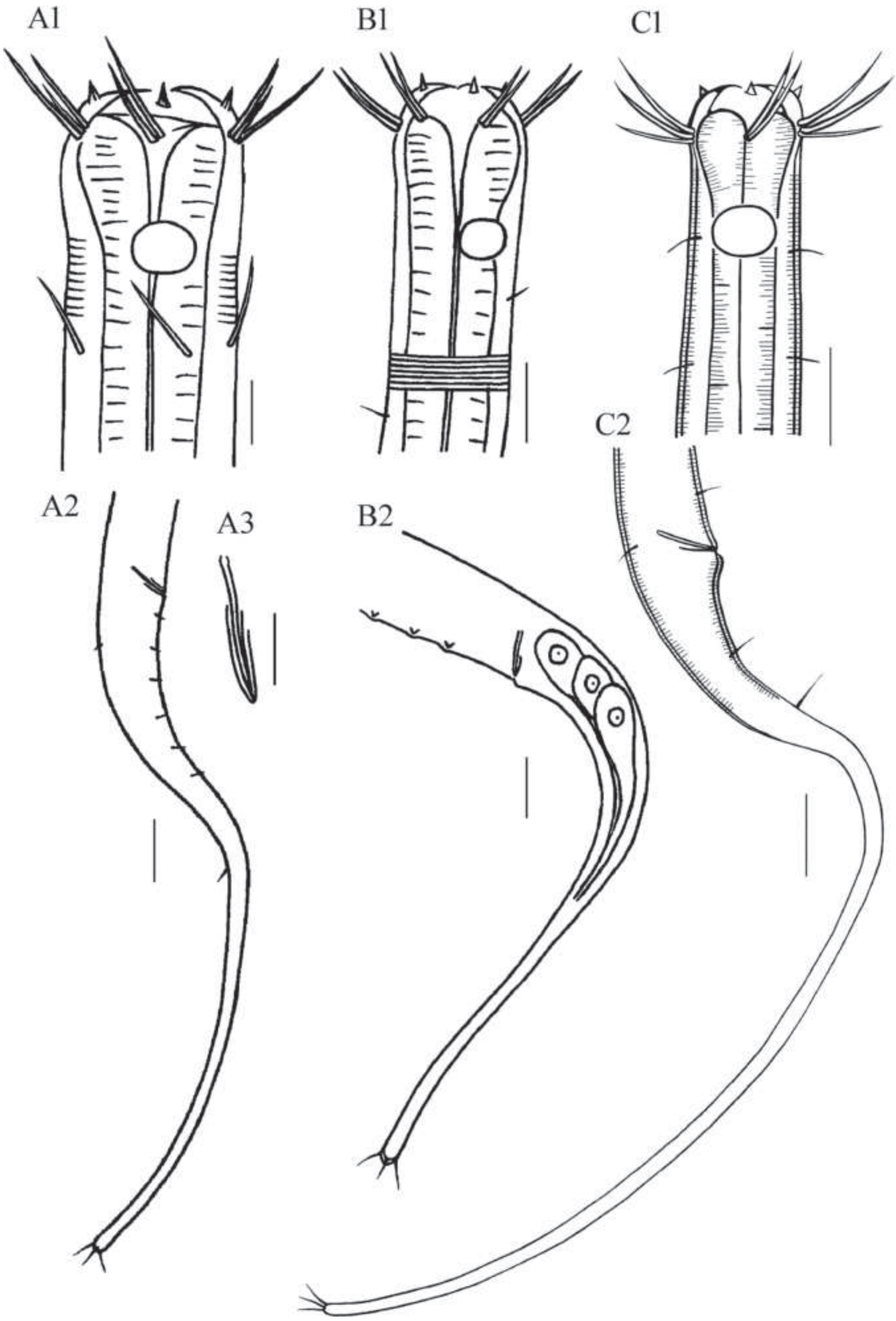

Figure 6. Pictorial key for genus *Stylotheristus* **A** *S. mutilus* (from Lorenzen 1973) **B** *S. multipapillatus* (from Pinto and Neres 2020) **C** *S. flagellicaudatus* sp. nov. Scale bars: 20 μm (**A1, B, C**), 50 μm (**A2**), 10 μm (**A3**).

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Project Management, work program, methodology and taxonomy: M.H.; experiment, data collection: T.L.; taxonomy, writing and editing of paper: Y.H. and T.L. All authors have read and agreed to the submitted version of the manuscript.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Research Article

Discovery of a new species of *Synergus* (Hymenoptera, Cynipidae, Synergini) based on morphology and molecular data

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Abstract

A new species of gall inquiline, *Synergus dilatatus* **sp. nov.**, is described from Hubei Province, China. Morphological descriptions, photographs and biological information are provided. Mitochondrial cytochrome oxidase (COI) sequences of the new species were newly obtained and a molecular species delimitation analysis of 12 species of *Synergus* performed using the ASAP method recovered 16 molecular operational taxonomic units, providing support for recognition of the new species. The results also highlight a few conflicts between morphological and molecular species delimitations in *Synergus*.

Key words: ASAP, COI, gall wasp, inquilines, integrative taxonomy

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Introduction

Cynipids (Hymenoptera: Cynipidae) are mainly known as gall inducers, making various kinds of galls from normal plant tissues that provide food and protection for the growing larvae. However, a small subset of cynipids, termed inquilines, which do not induce galls, live inside galls induced by other species, primarily cynipids, but also gall midges and cecidosid moths (Ronquist 1994; Csóka et al. 2005; Schwéger et al. 2015). Although, as an exception, *Synergus itoensis* Abe, Ide & Wachi, 2011, may induce its own gall in the seed coat of the acorn of *Quercus* (subgen. *Cyclobalanopsis*) *glauca* Thunb. (Abe et al. 2011). All inquiline cynipid wasps from the Holarctic were initially assigned to the tribe Synergini s. l., which was recently subdivided into three tribes (Synergini s. s., Ceroptresini and Diastrophini) by Ronquist et al. (2015) on the basis of molecular and morphological evidence. Synergini s. s. include only the inquiline species from cynipid galls of oaks and *Rhus*. To date, Synergini s. s. consists of six genera: *Agastoroxenia* Nieves-Aldrey & Medianero, *Lithosaphonecrus* Tang, Melika & Bozsó, *Saphonecrus* Dalla-Torre & Kieffer, *Synophrus* Hartig, *Synergus* Hartig and *Ufo* Melika & Pujade-Villar, with *Rhoophilus* Mayr, a genus endemic to South Africa, recently moved to a new tribe according to a recent comprehensive phylogenetic work on global Synergini (Schwéger et al. 2015; Lobato-Vila et al. 2022a). The Chinese Synergini were recently reviewed by Lobato-Vila et al. (2022a). Only four genera were found in mainland China: *Lithosaphonecrus*, *Saphonecrus*, *Synergus* and *Ufo*.

Synergus Hartig is presently the most species-rich genus of inquilines with 127 species known worldwide, including 76 species found from the Nearctic and Neotropical regions and 51 from the Palaearctic region. The monophyly of *Synergus* was considered dubious by previous authors, with New World groups considered to be separate genera (Schwéger et al. 2015; Lobato-Vila et al. 2022a). However, the Palaearctic group was considered to be a natural group, so-called "true" *Synergus*, which is distinct from the New World groups based on both morphology and molecular analysis (Pénzes et al. 2012; Lobato-Vila et al. 2022a).

The Eastern Palaearctic (EP) fauna of *Synergus* has been understudied with Pujade-Villar et al. (2014) providing the first revision of 10 species from this region. More recently, Pujade-Villar et al. (2017) described one new species from China. Eight new species and one new synonym were proposed by Schwéger et al. (2015). Lobato-Vila et al. (2020) found one new species from South Korea. Three species from China were described by Lobato-Vila et al. (2021), who also synonymized the recently described species *Synergus changtitangi* Melika & Schwéger, 2015 with *Synergus deqingensis* Pujade-Villar, Wang & Chen, 2014. Currently, 23 species of *Synergus* are recorded from the Eastern Palaearctic and mainland China (Lobato-Vila et al. 2022b), which was suspected to harbor an abundant gall wasp fauna due to the diversity of Fagaceae plants in this area.

This article describes a new species of *Synergus* collected from *Quercus variabilis* in Hubei Province. We use both morphological characters and DNA sequences to support the establishment of a new species and provide morphological descriptions, diagnostic remarks, localities, gall morphology and photographs.

Materials and methods

Material

Galls collected from late July 2021, in Hubei Province were kept and delivered to the laboratory for artificial breeding in sealed plastic jars with moistened cotton. The adult insects emerged from fine-meshed rearing cages under ambient temperature. All rearing cages were placed in the lab and checked daily for emergence. Emerged adult wasps were captured and preserved in labeled vials with 99% ethanol, stored in a freezer at -80 °C.

Morphology

The terminology follows Liljeblad and Ronquist (1998) and Melika (2006) for morphological structures, Ronquist and Nordlander (1989) for forewing venation and Harris (1979) for patterns of cuticular sculpture. Measurements and abbreviations used herein are: F1–F12, first and subsequent flagellomeres; POL (post-ocellar distance), the distance between the inner margins of the posterior ocelli; OOL (ocellar-ocular distance), the distance from the outer edge of a posterior ocellus to the inner margin of the compound eye; and LOL, the distance between posterior and frontal ocelli. The width of the forewing radial cell is measured from the margin of the wing to the Rs vein. Morphological studies were based on the dried and point-mounted specimens. A few specimens were dismembered for detailed photographs of characters and stored in small vials filled with dry cotton. Photographs were taken using a Leica M205C microscope system equipped (Leica Inc., Germany) with a Leica DMC6200 digital camera attached to a computer. Images of the galls were taken with a Nikon D80 camera. All types are deposited in the Insect Collection, Central South University of Forestry and Technology, Changsha, Hunan (**CSUFT**).

Molecular data and analyses

Total DNA was extracted from three individuals (destroyed) of the new species which have the same collection data as the types. The insects were washed in sterile water before DNA extraction to avoid cross-contamination. The methods of DNA extraction and PCR cycling conditions were previously described in Zhu et al. (2007). We chose a specific region of the cytochrome oxidase subunit I gene (COI), which was amplified using the primers HCO-2198 and LCO-1490 (Folmer et al. 1994). The barcode region of COI gene showed a clear barcoding gap among species and provided consistency in the phylogenetic topology inferred by mitochondrial and nuclear genes in *Synergus* (Ács et al. 2010).

Forty-five sequences from 12 species representing *Synergus* from the EP as ingroups and three sequences of *Rhoophilus loewi* Mayr (accession numbers: DQ012650, EF486875, EF486876) as outgroups were used for the analyses. The relationship between *Synergus* and remaining genera of Synergini was poorly resolved. Therefore, we chose *Rhoophilus* as an outgroup, which was reconstructed as sister to Synergini (Lobato-Vila et al. 2022a). Three sequences of the new species were newly obtained in this study. The remaining sequences were all downloaded from GenBank, with accession numbers listed in Table 1. Multiple sequence alignment was performed using online MAFFT 7 (https://mafft.cbrc.jp/alignment/server/) (Katoh et al. 2019) under the Q-INS-i algorithm, then adjusted manually after translation into amino acid sequences using MEGA 11 (Kumar et al. 2016). The intraspecific and interspecific genetic divergence values were estimated using a Kimura 2-parameter (Kimura 1980) distance model in MEGA 11. The maximum likelihood tree was constructed in IQ-TREE with 1000 ultrafast bootstrap replicates (Nguyen et al. 2015). The resulting tree file was viewed and adjusted using FigTree v.1.4.3. We also conducted an ASAP (Assemble Species by Automatic Partitioning) analysis to further test the morphological delimitation of the new species (Puillandre et al. 2021). ASAP analysis was conducted using a web interface (https://bioinfo.mnhn.fr/abi/public/asap/asapweb.html) under the Jukes-Cantor (JC69) model. Other parameters were default.

Results

The gall samples were collected in the summer of 2021 in Hubei Province. Seventeen females and six males emerged in succession during August of that year. Three of them were destroyed for DNA extraction, and eight were mounted as type specimens. Reminders were preserved in 99% ethanol for further genomic study. Assessment of morphological characters suggested that the emerging inquiline species belongs to the genus *Synergus*. The target 1062 base pair (bp) fragment of COI was successfully amplified from three individuals drawn from two different galls. The new species is morphologically similar to the known species, *S. formosanus*, discovered from Taiwan; however, the genetic distance of COI between those two species reached 9% (Suppl. material 1: appendix S1).

Table 1. GenBank accession numbers of haplotype sequences used in species delimitation and their original publications.

Species	GenBank accession numbers	References
Synergus abei	KR270552; KR27055; KR270553	Schwéger et al. 2015
Synergus belizinellus	KR270554; KR270555; KR270556; MW274094	Schwéger et al. 2015; Lobato-Vila et al. 2022a
Synergus castaneus	KC533845; KC533846; KC533847; KC533848; KC533849; KC533850	Bernardo et al. 2013
Synergus chinensis	EF486890 MW274096; MW274097; MW274095	Ács et al. 2010; Lobato-Vila et al. 2022a
Synergus formosanus	KR270547; KR270546; KR270545	Schwéger et al. 2015
Synergus gifuensis	LC272567	Ide et al. 2018
Synergus ishikarii	KR270548; KR270550; KR270549; MW274110	Schwéger et al. 2015; Lobato-Vila et al. 2022a
Synergus itoensis	LC272566	Ide et al. 2018
Synergus japonicus	KR270560; LC272564; EF486926; EF486927	Ács et al. 2010; Schwéger et al. 2015; Ide et al. 2018
Synergus khazani	KR270557; KR270558	Schwéger et al. 2015
Synergus symbioticus	KR270540; KR270544; KR270542; KR270541; KR537438; KR537437; KR537436; KR270543; MW274123	Schwéger et al. 2015; Lobato-Vila et al. 2022a
Synergus xiaolongmeni	EF486968	Ács et al. 2010
Synergus dilatatus sp. nov.	OQ850003; OQ850004; OQ850005	In this study

The analysis of twelve morphospecies of *Synergus* from the EP shows that all morphological species are monophyletic, except *S. chinensis*, *S. symbioticus*, *S. ishikarii* and *S. xiaolongmeni* (Fig. 1). For the ASAP analysis, ten best partitions were found, with 10 to 30 molecular operational taxonomic units (MOTUs) estimated for the 45 samples (Suppl. material 2: appendix S2). The number of species predicted based on the partitions ranked first is 16, suggesting that the diversity of *Synergus* from the EP may be underestimated by the current morphology-based species classification. However, all ten partitions strongly supported the validity of the new species.

Taxonomy

***Synergus dilatatus* sp. nov.**
https://zoobank.org/4F232E05-A89A-4F73-9D90-1B364818CA0C
Figs 2–18

Type materials. *Holotype*. China ·♀, Hubei Prov., Suizhou County; 31.69°N, 113.38°E (DD); galls coll. 30 Jul. 2021, ex. Aug. 2021; Yang Zeng leg.; from twigs on *Quercus variabilis*. ***Paratypes*.** China ·5 ♀ & 2 ♂, same data as the holotype.

Diagnosis. The new species is similar to *S. formosanus* Schwéger & Melika, 2015. *Synergus dilatatus* sp. nov. but differs from the latter by female head dark red to black (orbits, malar space and a band above clypeus chestnut brown in *S. formosanus* female); ventral margin of malar space expanded into a wide and recurved lamina (ventral margin not or slightly expanded in *S. formosanus*); medial mesoscutal line restricted to posterior half of mesoscutum (on posterior two-thirds of mesoscutum in *S. formosanus*); and parapsidal line absent (present in *S. formosanus*). The attacked galls of the new species, whose surface is covered with dense tomentum, is without tubercles or spots (the attacked galls of *S. formosanus* are covered with small raised tubercles and purple spots).

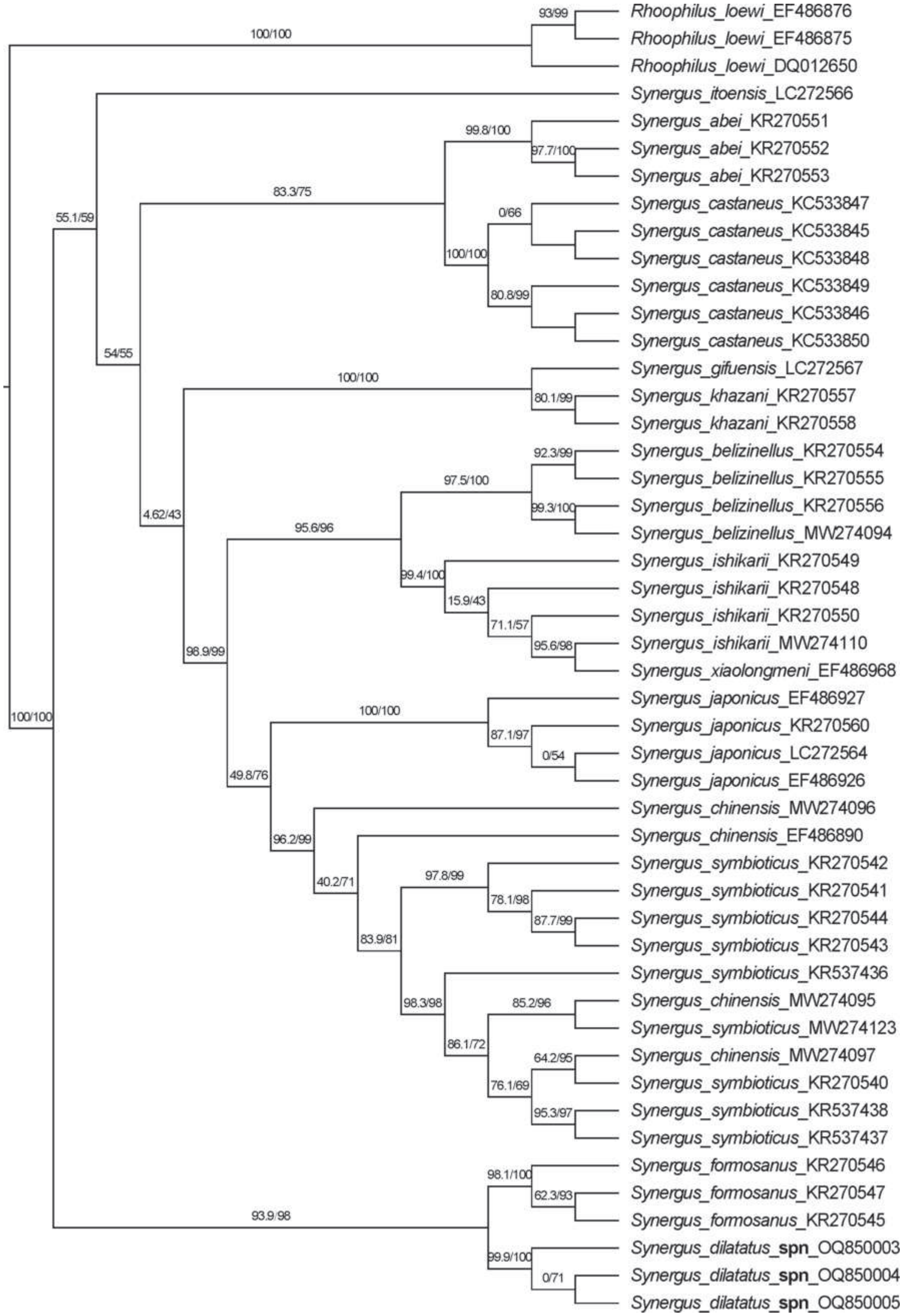
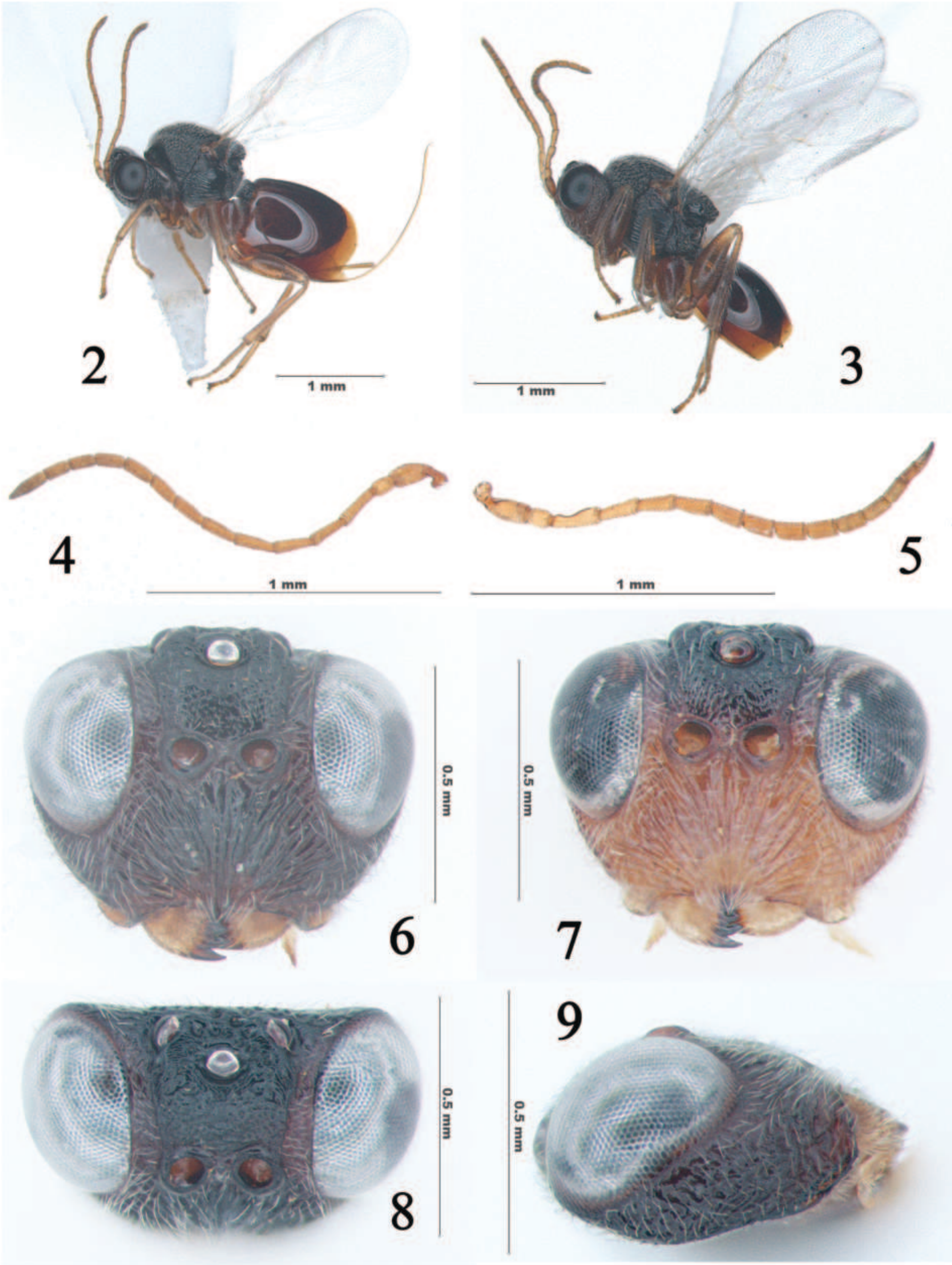


Figure 1. Maximum-likelihood tree derived from COI sequences of 45 species of *Synergus* from the EP, with 1000 bootstrap replicates. Numbers on nodes are SH-aLRT and bootstrap values.



Figures 2–9. *Synergus dilatatus* sp. nov. **2** general habitus (♀) **3** general habitus (♂) **4** antenna (♀) **5** antenna (♂) **6** head in anterior view (♀) **7** head in anterior view (♂) **8** head in dorsal view (♀) **9** head in lateral view (♀).

In the key to species of *Synergus* from the EP presented by Schwéger et al. (2015: 458), *S. dilatatus* sp. nov. follows item 15 and the key should be adapted as described below:

15 Postgena with dense white setae on lower half; median mesoscutal line strongly impressed, complete, reaches anterior margin of mesoscutum... .... ***S. symbioticus* Schwéger & Melika, 2015**

– Postgena mostly glabrous on lower half; median mesoscutal line strongly impressed only in posterior half, extending to 2/3 of mesoscutum length, never complete **16**

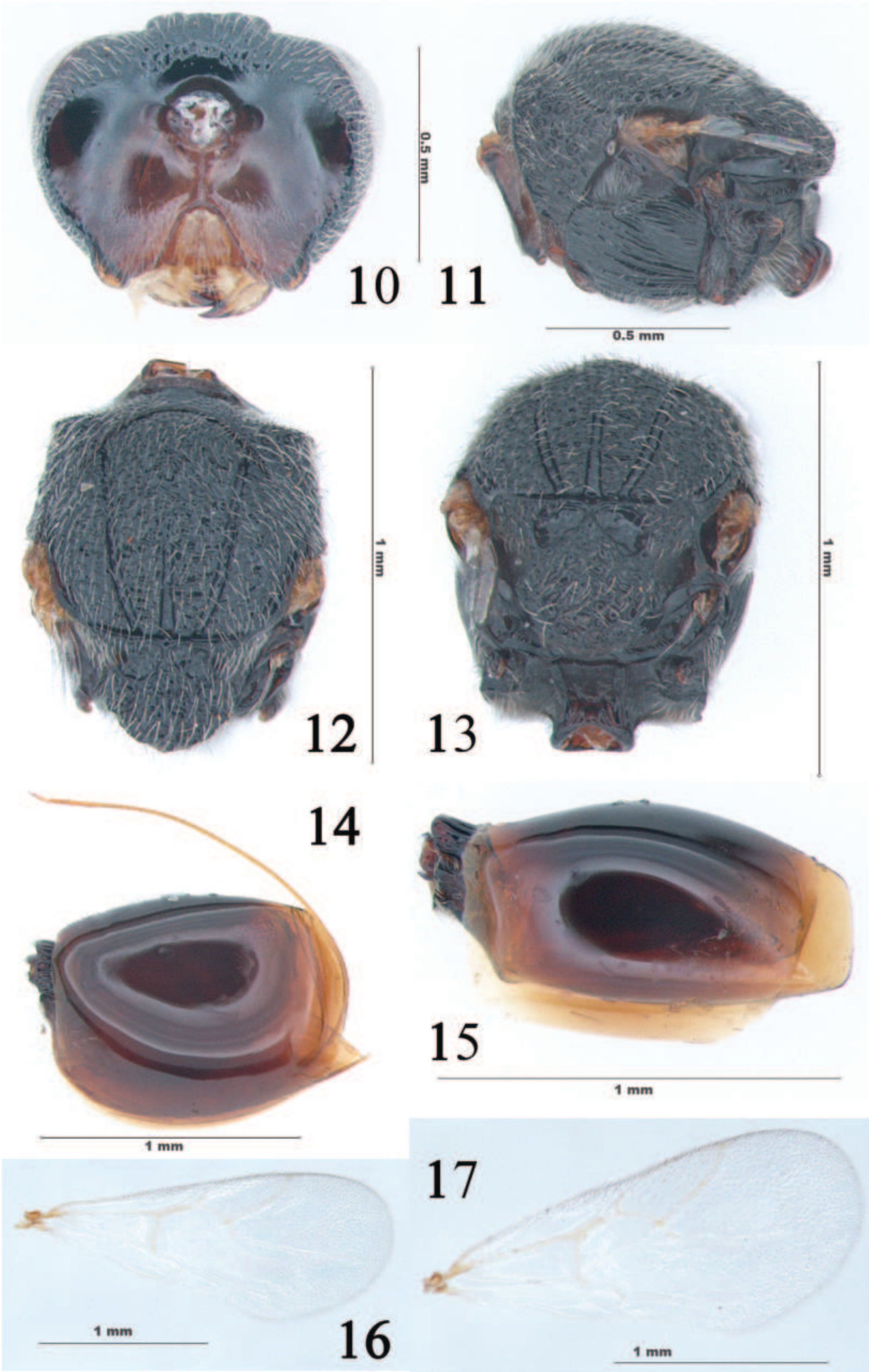
16 Ventral margin of malar space expanded into a wide and recurved lamina; medial mesoscutal line restricted to posterior half of mesoscutum; parapsidal line absent..***S. dilatatus* sp. nov.**

– Ventral margin not or slightly expanded; medial mesoscutal line on the posterior two-thirds of mesoscutum; parapsidal line present .... ***S. formosanus* Schwéger & Melika, 2015**

Description. Female. Body length 2.4–2.8 mm (*N* = 14).

***Color*:** Head reddish dark brown to black, except mouthparts yellowish brown; antenna yellowish to light brown. Mesosoma black. Legs yellowish or light brown. Wings hyaline with slightly darker coxae, veins pale yellowish. Metasoma with 1st tergite dark reddish brown and rest of metasoma reddish brown, ventral spine of hypopygium light brown.

Head (Figs 6, 8, 9): Nearly trapezoid, 1.2 times as wide as high in front view, distinctly broader than mesosoma, 2.6 times as broad as long in dorsal view. The central area of frons elevated and delimited by two dull lateral frontal carinae, the surface finely coriaceous, puncticulate, and sparsely setose; eyes 1.6 times as high as wide; height of eye 2.0 times as high as length of malar space (Fig. 6). Lower face, clypeus and malar space with dense, long, white setae, except area under antennal sockets sparsely setigerous. Lower face with distinct striae radiating from clypeus and reaching basal margin of compound eye and antennal toruli. Ventrolateral corner of malar space expanded as a wide and recurved lamina. Clypeus barely impressed, covered with long appressed setae; anterior tentorial pit small, distinct; clypeo-pleurostomal line and epistomal sulcus absent. Transfacial distance about the same as the height of the compound eye; distance between torulus and compound eye subequal to diameter of toruli and 1.67 times as great as the distance between toruli (Fig. 6). Vertex rugulose around the anterior ocellus, and from interocellar area to occiput sparsely foveolate; POL: OOL: LOL= 7: 3: 3; OOL and LOL as long as diameter of frontal ocellus (Fig. 8). Postgena glabrous, gular sulcus and posterior tentorial pits distinct, with slightly white setae close to posterior tentorial pits. Gena not broadened posterior to eye, and areolate-rugose (Fig. 9). Antenna filiform with 12 flagellomeres, slightly thickened toward apex; pedicel 1.3 times as long as broad, not broadened apically, with dense and short pubescence; placoid sensillae slightly visible on flagellar segments F3-F12. F1 about 1.2 times the length of F2 and as long as F3. Last flagellar segment 3.75 times as long as wide. Relative length from pedicel to F12: 14:12:14:14:13:13:11:12:10:9:9:15 (Fig. 4).



Figures 10–17. *Synergus dilatatus* sp. nov. **10** head in posterior view (♀) **11** mesosoma in lateral view (♀) **12** mesosoma in dorsal view (♀) **13** propodeum in dorsal view (♀) **14** metasoma in lateral view (♀) **15** metasoma in lateral view (♂) **16** fore wing (♀) **17** fore wing (♂).

***Mesosoma*:** slightly longer than high and 1.3 times as long as wide (Fig. 11). Pronotum slightly narrowed medially, median length 1/3 length of outer lateral margin; sides of pronotum angled in dorsal view (Fig. 12). Pronotum puncticulate medially and laterally with deep punctures. Propleuron alutaceous, with parallel longitudinal striae; pronotal lateral carina present. Mesoscutum slightly broader than long measured at anterior tip of tegulae; surface areolate-rugose, covering with dense white setae. Notaulus complete, with smooth bottom. Anterior parallel line invisible; distinct parascutal carina present; parapsidal lines hardly traceable; median mesoscutal line broadened posteriorly and never extending to anterior half of mesoscutum (Fig. 12). Dorsoaxillar area coriaceous, with numerous long hairs; lateroaxillar area joined by dorsoaxillar area at an acute angle. A median carina separates mesoscutellar foveae into two parts which are as long as wide, bottom hairless and coriaceous, and distinctly delimited posteriorly. Mesopleuron hairless laterally except the lower edge densely setae, fully covered with parallel longitudinal striae. Metapleural sulcus reaching posterior margin of mesopleuron in upper 1/3 of its height (Fig. 11). Mesopleural triangle densely pubescent. Propodeum uniformly coriaceous, pubescent; lateral propodeal carinae distinct, anteriorly flat and posteriorly thin, slightly curved; median propodeal area delicately coriaceous without setae, with few rugae posteriorly. Metanotal trough smooth, pubescent; propodeal spiracle transversely ovate. Nucha very small, with distinct longitudinal parallel rugae (Fig. 13).

Forewing (Fig. 16): Hyaline, margin with cilia; radial cell partially closed, 2.4 times as long as broad; R1 nearly straight and reaching wing margin, Rs curved distally, distinctly reaching wing margin; areolet small but distinct; Rs + M inconspicuous, not reaching basal vein.

***Metasoma*:** About as long as head and mesosoma combined and 1.4 times as long as high; petiole sulcate; syntergite almost completely covering remaining tergites, surface smooth and mainly glabrous, with very few white setae anterolaterally, posterodorsal area with lateral patch of sparse setae and indistinct micropunctures, not extending onto lateral sides. Subsequent tergites and hypopygium micropunctate; prominent part of the ventral spine of hypopygium small, smooth with few short setae distally (Fig. 14).

Male (Figs 3, 5, 7, 15, 17). Body length: 1.5–2.3 mm (*N* = 4). Lower face and mouthparts yellowish brown; frons, vertex and occiput reddish brown to black (Fig. 7). Antenna with 13 flagellomeres, scape length 3 times as long as wide; pedicel 1.6 times as long as broad, F1 strongly curved medially and broadened apically, 1.6 times as long as pedicel and 1.2 times as long as F2; relative length of F1-13: 13:11:11:10:9:9:8:8:8:8:7:7:8; placoid sensilla slightly visible on F3–F13, increasing in number per segment distally (Fig. 5). Metasoma distinctly shorter than head and mesosoma combined (Fig. 3) and slender than female in lateral view (Fig. 15). Otherwise, as described for female.

Biology and galls. All specimens were reared from two juicy, green, young galls resembling fruits, collected from shoots of *Quercus variabilis* on July 30, 2021. Galls are ball-shaped, with diameter 14–22 mm; surface smooth, covered with dense tomentum, without tubercles or spots. The galls became wrinkled and shriveled after inquilines emerged in late August (Fig. 18). Unfortunately, no gall makers emerged, so the species that formed the galls remains unknown.

Distribution. Known only from Hubei Province (China).

Etymology. The species is derived from Latin word "*dilatatus*" meaning dilated, extended, referring to the dilated gena of the new species.

Figures 18. General appearance of *Synergus dilatatus* sp. nov. galls on twigs of *Quercus variabilis*.

Discussion

Species delimitation is difficult for inquilines based on morphology. For example, *Synergus japonicus* and *S. gifuensis* Ashmead, 1904 were treated as two different forms of *Synergus japonicus* based on similarity in morphology, but are distinct in life cycles and impact on the gall structures (Masuda 1959; Abe 1990; Abe 1992; Pujade-Villar et al. 2002). DNA barcoding as a complementary taxonomic approach has considerable utility for inquilines and the status of some Western Palaearctic *Synergus* species has been questioned based on disagreement between morphospecies and MOTUs (Ács et al. 2010). In this study, the ASAP method was used in support of the new species, *Synergus dilatatus* sp. nov., with an integrative approach combining morphological and molecular data, and the results were consistent.

However, among the 12 morphospecies analysed here, 16 MOTUs were chosen by the best partition. The main differences are: (1) *S. belizinellus* is divided into two MOTUs; (2) *S. xiaolongmeni* and *S. ishikarii* are merged into one MOTU; and (3) *S. chinensis* and *S. symbioticus* are divided into four MOTUs, which is consistent with the results of Lobato-Vila et al. (2022b). Those mismatches between morphological and MOTU-based identification are unsurprising given the similar situation in the WP groups (Ács et al. 2010). Considering the phenotypic similarity shared by those problematic species (*S. xiaolongmeni* and *S. ishikarii*; *S. chinensis* and *S. symbioticus*) (Schwéger et al. 2015), the current morphological characters used to distinguish species should be reviewed by integrating molecular data.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

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Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.

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Supplementary material 1

appendix S1

Authors: Wang Xiudan, Liu Luan, Zeng Yang

Data type: xls

Explanation note: Genetic distance data of 12 species of EP *Synergus*.

Link: https://doi.org/10.3897/zookeys.1193.105756.suppl1

Supplementary material 2

appendix S2

Authors: Wang Xiudan, Liu Luan, Zeng Yang

Data type: jpg

Explanation note: Boxed subsets resluting from ASAP analyses.

Link: https://doi.org/10.3897/zookeys.1193.105756.suppl2

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Research Article

The solitary wasp genus *Orancistrocerus* from Vietnam, with descriptions of two new species (Hymenoptera, Vespidae, Eumeninae)

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Abstract

New data are presented for the potter wasp genus *Orancistrocerus* van der Vecht (Eumeninae, Odynerini) occurring in Vietnam. Two species are described as new to science: *Orancistrocerus thanhnhat* **sp. nov.** and *O. thanghen* **sp. nov.** *Orancistrocerus aterrimus erythropus* van der Vecht is synonymized with *Orancistrocerus aterrimus aterrimus* (de Saussure); the male genitalia of this species are described for the first time. An updated key is presented to all species of the genus.

Key words: Biodiversity, new description, Oriental region, potter wasps, synonym, taxonomy, Vietnam

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Introduction

Truong et al. (2019) explored the diversity and systematics of the little-known potter wasp genus *Orancistrocerus* van der Vecht, 1963 from Vietnam, and they described *Orancistrocerus altus* Truong, Bozdogan, & Nguyen, 2019, thereby raising the number of known species in the genus to five: *O. aterrimus* (de Saussure, 1852), *O. drewseni* (de Saussure, 1857, *O. bicoloripennis* (Gribodo, 1892), *O. moelleri* (Bingham, 1897), and *O. altus*. These species are distributed in Eastern Asia, from China and Japan south to Borneo.

During several recent field expeditions to Cao Bang Province, with support from the Vietnam Academy of Science and Technology under the project, "Developing the first-class research team on the discovery of diversity and application potential of hymenopterans, myriapods, and soil nematodes in the limestone mountains of northeastern Vietnam", specimens of two undescribed species of *Orancistrocerus* were collected. Based on the material deposited in the Insect Ecology Department, Institute of Ecology and Biological Resources, Hanoi, Vietnam, a new taxonomic study was undertaken on *Orancistrocerus* from Vietnam. The results of that work are presented here, with descriptions and figures of two new species. Additionally, an updated key is presented to all known species in the genus.

Materials and methods

Specimens of *Orancistrocerus* from the Insect Ecology Department, Institute of Ecology and Biological Resources (**IEBR**), Hanoi, Vietnam were examined. Morphological and color characters of mature specimens were observed using pinned and dried specimens under an Olympus SZ4 stereomicroscope, and measurements were made with an ocular micrometer. "Body length" indicates the combined lengths of the head, mesosoma, and the first two metasomal segments. Morphological terminology follows that of Carpenter and Cumming (1985) and Yamane (1990). Genitalic terminology follows Kojima (1999) and Nguyen et al. (2023). Photographic images were made with a Nikon SMZ 800N Digital Stereo Microscope and an attached Sony α6000 digital camera. Images were stacked using Helicon Focus v. 7, then grouped into a figure using Adobe Photoshop CS6. The abbreviations **F**, **S**, and **T** (**I**, **II**, **III**, …) refer to numbered flagellomeres, metasomal sterna, and metasomal terga, respectively. Other abbreviations are: **NP**, National Park; **NR**, National Reserve; **ISD-c**, collectors from the Insect Systematic Department (IEBR).

Systematics

Genus *Orancistrocerus* van der Vecht, 1963

Orancistrocerus van der Vecht, 1963: 58, 99. Type species: *Odynerus drewseni* de Saussure, 1857, by original designation.

Diagnosis. Anterior surface of pronotum without pits or foveae. Tegula not evenly rounded posteriorly, emarginate adjoining parategula and often shorter than the latter. Axillary fossa in dorsal view much narrower than long, slit-like. Propodeum without deep fossae, submarginal carina and valvula not protruding; propodeal dorsum not forming raised shelf-like area behind metanotum. Metasomal terga with short apical lamellae; TI transversely carinate, without broad longitudinal median furrow posterior to carina, long, dorsal surface ~2× or less as wide as long. Male antenna hooked apically.

Generic relationships. *Orancistrocerus* is a small genus, currently with five species and with four valid subspecies in *O. atterimus*, which is widely distributed from India to China, including Laos and Vietnam. The second most widely distributed species, *O. drewseni*, with three subspecies, is distributed in several tropical climatic zones of China (including Taiwan), Japan, and Laos, while the two subspecies of *O. bicoloripennis* is distributed only in Malaysia and Indonesia. *Orancistrocerus moelleri*, with two subspecies, is recorded from South China, northern India adjacent to South China, and Myanmar (van der Vecht 1963; Giordani Soika 1973; Tan et al. 2018). The remaining species, *O. altus*, *O. thanghen* sp. nov., and *O. thanhnhat* sp. nov., are known only from northern Vietnam, but it is assumed that these also occur in southern China as the type localities border that region. More interestingly, all three Vietnamese species have been found only in limestone areas.

Van der Vecht (1963) established the genus *Orancistrocerus* but did not discuss any similarities or relationships between *Orancistrocerus* and other eumenine genera. Recently, a phylogenetic tree showing relationships within the subfamily Eumeninae was provided based on molecular data (Luo et al. 2022), and in that study, *Orancistrocerus* is closely related to *Euodynerus*. Morphological similarities of these two genera are as follows: metasoma not petiolate; fore wing with second submarginal cell not petiolate; propodeum without deep fossae; metanotum without tubercles; anterior surface of pronotum without pits or foveae. TI transversely carinate is a character to separate *Orancistrocerus* from *Euodynerus* (TI not carinate in *Euodynerus*). In the phylogenetic tree by Luo et al. (2022), *Orancistrocerus* and *Pararrhynchium* are not closely related, but they are very similar to each other in morphology, owing to the metasoma not petiolate, forewing with second submarginal cell not petiolate, metanotum without tubercles, anterior face of pronotum without pits or foveae, propodeum with submarginal carina and valvula not produced, TI transversely carinate, axillary fossa narrower than long, slit-like, tegula not exceeding parategula, and male antenna hooked apically. *Orancistrocerus* differs from *Pararrhynchium* in having the propodeal dorsum not forming a shelf-like area behind the metanotum and the metasomal terga with short apical borders (propodeal dorsum usually forming a shelf-like area behind the metanotum more than one ocellar diameter long; metasomal terga usually with some well-developed apical lamellae in *Pararrhynchium*). The genus *Malayepipona* was not included by Luo et al. (2022), but, based on a study of the Vietnamese material, *Orancistrocerus* is morphologically also similar to *Malayepipona* in the shape of the mesosoma, propodeum, and metasoma in dorsal view, in having the first metasomal tergum angular in profile, and TI with the anterior portion separated from the horizontal part by a more or less distinct transverse ridge. These two genera can be distinguished in having the tegula not exceeding the parategula, axillary fossa in dorsal view much narrower than long, slit-like in *Orancistrocerus* (tegula at least equaling parategula posteriorly; axillary fossa in dorsal view not slit-like, oval in *Malayepipona*).

Origin of genus. Even if there is no existing hypothesis on biogeographic history of *Orancistrocerus*, our working hypothesis is that these species may have originated in the Himalayas running between China and India, perhaps during episodes of orogeny, then dispersed into South China and northern India as well as Southeast Asia, including Vietnam, Myanmar, Malaysia, and Indonesia. Naturally, a comprehensive revision and phylogenetic analysis are needed to test this hypothesis and establish a robust estimate for the complex biogeographic history of *Orancistrocerus* and other Asiatic Eumeninae.

Orancistrocerus thanghen **sp. nov.**

https://zoobank.org/C6CA3009-D439-41A3-8A14-0A8C974E964C

Fig. 1A–G

Material examined. ***Holotype*****.** Vietnam • ♀; Cao Bang, Tra Linh, Thang Hen lake; 22°45'48"N, 106°17'38"E; alt. 611 m; 3.viii.2022; Lien Thi Phuong Nguyen, Cuong Quang Nguyen, Ngat Thi Tran leg.; IEBR.

Paratypes**.** Vietnam • 4♀♀, same data as holotype • 1♀; Cao Bang, Tra Linh, Thang Hen Lake; 22°45'47.5"N, 106°17'35.7"E; alt. 619 m; 18.xi.2023; Lien Thi Phuong Nguyen, Duc Anh Nguyen, Ngat Thi Tran leg.; IEBR.

Figure 1. *Orancistrocerus thanghen* sp. nov., female holotype **A** frontal view **B** head, dorsal view **C** mesosoma, dorsal view **D** propodeum, posterior view **E** head and mesosoma, lateral view **F** metasoma, dorsal view **G** habitus. Scale bars: 1 mm.

Diagnosis. This species can be distinguished from other species in the genus in the following combination of characters: head in frontal view subcircular, 1.1× as wide as high; occipital carina slightly widened laterally; clypeus in frontal view 1.2× as wide as high, apical margin deeply emarginated medially, forming blunt tooth on each side, distance between teeth ~0.5× width of clypeus between inner compound eye margins; mesoscutum shorter than wide between tegulae; TI in dorsal view ~2.2× as wide as long; TII densely punctate, interspaces larger (~1.5×) than puncture diameter.

The new species is similar to *O. altus* in that both have TII densely punctate, interspaces larger (~1.0–1.5×) than puncture diameter, the occipital carina slightly widened laterally, mesoscutum slightly shorter than wide between tegulae, propodeum with border between dorsal and lateral surfaces rounded, dorsal and posterior surfaces angled. It differs from *O. altus* in the following characters: head in frontal view 1.1× as wide as high (head in frontal view 1.3× as wide as high in *O. altus*), clypeus in frontal view 1.2× as wide as high (clypeus in frontal view nearly as wide as high in *O. altus*), apical margin of clypeus shallowly emarginate with distance between teeth of clypeus about half width of clypeus between inner compound eye margins (apical margin of clypeus deeply emarginate, half-oval-shaped, distance between teeth of clypeus less than half width of clypeus between inner compound eye margins in *O. altus*).

Description. Female (Fig. 1G): body length 13.0–14.0 mm (holotype = 13.5 mm); forewing length 12.0–13.0 mm (holotype = 12.5 mm).

***Structure*.** Head in frontal view subcircular, 1.1× as wide as high (Fig. 1A). Vertex produced behind posterior ocelli, then sloping down towards occipital carina, with cephalic foveae small, bearing dense pubescence, situated on depressed area on vertex behind posterior ocelli, and with distance between foveae slightly greater than diameter of median ocellus. Distance from lateral ocelli to apical margin of vertex 2.5× distance from lateral ocellus to inner compound eye margin (Fig. 1B). Gena in lateral view narrower than compound eye, ~0.7× as wide as compound eye; occipital carina complete, present along entire length of gena, slightly widened laterally. Inner compound eye margins in frontal view slightly convergent ventrally, in anterior view 1.1× further apart from each other at vertex than at clypeus (Fig. 1A). Clypeus in lateral view gradually convex from base to apical margin; in frontal view 1.2× as wide as high (Fig. 1A), with basal margin slightly convex medially and distinctly separated from antennal toruli; apical margin deeply emarginate medially, forming blunt tooth on each side, distance between teeth ~0.5× width of clypeus between inner compound eye margins. Mandible with prominent wide teeth, fourth tooth blunt apically. Scape long, ~4.4× as long as its maximum width, slightly curved; FI ~1.8× longer than wide, FII–III longer than wide, FIV–IX wider than long, terminal flagellomere bullet-shaped, approximately as long as its basal width. Mesosoma longer than wide in dorsal view (Fig. 1C). Pronotal carina present, rounded at humeral angle, reaching ventral corner of pronotum. Mesoscutum slightly convex, shorter than wide between tegulae, length ~0.9× width, with depressed and parallel furrows apically (depression exceptionally inconspicuous and hard to recognize in holotype and three paratypes because they fuse with large punctures), and two carinae laterally at apical one-third (Fig. 1C), with middle narrow furrow present at basal one third. Disc of mesoscutellum slightly convex, with middle furrow present throughout (Fig. 1C). Metanotum slightly convex. Propodeum (Fig. 1D) conspicuously excavated medially, with posterior surface distinctly concave, at basal half of median carina running to apical margin; border between dorsal and lateral surfaces rounded, posterior and lateral surfaces angled. TI in dorsal view narrower than TII, truncate at base (Fig. 1F); anterior vertical surface of TI slightly convex, with sparse shallow punctures, clearly separated from posterior horizontal surface by carina. TI in dorsal view ~2.2× as wide as long; TII in dorsal view ~1.2 × wider than long (Fig. 1F); SII in lateral view depressed basally, then gradually and slightly convex to apical margin.

***Sculpture*.** Clypeus with coarse punctures on disc; border between punctures raised to form longitudinal striations medially, with smaller and deeper punctures laterally. Mandible with row of punctures laterally. Frons densely covered with coarse, flat-bottomed punctures, interspaces between punctures narrow and raised to form reticulation. Vertex and gena with punctures similar to those on frons; gena with several short, transverse, conspicuous striae laterally; occipital carina slightly widened laterally. Pronotum with punctures similar to those on vertex. Mesoscutum covered with flat-bottomed punctures, punctures smaller than those on vertex and usually forming row of punctures with interspaces between rows raised to form reticulations, reticulation tending to form longitudinal carina; mesoscutellum with punctures similar to those on mesoscutum, punctures on metanotum coarser than those on mesoscutum. Mesepisternum with flat-bottomed punctures, punctures coarser and larger to those on pronotum posterodorsally, smooth anteroventrally; border between posterodorsal and anteroventral parts distinct, without epicnemial carina. Dorsal part of metapleuron largely smooth and with several punctures at upper part, ventral part largely smooth, with several sparse and shallow punctures, and some short striae laterally. Propodeum with coarse, large, flat-bottomed punctures dorsally; punctures are shallower, smaller, and sparser laterally; angle between dorsal and lateral surfaces of propodeum somewhat rounded; posteriorly surface of propodeum with punctures at upper and lateral parts, and with oblique weak carina at lower part, with a large smooth area centrally. Tegulae with sparse small punctures laterally, the remaining surface with minute punctures. Metasomal segment I covered with dense, strong and well defined punctures dorsally, sparse and fine punctures dorso-anteriorly, distance between punctures on TI narrower than puncture diameter; TII with undefined punctures, punctures shallower than those on TI, punctures near apical margins deeper, larger and coarser than those on other part of the tergum, interspaces between punctures usually equal to puncture diameter at central part; TIII–V with punctures conspicuous and deep, smaller than those on TII apically; TVI with minute punctures; SII with punctures deeper and larger than those on margins of TII laterally; SIII–V with punctures smaller and shallower than those on SII; SVI with minute punctures; SI with narrow basal part smooth.

***Color*.** Black; a narrow, curved, yellow strip near base of clypeus; yellow spots near base of mandible; antennal scape orange-yellow beneath; mandible, propodeal valvulae, and all trochanters reddish-brown. Wings brown with violet reflection; veins dark brown.

***Pubescence*.** Body with short, sparse, yellow or silver setae except lower part of propodeum with longer and denser silver setae.

Male. Unknown.

Distribution. Central Vietnam.

Etymology. The specific epithet is a noun in apposition that refers to the name of the lake where the holotype was collected.

Orancistrocerus thanhnhat **sp. nov.**
https://zoobank.org/B92020E8-DE78-43BF-8050-E4359442C3D2
Figs 2A–G, 3A–D

Material examined. ***Holotype*****.** Vietnam • ♂, Cao Bang, Ha Lang, Thanh Nhat; 22°42'8"N, 106°39'49"E; alt. 332 m; 18.v.2023; Lien Thi Phuong Nguyen, Cuong Quang Nguyen & Ngat Thi Tran leg.; IEBR.

Diagnosis. This species can be distinguished from other species in the genus in the following combination of characters: clypeus in frontal view as wide as high, apical margin widely emarginate medially, forming short, blunt teeth on each side, distance between teeth >½ width of clypeus between inner compound eye margins (~0.55× width of clypeus between inner compound eye margins); occipital carina conspicuously widened laterally; mesoscutum in dorsal view slightly shorter than wide between tegulae; TI in dorsal view ~2.5 × as wide as long; TII sparsely punctate, interspaces much greater (2–3×) than puncture diameter, except at base and at apical margin with interspaces smaller than puncture diameter.

The new species is similar to *O. drewseni* in that both have TII sparsely punctate centrally, interspaces much greater (2–3×) than puncture diameter. However, it differs from *O. drewseni* in the following characters: mesoscutum in dorsal view slightly shorter than wide between tegulae (mesoscutum in dorsal view longer than wide between tegulae in *O. drewseni*); TII with punctures conspicuous (TII with punctures less conspicuous in *O. drewseni*); TII not lamellate apically (TII lamellate apically in *O. drewseni*); TI–II with narrow, lateral stripes of orange-yellow (TI–II with apical thick yellow bands in *O. drewseni*); and digitus gradually narrowed from base to apex, penis valves long, more than 2× as long as basal apodeme (digitus almost parallel from base to half, then narrowed to apex in *O. drewseni* (van der Vecht 1963: fig. 8f); penis valves shorter, less than 2× as long as basal apodeme (van der Vecht 1963: fig. 8g)).

Description. Male (Fig. 3A): body length 13.2 mm; forewing length 12.5 mm.

Structure**.** Head in frontal view subcircular, ~1.3× as wide as high (Fig. 2A). Vertex sloping down behind lateral ocelli towards occipital carina, without cephalic foveae. Distance from lateral ocelli to apical margin of vertex 2.7× distance from lateral ocellus to inner compound eye margin (Fig. 2B). Gena in lateral view much narrower than compound eye, ~0.6× as wide as compound eye; occipital carina complete, present along entire length of gena, markedly widened laterally (Fig. 2F). Inner compound eye margins in frontal view convergent ventrally, in anterior view 1.2× further apart from each other at vertex than at clypeus (Fig. 2A). Clypeus in lateral view gradually convex from base to apical margin; in frontal view as wide as high (Fig. 2A), with basal margin almost straight medially and distinctly separated from antennal toruli; apical margin widely emarginate medially, forming blunt short teeth on each side, distance between teeth >½ width of clypeus between inner compound eye margins (~0.55× width of clypeus between inner compound eye margins).

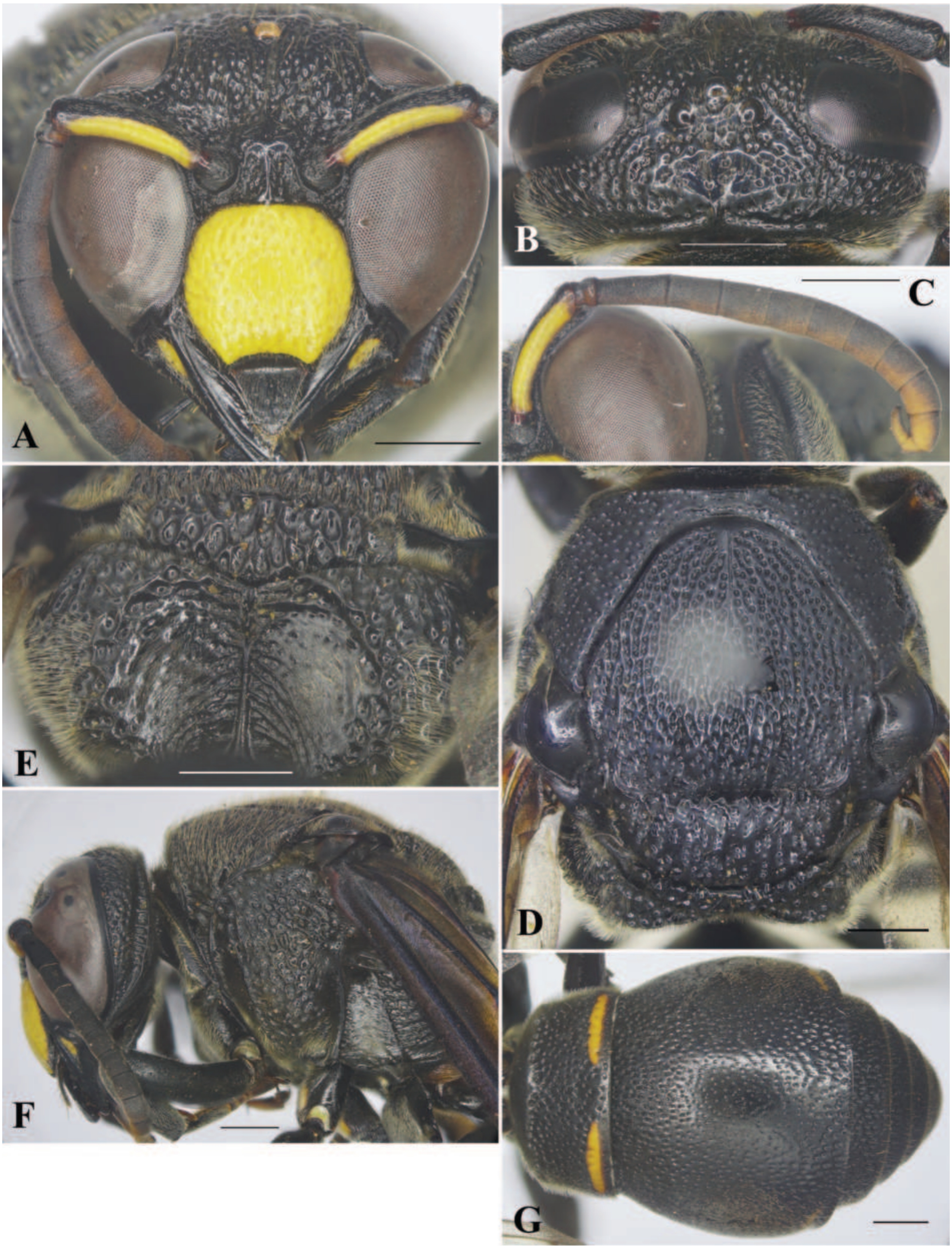

Figure 2. *Orancistrocerus thanhnhat* sp. nov., male holotype **A** frontal view **B** head, dorsal view **C** antenna **D** mesosoma, dorsal view **E** propodeum, posterior view **F** head and mesosoma, lateral view **G** metasoma, dorsal view. Scale bars: 1 mm.

Figure 3. *Orancistrocerus thanhnhat* sp. nov., male holotype **A** habitus, dorsolateral view **B** genitalia, inner aspect of paramere with volsella and digitus **C** aedeagus, ventral view **D** aedeagus, lateral view. Scale bars: 1 mm.

Mandible with prominent wide teeth. Scape long, ~4.2× as long as its maximum width, slightly curved; FI long, ~2.3× longer than wide, FII ~1.5× as long as wide, FIII ~1.3× as long as wide, FIV slightly longer than wide, FV–VIII almost as long as wide, FIX ~1.2× longer than wide, FX small, terminal flagellomere slender, ~2.7× as long as its basal width, slightly curved (Fig. 2C). Mesosoma longer than wide in dorsal view (Fig. 2D). Pronotal carina present, rounded at humeral angle, reaching ventral corner of pronotum. Mesoscutum slightly convex, slightly shorter than wide between tegulae, with depressed and oblique furrows apically, and two carinae laterally at apical one-third (Fig. 2D) (with middle narrow furrow present at basal one-third). Disc of mesoscutellum convex, in lateral view at same level as mesoscutum (Fig. 2F), narrowly depressed basally. Metanotum slightly convex. Propodeum (Fig. 2E) conspicuously excavated medially, with posterior surface distinctly concave, at basal quarter with median carina running to apical margin; border between dorsal and lateral surfaces slightly angled, posterior and lateral surfaces angled. TI in dorsal view narrower than TII, truncate at base (Fig. 2G); anterior vertical surface of TI slightly convex, with sparse shallow punctures, clearly separated from posterior horizontal surface by carina. TI in dorsal view ~2.5× as wide as long; TII in dorsal view ~1.1× wider than long (Fig. 2G); SII in lateral view slightly depressed basally, then gradually and slightly convex to apical margin, with weak medial furrow at basal half.

Sculpturing. Clypeus with sparse, shallow, large, undefined punctures on disc; border between punctures smooth. Mandible with row of punctures laterally. Frons densely covered with coarse, flat-bottomed punctures; interspaces between punctures narrow and raised to form reticulation. Vertex with coarse punctures, punctures equal in size; gena with punctures similar to those on apical half of vertex, punctures smaller and less coarse in basal half, with several short transverse conspicuous striae laterally; occipital carina markedly widened laterally (Fig. 2F). Pronotum with punctures less coarse than those on vertex. Mesoscutum covered with flat-bottomed punctures, punctures equal in size, interspaces between punctures forming reticulation that tends to form longitudinal carina centrally; mesoscutellum with punctures similar to those on pronotum, punctures on metanotum denser than those on mesoscutellum, interspaces between punctures narrow and raised to form reticulation. Mesepisternum with flat-bottomed punctures, punctures coarser and larger than those on pronotum posterodorsally, smooth anteroventrally; border between posterodorsal and anteroventral parts distinct, without epicnemial carina. Dorsal part of metapleuron largely smooth and with several short and conspicuous striae, ventral part largely smooth, with sparse and shallow punctures laterally. Propodeum with coarse, large, flat-bottomed punctures dorsally; punctures are shallower, smaller, and sparser laterally; angle between dorsal and lateral parts of propodeum somewhat rounded; posteriorly surface of propodeum with punctures at upper and lateral parts, with oblique weak carina at lower part, and with a large smooth area centrally. Tegulae with minute punctures. Metasomal segment I covered with sparse and conspicuous punctures dorsally, fine and sparse punctures dorso-anteriorly, distance between punctures greater than puncture diameter; TII with punctures shallower than those on TI, punctures near apical margins deeper, larger and coarser than those on other parts of the tergum, interspaces between punctures greater (~2–3×) than puncture diameter at central part; TIII–V with punctures conspicuous and deep, smaller than those on TII; TVI and TVII with minute punctures; SII with sparse punctures, punctures deeper and larger than those on margins of TII laterally; SIII–V with punctures smaller and shallower than those on SII; SI with narrow basal part smooth.

***Color*.** Black; clypeus yellow, except for black margin; yellow spot near base of mandible; beneath scape yellow; flagellomeres beneath light brown; two short, orange-yellow bands at apical margins of TI and TII. Propodeal valvulae dark brown. Middle coxae with two short, yellow strips; hind coxae with a yellow spot. Wings brown, transparent; veins dark brown (Fig. 3A).

***Pubescence*.** Head and thorax with long, dense, yellow setae; metasoma with short, dense, yellow setae.

Female. Unknown.

***Genitalia*.** As in Fig. 3B–D. Parameral spine lacking setae. Volsella flattened, spatulate, wide on inner aspect, and without setae apically. Digitus gradually narrowing from base to apex, all setose (Fig. 3B). Penis valve long, ~2.2× as long as basal apodeme (Fig. 3C), in profile apical part conspicuously produced into triangular lobe (Fig. 3D).

Distribution. Northern Vietnam.

Etymology. The specific epithet is a noun in apposition that refers to the name of the town where the holotype was collected.

***Orancistrocerus aterrimus* (de Saussure, 1852)**
Fig. 4A–C

Odynerus aterrimus de Saussure, 1852: 121 (key), 128.
Orancistrocerus aterrimus (de Saussure); Truong et al. 2019: 599 (key).

Material examined. Vietnam • 1♀; Ha Giang, Dong Van; 12 July 2015; Khuat Dang Long; • 2♀; Cao Bang, Nguyen Binh, Tam Kim; 22°36'17"N, 106°01'47.6"E; alt. 299 m; 18.x. 2015; • 1♀; Cao Bang, Nguyen Binh, Tran Hung Dao forest; 22°36'17"N, 106°01'47.6"E; alt. 470 m; 18.x. 2015; Nguyen Thi Phuong Lien, Nguyen Dac Dai & Nguyen Phuong Minh leg.; • 1♀; Cao Bang, Thanh Nhat, Ha Lang; 22°42'9"N, 106°39'52"E, alt. 250 m; 19.xi.2023; Nguyen Quang Cuong & Tran Thi Ngat leg.; • 2♀♀; Cao Bang, Tra Linh, Thang Hen Lake; 22°45'33"N, 106°17'46"E; alt. 578 m; 4.viii.2022; Nguyen Thi Phuong Lien et al. leg.; • 2♀♀; Cao Bang, Tra Linh, Thang Hen Lake; 22°45'33"N, 106°17'46"E; alt. 550 m; 18.ix.2023; Nguyen Thi Phuong Lien, Tran Thi Ngat, Nguyen Duc Anh leg.; • 4♀♀, Cao Bang, Trung Khanh, Dam Thuy, Nguom Ngao cave; 22°50'43.2"N, 106°22.2"E; 19.ix.2023; Nguyen Thi Phuong Lien, Tran Thi Ngat leg.; • 1♀; Bac Kan, Cho Don, Binh Trai, Nam Xuan Lac NP; 22°16'65"N, 108°11'08"E; alt. 780 m, 12.viii.2020; Nguyen Thi Phuong Lien et al. leg.; • 1♀; Lao Cai, Sa Pa, Ban Ho, Hoang Lien NP; 27–29.vii.2008; Nguyen Thi Phuong Lien leg.; • 1♀; Lao Cai, Bat Xat, Y Ty, Sim San, 22°37'48"N, 103°34'52"E; alt. 1324 m; 2.viii.2019; Nguyen Thi Phuong Lien, Nguyen Quang Cuong, Tran Thi Ngat leg.; • 1♀; Dien Bien, Muong Fang; alt. 500 m; 23.vii.2009; Nguyen Thi Phuong Lien, Pham Huy Phong, Kojima Junichi leg.; • 1♀; Tuyen Quang, Na Hang, Na Hang NR, Son Phu ranger station; 22°21.2'07"N, 105°24'34.7"E; alt. 264 m, 10.vi.2015, Nguyen Thi Phuong Lien, Nguyen Dac Dai, Truong Xuan Lam leg.; • 1♂; Lang Son, Huu Lung, Cai Kinh; 20°31'37.6"N, 105°0'24.2"E; alt. 86 m, 16.vii.2016; Nguyen Thi Phuong Lien, Nguyen Dac Dai, Tran Thi Ngat leg.; • 1♀; Lang Son, Huu Lung, Huu Lien, Lan Nghe, Huu Lien NR; 21°33'48.6"N, 106°24'36.4"E; alt. 289 m; 11.vi.2018; Nguyen Thi Phuong Lien et al. leg.; • 1♀; Bac Giang, Son Dong, An Lac, Dong Bay; 21°20'42.8"N, 106°56'31.1"E; 12.viii.2012; Kojima Junichi, Nugroho Hari, Nguyen Thi Phuong Lien leg.; • 1♀; Quang Ninh, Hoanh Bo, Dong Quang; 2.viii.2013; Tran Van Tuan leg.; • 1♀; Hai Phong, Cat Hai, Cat Ba NP, 20°47'38"N, 106°59'45"E; 25.vii.2013; Nguyen Thi Phuong Lien, Nguyen Dac Dai leg.; • 1♀; Vinh Phuc, Ngoc Thanh, Me Linh; 7.vi.2001; Truong Xuan Lam leg; • 4♀♀; Ha Noi, Ba Trai, Ba Vi; 9.vii.2017; Nguyen Thi Phuong Lien, Luong Viet Tuan leg.; • 1♀; Hoa Binh, Bao Hieu, Yen Thuy; 14.vii.1999; Truong Xuan Lam leg.; 1♀; Hoa Binh, Yen Thuy; 1.v.2012; Hoang Vu Tru leg.; • 1♂; Hoa Binh, Mai Chau, Chieng Chau, Lac village; alt. 600 m; 1.vi.2008; Nguyen Thi Phuong Lien leg.; • 1♀, 1♂; Thanh Hoa, Thuong Xuan, Van Xuan, Hon Can, Xuan Lien NP; 19°51'55.5"N, 105°14'28.8"E; alt. 120 m; Nest#2012-TH-Eumeninae-01; 23.viii.2012; Nguyen Thi Phuong Lien leg.; • 1♀; Thanh Hoa, Thuong Xuan, Van Xuan, Hon Can, Xuan Lien NP; 19°52'27.5"N, 105°14'20.8"E; alt. 110 m; 23.viii.2012; Nguyen Thi Phuong Lien leg.; • 1♀; Da Nang, Vinh Cuu, Phu Ly, Vinh An; 30.vii.2008; ISD-c leg.; • 1♀; Dak Lak, Krong Bong, Krong Kmar, Chu Yang Sin NP; 12°25'02.8"N, 108°22'30.8"E; alt. 1081 m; 4.v.2016; Nguyen Thi Phuong Lien, Nguyen Dac Dai, Tran Thi Ngat leg.; • 2♀♀; Lam Dong, Da Lat, Bidoup Nui Ba NP; 12°10'56.7"N, 108°40'47.9"E; alt. 1458 m; 7.v.2016; Nguyen Thi Phuong Lien, Nguyen Dac Dai, Tran Thi Ngat leg.; IEBR. CHINA: • 1♀, 1♂; Tianzhu, Guizhou, viii. 2009; Wang Yang-Wen leg.; IEBR.

***Male genitalia*.** As in Fig. 4A–C. Parameral spine without setae. Volsella flattened, spatulate, wide on inner aspect, without setae at top. Digitus almost parallel from near base to near apex, then gradually narrowed to apex (Fig. 4A), its surface covered with setae except glabrous at base, its inner lateral margin with some small and short tubercles at middle, serrated at base. Penis valve short, ~1.7× as long as basal apodeme (Fig. 4B), in profile apical part markedly produced into triangular lobe (Fig. 4C).

Remarks. Four subspecies have been recognized in *O. aterrimus*: *O. a. aterrimus* from China and Vietnam; *O. a. erythropus* (Bingham, 1897) from India, Myanmar, Laos, and Thailand; *O. a. khasianus* (Cameron, 1900) from India; and *O. a. nigriceps* van der Vecht, 1963 from China and Vietnam (van der Vecht 1963; Kumar and Sharma 2012; Selis 2018; Truong et al. 2019).

In Vietnam, *O. a. aterrimus* has been recorded in Da Nang province by Selis (2018). *Orancistrocerus a. nigriceps* has been recorded from Phu Quoc Island, Kien Giang province by van der Vecht (1963) and Truong et al. (2019). Having carefully examined specimens studied by Truong et al. (2019), we found that almost all specimens identified as *O. a. nigriceps* in their paper are actually *O. a. aterrimus*, with color of body and wing fitting well into the description by van der Vecht (1963): wings brown with violaceous effulgence, body black, a small spot on mandibles, two small inter-antennal spots, and a line at underside of scape yellow. Two males and two females have the wing base more or less clear hyaline, as the color character to separate *O. a. erythropus* from *O. a. aterrimus* as noted by van der Vecht (1963). Of those, one male from Xuan Lien NP, Thanh Hoa province has its wings fully clear hyaline, and this male comes from the same nest (Nest #2012-TH-Eumeninae-01) as a female, but the female is colored as *O. a. aterrimus* (wings brown with violaceous effulgence). Thus, the

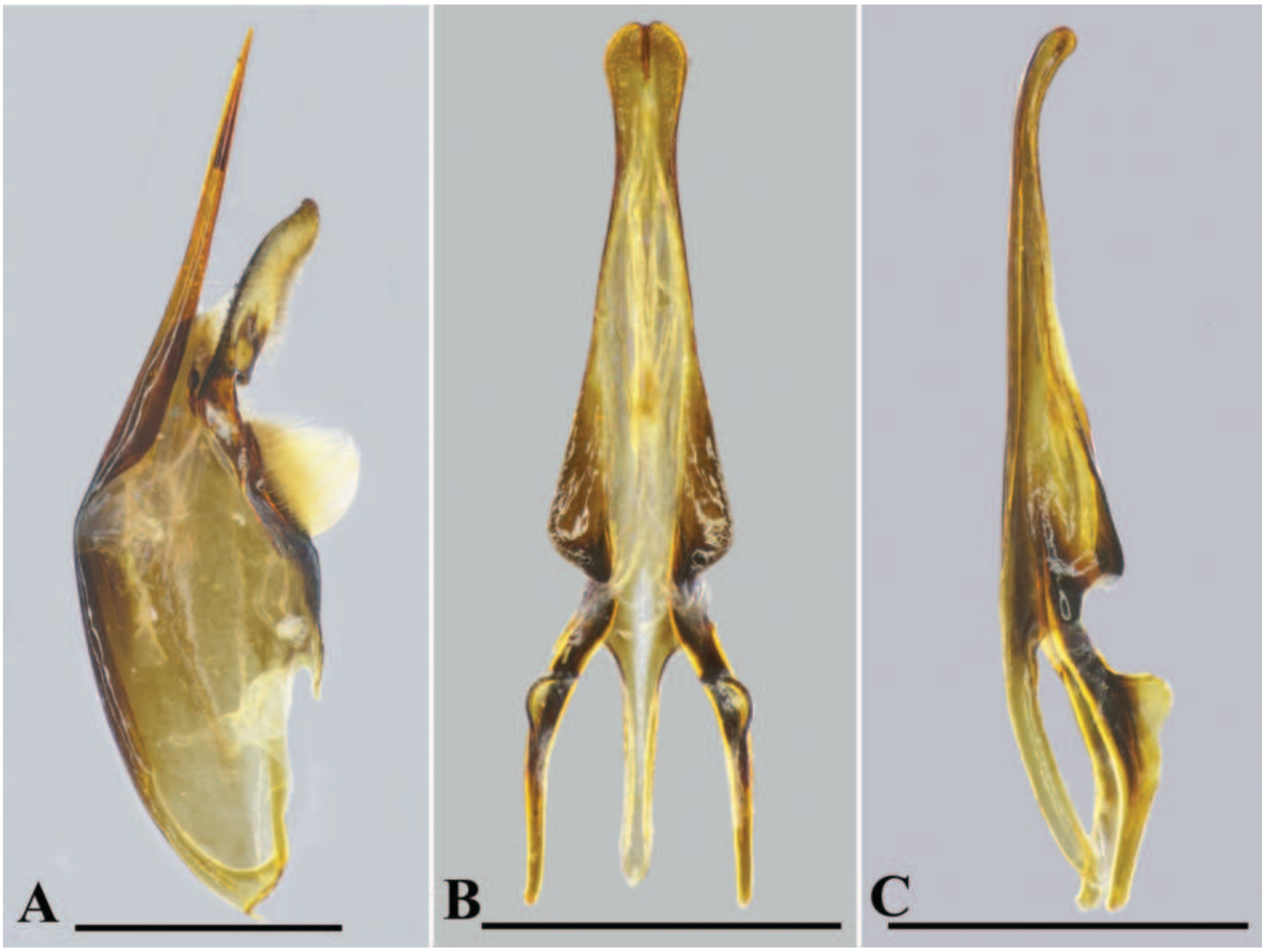

Figure 4. *Orancistrocerus atterimus*, male **A** genitalia, inner aspect of paramere with volsella and digitus **B** aedeagus, ventral view **C** aedeagus, lateral view. Scale bars: 1 mm.

color of wing base cannot be used to separate the subspecies *O. a. aterrimus* and *O. a. erythropus*, and, thus, we synonymize *O. a. erythropus* with the nominate subspecies (new synonymy). One specimen examined by Truong et al. (2019) has subhyaline wings, but the clypeus and antennal scape were not entirely black (clypeus black with two large yellow spots laterally and one small yellow spot medially; antennal scape yellow beneath), and we cannot assign this specimen to any subspecies of *O. aterrimus*. At the moment, two subspecies of *O. aterrimus* are recorded in Vietnam, namely *O. a. aterrimus* and *O. a. nigriceps*. Due to the lack of specimens, the status is left as it is until more specimens are available to us. In this paper, all specimens examined are treated at the species level. Herein, the male genitalia of the species are described and figured for the first time (based on a male of *O. a. aterrimus*).

***Orancistrocerus altus* Truong, Bozdoğan & Nguyen, 2019**

Orancistrocerus altus Truong, Bozdoğan & Nguyen, 2019: 596.

Remarks. The species is known only from the type locality, Huu Lien Nature Reserve, Lang Son Province, northern Vietnam.

Key to species of *Orancistrocerus*

This is an updated key based on that of Truong et al. (2019). The characters are applicable to both sexes unless specified.

1 TII sparsely punctate, interspaces much greater (2–3×) than puncture diameter (Fig. 2G), except at base and at apical margin with interspaces smaller than puncture diameter; mesosoma not colored as below **2**

– TII densely punctate, interspaces larger (~1.5×) than puncture diameter (Fig. 1F), except at base and at apical margin with interspaces equal or smaller than puncture diameter; mesosoma with yellow apical band on TI–II or extensively marked with red or entirely black **3**

2 Mesoscutum in dorsal view slightly shorter than wide between tegulae; TII not lamellate apically; punctures on TII conspicuous; digitus gradually narrowed from base to apex (Fig. 3B), penis valve long, more than 2× as long as basal apodeme (Fig. 3C); spot near base of mandibles and beneath scape yellow; lateral strips on TI–II short and narrowly orange-yellow .... ***O. thanhnhat* sp. nov.**

– Mesoscutum in dorsal view longer than wide between tegulae; TII lamellate apically; punctures on TII less conspicuous; digitus almost parallel from base to midlength, then narrowing to apex (van der Vecht 1963: fig. 8f), penis valve shorter, less than 2× as long as basal apodeme (van der Vecht 1963: fig. 8g); spot near base of mandibles, beneath scape, and large inter-antennal spot orange-yellow; apical bands of TI–II wide, orange-yellow .... ***O. drewseni* (de Saussure, 1857)**

3 Female clypeus with apical margin deeply emarginate, forming two sharp teeth laterally (Truong et al. 2019: fig. 3; Fig. 1A)....................................... **4**

– Female clypeus with apical margin shallowly emarginate, forming two blunt teeth laterally (Truong et al. 2019: fig. 1).. **5**

4 Female clypeal emargination exceedingly deep, half-oval shaped (Truong et al. 2019: fig. 3), with an inverse U-shaped mark near basal margin of clypeus and apical bands of TI–II yellow... .... ***O. altus* Truong, Bozdogan & Nguyen, 2019**

– Female clypeal emargination shallower (Fig. 1A), with a narrow, curved, yellow strip near base of clypeus, metasoma all black .... ***O. thanghen* sp. nov.**

5 Wings yellowish or light cupreous brown, not conspicuously infuscate in apical half; mesosoma extensively marked with red .... ***O. moelleri* (Bingham, 1897)**

– Wings subhyaline or yellow, conspicuously infuscate at apex; mesosoma not colored as above **6**

6 Mandible with ivory white spot at base; basal part of wings rich golden hyaline, apical half fuscous with golden and violaceous reflections........... .... ***O. aterrimus* (de Saussure,1852)**

– Mandibles with yellow spot at base; wings with less pronounced yellow tinge, apical cloud covers marginal cell, second and third submarginal cells and areas below and beyond these cells........... ***O. bicoloripennis* (Gribodo, 1892)**

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

L.T.P.N conceived the study, acquired funding, conducted the investigation (field work), wrote and revised the manuscript; A.D.N acquired funding, conducted the investigation (field work), and revised the manuscript; H.T.D revised the manuscript.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Research Article

A revision of the genus *Eurymesosa* Breuning, 1938 (Cerambycidae, Lamiinae, Mesosini)

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Abstract

A taxonomic revision and redescription of the genus *Eurymesosa* Breuning, 1938 are presented, including a key to species. Three of the five currently accepted species are considered valid: *Eurymesosa ventralis* (Pascoe, 1865), *Eurymesosa allapsa* (Pascoe, 1866) and *Eurymesosa ziranzhiyi* Yamasako & Lin, 2016. Three junior synonyms are proposed for *E. ventralis*: *Eurymesosa albostictica* Breuning, 1962, **syn. nov.**, *Eurymesosa affinis* Breuning, 1970, **syn. nov.**, and *Eurymesosa multinigromaculata* Breuning, 1974, **syn. nov.** Additionally, *E. allapsa* (Pascoe, 1866) is resurrected from synonyms of *E. ventralis*. Females of *E. allapsa* and *E. ziranzhiyi* Yamasako & Lin, 2016 are described for the first time.

Key words: Longhorn beetles, Oriental region, redescription, resurrection, synonymy, taxonomy

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Introduction

The genus *Eurymesosa* presently consists of five species distributed in East Asia and Southeast Asia (Tavakilian and Chevillotte 2023). It was established by Breuning (1938) within the tribe Mesosini Mulsant, 1839 based on the species *Ereis ventralis* Pascoe, 1865. Subsequently, *Eurymesosa albostictica* Breuning, 1962 and *Eurymesosa affinis* Breuning, 1970 were described from Laos (Breuning 1962, 1970), *Eurymesosa multinigromaculata* Breuning, 1974 was described from Cambodia (Breuning 1974) and *Eurymesosa ziranzhiyi* Yamasako & Lin, 2016 (only male) was described from China (Yamasako and Lin 2016).

We found that the taxonomic status of *E. albostictica*, *E. affinis*, *E. multinigromaculata* and *Mesosa allapsa* Pascoe, 1866 [currently a junior synonym of *Eurymesosa ventralis* (Pascoe, 1865)] are doubtful. Moreover, in some cases the sex of the type specimens was not specified in the original description. Therefore, this paper aims to revise and redescribe the genus *Eurymesosa*.

Materials and methods

The specimens examined are deposited in following institutional and private collections:

BMNH	The Natural History Museum, London, United Kingdom
CDJH	Collection Daniel J. Heffern, Houston, Texas, United States
CFV	Collection Francesco Vitali, Luxembourg, Grand-Duchy of Luxembourg
CZJL	Collection Zi-Jun Liu, Xi'an, Shaanxi, China
IZCAS	Insect collection of the Institute of Zoology, Chinese Academy of Sciences, Beijing, China
LPSNU	School of Biological Science and Technology, Liupanshui Normal University, Liupanshui, Guizhou, China
MNHN	Muséum National d'Histoire Naturelle, Paris, France
YZU	The Insect Collection, College of Agriculture, Yangtze University, Jingzhou, Hubei, China

The methods of taking photographs (Figs 4A–D, 5A–D) followed Huang et al. (2020). The photographs were taken with a Canon EOS 5DSR camera equipped with a Canon AF 100 mm macro lens and connected to the software Helicon Remote (Ver. 3.9.7 W); top and bottom focus of the specimens were chosen by adjusting the focus of the lens using Helicon Remote; the shoot was commenced to obtain images at different depths of focus; and finally, images were stacked into a single high resolution image with the software Helicon Focus (Ver. 6.7.1). The copyrights of other photographs were added to legend of corresponding figures. All photographs and figures were produced using Photoshop CS5 software.

Taxonomy

Eurymesosa **Breuning, 1938**

Eurymesosa Breuning, 1938: 366 (key), 391 (original description); Breuning 1959: 49 (catalogue); Rondon and Breuning 1970: 319 (catalogue); Yamasako and Lin 2016: 194 (diagnosis, distribution); Lin and Yang 2019: 331 (catalogue); Danilevsky 2020: 390 (catalogue).

Type species. *Ereis ventralis* Pascoe, 1865.

Redescription. Breuning (1938) described detailed characters in his original description of *Eurymesosa*, but we found it is necessary to improve the description of this genus after examining types of all species and additional material. Thus, we redescribe *Eurymesosa* based on the original description provided by Breuning.

Body elongated oval and robust. Head with single narrow and medial shallow sulcus extending from base of frons to posterior of vertex. Eyes coarsely faceted. Antennae moderately thin, sparsely fringed with long dark brown pubescence beneath, antennae more than 1/2 length of body in males, about 1/4 longer than body in females, apical cicatrix of antennal scape opened, 3rd

antennomere significantly longer than scape and 4th antennomere respectively. Pronotum transverse and slightly rounded laterally, with three irregular calluses (two located at sides of center and one near basal middle), with single anterior transverse groove (middle part nearly missing) and single posterior transverse groove; disc sparsely covered with short white setae. Prosternal process narrow and distinctly lower than procoxae; procoxal cavity closed posteriorly. Scutellum linguiform. Elytra elongated, distinctly wider than pronotum, expanded in middle, widely rounded at apex, with two large, oblique bumps behind middle of base; disc sparsely with coarse granules at base and punctation (punctation slightly coarse at about basal 2/3 of elytra and slightly fine at about apical 1/3 of elytra); each elytron sparsely covered with short white setae; with single sub-rounded or sub-oval dark brown haired spot on above bump, single irregular dark brown haired spot behind humeri and close to margin, single sub-rounded dark brown haired spot before middle, several dark brown haired spots behind middle (number and shape of maculae are different in different species), and with several patchy dark brown maculae near apex. Mesosternal process with single tubercle in center, midcoxal cavity open to epimeron externally. Femora strongly claviform, mid-tibiae without groove.

Differential diagnosis. Based on the descriptions of the genera *Eurymesosa* and *Mesosa* Latreille, 1829 provided by Breuning (1938), we found that *Eurymesosa* is similar to *Mesosa* in its elongated oval body, the antennae thin and fringed beneath, the apical cicatrix of antennal scape opened, the 3rd antennomere significantly longer than scape, the elytra widely rounded at apex, the prosternal process lower than procoxae, and the mid-tibiae without a groove. However, *Eurymesosa* differs from *Mesosa* in having the eyes strongly reniform (upper lobe and lower lobe of eyes subdivided in *Mesosa*), the elytra with two large, oblique bumps behind the middle of the base (without two large, oblique bumps behind middle of base in *Mesosa*), the mesosternal process with a single tubercle in the middle (without tubercles in middle in *Mesosa*).

Distribution. Cambodia, China, Indonesia (parts of Borneo), Laos, Malaysia (Peninsular Malayasia, parts of Borneo), Vietnam.

Eurymesosa allapsa **(Pascoe, 1866), stat. resurr.**

Fig. 1A–I

Mesosa allapsa Pascoe, 1866: 231 (type locality: “Penang, Malaysia”).
Eurymesosa ventralis m. *allapsa*: Breuning 1938: 391; Breuning 1959: 49 (catalogue).

Type material examined. ***Holotype***, ♂ (BMNH), *Mesosa allapsa* Typ Pasc (handwritten with black ink on a rectangular white label) / *Mesosa allapsa* Penang Pasc. (handwritten with black ink on a rectangular white label with a longitudinal black line at left side) / Penang (handwritten with black ink on an olive-green label) / Pascoe Coll. 93–60. (printed with black ink on a rectangular white label) / Type (printed with black ink on a circular white label with circular red borders) / NHMUK 014596800 plus a QR (quick response) code (printed with black ink on a rectangular white label); examined from five photographs (Fig. 1A–E).

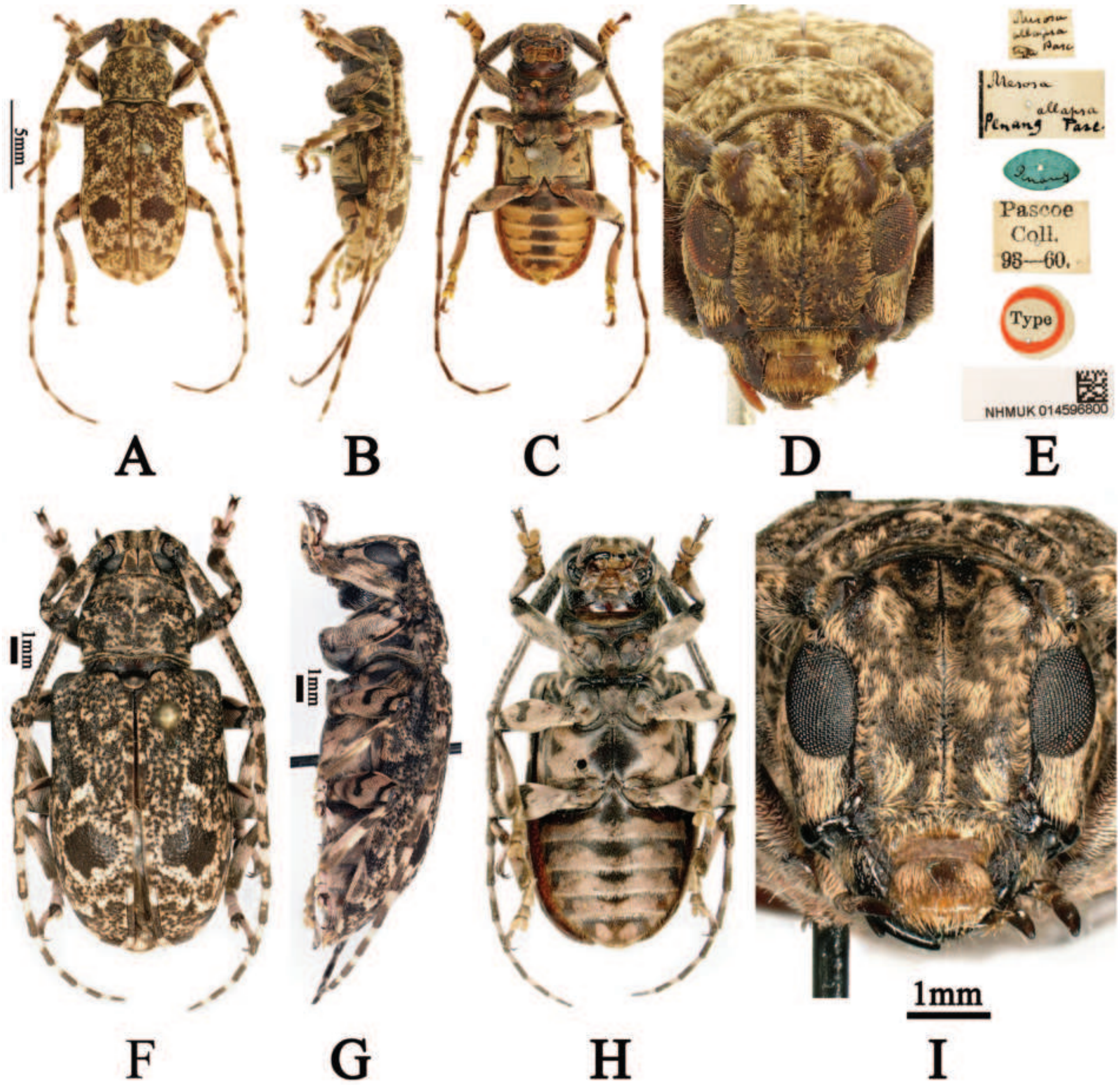

Figure 1. A–I *Eurymesosa allapsa* **A–E** *Mesosa allapsa*, holotype **A** male, dorsal habitus **B** male, lateral habitus **C** male, ventral habitus **D** male, frontal view **E** labels (photographs **A–E** were taken by Guang-Lin Xie) **F–I** *Eurymesosa allapsa*, female **F** dorsal habitus **G** lateral habitus **H** ventral habitus **I** frontal view (photographs **F–I** were taken by Francesco Vitali).

Additional materials examined. 1 ♀ (CFV), Mt. Bawang, Kalimantan, Borneo, Indonesia, II.2018, leg. local collector; examined from four photographs (Fig. 1F–I). 3 ♀♀ (CDJH), all from Sabah (Crocker Range, 18.III.1999; Mt. Trus-Madi, 14.IV.2001; Ranau, 17.II.2005), Borneo, Malaysia, leg. local collectors. 1 ♂ (CDJH), Tawau, Sabah, Borneo, Malaysia, 1.V.2016, leg. local collector.

Description of female. Similar to male, but with the body length: 14.0–15.4 mm (4 specimens). One of the specimens (Fig. 1F–I), body length: 15.4 mm, antennae 1.28 times as long as body, length (mm) of each antennomere: scape = 3.4, pedicel= 0.4, III = 3.8, IV= 2.7, V = 2.0, VI = 1.5, VII = 1.4, VIII = 1.2, IX = 1.2, X= 1.1, X I = 1.0; elytra 1.6 times as long as wide.

Comments. After exposing the lateral lobes of the tegmen (Fig. 1C), it was possible to confirm that the holotype of *M*. *allapsa* is a male. Breuning (1938) treated *M*. *allapsa* as an infraspecific variation or morph of *E*. *ventralis* based on the character "The two dark brown postmedian disc spots on each elytron are joined by a single larger spot". After comparing the holotypes of the above two species (Figs 1A–D, 2A–D), we found that *M*. *allapsa* can be clearly distinguished from *E*. *ventralis* by the following characters: the pubescent bands on the vertex are brown with light pink border (pubescent bands on vertex are yellowish brown for *E*. *ventralis*), each elytron covered with patchy dark brown maculae in basal half, with a single large irregular black spot behind middle, with patchy dark brown maculae in middle and near apical 1/4 (each elytron covered with patchy yellowish-brown maculae in basal half, with several small irregular black spots behind middle, with patchy yellowish-brown maculae in middle and near apical 1/4 for *E*. *ventralis*), femora, apical 2/3 of tibiae and dorsum of two basal joints and last joint of tarsi covered with short light pink pubescence (femora, apical 2/3 of tibiae and dorsum of two basal joints and last joint of tarsi covered with short yellowish-brown pubescence for *E*. *ventralis*). We thus resurrect *M*. *allapsa* and decide to keep it in the genus *Eurymesosa*.

Distribution. Malaysia (Penang, Sabah), Indonesia (Kalimantan).

***Eurymesosa ventralis* (Pascoe, 1865)**
Fig. 2A–P

Ereis ventralis Pascoe, 1865: 105 (type locality: "Cambodia").
Eurymesosa ventralis: Breuning 1938: 391 (redescription); Breuning 1959: 49 (catalogue).
Mesosa nigromaculata Pic, 1932: 26 (type locality: "Tonkin, Vietnam").
Eurymesosa ventralis m. *nigromaculata*: Breuning 1938: 391; Breuning 1959: 49 (catalogue).
Eurymesosa albostictica Breuning, 1962:15 (type locality: "Vientiane, Laos"); Rondon and Breuning 1970: 319, fig. 1b. syn. nov.
Eurymesosa affinis Breuning, 1970: 363 (type locality: "Laos"). syn. nov.
Eurymesosa multinigromaculata Breuning, 1974: 72 (type locality: "Cambodia"). syn. nov.

Type materials examined. *Ereis ventralis* Pascoe, 1865: *holotype*, ♂ (BMNH), *Ereis ventralis* Typ Pasc (handwritten with black ink on a rectangular white label) / *Ereis ventralis* Cambodia Pasc (handwritten with black ink on a rectangular white label with a black line under "Cambodia Pasc") / Cambodia (handwritten with black ink on a olive-green label) / Pascoe Coll. 93–60. (printed with black ink on a rectangular white label) / Type (printed with black ink on a circular white label with circular red borders) / NHMUK 014596801 plus a QR (quick response) code (printed with black ink on a rectangular white label); examined from five photographs (Fig. 2A–E). ***Mesosa nigromaculata* Pic, 1932: *holotype***, ♀ (MNHN), Tonkin (handwritten with black ink on a rectangular white label) / Bien hoa (handwritten with black ink on a rectangular white label) / *Mesosa nigromaculata* n sp (handwritten with black ink on a rectangular white label) / *Mesosa allapsa* Pasc. var. (Breuning vid 1935) (handwritten with black ink on a rectangular white label)

/ *M*. *nigromaculata* Pic (handwritten with black ink on a rectangular white label) / TYPE (printed with black ink on a rectangular red label) / Museum Paris Coll. M. Pic (printed with black ink on a rectangular white label with black borders); examined from three photographs (Fig. 2F–H). ***Eurymesosa affinis* Breuning, 1970: *holotype***, ♀ (MNHN), Pach Mouhot (“Pach” handwritten and “Mouhot” printed with black ink on a rectangular white label with a transversal back line in middle) / TYPE (printed with black ink on a rectangular red label) / *Eurymesosa affinis* mihi Typ Breuning dét. (“*Eurymesosa affinis* mihi Typ” handwritten and “Breuning dét.” printed with black ink on a rectangular white label) / HOLOTYPE (printed with black ink on a rectangular red label) / HOLOTYPE *Eurymesosa affinis* Breuning, 1970 (printed with black ink on a rectangular white label) \ MNHN, Paris EC23124 plus a QR (quick response) code (printed with black ink on a rectangular white label); examined from four photographs (Fig. 2I–L). ***Eurymesosa multinigromaculata* Breuning, 1974: *holotype***, ♀ (MNHN), Cambodia (handwritten with black ink on a rectangular white label) / MUSEUM PARIS COLL. H.W. BATES 1952 (printed with black ink on a rectangular white label) / *Eurymesosa multinigromaculata* mihi Typ Breuning dét. (“*Eurymesosa multinigromaculata* mihi Typ” handwritten and “Breuning dét.” printed with black ink on a rectangular white label) / TYPE (printed with black ink on a rectangular red label) / HOLOTYPE (printed with black ink on a rectangular red label) / HOLOTYPE *Eurymesosa multinigromaculata* Breuning, 1974 (printed with black ink on a rectangular white label) / MNHN, Paris EC23125 plus a QR (quick response) code (printed with black ink on a rectangular white label); examined from four photographs (Fig. 2M–P).

Comments. After comparing the holotypes of *E*. *ventralis* (Fig. 2A–D), *E*. *albostictica* (the holotype photograph is available at: http://bezbycids.com/byciddb/wdetails.asp?id=31562&w=o), *E*. *affinis* (Fig. 2I–K) and *E*. *multinigromaculata* (Fig. 2M–O), we found they were identical except for gender and body color. Pascoe (1865) did not mention the body color of *Ereis ventralis* in the original description, while Breuning (1938) transferred *E*. *ventralis* to *Eurymesosa* and stated that its body color was dark brown; the body color of *E*. *albostictica* was dark brown in the original description (Breuning 1962). The body color of *E*. *affinis* and *E*. *multinigromaculata* are reddish brown, but Breuning (1974) described the body color of *E*. *multinigromaculata* as dark brown in the original description. Perhaps the body color of *E*. *multinigromaculata* had faded to reddish brown and similarly for *E*. *affinis*.

There is no information in the literature regarding the sex of the holotypes of *E*. *ventralis*, *M*. *nigromaculata*, *E*. *affinis* and *E*. *multinigromaculata*, but we could confirm that the holotype of *E*. *ventralis* is a male, and the holotypes of *M*. *nigromaculata*, *E*. *affinis* and *E*. *multinigromaculata* are females, based on the description of *Eurymesosa* provided by Breuning (1938) and referring to other species (antennae are about 1/4 longer than body in females).

Breuning (1938) provided the following localities for *E*. *ventralis* (currently *E*. *ventralis* + *E*. *allapsa*): “Cambodge; Presqu’ île de Malacca: Penang (PASCOE); Tonkin: Hoa-Binh (collection Pic); Java; Bornéo: Sandakan (Musée de Dresde)”. We verified the localities of *E*. *ventralis* across Cambodia, Laos and Vietnam through the examined material (Fig. 2A–P). However, we could not confirm whether the Java locality mentioned by Breuning (1938) pertains to *E*. *allapsa* or *E*. *ventralis*; hence, we omitted the Java locality from the records of *E*. *ventralis*.

Distribution. Cambodia, Laos (Pachbon, Vientane), Vietnam (Hoa-Binh).

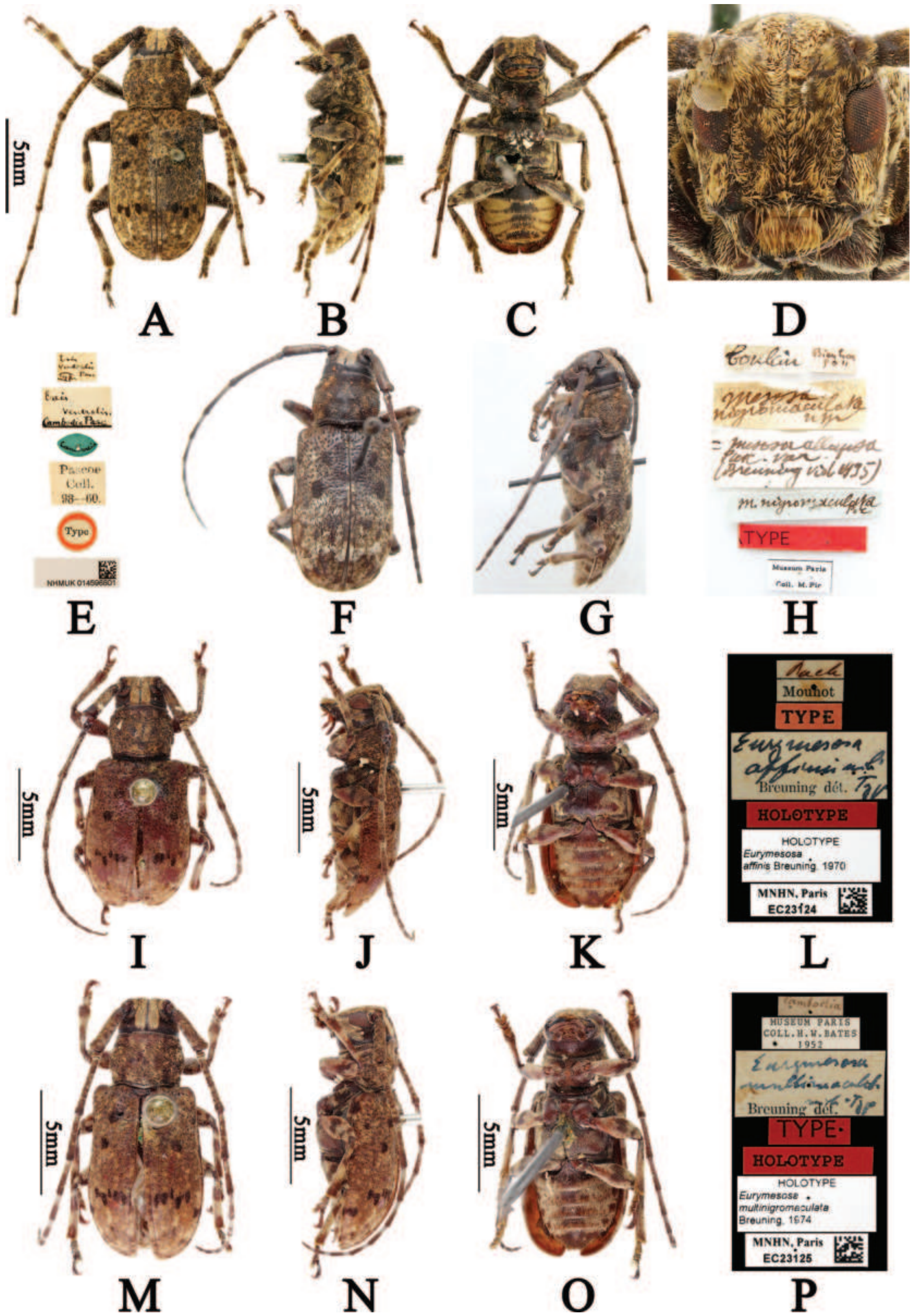

Figure 2. **A–P** *Eurymesosa ventralis* **A–E** *Ereis ventralis*, holotype **A** male, dorsal habitus **B** male, lateral habitus **C** male, ventral habitus **D** male, frontal view **E** labels (photographs **A–E** were taken by Guang-Lin Xie) **F–H** *Mesosa nigromaculata*, holotype **F** female, dorsal habitus **G** female, lateral habitus **H** labels (photographs **F–H** were taken by Xavier Gouverneur) **I–L** *Eurymesosa affinis*, holotype **I** female, dorsal habitus **J** female, lateral habitus **K** female, ventral habitus **L** labels **M–P** *Eurymesosa multinigromaculata*, holotype **M** female, dorsal habitus **N** female, lateral habitus **O** female, ventral habitus **P** labels (photographs **I–P** were taken by Christophe Rivier).

Eurymesosa ziranzhiyi **Yamasako & Lin, 2016**
Figs 3A–F, 4A–F, 5A–E

Eurymesosa ziranzhiyi Yamasako & Lin, 2016: 194 (type locality: "Yangjiahe, Huayangzhen, Yangxian, Shaanxi, China"), figs 1–3 (holotype, male), 4–10 (holotype, male genitalia); Lin and Yang 2019: 331 (catalogue); Danilevsky 2020: 390 (catalogue).

Type materials examined. *Holotype*, ♂ (IZCAS): left hind wing, male terminalia, metendosternite and abdomen are affixed with glue onto a rectangular white label / 陕西洋县华阳镇杨家河 2014-VI-2-7 张巍巍 中国科学院动物所 (printed with black ink on a rectangular white label with black borders) / IOZ(E)1905367 (printed in black ink on a rectangular white label with a red underline) / Ceram-82 (handwritten with black ink on a rectangular white label) / HOLOTYPE *Eurymesosa ziranzhiyi* Yamasako & Lin, 2016 (handwritten with black ink on a rectangular red label); examined from two photographs (Fig. 3A–B). ***Paratype***, 1♂ (IZCAS): 陕西佛坪 950m 1998.VII.23 姚建 中科院动物所 (printed with black ink on a rectangular white label with black borders) / IOZ(E)1905366 (printed in black ink on a rectangular white label with a red underline) / PARATYPE *Eurymesosa ziranzhiyi* Yamasako & Lin, 2016 (handwritten with black ink on a rectangular yellow label); examined from two photographs (Fig. 3C–D). ***Paratype***, 1♂ (IZCAS): No:95–7–036 目别：鞘翅目 种名： 采集时间:1993.3.5 采集人：昝艳燕 采集地点：木鱼 ("No:目别：种名：采集时间：采集人：采集地点:" with a black underline printed and "95–7–036 鞘翅 1993.3.5 昝艳燕 木鱼" handwritten with black ink on a rectangular white label) / IOZ(E)1905365 (printed in black ink on a rectangular white label with a red underline) / metendosternite, left hind wind, abdomen, male terminalia and antennomeres VI–XI were pasted with glue on a rectangular white label / PARATYPE *Eurymesosa ziranzhiyi* Yamasako & Lin, 2016 (handwritten with black ink on a rectangular yellow label); examined from two photographs (Fig. 3E–F).

Additional materials examined. 1♂ (LPSNU, fig. 4A–F), 1♀ (LPSNU, fig. 5A–E), Longwangping, Shengkang Town, Gucheng County, Xiangyang City, Hubei Province, China, 7.V.2023, leg. Mao-Ye; 1♀ (YZU), Hongshiyao Village, Huayang Town, Yang County, Shaanxi Province, China, 33.64°N, 107.49°E, Alt. 1270 m, 12.V.2018, leg. Xiaoqing Lu; 1♂ (CZJL), Zhuque Forest Park, Huyi District, Xi'an City, Shaanxi Province, China, Alt. 1500 m, 5.VII.2021. leg. Zi-Jun Liu; 1♀ (LPSNU ex CZJL), Shuitianping, Yangguan Village, Zhenping County, Ankang City, Shaanxi Province, China, 20.VII.2023, leg. Zi-Jun Liu.

Description of female. Similar to male, but body length: 12.27–16.2 mm (3 specimens). One of the specimens (Fig. 5A–D), body length: 16.2 mm, antennae 1.2 times as long as body, length (mm) of each antennomere: scape = 3.25, pedicel= 0.5, III = 3.6, IV= 2.5, V = 2.0, VI = 1.75, VII = 1.5, VIII = 1.4, IX = 1.25, X = 1.0, X I = 0.75; elytra 1.72 times as long as wide.

Comments. According to Mr Mao Ye (pers. comm.) an unknown rotten vine was broken apart by hand, exposing numerous ants, a live male adult (Fig. 4E–F) and a female pupa (Fig. 5E) of *E. ziranzhiyi*. The live adult was placed on surface litter and the pupa was placed on a dried leaf for photographs. The pupa eclosed after several days.

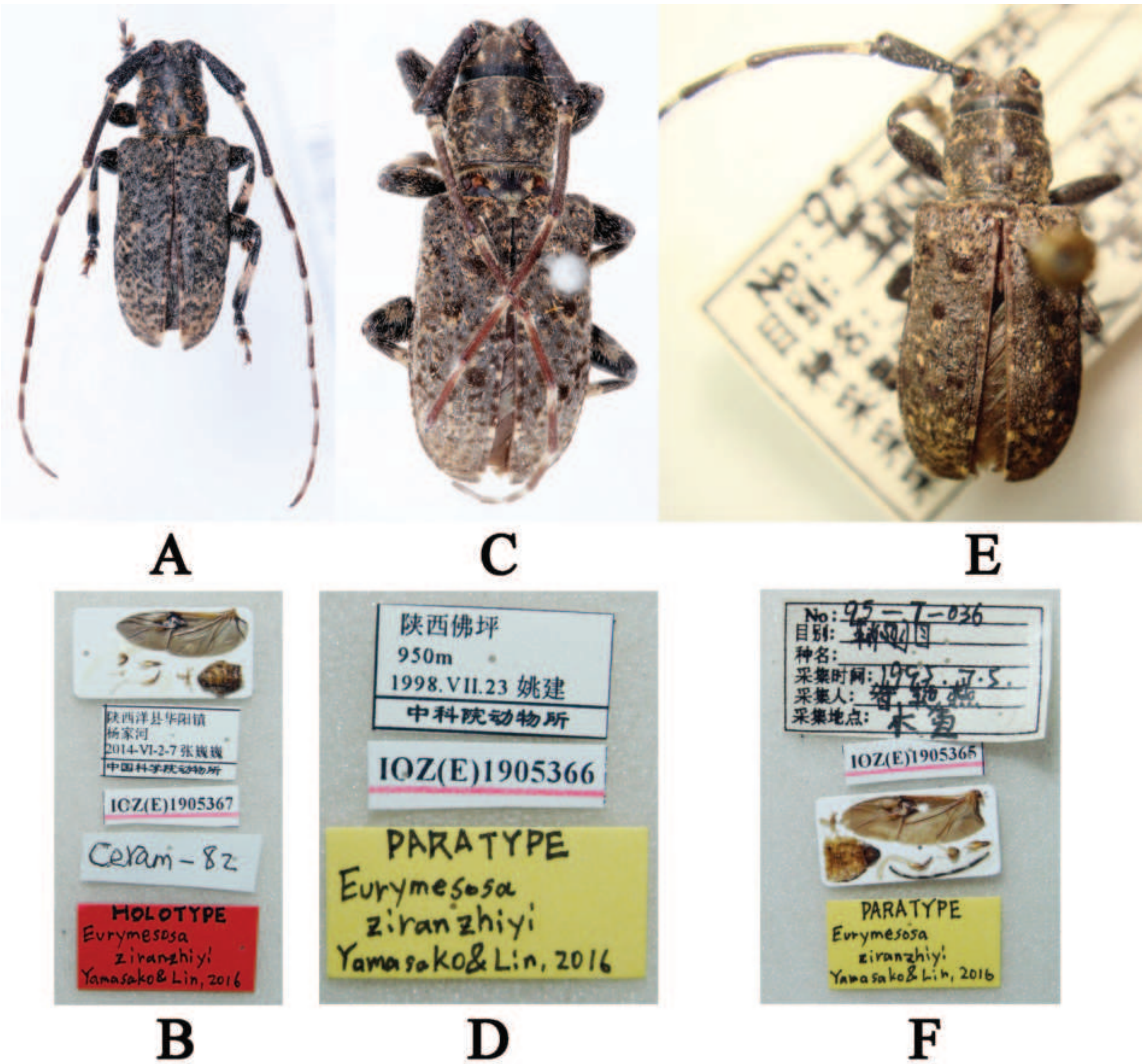

Figure 3. A–F *Eurymesosa ziranzhiyi* **A** holotype male, dorsal habitus **B** holotype labels **C** paratype male, dorsal habitus **D** paratype labels **E** paratype male, dorsal habitus **F** paratype labels (all photographs were taken by Mei-Ying Lin).

The two inward oblique and sub-oval pubescent pink spots on the vertex are not well-defined on some males (Figs 3A, 4A), the two sub-rounded pink spots on the sides of the center of the frons are not well-defined on some males (Fig. 3 in Yamasako and Lin 2016, fig. 4D) and a female deposited in YZU.

Distribution. China (Hubei, Shaanxi).

Key to species of *Eurymesosa*

1	Vertex covered with two inward oblique and sub-oval pink pubescent spots (Figs 3A, 3C, 3E, 4A, 4D, 5A, 5D) close to upper lobe of eyes............. ....***E. ziranzhiyi***	
–	Vertex covered with two longitudinal and wide pubescent bands (Figs 1A, 1D, 1F, 1I, 2A, 2D, 2F, 2I, 2M) close to upper lobe of eyes............................**2**	

2 Pubescent bands on vertex brown with light pink border (Fig. 1A, 1D, 1F, 1I). Each elytron covered with patchy dark brown maculae in basal half, with a large irregular black macula behind middle; disc with patchy dark brown maculae in middle and near apical 1/4 (Fig. 1A, 1F). Femora, apical 2/3 of tibiae and dorsum of two basal joints and last joint of tarsi covered with short light pink pubescence (Fig. 1A–C, F–H) .... ***E. allapsa***

– Pubescent bands on vertex yellowish brown (Fig. 2A, 2D, 2F, 2I, 2M). Each elytron covered with patchy yellowish-brown maculae in basal half, with several small irregular black maculae behind middle; disc with patchy yellowish-brown maculae in middle and near apical 1/4 (Fig. 2A, 2F, 2I, 2M). Femora, apical 2/3 of tibiae and dorsum of two basal joints and last joint of tarsi covered with short yellowish-brown pubescence (Fig. 2A–C, 2F, 2G, 2I–K, 2M–O) .... ***E. ventralis***

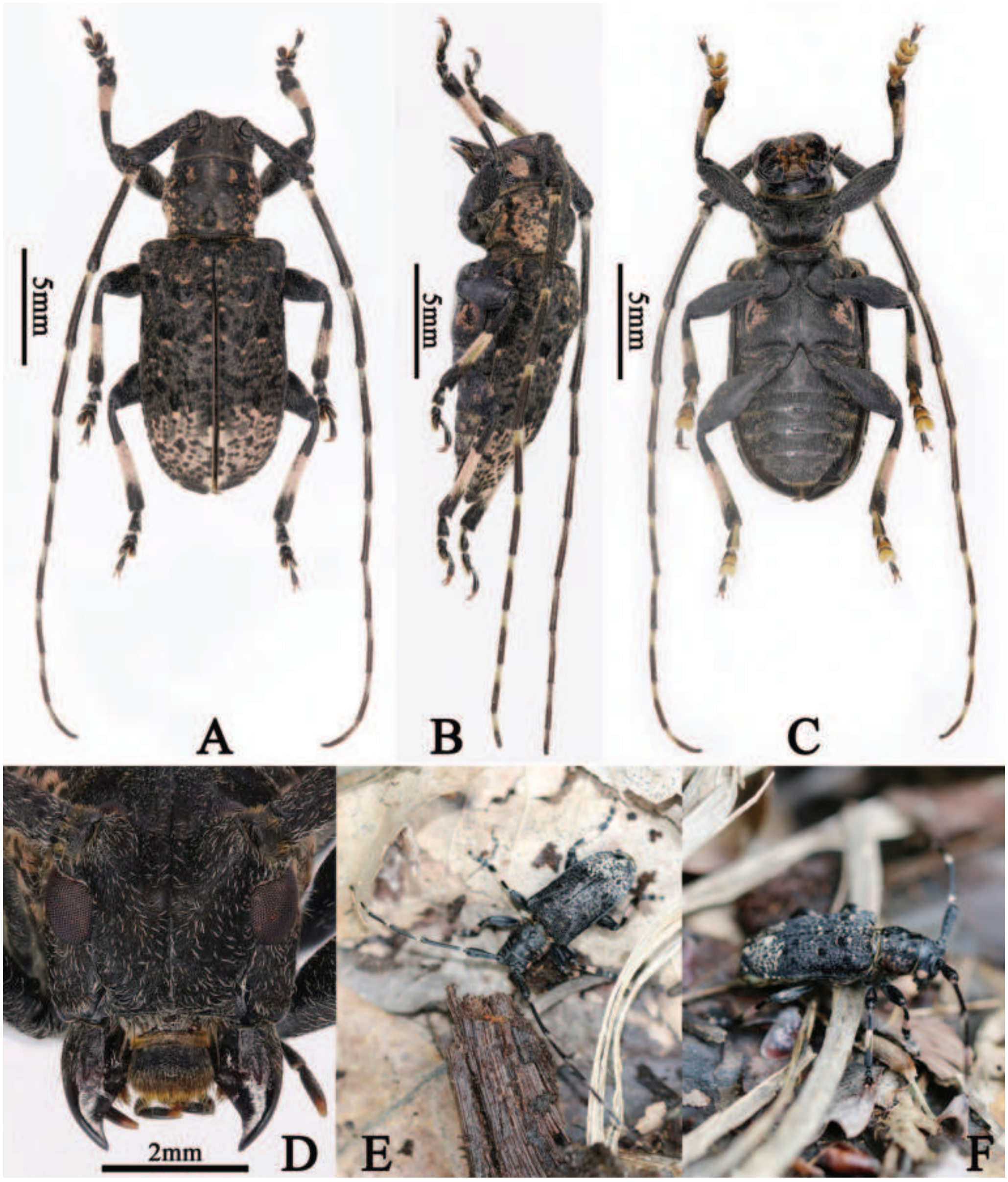

Figure 4. A–F *Eurymesosa ziranzhiyi*, male **A** dorsal habitus **B** lateral habitus **C** ventral habitus **D** frontal view (photographs **A–D** were taken by Xian Zhou) **E–F** live adult **E** dorsal habitus **F** lateral habitus (photographs **E–F** were taken by Mao Ye).

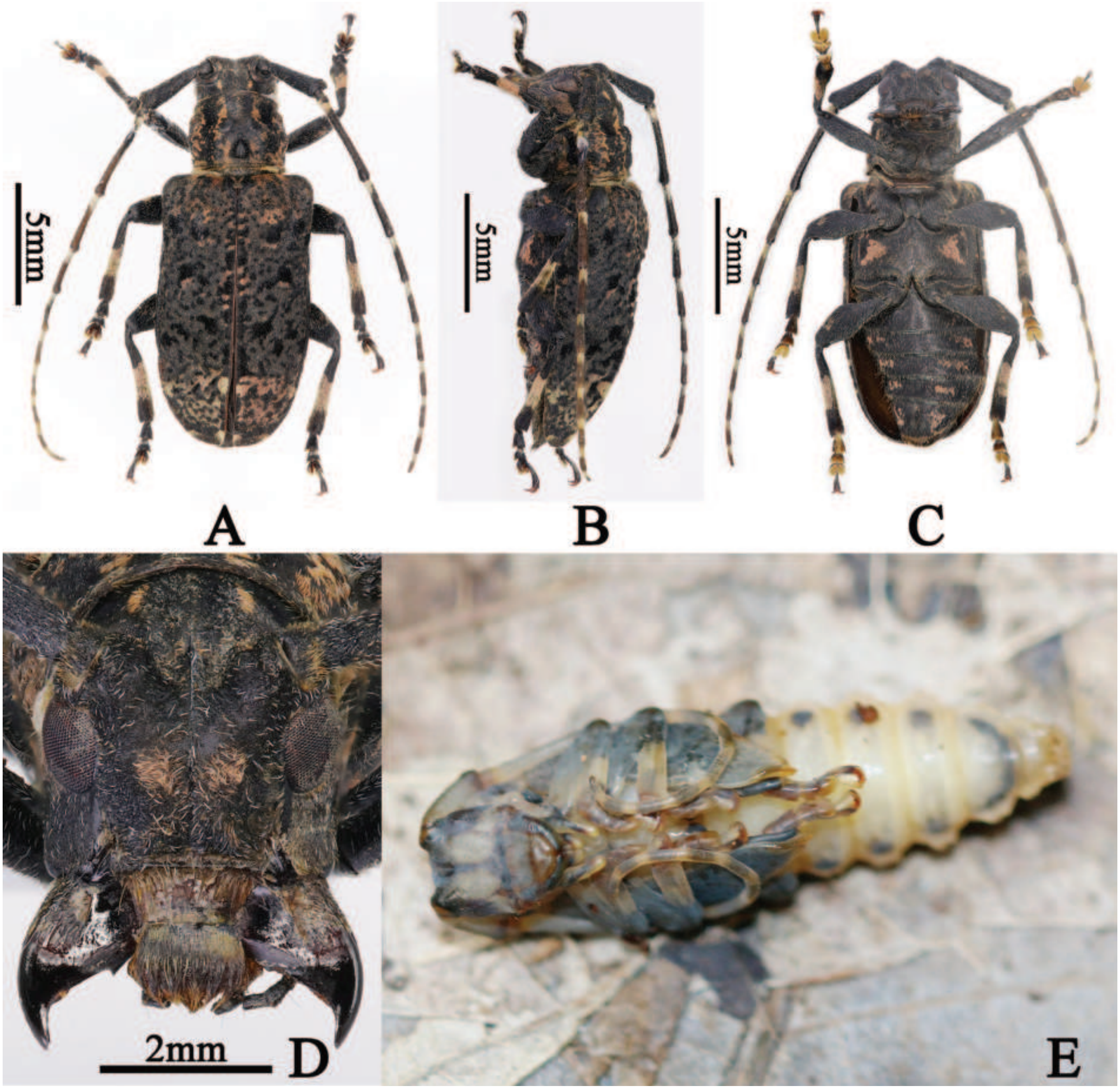

Figure 5. A–E *Eurymesosa ziranzhiyi*, female **A** dorsal habitus **B** lateral habitus **C** ventral habitus **D** frontal view (photographs **A–D** were taken by Xian Zhou) **E** living pupa (photograph **E** was taken by Mao Ye).

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Data availability

All of the data that support the findings of this study are available in the main text.

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DOI: 10.3897/zookeys.1193.116538

Research Article

Two new species and new host and distribution records of *Gnathia* Leach, 1814 (Crustacea, Isopoda, Gnathiidae) from Western Australia and the Great Barrier Reef, Australia

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Abstract

Gnathia antennacrassa **sp. nov.** from seagrass beds off Rottnest Island, Western Australia is the first record of any gnathiid from the entirety of Western Australia; the male can be distinguished from congeners by the stout peduncular articles of the antenna. *Gnathia taurus* **sp. nov.** is described from two adult specimens reared from praniza larvae found infecting elasmobranch fishes at Heron Island, southern Great Barrier Reef; the males can be distinguished from all congeners by the dorsally strongly elongate mandibles and smoothly rounded mediofrontal process on the anterior part of cephalosome. *Gnathia* aff. *maculosa* Ota & Hirose, 2009 is recorded from Australia, together with further records of *G. trimaculata* Coetzee, Smit, Grutter & Davies, 2009 and *G. grandilaris* Coetzee, Smit, Grutter & Davies, 2008, all from elasmobranch fishes.

Key words: Coral reefs, elasmobranchs, Heron Island, Lizard Island, marine fish parasites, Rottnest Island, taxonomy

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Introduction

The isopod family Gnathiidae Leach, 1814, exhibits a biphasic lifecycle characterised by morphological differentiation among its larvae (juveniles) as well as between adult males and adult females. Gnathiid larvae are temporary ectoparasites of marine teleosts and elasmobranchs. In contrast, the adult stage is non-parasitic and reproduces in benthic substrates (Smit and Davies 2004; Tanaka 2007).

The Gnathiidae includes 12 genera and approximately 240 species worldwide (Boyko et al. 2023). The Australia gnathiids are represented by seven genera and 60 species, which have almost exclusively been described from the eastern coasts of Australia from South Australia to Queensland. The majority of species in Australia were collected from benthic substrata (Haswell 1884; Beddard 1886; Hale 1924; Monod 1926; Cals, 1973; Seed 1979; Holdich and Harrison 1980; Cohen and Poore 1994; Svavarsson and Bruce 2012, 2019), while several studies have described species from adult specimens reared from juveniles collected from host fishes (Coetzee et al. 2008, 2009; Ferreira et al. 2009, 2010; Farquharson et al. 2012).

Two new species are here described, *Gnathia antennacrassa* sp. nov. from Rottnest Island, southern Western Australia and *Gnathia taurus* sp. nov. from Heron Island, southern Great Barrier Reef (GBR). Additionally, we report *Gnathia* aff. *maculosa* Ota & Hirose, 2009, a new record for Australia and provide new host and distribution records of two other *Gnathia* species from the GBR.

Materials and methods

Larval isopod samples from the GBR were collected from five elasmobranch species as part of parasitological research on elasmobranchs conducted during the 1990s (Great Barrier Reef Marine Park Permit no. G96/543). These samples were reared to adults in vials containing seawater. Some of these larvae moulted into adult males suitable for species description.

Adult male specimens were preserved in 70% ethanol, and total length measured between the tip of the mandibles and posterior margin of pleotelson. Additionally, their body length was measured between the anterior margins of the frontal processes and posterior margin of pleotelson. Specimens were cleaned using a fine hair of saturated polyester resin and dissected with sharpened tungsten needles. The appendages were removed from the body and then mounted in CMCP-10 high-viscosity medium (Polyscience, Warrington, PA, USA). Observations were conducted using a phase-contrast light microscope, and drawings were made using a camera lucida.

For scanning electron microscope (SEM) examination, one specimen was dehydrated in 99% ethanol for a day and air-dried. The dried specimen was mounted on brass SEM stubs using double-sided conductive tape, followed by sputter-coating with platinum, and then photographed using a Hitachi SU3900 SEM. New descriptions were prepared in DEscriptive Language for TAxonomy (DELTA; Dallwitz 2018) using a modified *Gnathia* character set (Erasmus et al. 2023). Descriptive terminology follows Smit and Davies (2004) for setal classification and Cohen and Poore (1994) for the male morphology. Most literature in Gnathiidae treats the fourth article of antennule as the first article of the flagellum, but this article has penicillate seta characteristic of the peduncles, so it is treated as the fourth article of the peduncles. The scientific names used in the host fish records follow FishBase (Froese and Pauly 2023).

Abbreviations: **BL**—body length; **GBR**—Great Barrier Reef, Queensland; **QM**—Queensland Museum, Brisbane; **SEM**—scanning electron microscope; **TL**—total body length; **WAM**—Western Australian Museum, Perth.

Taxonomy

Suborder Cymothoida Wägele, 1989
Superfamily Cymothooidea Leach, 1814
Family Gnathiidae Leach, 1814

***Gnathia* Leach, 1814**

Type species. *Gnathia termitoides* Leach, 1814 (= *Cancer maxillaris* Montagu, 1804); by monotypy (Cohen and Poore 1994); type locality: south coast of Devon, Cornwall Peninsula, south west England.

Gnathia antennacrassa **sp. nov.**
https://zoobank.org/DB30A1C7-2DCE-458B-920C-56AD365203EE
Figs 1–3

Diagnosis. Anterior part of body (cephalosome and pereonites 1–4) not densely covered by tubercles; frontal margin with serrated triangular mediofrontal process and two superior frontolateral processes; paraocular ornamentation not developed; pereonite 1 not reaching lateral margins of cephalon; pereonites 4–6 with two lateral lobes; epimera of pleonites 1–5 not prominent; pleotelson 0.8 × shorter than its anterior width; lateral side of pleotelson sinuate; maximum width of peduncle article of antenna 3.2 × maximum width of flagellar article; article 1 of pylopod with two areolae; appendix masculina of pleopod 2 0.8 × as long as endopod; endopod of uropodal rami extend beyond apex of pleotelson; exopod of uropodal rami almost apex of pleotelson.

Material examined. ***Holotype***. Australia • 1♂ (2.4 mm TL, 1.9 mm BL, dissected); sandy substrata of seagrass *Amphibolis griffithii* (J.M. Black) Hartog, 1970 patch bed surrounded by the seagrass *Posidonia sinuosa* Cambridge & Kuo, 1979 bed, 5 m depth, Thomson Bay, Rottnest Island, Western Australia (32°00'S, 115°32.5'E), 18 January 1996, Hiroshi Mukai leg. (WAM C-79675).

Type locality. Thomson Bay, Rottnest Island, Western Australia (32°00'S, 115°32.5'E).

Description. ***Body*** (Figs 1, 2A) 2.7 × as long as greatest width, widest at pereonite 2; dorsal surfaces smooth, sparsely setose. ***Cephalosome*** (Fig. 1A–C) rectangular, 0.7 × as long as wide, lateral margins parallel, posterior margin concave; dorsal surface tubercles around eyes; dorsal sulcus wide, shallow, short; translucent region present, elliptical; paraocular ornamentation not developed, posterior median tubercle absent. ***Frontolateral processes*** present. ***Frontal margin*** (Fig. 1B) straight, median point with process. ***External scissura*** present, wide, shallow. ***Mediofrontal process*** present, strong, serrate triangular, without ventral notch and fine setae. ***Superior frontolateral process*** present, single, strong, conical, with three pairs of long simple setae. ***Inferior frontolateral process*** absent. ***Supraocular lobe*** not pronounced; accessory supraocular lobe not pronounced. ***Eyes*** present, round, 0.3 × as long as cephalosome length, contiguous with head surface, ommatidia arranged in rows, eye colour faded.

Pereon (Figs 1, 2A) lateral margins narrowing posteriorly, with few setae; anteriorly smooth. ***Pereonite 1*** not fused dorsally with cephalosome. ***Pereonite 2*** wider than pereonite 1. ***Pereonite 4*** with anterior constriction, median groove present. ***Areae laterales*** present on pereonite 4 and pereonite 5, with two lateral lobes, dorsal sulcus wide. ***Pereonite 6*** with strongly developed lobi laterales, lobuii weak, conical. ***Pereonite 7*** short, narrow, and overlapping pleonite 1. ***Pleon*** epimera not dorsally visible on pleonites. ***Pleonites*** (Figs 1, 2A) lateral margins with one pair of simple setae, with two pairs of simple setae medially. ***Pleotelson*** (Fig. 2D) 0.8 × as long as anterior width, not covered in pectinate scales; lateral margins smooth, anterolateral margins concave, without submarginal seta; posterolateral margin concave, with one pair of submarginal setae, mid-dorsal surface with a pair of sub-median setae, apex with two setae.

Antennula (Fig. 2E) composed of four peduncular and three flagellar articles, 0.8 × as long as antenna; peduncle article 2 0.6 × as long as article 1; article 3 2.1 × as long as article 2, 2.9 × as long as wide; flagellum as long article 3;

Figure 1. Photograph of fixed *Gnathia antennacrassa* sp. nov. (holotype, WAM C-79675). Scale bar: 1 mm.

article 3 with one aesthetasc and one simple seta; article 4 terminating with one aesthetasc and four simple setae. ***Antenna*** (Fig. 2F) composed of four peduncular and seven flagellar articles; maximum width of peduncle article 3.2 × the maximum width of flagellar articles; peduncle article 3 1.7 × as long as wide, 0.7 × as long as article 2, with one penicillate seta, and nine simple setae; article 4 as long as article 3, 1.5 × as long as wide, and with 20 simple setae; flagellum 1.2 × as long as article 4, with seven articles, terminating with two simple setae.

Mandible (Figs 1, 2A–C) 0.7 × as long as cephalosome; triangular, weakly mesially curved; apex 20% total length; mandibular seta present. ***Carina*** present, smooth along proximal half. ***Incisor*** elevated, standing clear of surface. ***Blade*** present, dentate, weakly convex, straight, dentate along 58% of margin. ***Pseudoblade***, internal lobe, and dorsal lobe absent; basal neck short; erisma present; lamina dentata not visible in dorsal view.

Maxilliped (Fig. 3A). Article 1 lateral margin with continuous marginal scale-setae; article 2 lateral margin with three plumose setae; article 3 lateral margin with eight plumose setae; article 4 lateral margin with five plumose setae; 5 lateral margin with six plumose setae, and three simple setae; endite extending to distal margin of article 2.

Pylopod (Fig. 3B). Article 1 2.0 × as long as wide; with two distinct areolae; without distolateral lobe; posterior and lateral margins forming rounded curve; lateral margin with 24 plumose setae; mesial margin with continuous fringe setae; distal margin with five simple setae; article 2 1.2 × as long as wide, with five simple setae; article 3 semicircular with two short setae.

Pereopod 2 (Fig. 3C) sparsely covered with short simple setae on basis and ischium, inferior margins with prominent tubercles on basis to carpus; basis 1.3 × as long as greatest width, superior margin with three simple setae, inferior

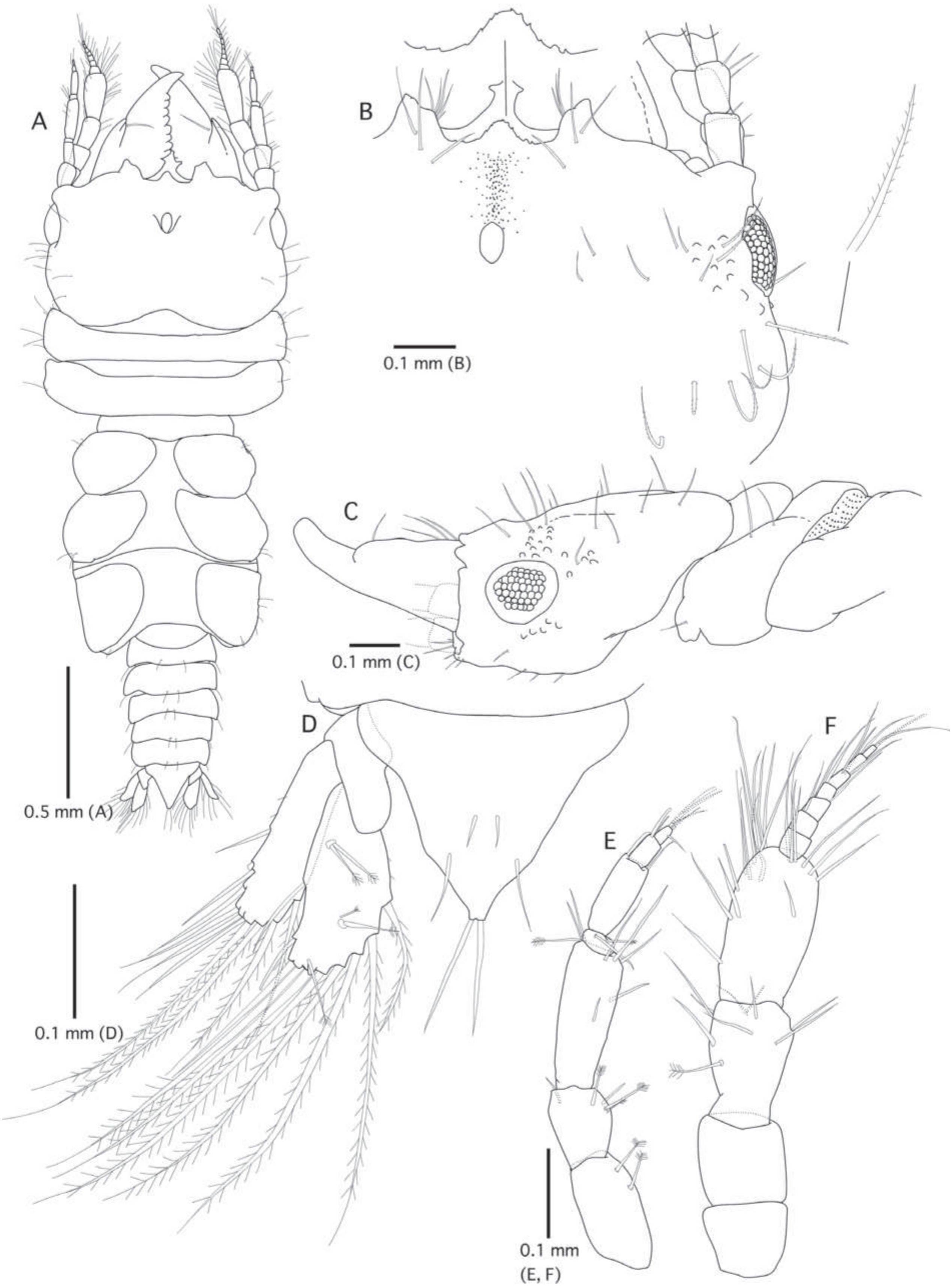

Figure 2. *Gnathia antennacrassa* sp. nov. (holotype, WAM C-79675) **A** whole body (dorsal view) **B** cephalosome and mandible (dorsal view) **C** pereonite 1, cephalosome, and mandible (left lateral view) **D** pleotelson (dorsal view) **E** left antennula **F** left antenna.

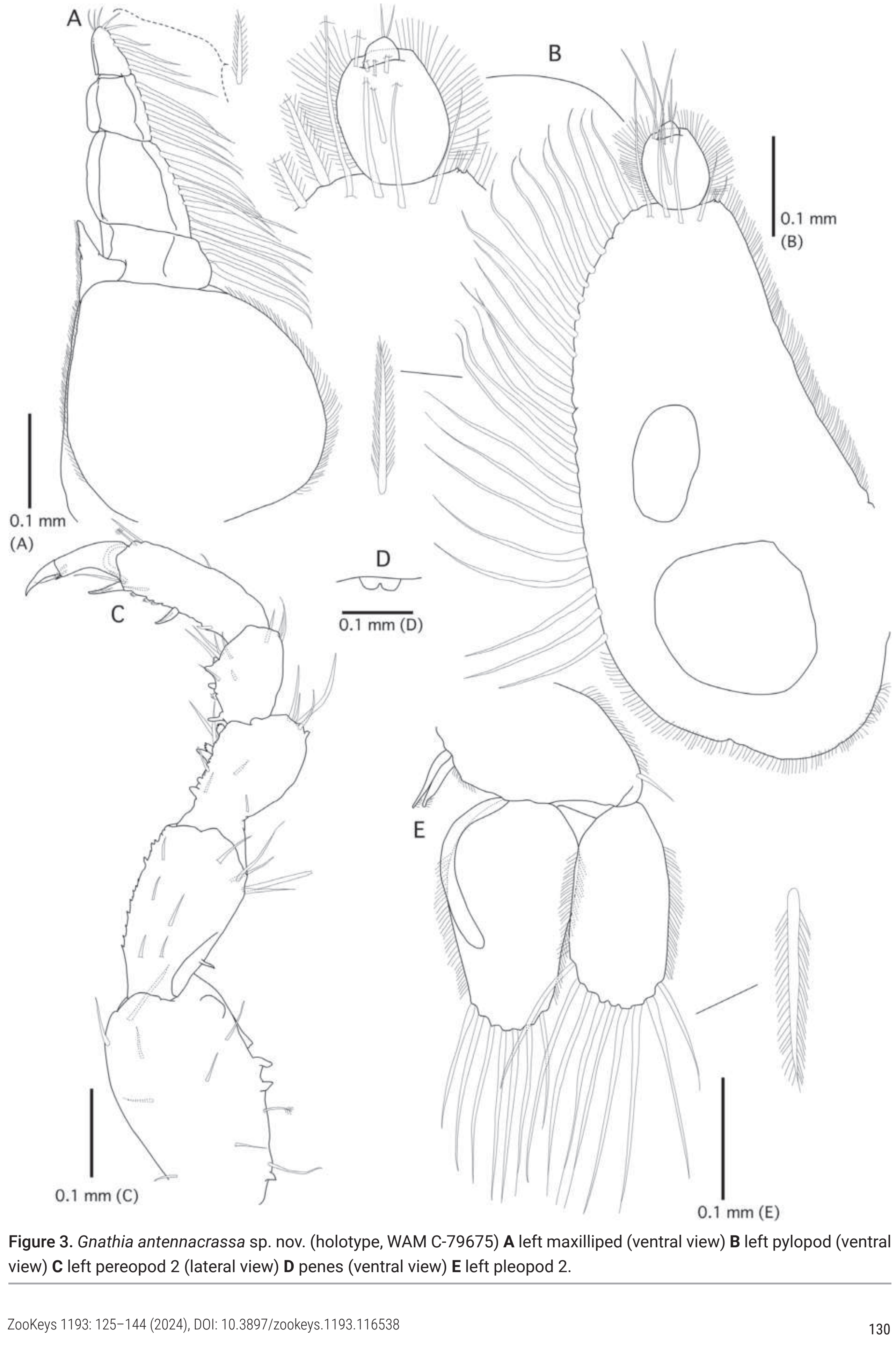

Figure 3. *Gnathia antennacrassa* sp. nov. (holotype, WAM C-79675) **A** left maxilliped (ventral view) **B** left pylopod (ventral view) **C** left pereopod 2 (lateral view) **D** penes (ventral view) **E** left pleopod 2.

margin with two simple setae; ischium as long as basis, 2.2 × as long as wide, superior margin with five simple setae; merus 0.4 × as long as ischium, 1.1 × as long as wide, superior margin with four simple setae, and bulbous protrusion, inferior margin with three simple setae; carpus 1.1 × as long as ischium, 0.9 × as long as wide, superior margin with three setae, inferior margin with five setae; propodus 1.6 × as long as ischium, 2.6 × as long as wide, superior margin with two simple setae and one penicillate seta, inferior margin with three pectinate scales, and two robust setae; dactylus 0.4 × as long as propodus. ***Pereopods 3 and 5*** similar proportions of each article as pereopod 2. ***Pereopod 4*** longer than pereopod 2, basis, ischium, and merus slightly longer than those of pereopod 2; propodus somewhat rounded. ***Pereopod 6*** slightly shorter than pereopod 2, basis shorter than that of pereopod 2, distal margin of merus rounded.

Penes (Fig. 3D) with two small papillae, 0.5 × as long as basal width.

Pleopod 2 (Fig. 3E). ***Exopod*** 2.2 × as long as wide, distally broadly rounded, with nine plumose setae; ***endopod*** 1.8 × as long as wide, distally narrowly rounded, with seven plumose setae; appendix masculina present, with parallel margins, 0.8 × as long as endopod, distally narrowly rounded; ***peduncle*** 0.5 × as wide as long, mesial margin with two coupling setae, lateral margin with one simple seta. All pleopods similar in shape; exopods each with eight or nine plumose setae; endopods each with 7–9 plumose setae.

Uropod (Fig. 1D). ***Peduncle*** without dorsal setae. ***Uropodal endopod*** 1.6 × as long as greatest width, apex broadly rounded, extending beyond apex of the pleotelson, dorsally with five penicillate setae; lateral and proximomesial margin with seven plumose and three simple setae. ***Uropodal exopod*** not extending to end of endopod, 3.8 × as long as greatest width, apex broadly rounded, reaching almost apex of pleotelson; lateral and proximomesial margin with four plumose and seven simple setae.

Distribution. Known only from the type locality.

Habitat of adults. Sandy substrata of seagrass; 5 m depth.

Hosts. Unknown.

Etymology. The specific name, *antennacrassa*, is derived from Latin, meaning “stout antenna”.

Remarks. Among the other *Gnathia* species worldwide, *G. illepida* Monod, 1923 is similar to *G. antennacrassa* sp. nov., but differs in that the tubercles densely cover the anterior part of the body (cephalosome and pereonites 1–4), the paraocular ornamentation is developed with several distinct tubercles and setae, and the maximum width of peduncle articles of the antenna is 2.4 × of that of the flagellar articles (Monod 1926).

Gnathia vellosa Müller, 1988 is also similar, but differ in that tubercles and long setae densely cover the anterior part of the cephalosome and pereonites 2, 3, and anterior part of pereonite 4; the maximum width of peduncle articles of antenna is 2.4 × that of flagellar articles; and three areolae are present on article 1 of the pylopod (Müller 1988).

Gnathia luxata Kensley, Schotte & Poore, 2009 differs from our new species as it has three processes on the frontal border but the mesial lobe is present on the mandible and, similarly to *G. vellosa*, it has three areolae present on article 1 of the pylopod (Kensley et al. 2009).

The gnathiid fauna of Western Australia, in contrast to the eastern Australian coast (see Cohen and Poore 1994; Coetzee et al. 2008, 2009; Ferreira et al.

2009, 2010; Farquharson et al. 2012; Svavarsson and Bruce 2012, 2019) remains almost undocumented. Cohen and Poore (1994) mention that *G. mulieraria* Hale, 1924 occurred from Victoria and south Australia to Western Australia. However, the original description mentioned *G. mulieraria* only from South Australia and there is no evidence or reference to its distribution as referred to in Cohen and Poore (1994). Therefore, *G. antennacrassa* represents the first recorded species of Gnathiidae from Western Australia.

***Gnathia taurus* sp. nov.**
https://zoobank.org/450C54D2-99D1-495C-9E66-DA81A9CA3D9F
Figs 4–6

Diagnosis. Large body length more than 8.0 mm; long setae covering most part of dorsal body (cephalosome, pereonites 1–7, and mid-dorsal and lateral parts of pleonites 1–5); frontal margin with rounded mediofrontal process and two superior frontolateral processes; paraocular ornamentation composed of several tubercles and setae; pereonite 1 reaching lateral margins of cephalon, epimera of pleonites 1–5 not prominent; pleotelson 1.3 × longer than its anterior width, eight or nine long setae present on lateral side of pleotelson; mandible almost vertically elongated; article 1 of pylopod with one areolae; appendix masculina of pleopod 2 extending half-length of the endopod; endopod of uropodal rami extends beyond apex of pleotelson; exopod of uropodal rami not extends apex of pleotelson.

Material examined. ***Holotype*.** Australia • 1♂ (9.6 mm TL, 8.2 mm BL, dissected); reared from a juvenile collected from a species of *Rhynchobatus* (TL 129 cm, female), Heron Island, Great Barrier Reef (23°26'32.9"S, 151°54'53.8"E), 7 October 1998. Ian D. Whittington leg. (QM W29819). ***Paratype*.** 1♂ (9.4 mm TL, 8.2 mm BL); same data as holotype (QM W29820).

Type locality. Heron Island, Great Barrier Reef, Australia (23°26'32.9"S, 151°54'53.8"E).

Description. ***Body*** (Figs 4, 5A) 2.6 × as long as greatest width, widest at pereonite 5; dorsal surfaces with tubercules or granules, densely setose. ***Cephalosome*** (Figs 4, 5A–C) rectangular, 0.7 × as long as wide, lateral margins sub-parallel, posterior margin concave; dorsal surface conspicuous granules anteriorly; dorsal sulcus narrow, shallow, short; translucent region absent; paraocular ornamentation weakly developed and with several tubercles and setae; posterior median tubercle present; lateral tubercles with several long setae. ***Frontolateral processes*** present. ***Frontal margin*** (Fig. 5B) straight and medially concave, median point with process. ***External scissura*** present, wide, shallow. ***Mediofrontal process*** present, weak, rounded, without ventral notch, without setae. ***Superior frontolateral process*** present, single, strong, rounded, with four or five long simple setae. ***Inferior frontolateral process*** absent. ***Supraocular lobe*** not pronounced; accessory supraocular lobe not pronounced. ***Eyes*** present, round, 0.2 × as long as cephalosome length, contiguous with head surface, ommatidia not arranged in rows, eye colour dark brown.

Pereon (Figs 4, 5A) lateral margins ovate, with many setae; with sparse fine granules on anterior parts of pereonites 2–4. ***Pereonite 1*** not fused dorsally with cephalosome; dorsolateral margins not obscured by cephalosome. ***Pereonite 2*** wider than pereonite 1. ***Pereonite 4*** with anterior constriction, median groove absent.

Figure 4. Photograph of fixed *Gnathia taurus* sp. nov. (paratype, QM W29820). Scale bar: 1 mm.

Areae laterales present on pereonite 5, dorsal sulcus wide. ***Pereonite 6*** with strongly developed lobi laterales, lobuii absent. ***Pereonite 7*** short, narrow, and overlapping pleonite 1. ***Pleon*** epimera not dorsally visible on all pleonites. ***Pleonites*** (Figs 4, 5A) lateral margins with 5–7 pairs of simple setae, with 6–9 simple setae medially. ***Pleotelson*** (Fig. 5D) 0.8 × as long as anterior width, covered in pectinate scales; lateral margins smooth, anterolateral margins strongly concave, with 1–3 submarginal setae; posterolateral margin weakly convex, with eight or nine pairs of submarginal setae; mid-dorsal surface with one pair of sub-median setae, apex with two setae.

Antennula (Fig. 5E) composed of four peduncular and four flagellar articles, 0.6 × shorter than antenna; peduncle article 2 1.1 × as long as article 1; article 3 2.2 × as long as article 2, 4.4 × as long as wide; flagellar article 3 with one aesthetasc seta, and one simple seta; article 4 with one aesthetasc seta; article 5 with one penicillate seta, terminating with one aesthetasc seta and three simple setae. ***Antenna*** (Fig. 5F) composed of four peduncular and seven flagellar articles; peduncle article 3 2.8 × as long as wide, 2.5 × as long as article 2, with two penicillate setae, and seven simple setae; article 4 1.3 × as long as article 3, 4.3 × as long as wide, with five penicillate setae, and 18 simple setae; flagellum 0.8 × as long as article 4, terminating with four simple setae.

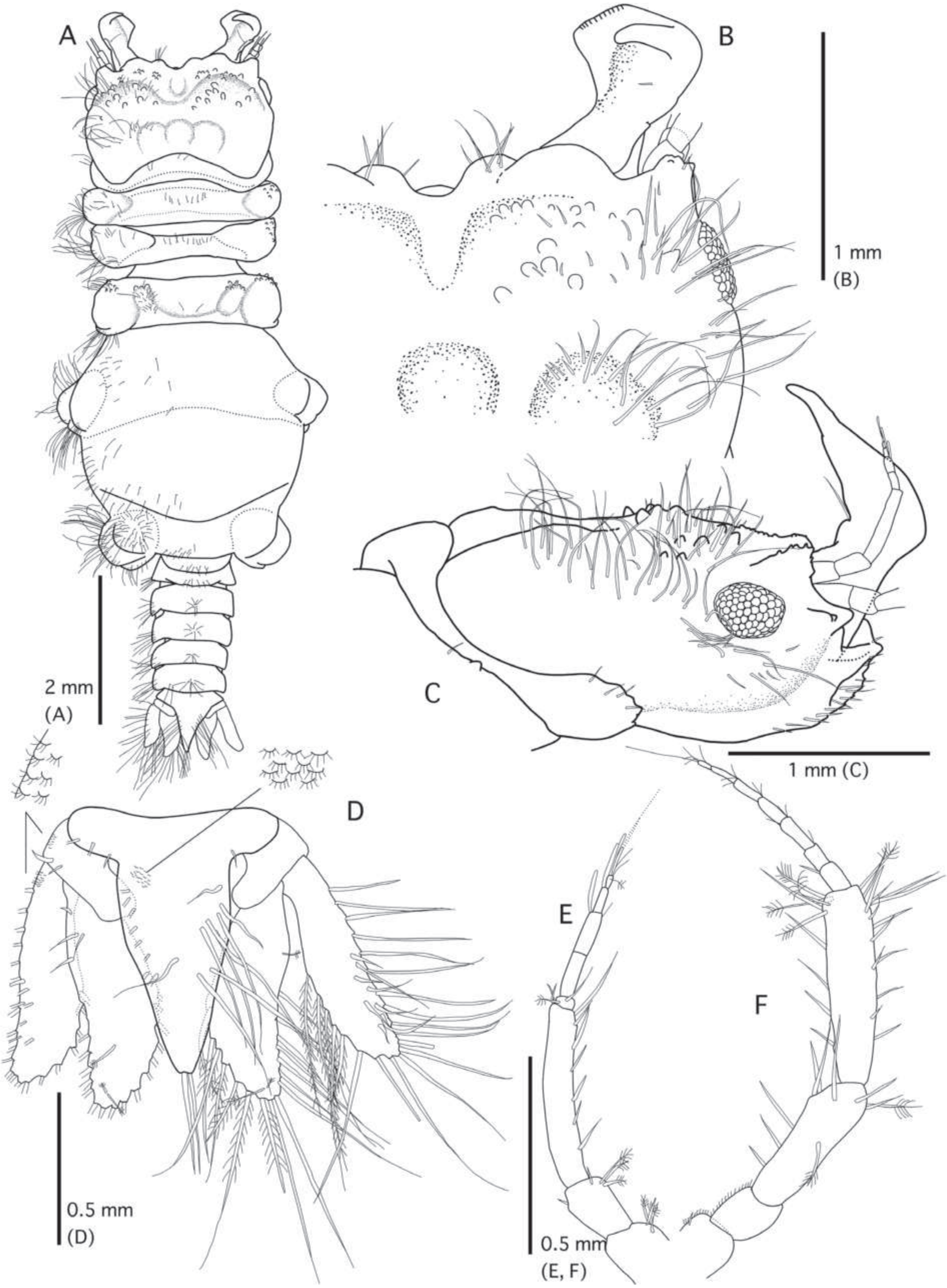

Figure 5. *Gnathia taurus* sp. nov. (holotype QM W29819) **A** whole body (dorsal view) **B** cephalosome and mandible (dorsal view) **C** pereonite 1, cephalosome, and mandible (right lateral view) **D** pleotelson (dorsal view) **E** right antennula **F** right antenna.

Mandible (Fig. 5B, C) 0.4 × the head length; strongly curved dorsally; apex positions before dentate blade (but it positions after dentate blade in paratype of Fig. 4), 23% of total length; mandibular seta present. ***Carina*** absent. ***Incisor*** dentate, distal denticulation absent. ***Blade*** present, dentate, straight, proximally convex, dentate for 28% of margin. Pseudoblade, internal lobe and dorsal lobe absent; basal neck long; erisma present; lamina dentata absent.

Maxilliped (Fig. 6A). Article 1 lateral margin with continuous marginal scale-setae; article 2 lateral margin with six plumose setae; article 3 lateral margin with seven plumose setae; article 4 lateral margin with six plumose setae; article 5 with nine plumose setae, and six simple setae; endite extending to distal margin of article 2.

Pylopod (Fig. 6B). Article 1 1.9 × as long as wide; with one areola; without distolateral lobe; posterior and lateral margins forming rounded curve; lateral margin with 59 plumose setae; mesial margin with continuous fringe setae; distal margin with five simple setae; article 2 1.3 × as long as wide, with 11 simple setae; article 3 minute and semicircular without setae.

Pereopod 2 (Fig. 6C) covered in pectinate scales on inferior margins of ischium, merus carpus, and propodus; basis 2.2 × as long as greatest width, superior margin with 19 simple setae, inferior margin with 21 simple setae; ischium 4.5 × as long as basis, 4.5 × as long as wide, superior margin with 21 simple setae, inferior margin with 11 simple setae; merus 0.3 × as long as ischium, 1.1 × as long as wide, superior margin with eight simple setae and bulbous protrusion, inferior margin with eight simple setae; carpus 1.1 × as long as ischium, 1.9 × as long as wide, superior margin with eight simple setae, inferior margin with four simple setae; propodus 1.1 × as long as ischium, 2.5 × as long as wide, superior margin with three simple setae, superior margin with one penicillate seta, inferior margin with four simple setae, and two denticulate compound spines; dactylus 0.5 × as long as propodus. ***Pereopods 3*, *5*, and *6*** almost same proportion of each article as pereopod 2; basis of pereopod 4 slightly shorter than that of pereopod 2.

Penes (Fig. 6D) produced, penial process 0.4 × as long as basal width.

Pleopod 2 (Fig. 6E) ***exopod*** 1.8 × as long as wide, distally broadly rounded, with nine plumose setae; ***endopod*** 2 × as long as wide, distally broadly rounded, with seven plumose setae; appendix masculina present, with parallel margins, 0.5 × as long as endopod, distally bluntly rounded; ***peduncle*** 1.4 × as wide as long, mesial margin with two coupling setae, lateral margin with one simple seta. All pleopods similar in shape; exopods each with 7–11 plumose or simple setae; endopods each with seven or eight plumose or simple setae in total.

Uropod (Fig. 5D). ***Peduncle*** with two dorsal setae. ***Uropodal endopod*** 2.9 × as long as greatest width, apex narrowly rounded, extending beyond apex of pleotelson, dorsally with three penicillate setae; lateral margin weakly convex, lateral margin with nine simple setae; proximomesial margin sinuate, with seven long plumose setae. ***Uropodal exopod*** not extending to end of endopod, apex narrowly rounded, not extending beyond apex of pleotelson, 3.6 × as long as greatest width; lateral margin weakly convex, with 24 simple setae; proximomesial margin weakly convex and sinuate, with five plumose setae.

Distribution. Heron Island, Great Barrier Reef, Australia.

Habitat of adults. Unknown.

Hosts. A species of *Rhynchobatus*. The original data label identified the host as *Rhynchobatus djiddensis*, but the distribution range of this species is the

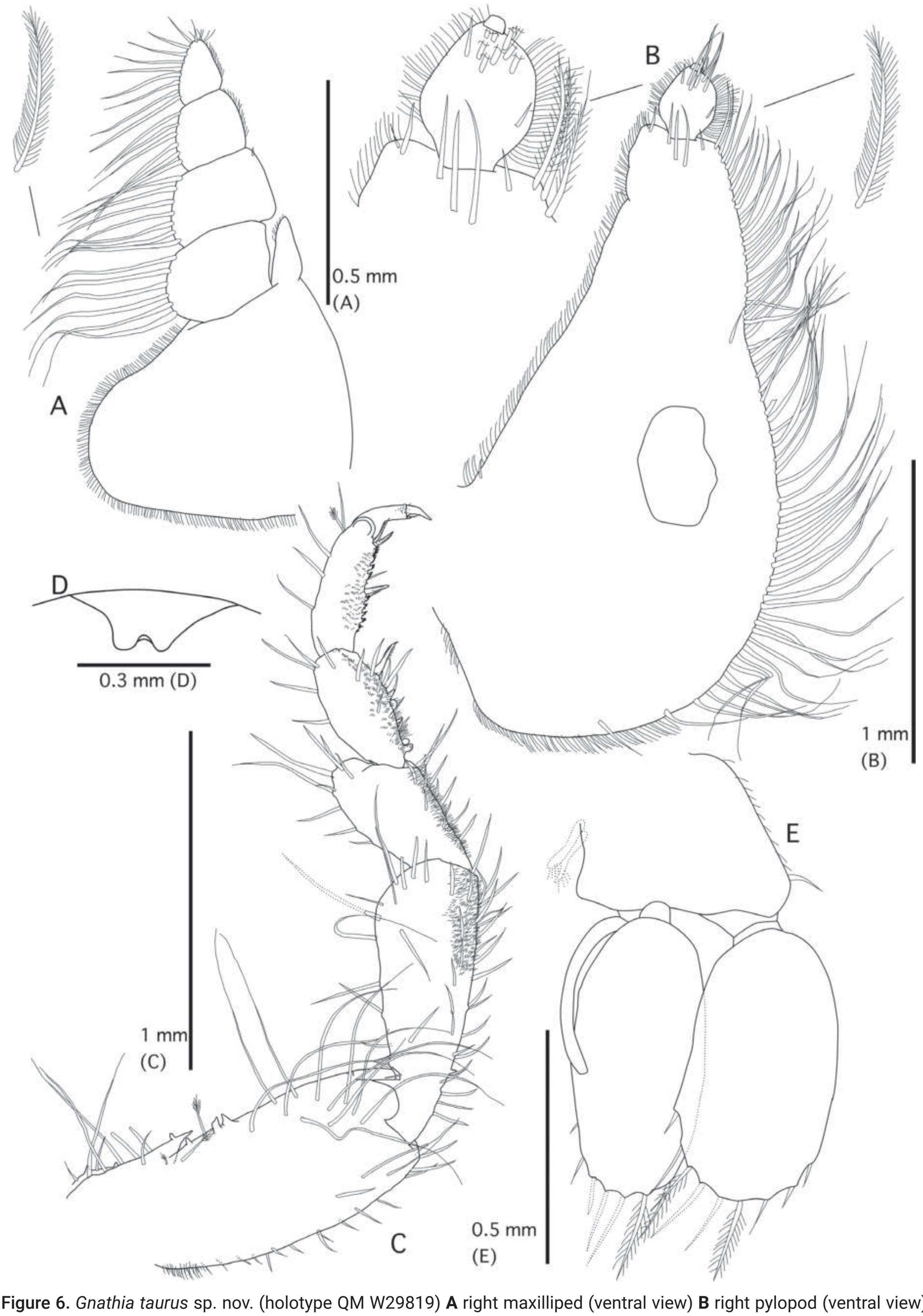

Figure 6. *Gnathia taurus* sp. nov. (holotype QM W29819) **A** right maxilliped (ventral view) **B** right pylopod (ventral view) **C** right pereopod 2 (lateral view) **D** penes (ventral view) **E**. right pleopod 2.

western Indian Ocean; therefore, the host is most probably *Rhynchobatus australiae* Whitley, 1939 or *R. palpebratus* Compagno & Last, 2008, two species that do occur on the GBR (Last et al. 2016).

Etymology. The specific name *taurus*, the second sign of the zodiac, is derived from *taûros*, Latin for bull, and refers to the gnathiid's dorsally elongated mandible which resemble the horns of a bull.

Remarks. Among *Gnathia* species worldwide, *Gnathia grandilaris* Coetzee, Smit, Grutter & Davies, 2008 is most similar to *Gnathia taurus* sp. nov., but differs in that its mediofrontal process is acute, the mandible is not vertically elongated, and two areolae are present on article 1 of the pylopod (Coetzee et al. 2008).

Gnathia nubila Ota & Hirose, 2009 is also similar but the apex of the mediofrontal process is bifid and dentate, the epimera is prominent on pleonites 3–5, and two areolae are present on article 1 of the pylopod (Ota and Hirose 2009b).

Gnathia aff. *maculosa* Ota & Hirose, 2009

Figs 7A–D, 8

Gnathia maculosa Ota & Hirose, 2009a: 50, 51, 56, 57, figs 1–3, 5.

Type locality. Nakagusku Bay (26°N, 127°E), Okinawajima Island, Japan.

Material examined. Australia • 1♂ (5.0 mm TL, 4.5 mm BL, SEM); reared from a juvenile collected from a cowtail stingray *Pastinachus sephen* (Forsskål, 1775) (TL and sex, unknown), Lizard Island, GBR (14°40'08"S, 145°27'34"E), 19 June 1998, Ian D. Whittington leg. (QM W29821). 1♂ (5.5 mm TL, 4.9 mm BL, dissected); reared from a juvenile collected from a species of *Rhynchobatus* (TL 126.5 cm, female), Shark Bay, Heron Island, GBR (23°26'37.03"S, 151°55'5.64"E), 7 Oct. 1998, Ian D. Whittington leg. (QM W29822).

Remarks. The male morphologies of these GBR specimens show the deep and narrow dorsal sulcus on the cephalosome, the narrow body (Fig. 7A, B), and the almost semicircular pylopod article 1 with three areolae (Fig. 7C). These characters can be identified as *Gnathia maculosa* Ota & Hirose, 2009. However, this species was originally described from the Ryukyu Islands, southwestern Japan (Ota and Hirose 2009a) and our records are a great distance from this island group. The apices of the frontolateral processes on anterior margin of heads of the present specimens are smooth, while those of original description are serrate (Ota and Hirose 2009a). The number of setae on the pleotelson of the present species is two pairs (Fig. 7D), while that of the original description is three pairs (Ota and Hirose 2009a). Thus, these GBR specimens are identified as *G.* aff. *maculosa*.

The GBR specimens of *G.* aff. *maculosa* have a bundle of several long setae on the ventral frontal border (Fig. 8). Ota and Hirose (2009a) did not show the ventral frontal border but the Japanese specimens *G. maculosa* also have a bundle of several long setae (YO pers. obs.).

Distribution. *Gnathia* aff. *maculosa*: Lizard Island and Heron Island, Great Barrier Reef, Australia; *Gnathia maculosa*: Okinawa-jima Island, Kume-jima Island, Ishigaki-jima Island, Japan.

Habitat of adults. Unknown.

Hosts. Two elasmobranch species from GBR: *Pastinachus sephen* (Forsskål, 1775), *Rhynchobatus* sp.

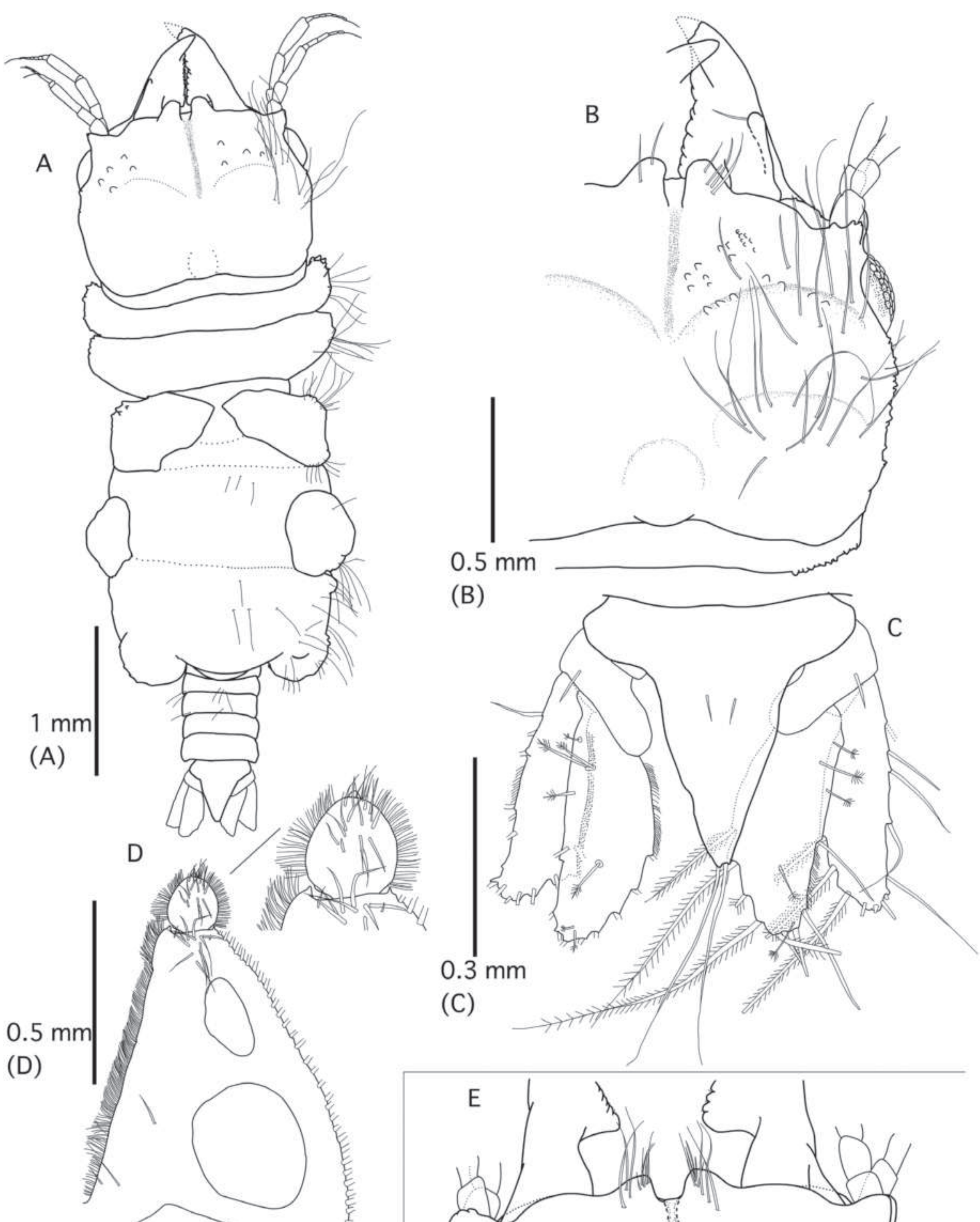

Figure 7. *Gnathia* aff. *maculosa* Ota and Hirose, 2009 (**A–D**; QM W29822) and *G. trimaculata* Coetzee, Smit, Grutter & Davies, 2009 (**E**; QM W29825) **A** whole body (dorsal view) **B** pereonite 1, cephalosome, and mandible (dorsal view) **C** pleotelson (dorsal view) **D** right pylopod (ventral view) **E** frontal border of *G. trimaculata* (dorsal view).

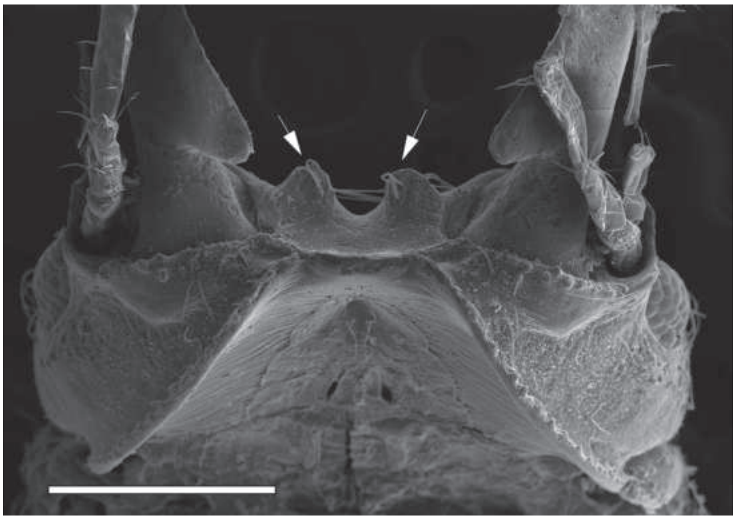

Figure 8. Scanning electron micrograph of the ventral view of the frontal border of *Gnathia* aff. *maculosa* Ota & Hirose, 2009 (QM W29821) showing bundles of several long setae (two arrows). Scale bar: 500 μm.

Hosts of *G. maculosa*. Ota and Hirose (2009a) recorded the two host elasmobranchs of *G. maculosa* and Ota (2015: table 2) summarised gnathiids ectoparasitising on elasmobranchs in the Ryukyu Islands and documented *G. maculosa* obtained from 11 elasmobranch species including two host species previously recorded by Ota and Hirose (2009a): *Rhynchobatus djiddensis* (Forsskål, 1775), *Neotrygon orientalis* Last, White & Séret, 2016 [*Neotrygon kuhlii* Müller & Henle, 1841 in Ota 2015], *Taeniura meyeni* Müller & Henle, 1841, *Himantura undulata* (Bleeker, 1852), *Himantura* sp., *Aetomylaeus vespertilio* (Bleeker, 1852), *Aetobatus ocellatus* (Kuhl, 1823) [*Aetobatus narinari* (Euphrasen, 1790) in Ota 2015], *Rhinoptera javanica* Müller & Henle, 1841, *Nebrius ferrugineus* (Lesson, 1831), *Triaenodon obesus* (Rüppell, 1837), and *Negaprion acutidens* (Rüppell, 1837).

Site of infection on host in *G. maculosa*. Gill chambers, interbranchial septa, gill filaments, and the floor of oral cavities. Rarely nostrils, body surface near the gill slits, or claspers.

Gnathia trimaculata Coetzee, Smit, Grutter & Davies, 2009
Fig. 7E

Gnathia trimaculata Coetzee, Smit, Grutter & Davies, 2009: 97, 98, 109–111, figs 1–11.— Ota and Hirose 2009a: 50, 51, figs 4, 5.

Type locality. Off Lizard Island (14°40'54.68"S, 145°26'53.72"E), Australia.

Material examined. Australia • 1♂ (6.4 mm TL, 5.2 BL); reared from a juvenile collected from a cowtail stingray *Pastinachus sephen* (Forsskål, 1775) (TL and sex, unknown), Lizard Island, GBR (14°40'54.68"S, 145°26'53.72"E), 19 June 1998, Ian D. Whittington leg. (QM W29823). 2♂ (5.8 mm TL and 4.6 mm BL, 5.7 mm TL and 4.6 mm BL); reared from a juvenile, infested on *P. sephen* (TL and sex, unknown), Heron Island, GBR (23°26'32.9"S, 151°54'53.8"E), 9 July 1998, Ian D. Whittington leg. (QM W29824). 1♂ (4.2 mm TL, 3.6 mm BL, drawings); reared from a juvenile, infested on epaulette shark, *Hemiscyllium ocellatum*

(Bonnaterre, 1788), Heron Island, GBR (23°26'32.9"S, 151°54'53.8"E), 7 November 1998, Ian D. Whittington leg. (QM W29825).

Remarks. This species can be identified as *Gnathia trimaculata* Coetzee, Smit, Grutter, & Davies, 2009 by a frontal border with a mediofrontal process divided into two lobes which almost touch anteriorly and form a distinct keyhole shape, four or five pairs of long pappose setae present ventrally on both lobes, a mandible with seven or eight processes on the dentate blade, a cluster of setae between all processes, and an armed carina (Coetzee et al. 2009).

Ota and Hirose (2009a) reported *G. trimaculata* from the Ryukyu Islands, demonstrating a greater number of setae on peduncle 4 of antenna than that of the GBR specimens. In the present material, we observed that the mediofrontal process of our specimens does not almost touch and has a smooth margin (Fig. 7E). Therefore, it appears to be two frontolateral processes instead of one mediofrontal process.

This shape of mediofrontal process looks like that of *G.* aff. *maculosa*. *Gnathia* aff. *maculosa* of GBR also has a bundle of several long setae on the ventral frontal border. Thus, these two species cannot be distinguished by the morphology of the frontal border alone. However, *G. trimaculata* can be distinguished from *G. maculosa* by pectinate scales covering the pleotelson, four pairs of long setae on the lateral margin of pleotelson, and a long pear-shaped pylopod with one areola.

This record of *G. trimaculata* establishes two new hosts for this widely distributed species. Ota et al. (2012) recorded *G. trimaculata* from several areas in the Ryukyu Islands and southern Pacific coast of Japan. They demonstrated the first and second stages of the juveniles ectoparasitised four teleost species, while the third stage ectoparasitised 25 elasmobranch species including two unidentified elasmobranch species (see Ota et al. 2012: table 3). Ota (2015: table 2) also showed *G. trimaculata* collected from 18 elasmobranch species including two unidentified elasmobranch species but all of them except for one were already reported by Ota et al. (2012). These host species are listed below; in GBR, our host records of *Pastinachus sephen* and *Hemiscyllium ocellatum* were not included the previous studies and these are new host records.

Distribution. Off Lizard Island and Heron Island, Great Barrier Reef, Australia. The Ryukyu Islands and southern Pacific coast of Japan.

Habitat of adults. Unknown.

Hosts. Four elasmobranch species from GBR: *Carcharinus melanopterus* (Quoy & Gaimard, 1824), *Carcharinus amblyrhynchos* (Bleeker, 1856), *Pastinachus sephen* (Forsskål, 1775), and epaulette shark *Hemiscyllium ocellatum* (Bonnaterre, 1788). Three teleost species from Japan: *Enneapterygius etheostomus* (Jordan & Snyder, 1902), *Enneapterygius miyakensis* Fricke, 1987, *Springerichthys bapturus* (Jordan & Snyder, 1902), 24 elasmobranch species and two unidentified species from Japan: *Urolophus aurantiacus* Müller & Henle, 1841, *Gymnura japonica* (Temminck & Schlegel, 1850), *Rhynchobatus djiddensis* (Forsskål, 1775), *Neotrygon orientalis* Last, White & Séret, 2016 [*Neotrygon kuhlii* Müller & Henle, 1841 in Ota et al. 2012 and Ota 2015], *Taeniura meyeni* Müller & Henle, 1841, *Dasyatis izuensis* Nishida & Nakaya, 1988, *Hemitrygon akajei* (Müller & Henle, 1841) [*Dasyatis akajei* (Müller & Henle, 1841) in Ota et al. 2012 and Ota 2015], *Himantura undulata* (Bleeker, 1852), *Himantura* spp., *Aetomylaeus vespertilio* (Bleeker, 1852), *Aetobatus ocellatus* (Kuhl, 1823) [*Aetobatus narinari* (Euphrasen, 1790) in Ota et al 2012 and Ota 2015], *Aetobatus flagellum* (Bloch & Schneider, 1801), *Rhinoptera javanica* Müller & Henle, 1841, *Mobula mobular* (Bonnaterre, 1788) [*Mobula japanica* (Müller & Henle, 1841) in Ota et al. 2012 and Ota 2015], *Mobula thurstoni* (Lloyd, 1908) [*Mobula diabolus* (Shaw, 1804) in Ota et al. 2012 and Ota 2015], *Mobula tarapacana* (Philippi, 1892), *Nebrius ferrugineus* (Lesson, 1831), *Rhincodon typus* Smith, 1828, *Stegostoma fasciatum* (Hermann, 1783), *Sphyrna lewini* (Griffith & Smith, 1834), *Triaenodon obesus* (Rüppell, 1837), *Negaprion acutidens* (Rüppell, 1837), *Galeocerdo cuvier* (Péron & Lesueur, 1822), *Carcharhinus albimarginatus* (Rüppell, 1837), *Carcharhinus limbatus* (Müller & Henle, 1839), and *Carcharhinus* spp.

Site of infection on host. Gill chambers, interbranchial septa, gill filaments, and the floor of oral cavities. Rarely nostrils, body surface near the gill slits, or claspers of elasmobranchs. Fins and skin of teleosts.

Gnathia grandilaris Coetzee, Smit, Grutter, & Davies, 2008

Gnathia grandilaris Coetzee, Smit, Grutter, & Davies, 2008: 608, 613, 614, figs 1–26. —Ota and Hirose 2009b, 43, 44, 51, 54, figs 5–7.

Type locality. Off Lizard Island (14°40'S, 145°27'E), Australia.

Material examined. Australia •1♂ (7.1 mm TL, 6.6 mm BL); reared from a juvenile collected from *P. sephen* (TL and sex, unknown), Heron Island, GBR (23°26'32.9"S, 151°54'53.8"E), 9 July 1998, Ian D. Whittington leg. (QM W29826).

Remarks. The original description of *G. grandilaris* was based on males reared from larvae found infesting a white tip reef shark, *Triaenodon obesus* (Rüppell, 1837), and grey reef sharks, *C. amblyrhynchos*, collected off Lizard Island, GBR (Coetzee et al. 2008) and subsequently reported from the Ryukyu Islands (Ota and Hirose 2009b; Ota 2015). The specimen from Heron Island corresponded well with the original description. This record constitutes a new host and a new locality record for *G. grandilaris*.

Distribution. Lizard Island and Heron Island, Great Barrier Reef, Australia. Okinawa-jima Island, Kume-jima Island, Ishigaki-jima Island, the Ryukyu Islands, Japan.

Habitat of adults. Unknown.

Hosts. Three elasmobranch species from GBR: *Triaenodon obesus* (Rüppell, 1837), *Carcharhinus amblyrhynchos* (Bleeker, 1856), and *Pastinachus sephen* (Forsskål, 1775). Seven elasmobranch species from Japan: *Himantura* sp., *Himantura fai* Jordan & Seale, 1906, *Neotrygon orientalis* Last, White & Séret, 2016 [*Neotrygon kuhlii* Müller & Henle, 1841 in Ota and Hirose 2009b and Ota 2015], *Taeniura meyeni* Müller & Henle, 1841, *Mobula japanica* (Müller & Henle, 1841), *Nebrius ferrugineus* (Lesson, 1831), *Triaenodon obesus* (Rüppell, 1837), and *Negaprion acutidens* (Rüppell, 1837).

Site of infection on host. Gill chambers, interbranchial septa, gill filaments, and the floor of oral cavities. Rarely nostrils, body surface near the gill slits, or claspers.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Research Article

A new species of *Svistella* Gorochov, 1987 from Xizang, China (Orthoptera, Trigonidiidae, Trigonidiinae)

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Abstract

The genus *Svistella* Gorochov, 1987 includes 10 species from Asia, with nine documented in China. In this study, a new species, *Svistella yayun* He, **sp. nov.**, is described from Xizang, China. Morphologically, it resembles *S. rufonotata* (Chopard, 1932) but can be distinguished by a smaller inner tympanum, dark-brown setae on the 5th segment of the maxillary palp, and a rounded apex on the ectoparamere. To validate our morphological inferences and support the description of *S. yayun* **sp. nov.** as a new species, we performed a PCA based on bioacoustics parameters and molecular analysis. All *Svistella* species documented in China are distinguished by integrating their songs and DNA barcoding.

Key words: *COI*, DNA barcoding, PCA, songs, taxonomy, Zayu

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Introduction

The genus *Svistella* Gorochov, 1987 belongs to the family Trigonidiidae Saussure, 1877, with all 10 species endemic to Asia (Cigliano et al. 2023). Over the past 50 years, the number of *Svistella* species has increased significantly. Initially, it comprised two species: *S. bifasciata* (= *Paratrigonidium bifasciatum* Shiraki, 1911) and *S. rufonotata* (= *Anaxipha rufonotata* Chopard, 1932), with the former designated as the type species. In 1993, *Anaxipha dubia* Liu & Yin, 1993 was described from Yunnan, China. Subsequently, He et al. (2009) reassigned *A. dubia* to the genus *Svistella* and described three new species: *S. tympanalis* He, Li & Liu, 2009, *S. anhuiensis* He, Li & Liu, 2009, and *S. fallax* He, Li & Liu, 2009. A new addition, *S. chekjawa* Tan & Robillard, 2012, was revealed in Singapore by Tan and Robillard (2012). Lu et al. (2018a) compared the morphological characters and DNA barcoding of the genera *Svistella* and *Paratrigonidium* Brunner von Wattenwyl, 1893 species, and described a new species, *S. fuscoterminata* He & Liu, 2018, from Yunnan, China. Additional contributions have included the description of *S. argentata* Ma, Jing & Zhang, 2019 by Ma et al. (2019), who also proposed *S. tympanalis* as a junior synonym of *S. rufonotata*. Li et al. (2021a) reported two additional species, *S. wuyong* He, 2021 and *S. malu* He, 2021, from Yunnan, China, based on morphological characteristics, calling-song analysis and molecular study (*COI*). Currently, nine *Svistella* species are known to occur in China (Cigliano et al. 2023).

The divergence of cricket songs usually precedes visible morphological differences, making song variations a significant driving factor for the divergence of cricket species (Otte 1992). Many male cricket species produce songs by stridulating their forewings to attract mates (Alexander 1962; Desutter-Grandcolas 1997; Mhatre and Balakrishnan 2006). Some perspectives indicated that songs may function as a significant mechanism for pre-mating isolation among species and a valuable tool in inferring species boundaries (Lu et al. 2018b; Tan et al. 2023). The song features are stable parameters within the same species (Fulton 1928), which may serve as cues for species recognition (Walker and Carlysle 1975). Thus, many new species are often initially identified based on their songs (Walker and Funk 2014). However, the calling songs can be easily influenced by temperature (Walker and Cade 2003; Jang and Gerhardt 2007). Song analysis is often combined with morphological observations and molecular analysis to identify new species (Chen et al. 2019; Tian et al. 2019; Li et al. 2021b).

During entomological surveys conducted in 2023, we first noticed unique songs different from any known cricket species. Our morphological, bioacoustics, and molecular analyses placed those newly collected individuals within the genus *Svistella*. However, the new specimens are different from any known *Svistella* species. Here we describe a new species, *Svistella yayun* He, sp. nov. from Xizang, China, and all Chinese *Svistella* species are characterized by a combination of their morphology, songs, and DNA barcoding.

Materials and methods

Sampling

We discovered this unknown species through its sounds during the night. Five individuals were collected from the wild and immediately preserved in 65% ethanol. After returning to the lab, a hind leg was preserved in anhydrous ethanol at −40 °C for molecular studies, and the remaining parts were preserved as dry specimens.

Song recording and analyses

We recorded songs by using a SONY PCM A10 (ICX-0471) recorder. Three song recordings of *Svistella yayun* He, sp. nov. and all song recordings of other Chinese *Svistella* species from Li et al. (2021a) were replayed on a computer and analyzed using the Cool Edit software. *Svistella fallax* was not included in our PCA, because the audio file was lost, and the peak frequency was not available. Since most song recordings are shorter than 1 minute, we analyze the number of echemes in a randomly captured 10-second fragment from each recording, repeating this process 10 times. *Svistella anhuiensis*, *S. bifasciata*, and *S. argentata* are regarded as continuous groups, and thus we define 10-second fragment of their song recordings as an echeme. We randomly select 10 echemes to analyze both their duration and the number of syllables in each. Bioacoustics characters—echeme interval, number of echemes per minute, number of syllables in each echeme, and peak frequency (Table 1)—are used in our PCA analysis. A principal component analysis (PCA) was performed in RStudio v. 2022.12.0 + 353 with *PCAtools* (Blighe and Lun 2023) based on collected bioacoustics parameters of the male calling songs (described below in song analysis).

Table 1. Features of *Svistella* spp. calling songs.

Species	Record site	Record time	Temperature (°C)	Echeme duration (s)	Echemes interval (s)	No. of echemes per minute	No. of syllables in each echeme	Peak frequency (Hz)	Data Source
S. anhuiensis	Wuyi Mountain, Fujian, China	20180911	27	10 +	0	–	–	7449.870 ± 83.908	This study
S. argentata	Jianfengling, Hainan, China	20090721	28	10 +	0	–	–	6245.520 ± 70.210	This study
S. bifasciata	Shenzhen, Guangdong, China	20190901	22	10 +	0	–	–	5496.450 ± 27.124	This study
S. fallax	Ankang, Shanxi, China	20190923	22	0.305 ± 0.010	0.320 ± 0.020	96.000 ± 0.000	16.400 ± 0.516	–	This study
S. fuscoterminata	Xishuangbanna, Yunnan, China	20171025	20	0.950 ± 0.020	2.024 ± 0.231	19.500 ± 2.550	29.700 ± 0.949	5127.970 ± 23.356	This study
S. malu	Kunming, Yunnan, China	20160926	25	0.440 ± 0.010	0.348 ± 0.030	83.400 ± 5.254	14.900 ± 0.994	6387.470 ± 23.299	This study
S. rufonotata	Wuyi Mountain, Fujian, China	20190312	18	0.150 ± 0.002	0.276 ± 0.004	138.000 ± 0.000	2.000 ± 0.000	5187.870 ± 30.050	This study
	Baisha, Hainan, China	20190403	18	0.150 ± 0.002	0.270 ± 0.004	138.000 ± 0.000	2.000 ± 0.000	4526.890 ± 29.970	This study
S. wuyong	Flowers-birds Market, China	20160920	24	0.443 ± 0.026	0.303 ± 0.049	87.600 ± 3.098	10.900 ± 0.738	5665.760 ± 72.207	This study
	Flowers-birds Market, China	20160930	24	0.393 ± 0.012	0.335 ± 0.030	82.800 ± 3.795	14.400 ± 0.516	6029.440 ± 44765	This study
	Flowers-birds Market, China	20160930	24	0.398 ± 0.017	0.407 ± 0.058	72.000 ± 7.483	14.200 ± 0.632	5930.810 ± 19.250	This study
	Flowers-birds Market, China	20160930	24	0.393 ± 0.017	0.461 ± 0.054	71.400 ± 3.406	13.700 ± 0.675	5942.970 ± 29.030	This study
	Flowers-birds Market, China	20160918	24	0.426 ± 0.027	0.273 ± 0.040	85.200 ± 2.530	11.300 ± 0.675	6242.520 ± 40.999	This study
S. yayun	Zayu, Xizang, China	20230709	20	0.939 ± 0.041	0.627 ± 0.045	42.000 ± 0.000	18.700 ± 0.949	5406.360 ± 116.973	This study
	Zayu, Xizang, China	20230709	20	0.992 ± 0.071	0.568 ± 0.037	37.200 ± 2.530	21.700 ± 1.494	5594.540 ± 34.098	This study
	Zayu, Xizang, China	20230709	20	0.967 ± 0.034	0.978 ± 0.135	31.800 ± 2.898	18.900 ± 0.738	5332.420 ± 65.809	This study

Measurements

The sizes of the following body parts were measured on photographs by the ruler tool of Adobe Photoshop CC 2015.5. All the measurements are in millimeters (mm).

Terminology

Terminology used to describe the male genitalia follows Tan and Robillard (2012).

Abbreviations:

SZ Body size (from head to tip of abdomen)
FWL Forewing length
HFL Length of hind femur
PL Pronotal length
OL Ovipositor length
ec ap Ectophallic apodeme
en s Endophallic sclerite

ps ind Pseudephiphallic indentation
ps lo Pseudephiphallic lophi
r Pseudephiphallic rami
v Ectophallic virgu (ectophallic fold)

All specimens are deposited in the Museum of Biology, East China Normal University (ECNU).

DNA extraction and amplification

The total genomic DNA was extracted from the muscles of a hind leg by AxyPrep Genomic DNA Miniprep Kit (AXYGEN), according to the manufacturer's instructions. The fragments of the mitochondrial cytochrome c oxidase subunit I gene (*COI*, 658 bp) were sequenced. Primers COBU (TYTCAACAAAYCAYAARGATATTGG) and COBL (TAAACTTCWGGRTGWCCAAARAATCA) were used (Pan et al. 2006). GenBank accession numbers are shown in Table 2.

Molecular study

The *COI* sequences from newly reported species, along with 36 individuals and the outgroup *Amusurgus genji* obtained from GenBank, were aligned using the MUSCLE method in MEGA 11 (Tamura et al. 2021). A distance tree was constructed employing the neighbor-joining (NJ) method following Kimura 2-parameter (K2P) model, with 0.19 gamma parameter and 95% partial deletion. The bootstrap test was performed with 10000 replicates. To define species partitions and estimate the number of molecular operational taxonomic units (MOTUs), we used two DNA-based species delimitation methods: Automatic Barcode Gap Discovery (ABGD, Puillandre et al. 2012) and Assemble Species by Automatic Partitioning (ASAP, Puillandre et al. 2021).

Table 2. Collection information and *COI* GenBank accession number.

Genus	Species	Voucher	Collection site	GenBank	Data source
Svistella	*S. yayun*	4970	Zayu, Xizang, China	OR899297	This study
		4967	Zayu, Xizang, China	OR899298	This study
	S. anhuiensis	242	Chakou, Anhui, China	MG549837	Lu et al. 2018a
	S. argentata	302	Flowers-birds Market, China	MW647096	Li et al. 2021a
		333	Shenzhen, Guangdong, China	MW647097	Li et al. 2021a
	S. bifasciata	1254	Changjiang, Hainan, China	MW647098	Li et al. 2021a
		1427	Chebaling, Guangdong, China	MW647099	Li et al. 2021a
		260	Lishui, Zhejiang, China	MG549832	Lu et al. 2018a
		2014	Gutian Mountain, Zhejiang, China	MW647100	Li et al. 2021a
		33	Weng'ang, Guizhou, China	MG549831	Lu et al. 2018a
		2279	Tianmu Mountain, Zhejiang, China	MW647101	Li et al. 2021a
		318	Tianmu Mountain, Zhejiang, China	MW647102	Li et al. 2021a
		671	Hangzhou, Zhejiang, China	MG549833	Lu et al. 2018a
	S. dubia	637	Tengchong, Yunnan, China	MW647124	Li et al. 2021a
		740	Baoshan, Yunnan, China	MW647125	Li et al. 2021a

Genus	Species	Voucher	Collection site	GenBank	Data source
Svistella	*S. fallax*	1017	Tongjiang, Sichuan, China	MW647109	Li et al. 2021a
		2326	Xunyangba, Shaanxi, China	MW647110	Li et al. 2021a
		1513	Flowers-birds Market, China	MW647111	Li et al. 2021a
		1514	Flowers-birds Market, China	MW647112	Li et al. 2021a
	S. fuscoterminata	1133	Nabang, Yunnan, China	MW647113	Li et al. 2021a
		2274	Nabang, Yunnan, China	MW647114	Li et al. 2021a
		2307	Nabang, Yunnan, China	MW647115	Li et al. 2021a
		1161	Ruili, Yunnan, China	MW647116	Li et al. 2021a
		551	Xishuangbanna, Yunnan, China	MG549834	Lu et al. 2018a
		954	Xishuangbanna, Yunnan, China	MG549835	Lu et al. 2018a
	S. malu	1961	Tengchong, Yunnan, China	MW647103	Li et al. 2021a
		2288	Kunming, Yunnan, China	MW647104	Li et al. 2021a
		1960	Tengchong, Yunnan, China	MW647105	Li et al. 2021a
		289	Kunming, Yunnan, China	MW647106	Li et al. 2021a
		297	Kunming, Yunnan, China	MW647107	Li et al. 2021a
		2289	Kunming, Yunnan, China	MW647108	Li et al. 2021a
	S. rufonotata	1634	Baisha, Hainan, China	MW647117	Li et al. 2021a
		494	Mengla, Yunnan, China	MW647118	Li et al. 2021a
		1756	Wuyi Mountain, Fujian, China	MW647119	Li et al. 2021a
		243	Flowers-birds Market, China	MW647120	Li et al. 2021a
	S. wuyong	2318	Nabang, Yunnan, China	MW647121	Li et al. 2021a
		2320	Nabang, Yunnan, China	MW647122	Li et al. 2021a
		286	Flowers-birds Market, China	MW647123	Li et al. 2021a
Amusurgus	*A. genji*	317	Lin'an, Zhejiang, China	MT706087	He et al. 2020

Taxonomy

Order Orthoptera
Family Trigonidiidae
Subfamily Trigonidiinae

Genus *Svistella* Gorochov, 1987

Svistella Gorochov, 1987; He et al. 2009; Tan and Robillard 2012; Lu et al. 2018; Ma et al. 2019; Li et al. 2021.

Type species. *Svistella bifasciata* (= *Paratrigonidium bifasciatum* Shiraki, 1911).

Svistella yayun He, sp. nov.

https://zoobank.org/BD70EE0F-2270-44F8-8751-401E8DE434D3
Figs 1A, B, 2A–E, 3A–F, 4D–F

Diagnosis. The new species is characterized as follows: small to medium body size for the genus; dark-brown setae on the 5th segment of maxillary palp; small, inner tympanum; hind femora without black stripe; tegmina unicolor. It is morphologically similar to *S. rufonotata* but differs in having

Figure 1. Living *Svistella yayun* He, sp. nov. **A** male **B** female.

dark-brown setae on the 5th segment of maxillary palp (Fig. 4A–F), an ectoparamere with rounded corner (Fig. 5A–C), and a smaller inner tympanum (Fig. 5D–G).

Materials examined. ***Holotype*:** China • ♂; Xizang, Zayu; 28°28.20'N, 97°01.22'E; 1565 m); 9 July 2023; He Zhu-Qing leg.; ECNU 4969. ***Paratypes*:** 2♂, ECNU 4961, ECNU 4970 & 2♀, ECNU 4967, ECNU 4968; same data as for holotype.

Description. Male. Body size small. Head slightly wider than anterior margin of pronotum, occiput slightly convex (Figs 1A, 2A); frontal rostrum about as wide as first antennal segment, with two rows of setae extending to vertex (Fig. 2C); vertex not dorsally flattened; antennae long and pubescent; compound eyes slightly protruding forwards; 5th segment of maxillary palpi triangular and swollen (Fig. 2D). Pronotum with setae, posterior margin widened; fore tibiae armed with two oval tympanums, with outer one bigger than inner one

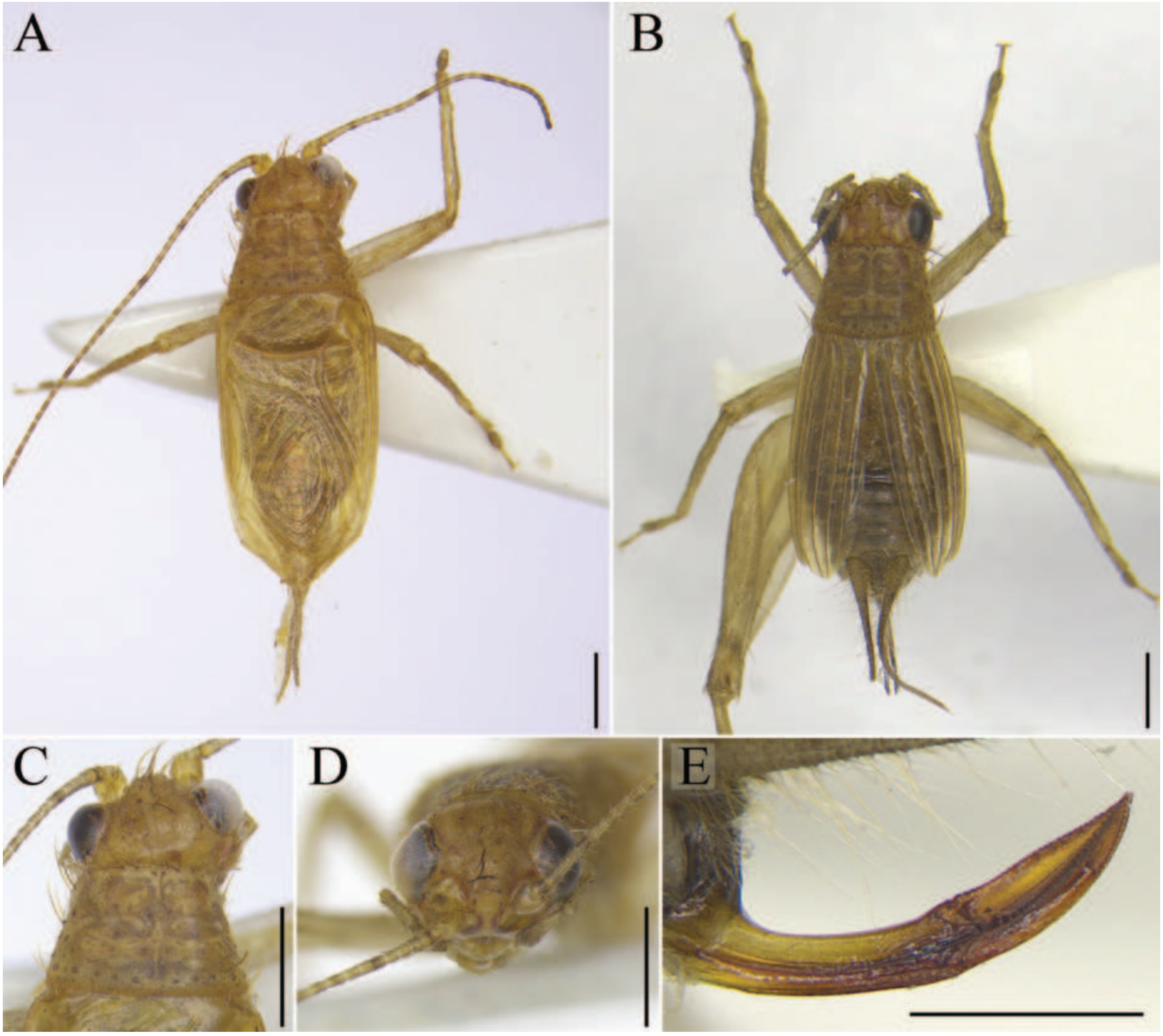

Figure 2. *Svistella yayun* He, sp. nov., male holotype, ECNU 4969, and female paratype, ECNU 4968 **A** habitus of male **B** habitus of female **C** male head and pronotum in dorsal view **D** male face in front view **E** female ovipositor in lateral view. Scale bars: 1 mm.

(Fig. 3A, B); hind tibiae bearing three pairs of dorsal spurs (Fig. 3C) and five apical spurs (two internal ones distinctly longer and three external ones shorter); tegmina barely reaching apex of abdomen. Cercus with long, thin hair.

***Genitalia*.** Pseudepiphallus separated into two lateral parts joined by a straight sclerotized bridge. Pseudepiphallic lophi curved inwards with 3 or 4 forks apically. Posterior marginal area of endoparameron with minute teeth and short setae (Fig. 3E, F).

Female. Similar to male (Fig. 1B). Tegmina slightly convex and not extending to abdominal apex (Fig. 2B). Ovipositor long and curved upwards, finely denticulate on dorsal and ventral sides (Fig. 2E).

***Coloration*.** Body brown; legs yellowish brown. Head orange and marked with five vertical red stripes extending to pronotum in dorsal view. Setae on the 5th segment of maxillary palpi dark brown (Fig. 4D, E). Abdomen with 1 lateral red spot on both sides of each abdominal segment in female. Each hind femur with a dark-brown stripe near knees when alive (Fig. 1A, B) but

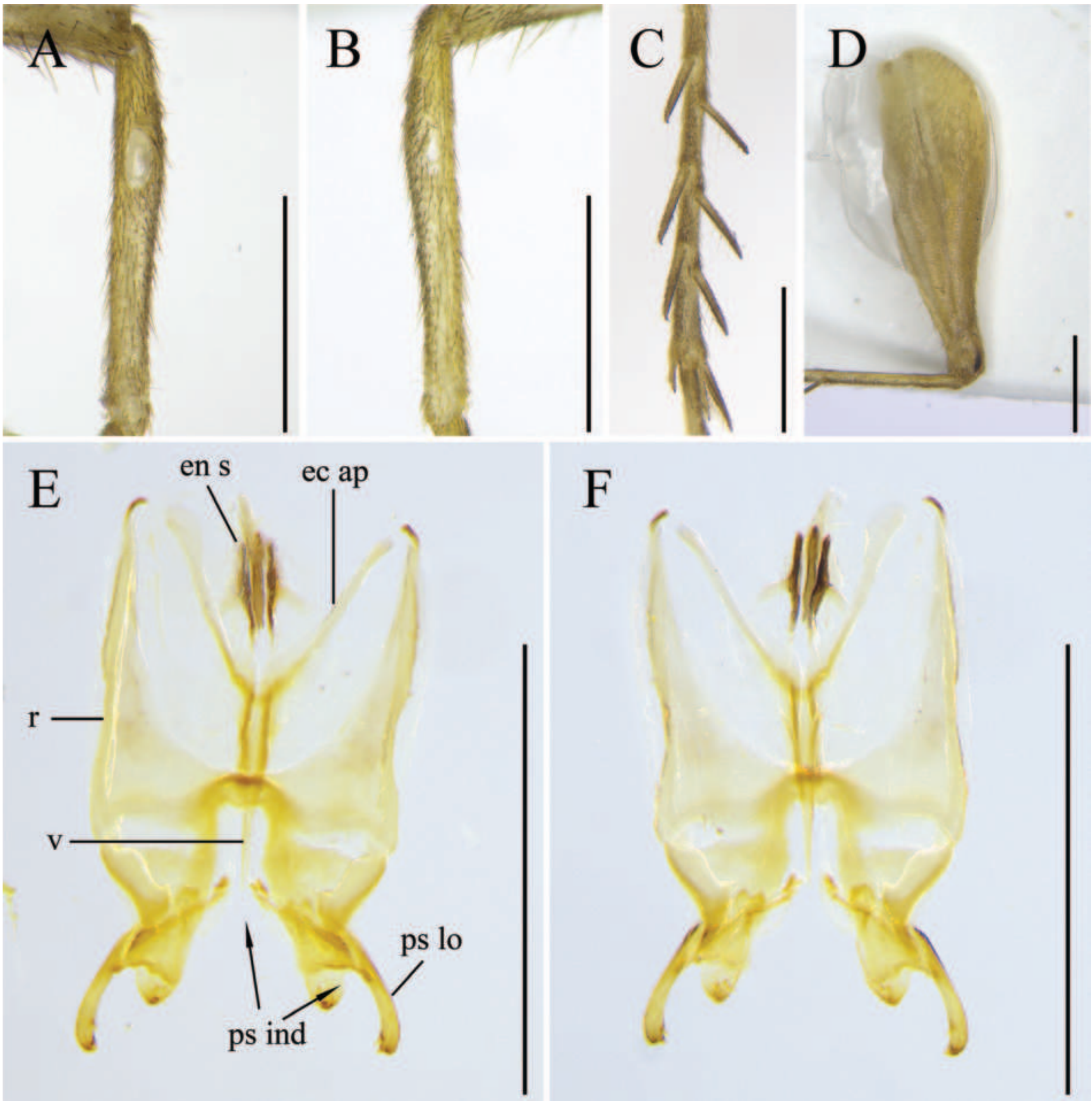

Figure 3. *Svistella yayun* He, sp. nov. **A** outer side of fore tibiae **B** inner side of fore tibia **C** hind tibiae in dorsal view **D** hind femora in lateral view **E** male genitalia in dorsal view **F** male genitalia in ventral view. All images are from holotype, ECNU 4969. Scale bars: 1 mm.

disappearing after drying (Fig. 3D). Ovipositor dark brown; apical half darker than basal part.

***Variation*.** A paratype (ECNU 4961) has seven dorsal spurs on the hind tibiae (four internal ones and three external ones), while all the other examined specimens bear six dorsal spurs on the hind tibiae.

Measurements. *Holotype*: ♂ BL 5.63, PL 1.09, FWL 4.08, HFL 4.35; ***Paratypes*:** ♂ BL 5.86–6.16, PL 1.05–1.18, FWL 4.09–4.14, HFL 4.07–4.30; ♀ BL 5.55–5.63, PL 1.19–1.27, FWL 3.36–3.41, HFL 4.19–4.30, OL 2.05–2.07.

Distribution. China (Xizang).

Etymology. The specific epithet *yayun* is for the Chinese phonetic alphabet, 雅韵, which means "beautiful music".

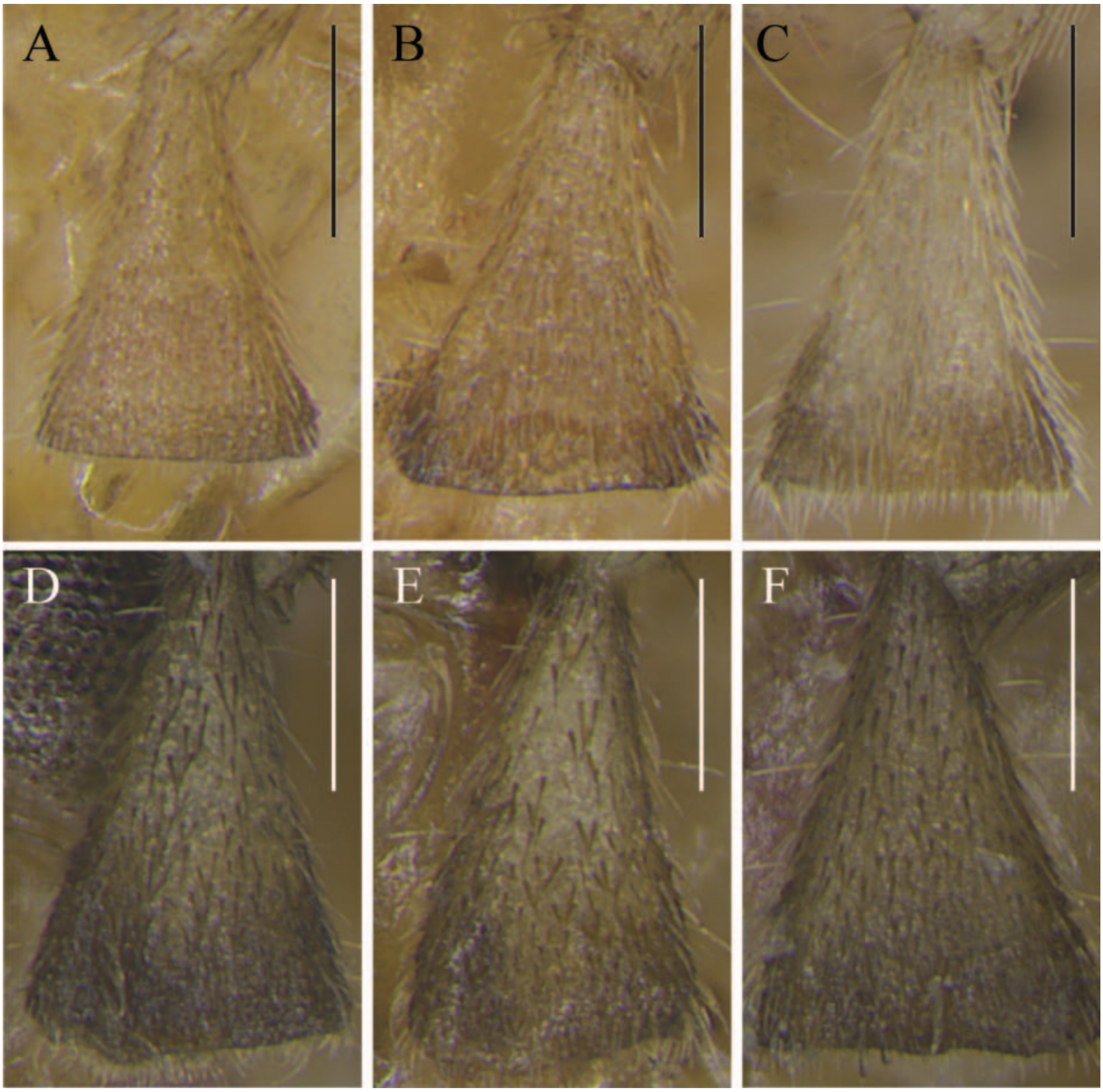

Figure 4. The 5th segment of left maxillary palp of *Svistella rufonotata* (**A–C**) and *S. yayun* He, sp. nov. (**D, E**) images **A–C** from specimens ECNU 494, ECNU 1634, and ECNU 1756, respectively **D–F** from paratypes ECNU 4961, ECNU 4967, and holotype ECNU 4969, respectively. Scale bars: 250 μm.

Molecular study

In total, 39 *COI* sequences including our newly described *S. yayun* He, sp. nov., as well as the *COI* sequence of *Amusurgus genji* as the outgroup, were obtained. The results of the two molecular methods identified 11 putative species, which largely conform to the distance tree inferred from the NJ topology and are all consistent with separating *S. yayun* He, sp. nov. as a species (Fig. 6).

Song analysis

The calling song of *Svistella yayun* sp. nov. is stereotyped with 37.11 ± 5.00 [30–42] echemes/minute. Each echeme continues 0.966 ± 0.049 [0.901–1.094]

Figure 5. Male genitalia and right inner tympanum of *Svistella rufonotata* and *S. yayun* He, sp. nov. **A** male genitalia of *S. yayun* He, sp. nov. in ventral view, holotype, ECNU 4969 **B, C** male genitalia of *S. rufonotata* in ventral view from specimens ECNU 266 and ECNU 494, respectively **D, E** inner tympanum of *S. yayun* He, sp. nov. from a paratype ECNU 4961 and the holotype, ECNU 4969, respectively **F, G** inner tympanum of *S. rufonotata* from specimens ECNU 494 and ECNU 1756, respectively. Black arrows indicate the tip and a lateral process of ectoparamere. Scale bars: 0.5 mm.

second and consists of 19.77 ± 1.060 [18–24] syllables (Fig. 7). The peak frequency is 5332.420–5594.540 Hz (Fig. 7). Although *S. rufonotata* and *S. yayun* are similar morphologically, they can be distinguished by their songs. The characteristics of the songs of all included species in PCA are shown in Table 1. The species *S. fallax* was not included in PCA, because the audio file was lost, and the peak frequency for this species was unavailable.

PCA results are shown in Fig. 8. The extracted components PC1 eigenvectors accounted for 57.90% of the variance, PC2 for 24.04%, PC3 for 15.05%, PC4 for 2.02%, and PC5 for 0.99%. Except for *S. wuyong* and *S. malu*, the remaining species can be clearly identified via the analysis of their calling songs.

Other materials examined

Svistella rufonotata: China • ♂; bought from Flowers-birds Market; September 2016; He Zhu-Qing; ECNU 266 • ♂; Yunnan, Mengla, Wangtianshu (望天树景区); 21°37.04'N, 101°33.56'E; 26 April 2017; He Zhu-Qing leg.; ECNU 494 • ♂; Hainan, Baisha, Nankai; 19°04.78'N, 109°22.57'E; 18 March 2019; He Zhu-Qing leg.; ECNU 1634 • ♂; Fujian, Wuyishan; 27°41.28'N, 117°44.38'E; 22 September 2018; He Zhu-Qing leg.; ECNU 1756.

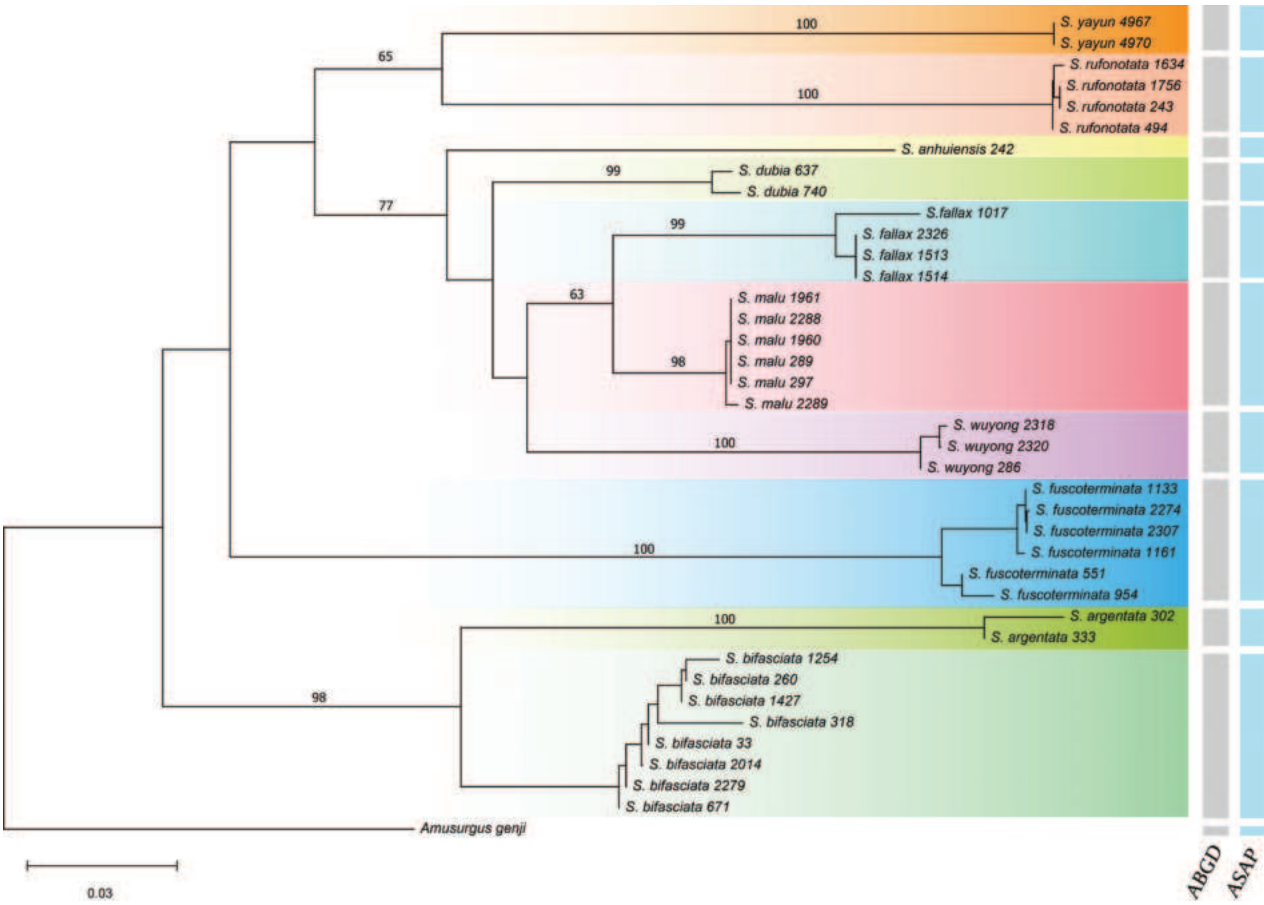

Figure 6. Distance tree of *Svistella* species based on *COI* genes. Rooted by *Amusurgus genji*, the tree was constructed using the neighbor-joining (NJ) method with the Kimura 2-parameter model and a 0.19 gamma parameter. Topology supports of major nodes are indicated above branches by bootstrap value. Two DNA barcode-based (ABGD, ASAP) delimitation methods are represented by vertical bars in grey and blue, respectively, on the right side of the tree.

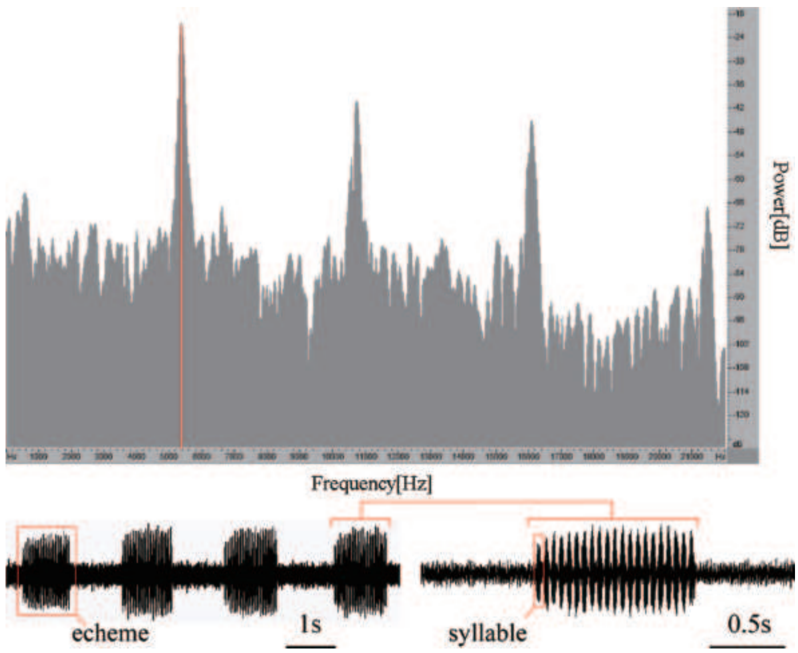

Figure 7. Spectrogram (upper) and oscillograms (lower) of male calling songs of *Svistella yayun* sp. nov. The red line in spectrogram indicates the peak frequency.

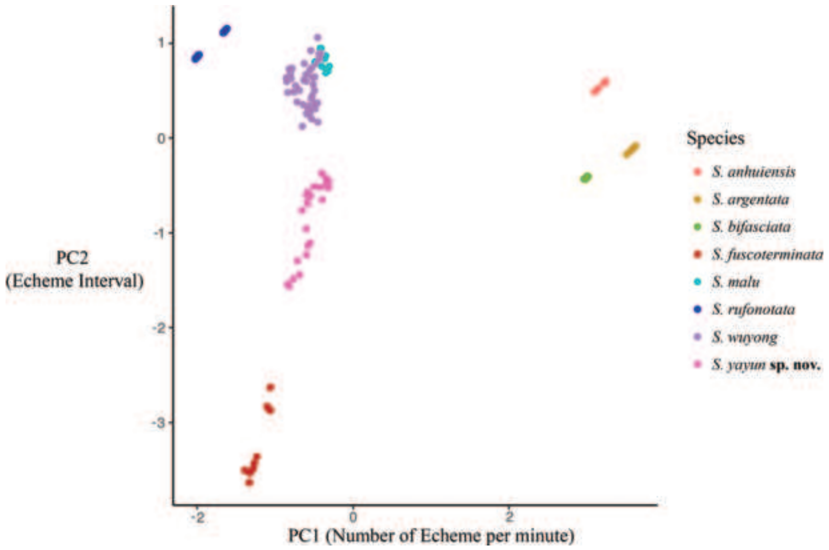

Figure 8. PCA figure description of *Svistella* species songs. Scatter plot of PC1 and PC2 of PCA based on bioacoustics measurements. Except for *S. wuyong* and *S. malu*, the remaining species can be clearly identified through the analysis of their calling songs.

Discussion

In this study, the distance tree based on *COI* sequences shows that *Svistella yayun* sp. nov. is separate and distinct from other *Svistella* species and the reconstructed tree topology aligns with the earlier study using the same gene for eight species (Li et al. 2021a). Morphologically, *S. yayun* sp. nov. is similar to *S. rufonotata*, but it can be distinguished by the dark-brown setae on the 5th segment of maxillary palp (light colored in *S. rufonotata*, Fig. 4), smaller inner tympanum with only 83.3–119.1 μm in long diameter (185.7–214.3 μm in *S. rufonotata*, Fig. 5D–G) and rounded apex of the ectoparamere (relatively abrupt in *S. rufonotata*, Fig. 5A–C). Additionally, bioacoustics PCA unveils that the songs of *S. yayun* sp. nov. form a distinct cluster compared to *S. rufonotata* and all other previously described species. Collectively, our molecular, morphological, and bioacoustics analyses provide support for recognizing *S. yayun* sp. nov. as a new species.

Probably due to its small size, it is challenging to collect or observe *S. yayun* sp. nov. in the field without relying on its distinctive songs. In our prior experience, we have occasionally identified new orthopteran species in the field based on their unique songs (Liu et al. 2018; Chen et al. 2019; Tian et al. 2019; Li et al. 2021b). Despite the crucial role of song in the speciation and evolution of Orthoptera, bioacoustic data can significantly enhance our understanding of orthopteran taxonomy, particularly considering that the divergence in songs among species often precedes noticeable morphological differences (Otte 1992). This highlights the importance of incorporating bioacoustic data as a defining characteristic in studies of Orthoptera.

Discoveries of new *Svistella* and other new species of Trigonidiidae often reveal the influence of geographical barriers and communication signals on species isolation (Mendelson et al. 2004; Grace and Shaw 2011; Stamps and Shaw 2019; Li et al. 2021a). Most *Svistella* species have allopatric distributions, while parapatric *Svistella* species produce distinctive songs to attract females (Li et al. 2021a). This highlights the role of both geographical barriers and bioacoustic signals in isolating these species. Moreover, despite bioacoustic signals, chemical, and/or tactile cues may contribute to species' recognition to isolate different *Svistella* species in contact zones (Mullen et al. 2007). Similar patterns have been observed in other trigonidiid species, such as *Laupala* (Grace and Shaw 2011; Stamps and Shaw 2019). In line with recent studies, the discovery of *S. yayun* sp. nov. may underscore the association of geographical barriers, behavioral ecology, and *Svistella* speciation.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Funding

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Author contributions

Data curation: YX, ZHZ, JWH. Methodology: YX, SYW, ZHZ, JWH. Project administration: ZQH. Supervision: PG, ZQH. Writing - original draft: JWH, YX, THH. Writing - review and editing: SYW, PG, JWH, ZQH, YX, THH.

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Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.

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Supplementary material 1

A song recording of *Svistella yayun* 1

Author: Zhu-Qing He

Data type: wav

Link: https://doi.org/10.3897/zookeys.1193.117612.suppl1

Supplementary material 2

A song recording of *Svistella yayun* 2

Author: Zhu-Qing He
Data type: wav

Link: https://doi.org/10.3897/zookeys.1193.117612.suppl2

Supplementary material 3

A song recording of *Svistella yayun* 3

Author: Zhu-Qing He
Data type: wav

Link: https://doi.org/10.3897/zookeys.1193.117612.suppl3

Supplementary material 4

A video of a chirping male *Svistella yayun*

Author: Zhu-Qing He
Data type: mp4

Link: https://doi.org/10.3897/zookeys.1193.117612.suppl4

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Research Article

A new species of the genus *Scorpiops* Peters, 1861, subgenus *Euscorpiops* Vachon, 1980 from Thailand (Scorpiones, Scorpiopidae)

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Abstract

A new species, *Scorpiops* (*Euscorpiops*) *krachan* **sp. nov.**, belonging to the family Scorpiopidae Kraepelin, 1905 is described based on three adult males and one adult female collected in the Kaeng Krachan National Park, Phetchaburi Province, Thailand. The new species presents most features exhibited by scorpions of the subgenus *Euscorpiops* and can be characterized notably by a very small size, a sexual dimorphism strongly marked with male pedipalps elongated, a distinct trichobothrial pattern and other morphological features. This new taxon may represent one endemic element for the scorpion fauna of Thailand. Aspects of the ecology and distribution of the new species are discussed and compared with that of other relative *Scorpiops* species.

Key words: Description, Kaeng Krachan National Park, morphology, scorpion, Southeast Asia, wet forest

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Introduction

As already discussed in several previous papers (e.g. Lourenço and Košulič 2018; Lourenço 2019; Lourenço and Ythier 2022), the generic composition of the now accepted family Scorpiopidae was mainly due to Vachon (1980), who revised the genus *Scorpiops* Peters, 1861 and described three new subgenera (*Alloscorpiops*, *Euscorpiops*, and *Neoscorpiops*) in addition to the nominotypical subgenus *Scorpiops*. These four subgenera were later elevated to generic rank by Lourenço (1998), and new taxa of the generic level were subsequently added to the family (*Parascorpiops* Banks, 1928, *Dasyscorpiops* Vachon, 1974, *Laoscorpiops* Lourenço, 2013, *Vietscorpiops* Lourenço & Pham, 2015, and *Plethoscorpiops* Lourenço, 2017). Later, Kovařík (2000) rejected the validity of the genus *Euscorpiops*, which was subsequently reestablished by Soleglad and Sissom (2001), mainly based on the position of chelal trichobothrium *Eb3* and the presence of an annular ring on the telson. The generic composition of the family Scorpiopidae was then globally well accepted for about 20 years until Kovařík et al. (2020) simply decided to place all the known and accepted genera of the family in the synonymy of *Scorpiops*, with the single exception of *Parascorpiops*. This drastic decision was not accepted by Lourenço and Ythier (2022), who restored some division of the family Scorpiopidae by revalidating, as subgenera of the genus *Scorpiops*, several previously defined genera: *Alloscorpiops*, *Euscorpiops*, *Neoscorpiops*, *Dasyscorpiops*, and *Plethoscorpiops*. In the same paper, *Parascorpiops* was maintained as a distinct genus, while the synonymy of *Laoscorpiops* and *Vietscorpiops* with *Alloscorpiops* and *Scorpiops*, respectively, was maintained. In the present study, a new species belonging to the subgenus *Euscorpiops* is described from Kaeng Krachan National Park located in Phetchaburi Province of Central Thailand. This new taxon may represent an endemic element of the scorpion fauna of Thailand.

Methods

Illustrations and measurements were made using a Wild M5 stereomicroscope with a drawing tube and an ocular micrometer, a Canon EOS 7D camera, and Adobe Photoshop software. The map was made using QGIS and Adobe Photoshop. Measurements follow Stahnke (1970) and are given in millimeters. Trichobothrial notations follow Vachon (1974) and morphological terminology mostly follows Vachon (1952) and Hjelle (1990). A collecting permit was provided by the Department of National Parks, Wildlife and Plant Conservation, Ministry of Natural Resources and Environment in Thailand.

Taxonomic treatment

Family Scorpiopidae Kraepelin, 1905
Genus *Scorpiops* Peters, 1861
Subgenus *Euscorpiops* Vachon, 1980

***Scorpiops* (*Euscorpiops*) *krachan* Nawanetiwong, Košulič, Warrit, Lourenço & Ythier, sp. nov.**
https://zoobank.org/53269528-C6AC-44AE-AB99-FF60D486DF8E
Figs 1–3

Type locality. Thailand, Phetchaburi Province: Kaeng Krachan National Park, Ban Krang Campsite, 12°47.970'N, 99°27.236'E, 324 m a.s.l., wet secondary forest (cloud-forest), 14 Nov. 2022, O. Košulič leg.

Type specimen. ***Holotype***, ♂. Original label: almost same as designation in type locality, deposited at the Muséum national d'Histoire naturelle, Paris, France. • ***Paratypes*:** 1 ♀. same data as holotype; 2 ♂. Original label: Thailand: Phetchaburi Province, Kaeng Krachan National Park, Ban Krang Campsite, 12°47.948'N, 99°27.250'E, 317 m a.s.l., wet secondary forest (cloud-forest), 14 Nov. 2022, O. Košulič leg., deposited at Department of Biology, Faculty of Science, Chulalongkorn University, Bangkok, Thailand (SCO-2022-005, SCO-2022-006).

Etymology. The specific name refers to the National Park of Kaeng Krachan where the new species was collected.

Diagnosis. The new species exhibits the general characteristics of the subgenus *Euscorpiops* (Vachon 1980; Soleglad and Sissom 2001). Total length of male and female 21.7–26.9 and 25.9 mm, respectively, defining the new species as very small in comparison to most other species of the subgenus. General coloration brownish yellow; female darker than male; chelicerae yellow without any variegated spots. Pectines with 6–7 and 5–5 teeth in male and female, respectively; two marginal and two middle lamellae present; fulcra present. Sexual dimorphism strongly marked, with male pedipalps markedly elongated; chela length/width ratio 4.5–5.1 in male, 3.0 in female. Chelal fingers straight in both sexes; movable fingers with two parallel longitudinal rows of granules almost fused, formed by a row of about 50 median granules and a row of 19–20 inner granules (4–5) and inner accessory granules (15); 7–8 outer granules are present. Annular ring conspicuous in both sexes; telson length/depth ratio 2.6–2.8 in male, 2.6 in female. Trichobothriotaxy of type C (Vachon 1974, 1980); three trichobothria on femur (dorsal, internal, and external); patella with two dorsal, one internal, six ventral, and 16(15) external trichobothria; chelal manus with four ventral, two dorsal (*Dt*, *Db*), two internal (*ib*, *it*), one *Est*, five *Et*, one *Esb*, and three trichobothria in the *Eb* series; trichobothrium Eb_3 located in distal half of manus, between trichobothria *Dt* and *Est*.

Description. Based on male holotype and female and male paratypes.

Coloration. Basically yellowish to brownish yellow. Carapace brownish yellow, with paler zones posteriorly and on furrows. Tergites brownish yellow. Metasomal segments brownish yellow, darker in female; telson yellow; base of aculeus blackish and tip reddish. Chelicerae yellow, without any variegated spots; one blackish spot at the base of fixed finger; fingers brownish yellow, with reddish teeth. Pedipalps reddish brown to brownish, darker in female; fingers darker than chela manus, almost blackish. Legs yellow, intensely spotted with brownish. Venter yellow; coxapophysis, sternum and sternites markedly infuscated.

Morphology. Carapace weakly granular, rather shagreened; furrows weakly deep. Median eyes anterior to the middle of carapace; three pairs of lateral eyes, the posterior one small in female and relictual in male. Sternum pentagonal, slightly longer than wide. Tergites weakly granulated, mostly shagreened; VII with five carinae, moderately marked; median carinae vestigial. Pectines large in male and reduced in female with a pectinal tooth count of 6-6 and 5-5, respectively; two marginal and two middle lamellae present; fulcra present. Sternites almost smooth and slightly punctated, with round spiracles; sternite VII with four vestigial carinae and some granulations, better marked in male. Metasomal segments I to V with 10-8-8-8-7 carinae; dorsal carinae on segments II–IV with several spinoid granules and one larger posterior spinoid granule; metasomal tegument weakly granulated; ventral carina on segment V with weakly marked spinoid granules. Telson vesicle with minute granulations, but largely smooth; annular ring conspicuous; telson length/depth ratio 2.6–2.8 in male, 2.6 in female. Setation moderate on metasomal segments and telson. Pedipalps: femur with dorsal internal, dorsal external, ventral internal and ventral external carinae moderately marked; tegument weakly granular. Patella with dorsal internal, dorsal external, ventral internal, ventral external, and external carinae weakly marked; one moderately to weakly marked spinoid granule present on internal aspect; tegument weakly granular. Chela with dorsal marginal, external secondary, ventral internal, and ventral carinae moderately marked; other carinae weak; tegument weakly granulated. Sexual dimorphism strongly marked with male pedipalps markedly elongated; chela length/width ratio 4.5–5.1 in male, 3.0 in female. Chelal fingers straight in both sexes; movable fingers with two parallel longitudinal rows of granules almost fused, formed by a row of about 50 median granules and a row of 19–20 inner granules (4–5) and inner accessory granules (15); 7–8 outer granules present. Cheliceral dentition as defined for the family (Vachon 1963); a few teeth on ventro-internal face of movable finger. Trichobothriotaxy of type C, as shown in Fig. 2 (Vachon 1974, 1980); three trichobothria on femur (dorsal, internal, and external); patella with two dorsal, one internal, six ventral, and 16(15) external trichobothria; chelal manus with four ventral, two dorsal (*Dt*, *Db*), two internal (*ib*, *it*), one *Est*, five *Et*, one *Esb*, and three trichobothria in the *Eb* series. Trichobothrium Eb_3 distal in relation to Eb_2 (Vachon 1974, 1980), located in distal half of manus, between trichobothria *Dt* and *Est*. Legs tarsi with 4–5 long setae; tibial spurs absent.

Morphometric values. Male holotype and female paratype of *Scorpiops* (*Euscorpiops*) *krachan* sp. nov. Total length including the telson 26.9/25.9. Carapace: length 4.2/4.1; anterior width 2.7/2.5; posterior width 4.2/4.2. Mesosoma length 8.6/9.8. Metasomal segments. I: length 1.3/1.2, width 1.7/1.5; II: length 1.6/1.4, width 1.5/1.3; III: length 1.8/1.6, width 1.4/1.2; IV: length 2.2/2.0, width 1.3/1.1; V: length, 3.6/2.9, width 1.1/1.0, depth 1.2/1.1. Telson length 3.6/2.9; vesicle: width 1.6/1.2, depth 1.3/1.1. Pedipalp: femur length 5.8/3.9, width 1.4/1.4; patella length 6.1/4.2, width 1.5/1.4; chela length 9.5/6.9, width 2.1/2.3, depth 1.8/1.9. Movable finger length 3.1/2.9.

Relationships. The most similar species seem to be *Scorpiops* (*Euscorpiops*) *phatoensis* and *Scorpiops* (*Euscorpiops*) *dunlopi*, both described by Kovařík et al. (2020) from South Thailand (Fig. 4), notably based on size, number of pectine teeth, marginal and middle lamellae, shape of fingers, and number of external trichobothria on patella. *Scorpiops krachan* sp. nov. can, however, be separated from these two species by the following main features:

(i) lighter coloration pattern (reddish brown to reddish black in *S. phatoensis* and *S. dunlopi*);
(ii) chelicerae without any variegated spots (variegated in *S. phatoensis* and *S. dunlopi*);
(iii) pectines with fulcra present (absent in *S. phatoensis* and reduced in *S. dunlopi*);
(iv) male chela slenderer than in *S. phatoensis* with length to width ratio 4.5–5.1 (3.7 in *S. phatoensis*);
(v) chelal movable fingers with about 50 median granules (about 40 in *S. phatoensis* and 35 in *S. dunlopi*), 4–5 inner granules (5–7 in *S. phatoensis* and absent in *S. dunlopi*), 15 inner accessory granules (about 10 in *S. phatoensis* and 10–12 in *S. dunlopi*) and 7–8 outer granules (absent in *S. dunlopi*);
(vi) female telson less elongated with length to depth ratio 2.6 in female (2.8–3.0 in *S. phatoensis* and 3.1 in *S. dunlopi*);
(vii) chelal manus trichobothrium Eb_3 located in distal half of manus, between trichobothria *Dt* and *Est* (located in middle of manus, at same level or distal to *Dt* in *S. phatoensis*);
(viii) an allopatric geographic distribution (type localities of *S. phatoensis* and *S. dunlopi* about 350 km and 500 km to the south, respectively).

Another species, *Scorpiops* (*Euscorpiops*) *binghamii* Pocock, 1893, described from southern Myanmar, is geographically close to *S. krachan* sp. nov. but can easily be distinguished from the new species, notably by the number of external trichobothria on patella (20–21), whereas *S. krachan* sp. nov. has 15–16.

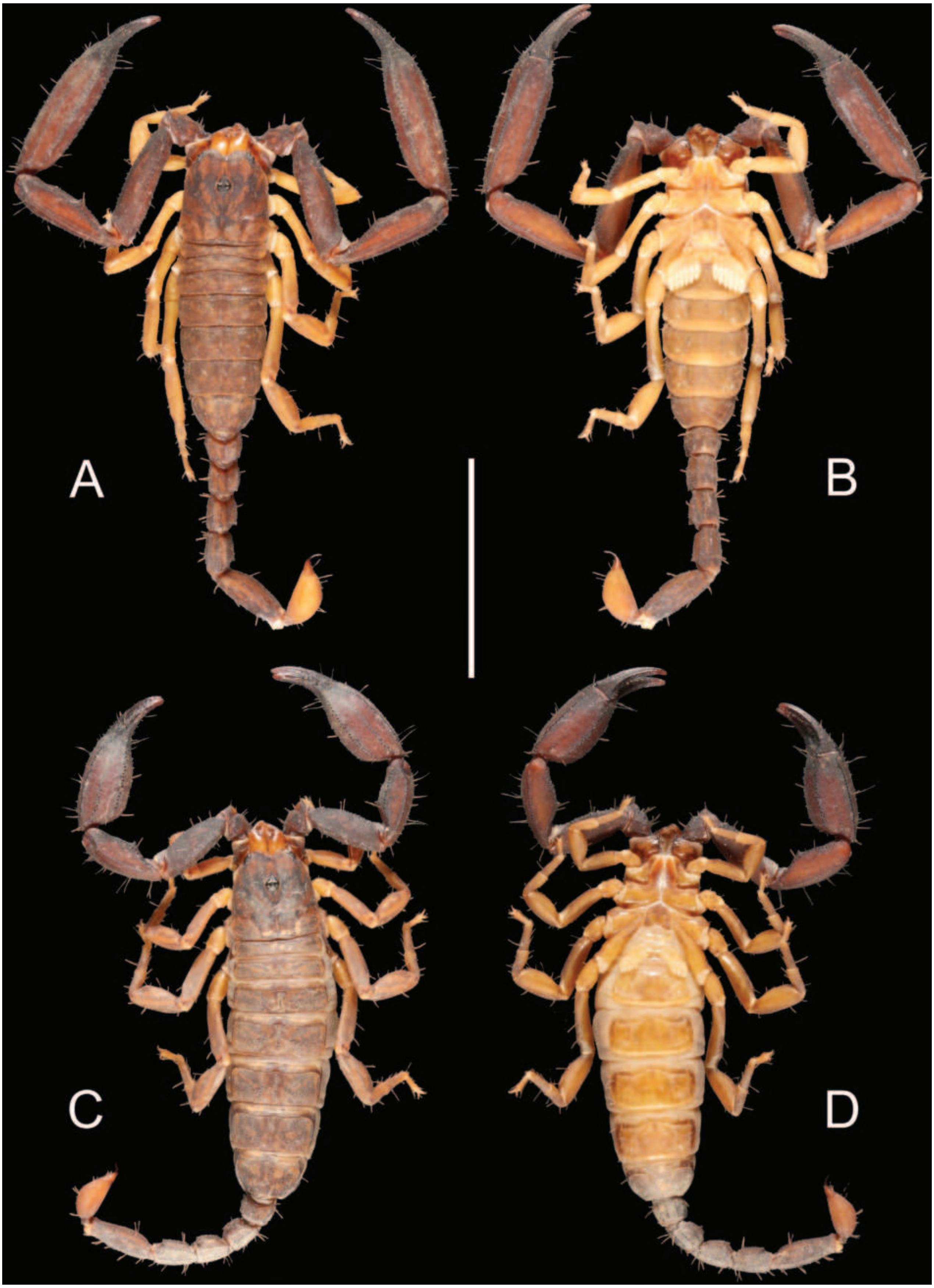

Figure 1. *Scorpiops* (*Euscorpiops*) *krachan* sp. nov. **A, B** male holotype, habitus, dorsal **A** and ventral **B** aspects **C, D** female paratype, habitus, dorsal **C** and ventral **D** aspects. Scale bar 1 cm.

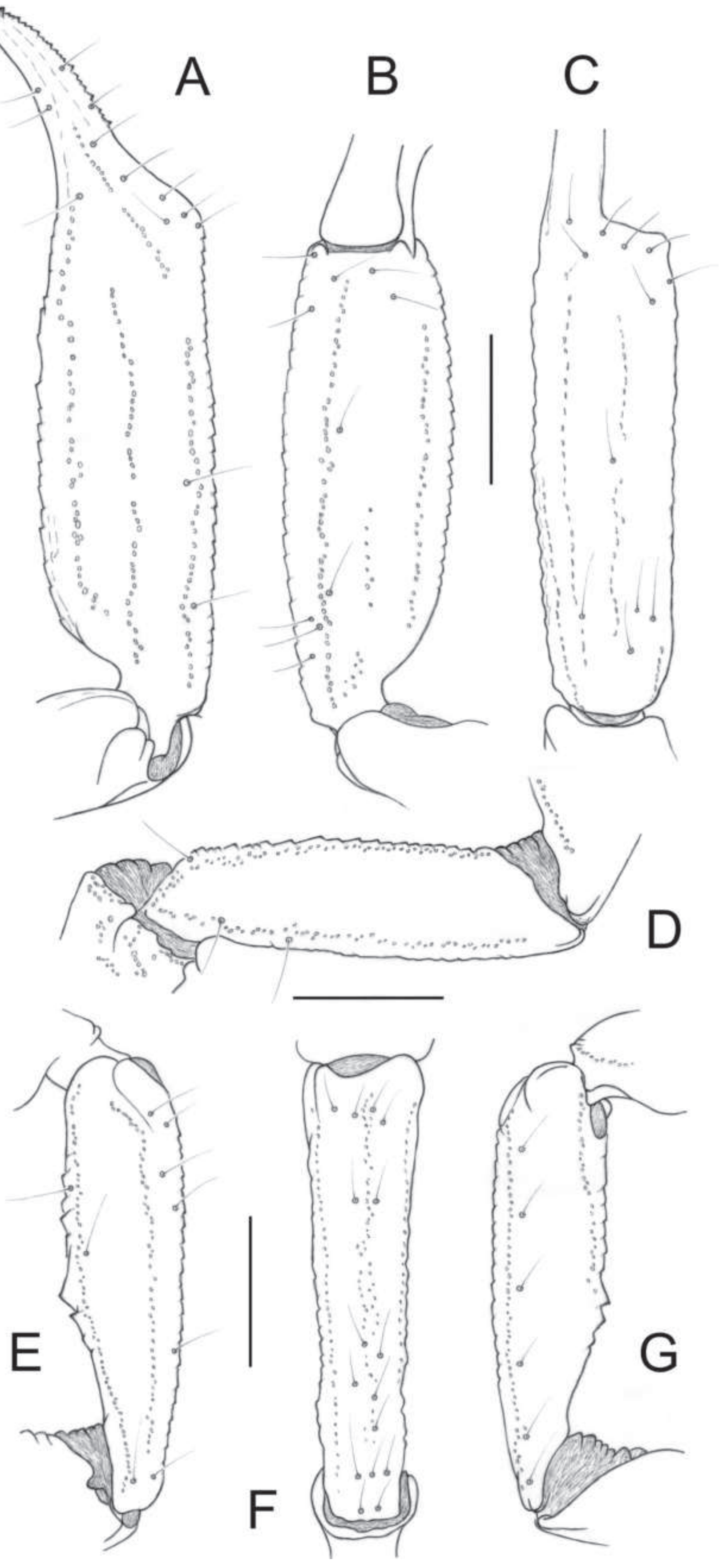

Figure 2. *Scorpiops* (*Euscorpiops*) *krachan* sp. nov. Male holotype, trichobotrial pattern **A–C** chela, dorso-external **A** ventral **B** and external **C** aspects **D** femur, dorsal aspect **E–G** patella, dorsal **E** external **F** and ventral **G** aspects. Scale bars 2 mm.

Figure 3. Scorpiops (Euscorpiops) krachan sp. nov., alive with pre-juveniles (instar I).

Distribution and ecological affinities of *Scorpiops* species in Thailand

The members of this genus can be found in altitudes ranging from 40 to 1800 m a.s.l. (Kovařík 1993, 2000, 2013; Kovařík et al. 2013a, 2013b, 2015, 2020; Lourenço 2019). Habitats are mostly covered with various forest types from deciduous forest to lower mountain forest (Maxwell 2004). *Scorpiops krachan* sp. nov. is the second species reported from Phetchaburi province; the other species is *S. anthracinus* (Kovařík et al. 2020). *Scorpiops krachan* sp. nov. inhabits the Tenasserim Mountain Range, which is covered with rainforest (wet forest including secondary and primary forests), similar to other *Scorpiops* species found in the country.

The microhabitats of *Scorpiops* species in Thailand include soil walls, dead logs, piled stones, and buffalo feces (Kovařík 1993). These microhabitats can often be found near caves. *Scorpiops krachan* sp. nov. was collected underneath a rock in transitional habitat between secondary to primary forests (Fig. 5). In the same habitat, several subadult specimens of *Heterometrus* scorpions, most likely belonging to *H. minotaurus* Plíšková, Kovařík, Košulič & Šťáhlavský, 2016, were found.

Scorpiops microhabitats suggest that these predators have an ambush or sit-and-wait type of foraging (McCormick and Polis 1990). It is predicted that scorpions in this genus have limited distribution ranges with high degree of endemism, as it has been reported for *S. dunlopi*, *S. phatoensis* (Kovařík et al. 2020), and *S.* (*Alloscorpiops*) *viktoriae* (Lourenço and Košulič 2018).

Figure 4. Distribution map showing the type localities of the new species and its most relative *Scorpiops* species: *S.* (*Euscorpiops*) *krachan* sp. nov. (red triangle), *S. phatoensis* Kovařík et al., 2020 (green square), *S. dunlopi* Kovařík et al., 2020 (purple square).

Figure 5. Natural habitat of *Scorpiops* (*Euscorpiops*) *krachan* sp. nov. in Kaeng Krachan National Park, Phetchaburi Province, Thailand.

Until now, all *Scorpiops* species reported in Thailand were believed to be endemic to their habitats (Kovařík 1993, 2000, 2013; Kovařík et al. 2013a, 2013b, 2015, 2020; Lourenço 2019). They can be found mainly in mountain areas, particularly in places with numerous rock crevices. Despite several studies on *Scorpiops* in Thailand, additional areas of the country are still unexplored and needed investigation. We suggest that future studies focus on cavernous mountainous habitats.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Conceptualization: OK, WL, EY. Data curation: WN, NW, WL. Formal analysis: EY, WL, WN. Funding acquisition: NW, OK. Investigation: OK, WN, WL, EY. Methodology: WL, EY, WN. Visualization: WL, EY, WN. Writing - original draft: EY, WL, WN, Writing - review and editing: WN, EY, NW.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Research Article

A new species of the *Pholcus phungiformes* species group (Araneae, Pholcidae) from Liaoning, China, with identification keys to four closely related species

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Abstract

A new species of pholcid spiders, *Pholcus fengmeii* Zhang, He & Yao, **sp. nov.** (♂♀), is described from Liaoning Province, China. The new species belongs to the speciose *phungiformes* species group. Taxonomic keys to four closely related species are provided.

Key words: Biodiversity, daddy-long-legs spider, morphology, Northeast Asia, Pholcinae, taxonomy

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Introduction

Pholcidae C.L. Koch, 1850 is one of the most species-rich spider families, with 1,946 extant species in 97 genera (WSC 2024). *Pholcus* Walckenaer, 1805 is the most diverse genus in the family, with 384 described species mainly distributed in the Afrotropical, Palaearctic, Indo-Malayan, and Australasian regions (Huber 2011; Yao and Li 2012; WSC 2024). The genus was split to 21 species groups by Huber (2011) and Huber et al. (2018), of which the *phungiformes* group is the most speciose and contains 108 species (Huber 2011; Wang et al. 2020; Yao et al. 2021; Lu et al. 2022; Zhao et al. 2023a, 2023b). Almost all species of this group are recorded from four mountain ranges: the Lüliang Mountains (9 spp.) and the Yanshan–Taihang Mountains (35 spp.) in North China, the Changbai Mountains (27 spp.) at the border between northeastern China and North Korea, and the Taebaek Mountains (44 spp.) on the Korean Peninsula (Jang et al. 2023). The only exception is *P. phungiformes* Oliger, 1983, which is known in the Maritime Territory, Sakhalin Island, and the Kurile Islands, Russia (Huber 2011). The Lüliang Mountains represent the westernmost limit of the distribution of the *phungiformes* group (Zhao et al. 2023b). The aim of this work is to describe a new species from Liaoning (Fig. 1), which occurs in the Changbai Mountain range in northeastern China. Taxonomic keys are provided to separate it from three other morphologically similar species, also occurring in Liaoning.

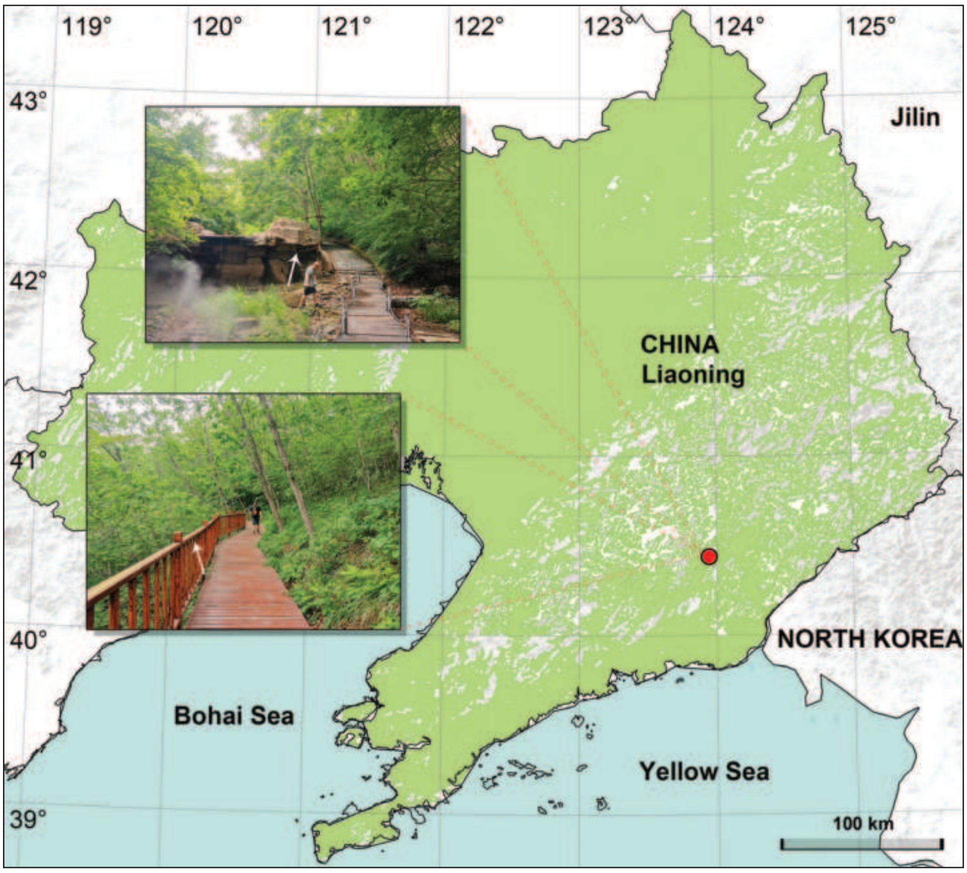

Figure 1. Distribution of *Pholcus fengmeii* sp. nov. from Liaoning, China. Arrows indicate habitats.

Materials and methods

Specimens were examined and measured with a Leica M205 C stereomicroscope. The left male palp was photographed. The epigyne was photographed before dissection. The vulva was photographed after treating it in a 10% warm solution of potassium hydroxide (KOH) to dissolve soft tissues. Images were captured with a Canon EOS 750D wide zoom digital camera (24.2 megapixels) mounted on the stereomicroscope mentioned above and assembled using Helicon Focus v. 3.10.3 image-stacking software (Khmelik et al. 2005). All measurements are given in millimeters (mm). Leg measurements are shown as: total length (femur, patella, tibia, metatarsus, tarsus). Leg segments were measured on their dorsal side. The distribution map was generated with ArcGIS v. 10.2 (ESRI Inc.). The specimens studied are preserved in 75% ethanol and deposited in the College of Life Science, Shenyang Normal University (SYNU) in Liaoning, China.

Terminology and taxonomic descriptions follow Huber (2011) and Yao et al. (2015, 2021). The following abbreviations are used in the descriptions: **ALE** = anterior lateral eye, **AME** = anterior median eye, **PME** = posterior median eye, **L/d** = length / diameter ratio; used in the illustrations: **aa** = anterior arch, **b** = bulb, **da** = distal apophysis, **e** = embolus, **fa** = frontal apophysis, **pa** = proximo-lateral apophysis, **pp** = pore plate, **pr** = procursus, **u** = uncus.

Taxonomic accounts

Family Pholcidae C.L. Koch, 1850
Subfamily Pholcinae C.L. Koch, 1850

Genus *Pholcus* Walckenaer, 1805

Type species. *Aranea phalangioides* Fuesslin, 1775.

***Pholcus phungiformes* species group**

The species group was recognized by Huber (2011). Currently, 23 species belonging to this group have been recorded from Liaoning Province. Of these, three species are similar to *P. fengmeii* sp. nov., and therefore we provide keys that allow distinguishing these four sibling species.

Identification keys to four closely related species from Liaoning Province, China

Males

1 Procursus with ventro-subdistal apophysis (e.g. arrow 2 in Fig. 4G); uncus not half-round (e.g. Fig. 4H)..**2**

– Procursus without ventro-subdistal apophysis (Fig. 2C); uncus nearly half-round, with latero-median protrusion (arrow in Fig. 3C) .... ***P. fengmeii* sp. nov.**

2 Procursus with wide (length/width ratio: 2) prolatero-subdistal sclerite (arrow 1 in Fig. 4D); prolatero-subdistal sclerite with angular proximal apophysis (arrow 3 in Fig. 4D) ....***P. phoenixus***

– Procursus with narrow (length/width ratio: 4) prolatero-subdistal sclerite (e.g. arrow 1 in Fig. 4G); prolatero-subdistal sclerite without angular proximal apophysis (e.g. Fig. 4G) **3**

3 Prolatero-subdistal sclerite of procursus curved (arrow 1 in Fig. 4A); procursus with short (as wide as long) and weakly sclerotized ventro-subdistal apophysis (arrow 2 in Fig. 4A); uncus medially strongly protruding and distally strongly curved (arrows 1, 2 in Fig. 4B).......................***P. jiguanshan***

– Prolatero-subdistal sclerite of procursus straight (arrow 1 in Fig. 4G); procursus with long (length/width ratio: 2) and strongly sclerotized ventro-subdistal apophysis (arrow 2 in Fig. 4G); uncus not protruding medially, distally slightly curved (arrows 1, 2 in Fig. 4H)........................ ***P. yaoshan***

Females

1 Anterior arch straight (Fig. 4F); pore plates nearly triangular (Fig. 4F)........ ....***P. phoenixus***

– Anterior arch curved (e.g. Fig. 3B); pore plates nearly elliptical or half-round (e.g. Fig. 4I, Fig. 3B) **2**

2 Anterior arch laterally curved (Fig. 4I); pore plates nearly elliptical (Fig. 4I) .... ***P. yaoshan***
– Anterior arch medially curved; pore plates nearly half-round or anteriorly wide and posteriorly narrow and pointed 3
3 Anterior arch medially strongly curved (bow-shaped; Fig. 3B); pore plates nearly half-round (Fig. 3B) .... ***P. fengmeii* sp. nov.**
– Anterior arch medially slightly curved (ridge-shaped; Fig. 4C); pore plates nearly elliptical but anteriorly wide and posteriorly narrow and pointed (Fig. 4C).. ***P. jiguanshan***

***Pholcus fengmeii* Zhang, He & Yao, sp. nov.**

https://zoobank.org/6A3D5A94-C9FC-411E-8E5E-13E13B8AE018
Figs 2, 3

Type material. ***Holotype*:** ♂ (SYNU-Ar00357), **China**, **Liaoning**, Dandong, Fengcheng, Dalishu Village, Yaowanggu (40°26.30'N, 123°56.65'E, 298 m), 2 July 2023, Q. He & Z. Yao leg. ***Paratypes*:** 2♂ (SYNU-Ar00358–59), 3♀ (SYNU-Ar00360–62), same data as for the holotype.

Etymology. The specific name is dedicated to the late Deputy of China's National People's Congress, Fengmei Mao (1949–2014). Under the leadership of Fengmei Mao, the villagers of Dalishu in Liaoning Province were inspired to work hard and work smart, embarked on an entrepreneurial journey from 1980, and transformed their spartan hamlet into the prosperous and flourishing community it is today.

Diagnosis. The new species resembles *P. phoenixus* (Fig. 4D–F; Yao and Li 2012: figs 144A–D, 145A–C) by having similar epigyne (Fig. 3A) and male chelicerae (Fig. 3D), but it can be easily distinguished by procursus lacking ventro-subdistal apophysis (Fig. 2C; vs present, arrow 2 in Fig. 4D), by prolatero-subdistal sclerite of procursus lacking angular proximal apophysis (Fig. 2C; vs present, arrow 3 in Fig. 4D), by uncus nearly half-round, with latero-median protrusion (arrow in Fig. 3C; vs with latero-median and distal protrusions, Fig. 4E), by anterior arch medially strongly curved (bow-shaped, Fig. 3B; vs straight, Fig. 4F), and by pore plates nearly half-round (Fig. 3B; vs nearly triangular, Fig. 4F).

Description. Male (*holotype*): Habitus as in Fig. 3E, F. Total length 4.85 (5.08 with clypeus), carapace 1.41 long, 1.62 wide, opisthosoma 3.44 long, 1.34 wide. Legs: I: 36.90 (9.55, 0.74, 9.04, 15.19, 2.38), II: 25.06 (6.99, 0.64, 6.22, 9.68, 1.53), III: 17.98 (5.19, 0.60, 4.17, 6.79, 1.23), IV: 23.47 (6.79, 0.68, 5.77, 8.85, 1.38); tibia I L/d: 65. Eye interdistances and sizes: PME–PME 0.26, PME 0.15, PME–ALE 0.04, AME–AME 0.06, AME 0.10. Sternum width/length: 1.10/0.97. Carapace yellowish, with brown radiating marks and marginal brown bands; ocular area yellowish, with median and lateral brown bands; clypeus yellowish, with brown median marks; sternum yellowish, with brown marks and posterior median stripe. Legs yellowish, but dark brown on patellae and whitish on distal parts of femora and tibiae, with darker rings on subdistal parts of femora and proximal and subdistal parts of tibiae. Opisthosoma yellowish, with dorsal and lateral spots. Chelicerae (Fig. 3D) with pair of proximo-lateral apophyses, pair of distal apophyses with 2 teeth each, and pair of frontal apophyses. Legs with short erected setae on tibiae, metatarsi, and tarsi; retrolateral trichobothrium on tibia I at 3% proximally; tarsus I with 33 distinct pseudosegments.

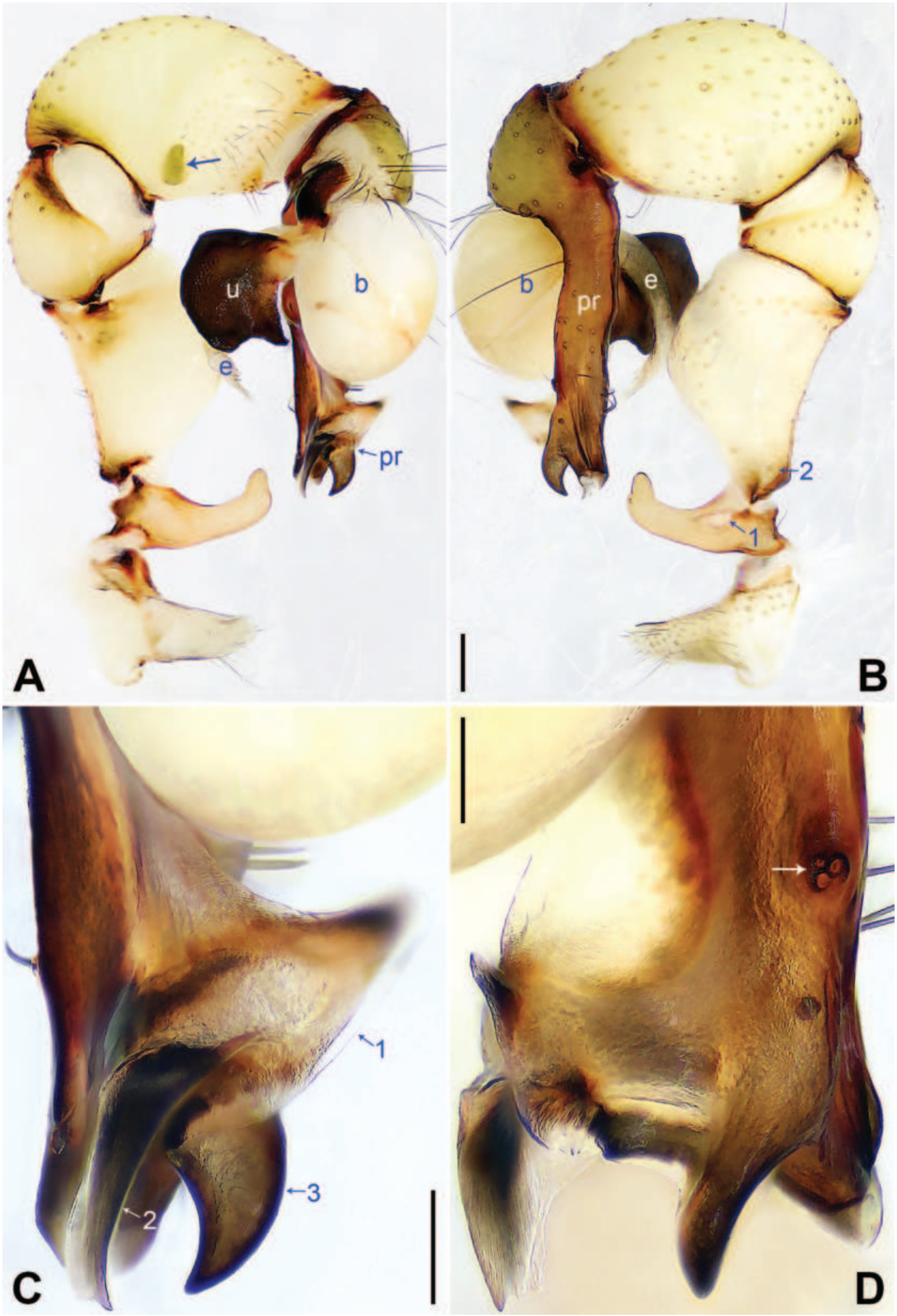

Figure 2. *Pholcus fengmeii* sp. nov., holotype male **A, B** palp (**A** prolateral view, arrow indicates prolatero-ventral protrusion **B** retrolateral view, arrow 1 indicates retrolaterally strongly bulged part, arrow 2 indicates retrolatero-proximal protrusion) **C, D** distal part of procursus (**C** prolateral view, arrow 1 indicates wide prolatero-subdistal sclerite, arrow 2 indicates curved proximal apophysis, arrow 3 indicates curved distal apophysis **D** dorsal view, arrow indicates dorsal spines). Abbreviations: b = bulb, e = embolus, pr = procursus, u = uncus. Scale bars: 0.20 mm (**A, B**); 0.10 mm (**C, D**).

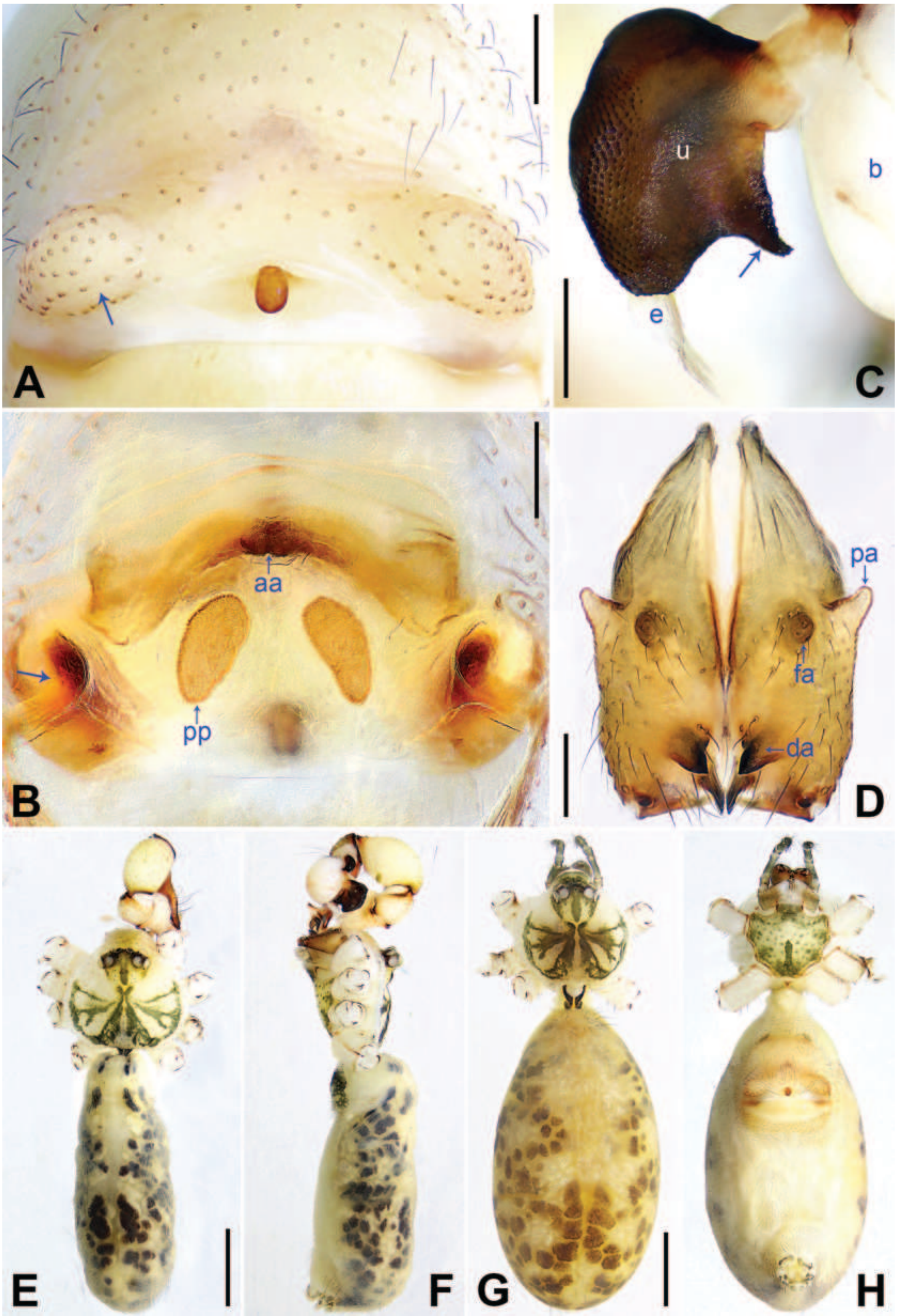

Figure 3. *Pholcus fengmeii* sp. nov., holotype male (**C–F**) and paratype female (**A, B, G, H**) **A** epigyne, ventral view, arrow indicates lateral protrusion **B** vulva, dorsal view, arrow indicates lateral sclerite **C** bulbal apophyses, prolateral view, arrow indicates latero-median protrusion **D** chelicerae, frontal view **E–H** habitus (**E, G** dorsal view **F** lateral view **H** ventral view). Abbreviations: aa = anterior arch, b = bulb, da = distal apophysis, e = embolus, fa = frontal apophysis, pa = proximo-lateral apophysis, pp = pore plate, u = uncus. Scale bars: 0.20 mm (**A–D**); 1.00 mm (**E–H**).

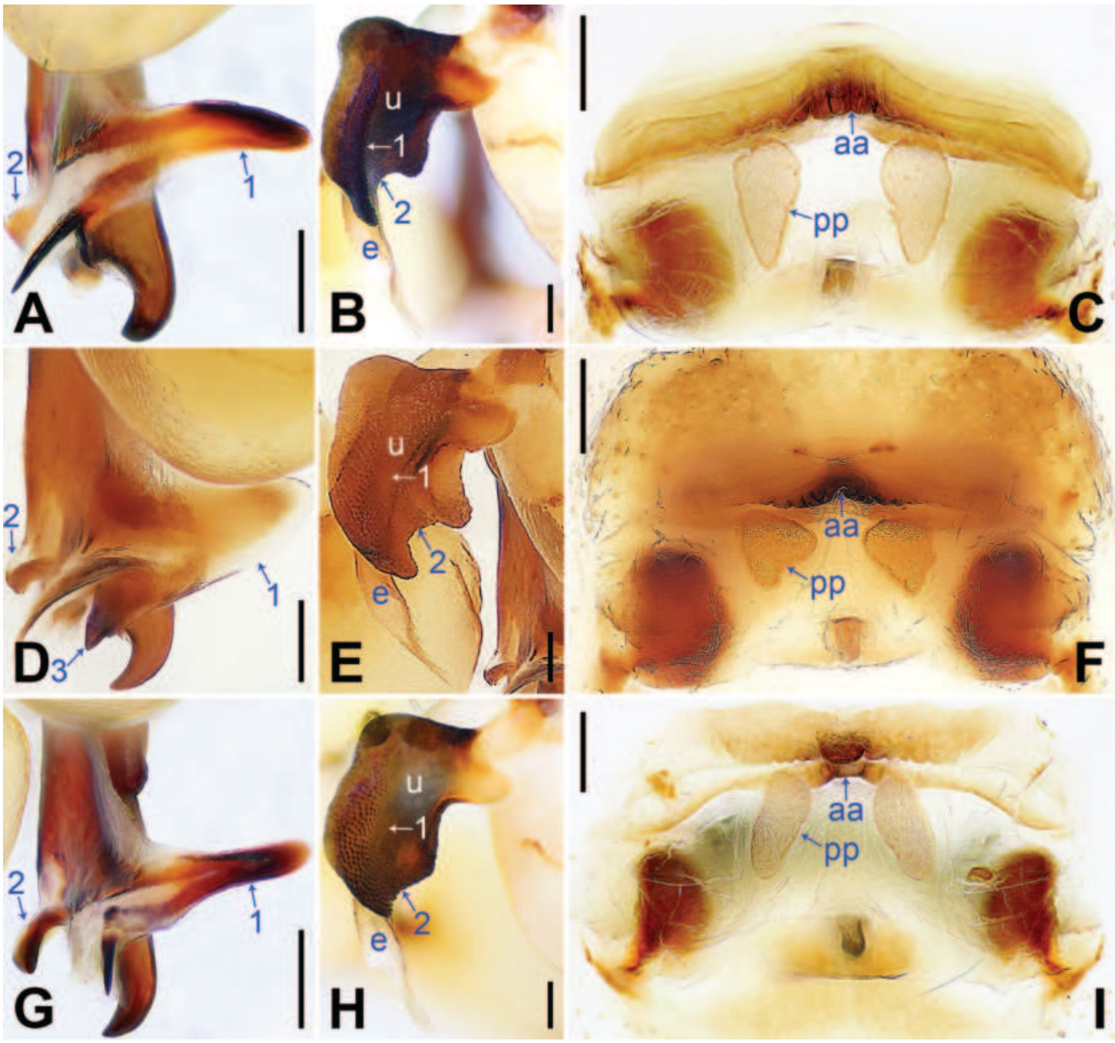

Figure 4. *Pholcus jiguanshan* (**A–C**), *P. phoenixus* (**D–F**), *P. yaoshan* (**G–I**) **A, D, G** distal parts of procursus, prolateral views, arrows 1 indicate prolatero-subdistal sclerite, arrows 2 indicate ventro-subdistal apophysis, arrow 3 indicates angular proximal apophysis **B, E, H** bulbal apophyses, prolateral views, arrows 1 indicate median part, arrows 2 indicate strongly/slightly curved distal part **C, F, I** vulvae, dorsal views. Abbreviations: aa = anterior arch, e = embolus, pp = pore plate, u = uncus. Scale bars: 0.10 mm (**A, B, D, E, G, H**); 0.20 mm (**C, F, I**).

Palp as in Fig. 2A, B; trochanter with long (4 times longer than wide), retrolaterally strongly bulged ventral apophysis (arrow 1 in Fig. 2B); femur with small retrolatero-proximal protrusion (arrow 2 in Fig. 2B) and indistinct ventral protrusion; tibia with prolatero-ventral protrusion (arrow in Fig. 2A); procursus simple proximally and complex distally, with proximally wide prolatero-subdistal sclerite (arrow 1 in Fig. 2C) equipped with curved proximal apophysis (arrow 2 in Fig. 2C), curved distal apophysis (arrow 3 in Fig. 2C), and 3 dorsal spines (arrow in Fig. 2D); uncus nearly half-round, 1.3 times longer than wide, with scales and latero-median protrusion (arrow in Fig. 3C); bulb without appendix; embolus weakly sclerotized, with some indistinct transparent distal projections (Fig. 3C).

Female (***paratype***, SYNU-Ar00360): Similar to male, habitus as in Fig. 3G, H. Total length 5.83 (5.99 with clypeus), carapace 1.45 long, 1.68 wide, opisthosoma 4.38 long, 2.33 wide; tibia I: 8.85; tibia I L/d: 52. Eye interdistances and sizes: PME–PME 0.22, PME 0.15, PME–ALE 0.05, AME–AME 0.06, AME 0.09. Sternum width/length: 1.11/0.95. Clypeus brown.

Epigyne (Fig. 3A) 1.2 times wider than long, with antero-median brownish marks, short oval knob (1.6 times longer than wide), and pair of lateral protrusions anterior to epigynal plate (arrow in Fig. 3A). Vulva (Fig. 3B) with strongly curved, sclerotized anterior arch, pair of nearly half-round pore plates (2 times longer than wide), and pair of curved lateral sclerites (arrow in Fig. 3B).

Variation. Tibia I in two paratype males (SYNU-Ar00358–59): 10.51, 10.90. Tibia I in the other two paratype females (SYNU-Ar00361–62): 7.76, 8.01.

Natural history. Specimens were found on the underside of overhang on rocky outcrop and wooden railings in rural areas.

Distribution. China (Liaoning, type locality; Fig. 1).

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

ZY and QH designed the study, contributed the fieldwork, and performed morphological species identification. LZ and BW finished the species descriptions and took the photos. ZY, QH and LZ drafted and revised the manuscript.

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Data availability

All of the data that support the findings of this study are available in the main text.

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DOI: 10.3897/zookeys.1193.114957

Research Article

Pisachini planthoppers of Vietnam: new records of *Pisacha* and a new *Goniopsarites* species from Central Vietnam (Hemiptera, Fulgoromorpha, Nogodinidae)

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Abstract

Two planthopper species of the family Nogodinidae are added to the fauna of Vietnam, both from two localities in Thua Thien-Hue Province: Bach Ma National Park and Phong Dien District. The first species belongs to *Goniopsarites* Meng, Wang & Wang, 2014, *G. mientrunganus* Constant & Pham, **sp. nov.**, and the second belongs to *Pisacha* Distant, 1906, *P. yinggensis* Meng, Wang & Wang, 2014. *Pisacha yinggensis* was previously recorded from Hainan Island, China. These new records greatly extend the distribution of both genera, which were known from southern China, Hainan and North Vietnam, to the south, reaching the mid area of Central Vietnam. Sexual dimorphism is reported in *P. yinggensis* for the first time. Illustrations of habitus and male terminalia of the new species are given as well as distribution maps and photographs of live specimens and their habitat. The family Nogodinidae now comprises nine species in Vietnam, with three of them present in Bach Ma National Park.

Key words: Bach Ma National Park, biodiversity, Fulgoroidea, Indochina, Phong Dien District

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Introduction

The family Nogodinidae Melichar, 1898 is distributed worldwide in the tropics and subtropics and contains 378 species in 99 genera, including 11 species in Vietnam (Bourgoin 2023). Of these 11 species, five were described in the last 10 years (Constant and Pham 2014; Gnezdilov and Constant 2014; Meng et al. 2014; Constant and Pham 2016). Within the subfamily Nogodininae Melichar, 1898, the tribe Pisachini Fennah, 1978 was recently reviewed by Meng et al. (2014) and currently counts 10 species in three genera distributed in Southeast Asia (Constant and Pham 2016; Bourgoin 2023).

Study of the recent material of Nogodinidae in the collections of the Vietnam National Museum of Nature and Royal Belgian Institute of Natural Sciences revealed two species of Pisachini from Central Vietnam, which are new to the fauna of the country, including a species of *Goniopsarites* Meng, Wang & Wang, 2014 new to science.

The present paper describes this new species and provides the first Vietnamese records of *Pisacha yinggensis* Meng, Wang & Wang, 2014 as a new contribution to the Vietnamese nogodinid fauna.

Material and methods

The terminalia were extracted after soaking the abdomen overnight in a 10% solution of potassium hydroxide (KOH) at room temperature. The pygofer was separated from the abdomen, thoroughly rinsed in 70% ethanol, and the aedeagus dissected with a needle blade for examination. The whole was then placed in glycerin for preservation in a tube attached to the pin of the corresponding specimen. The hind wing was mounted, glued on a white cardboard rectangle with white glue, and the cardboard attached to the pin of the specimen. Photographs of collection specimens were taken with a Leica EZ4W stereomicroscope, stacked with CombineZ software, and optimized with Adobe Photoshop software; photographs from the field were taken with an Olympus Tough 6 camera. The maps were produced with SimpleMappr (Shorthouse 2010) and include records available from Meng et al. (2014) and Constant and Pham (2016). The external morphological terminology follows O'Brien and Wilson (1985), the wing venation terminology follows Bourgoin et al. (2015) and, for the male terminalia, Bourgoin and Huang (1990). The metatibiotarsal formula gives the number of spines on (side of metatibia) apex of metatibia / apex of first metatarsomere / apex of second metatarsomere.

The measurements were taken as by Constant (2004) and the following acronyms are used:

BB maximum breadth of the body;
BF maximum breadth of the fron;
BTg maximum breadth of the tegmen;
BV maximum breadth of the vertex;
LF length of the frons at median line;
LT total length (apex of head to apex of tegmina);
LTg length of the tegmen;
LV length of the vertex at median line.

Acronyms used for the collections:

RBINS Royal Belgian Institute of Natural Sciences, Brussels, Belgium;
VNMN Vietnam National Museum of Nature, Hanoi, Vietnam.

Other abbreviations:

CCRR Centre for Conservation of Vietnam Natural Resources and Rescue of Animals and Plants.

Taxonomy

Family Nogodinidae Melichar, 1898
Subfamily Nogodininae Melichar, 1898
Tribe Pisachini Fennah, 1978

Genus *Goniopsarites* Meng, Wang & Wang, 2014

Goniopsarites Meng et al., 2014: 80, figs 1–27.

Type species. *Goniopsarites fronticonvexus* Meng, Wang & Wang, 2014, by original designation.

Distribution. Southern China (Guangdong, Hainan); North and Central Vietnam.

Species included.

G. fronticonvexus Meng, Wang & Wang, 2014 – China: Hainan and Guangdong.

G. mientrunganus Constant & Pham, sp. nov. – Vietnam: Bach Ma National Park and Phong Dien CCRR.

G. tonkinensis Constant & Pham, 2016 – Vietnam: Ba Be and Cuc Phuong national parks, and Me Linh Biodiversity Station.

Key to the species of *Goniopsarites*

1 Posterior processes of the periandrium (*ppp* – Fig. 2D) large and laminate, curved dorsocephalad in lateral view; posterodorsal process of the gonostyli bulging apically (*G* – Fig. 2A); basiventral lobe of the proximal half of the anal tube strongly developed in lateral view (*An* – Fig. 2A) .... ***Goniopsarites mientrunganus* Constant & Pham, sp. nov.**

– Posterior processes of the periandrium not large and laminate, but instead indistinct (Meng et al. 2014: fig. 19) or slender and curved posterodorsad (Constant and Pham 2016: fig. 4C); posterodorsal process of the gonostyli not bulging apically (Meng et al. 2014: fig. 18; Constant and Pham 2014: fig. 4A); basiventral lobe of the proximal half of the anal tube moderately developed in lateral view (Meng et al. 2014: fig. 18; Constant and Pham 2014: fig. 4A)..... **2**

2 Anal tube strongly curved and very wide apically in lateral view (Constant and Pham 2016: fig. 4A) and with lateral margins strongly sinuate and narrowing towards base in dorsal view (Constant and Pham 2016: fig. 4B); apex of aedeagus more elongate and curved ventrally at apex (Constant and Pham 2016: fig. 4C); lateral processes of aedeagus strongly sinuate (Constant and Pham 2016, fig. 4C); posterior processes of the periandrium slender and curved posterodorsad (Constant and Pham 2016: fig. 4C) .... ***Goniopsarites tonkinensis* Constant & Pham, 2016**

– Anal tube moderately curved, and roundly truncate apically in lateral view (Meng et al. 2014: fig. 18) and with lateral margins weakly sinuate and wider towards base in dorsal view (Meng et al. 2014: fig. 14); apex of aedeagus roundly truncate and not curved ventrally at apex (Meng et al. 2014: fig. 19); lateral processes of aedeagus regularly curved in lateral view (Meng et al. 2014: fig. 19); posterior processes of the periandrium indistinct (Meng et al. 2014: figs 19, 20) .... ***Goniopsarites fronticonvexus* Meng, Wang & Wang, 2014**

Goniopsarites mientrunganus **Constant & Pham, sp. nov.**
https://zoobank.org/689317C8-D1E4-4526-81CC-E89B9C11E42B
Figs 1–4A

Type material. ***Holotype*** ♂, Vietnam • Thừa Thiên-Huế Province, Bach Ma National Park, near ranger station; 16°08'37"N, 107°49'36"E; 18 May 2023; alt. 300–600 m; J. Constant & L. Semeraro leg.; VNMN_E000.017.000.

Paratypes, Vietnam • 1 ♀; Thừa Thiên-Huế Province, Bach Ma National Park; 16°13'14"N, 107°53'10"E; 9 Mar. 2023; by net; V.T. Trung leg.; VNMN_E000.017.001 • 1 ♂; Thừa Thiên-Huế Province, Bach Ma National Park, Pheasant trail; 16°13'38"N, 107°51'20"E; 10–20 May 2023; alt. 500–600 m; J. Constant & L. Semeraro leg.; I.G.: 34.640; RBINS • 2 ♂♂, 1 ♀; Thừa Thiên-Huế Province, Bach Ma National Park; low altitude; 16°13'05"N, 107°42'27"E; 17 May 2023; alt. 100–200 m; J. Constant & L. Semeraro leg.; I.G.: 34.640; RBINS • 1 ♀; Thừa Thiên-Huế Province; Phong Dien District, CCRR; 16°30'27"N, 107°16'05"E; 23 May 2023; alt. 350–400 m; J. Constant & L. Semeraro leg.; I.G.: 34.640; RBINS • 1 ♀; same collection data as for preceding; VNMN_E000.017.002.

Diagnosis. The species is very close externally to *G. fronticonvexus* Meng, Wang & Wang, 2014 and *G. tonkinensis* Constant & Pham, 2016 but has slightly more elongate tegmina, 2.2 times as long as wide (1.9 times in *G. fronticonvexus*; 2.0 times in *G. tonkinensis*). These species are better separated by the male genitalia characters as follows.

Goniopsarites mientrunganus Constant & Pham, sp. nov. can be separated from the other two species by **(1)** its large laminate posterior processes of the periandrium (*ppp* – Fig. 2D), which are absent in *G. fronticonvexus* and much more slender, curved the other way round, in *G. tonkinensis*; **(2)** the posterodorsal process of the gonostyli bulging apically (*G* – Fig. 2A), not bulging in both other species; and **(3)** the strongly developed basiventral lobe of the proximal half of the anal tube (*An* – Fig. 2A), clearly less developed in both other species.

From *G. tonkinensis*, *G. mientrunganus* Constant & Pham, sp. nov. also differs in **(1)** having the maximum width of the anal tube in the basal third (*An* – Fig. 2C), which is in the distal half of the anal tube in *G. tonkinensis* (the state of this character is not known for *G. fronticonvexus*); **(2)** in having a strongly developed dorsal laminate process along basal half of periandrium (*dlp* – Fig. 2D, F, G).

Description. ***Measurements and ratios*:** LT: ♂ (*n* = 4): 11.3 mm (11. 1–11.7); ♀ (*n* = 4): 13.5 (13. 0–14.5). LTg/BTg = 2.2; LW/BW = 1.4; LV/BV = 8.5; LF/BF = 1.4.

***Head*:** (Fig. 1A–E) vertex dark brown, with yellowish median and lateral carinae; concave with lateral margins carinate, and with anterior and posterior margins slightly carinate and rather strongly concave in dorsal view, resulting in a very narrow central portion. Frons varying from variegated brown and yellowish, darker under V-shaped carina, carina yellowish to reddish, to nearly completely black-brown, sometimes with yellowish markings around mid-height of lateral margin; narrow, well-defined, yellowish line above frontoclypeal suture; frons elongate, broader dorsally, concave with median carina on middle of disc and with a strong projection on ventral half marked by strong, V-shaped carina extending ventrad on clypeus; projection rounded in lateral view; lateral margins of frons carinate; frontoclypeal suture grooved and rounded ventrally. Genae largely variegated yellow-brown, dark brown under antennae, with pale yellowish spot along anterior margin. Clypeus yellowish, variegated with black-brown

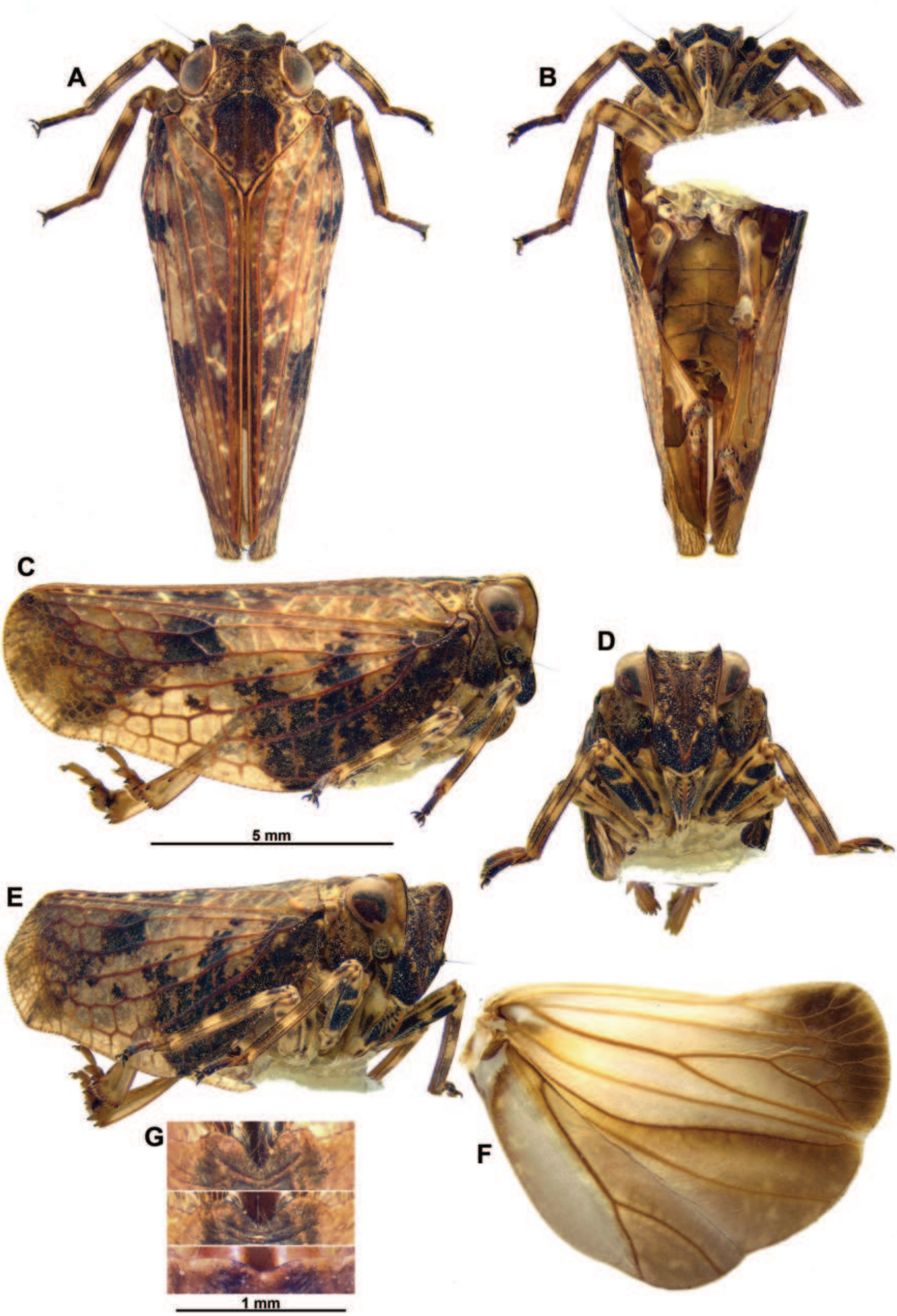

Figure 1. *Goniopsarites mientrunganus* Constant & Pham, sp. nov. **A–F** holotype ♂ **A** habitus, dorsal **B** habitus, ventral **C** habitus, lateral **D** habitus, perpendicular view of frons **E** habitus, anterolateral **F** right hind wing **G** paratypes ♀♀, posterior margin of sternite VII.

on sides towards apex, and with brown oblique lines on each side; clypeus elongate, narrower and shorter than frons, and showing a strong median carina; roundly convex in lateral view. Labium elongate and narrow, yellow-brown, slightly surpassing posterior coxae. Antennae black with scape ring-shaped; pedicel subglobose.

***Thorax*:** (Fig. 1A, C–E) pronotum variegated yellow-brown, darker in middle portion, rather densely pitted, and with median carina weakly marked; lateral fields of prothorax coloured as pronotum, darker in ventral portion, widening ventrally and with ventral margin rounded. Mesonotum dark brown, with yellowish markings on sides and yellowish spot on scutellum; lateral fields moderately pitted; median carina obsolete; lateral carinae marked with yellowish, fusing anteriorly in a rounded carina parallel to posterior margin of pronotum. Tegulae brown.

***Tegmina*:** (Fig. 1A–C) elongate, with costal margin broadly rounded on proximal half and rather strongly sinuate on posterior half; brown with large, irregular, black-brown marking on basal half, not extending on clavus; large, pale yellowish marking along costal margin in distal half; clavus with irregular, slightly darker markings on posterior half; hypocostal plate narrow, visible in proximal third; posterior margin obliquely rounded; clavus closed, extending to posterior angle of tegmen. Veins reddish brown, sometimes black in black areas.

***Hind wings*:** (Fig. 1F) brown, darker towards posterocostal angle and with large basicostal yellow-brown area; well developed, with posterior margin trilobed; costal margin sinuate, with coupling apparatus at 2/3 of length.

***Legs*:** (Fig. 1A–C) profemora black-brown, with narrow, pale yellow rings; mesofemora pale yellow, with brown rings; pro- and mesotibiae elongate and slender, with 6 rings alternatively pale yellow and brown, basal one brown, apical one yellow; metafemora yellow, with brown markings; metatibiae rather short, broadening towards apex, pale yellow, infuscate basally, with 2 strong lateral spines near apex. Tarsi brown, darker apically. Metatibiotarsal formula: (2) 10 / 2 (+7 on underside) / 2.

***Abdomen*:** (Fig. 1B) pale yellowish brown.

***Terminalia* ♂:** (Fig. 2) pygofer (*Py*) higher than long in lateral view, with anterior and posterior margins moderately sinuate; posterodorsal angles with dorsally developed, subtriangular laminate process, with posterodorsal angle right and rounded. Anal tube (*An*) massive, elongate, with lateral margins in dorsal view, widely rounded in proximal half, then sinuately tapering towards posterior, leaving widely rounded ventral margin visible on sides in distal half; 1.78 times as long in midline, as wide with maximum width at proximal 1/3 in dorsal view; basal half in lateral view with large ventral lobe; strongly curved ventrally at midlength with lateral margins strongly produced ventrally into broad lobe in distal half. Gonostyli (*G*) (Fig. 4A) elongate in lateral view, rounded apically and with strong process projecting dorsomesad at posterodorsal angle; ventral margin nearly straight and posterior margin weakly sinuate in lateral view; dorsal process slightly twisted internally, bulging in distal portion and with apex with blunt point directed anteromesad. Aedeagus (Fig. 2D–I) strongly curved in lateral view, with a pair of lateral, elongate, strongly sinuate processes (*lpa*) directed anteriorly, attached posteriorly at 2/3 of length; processes well visible and sinuate in ventral view. Periandrium posteriorly with a pair of large laminate processes (*ppp*), lobe-shaped and developed dorsally into sinuate, elongate, narrowly pointed processes directed mesodorsad; well-developed

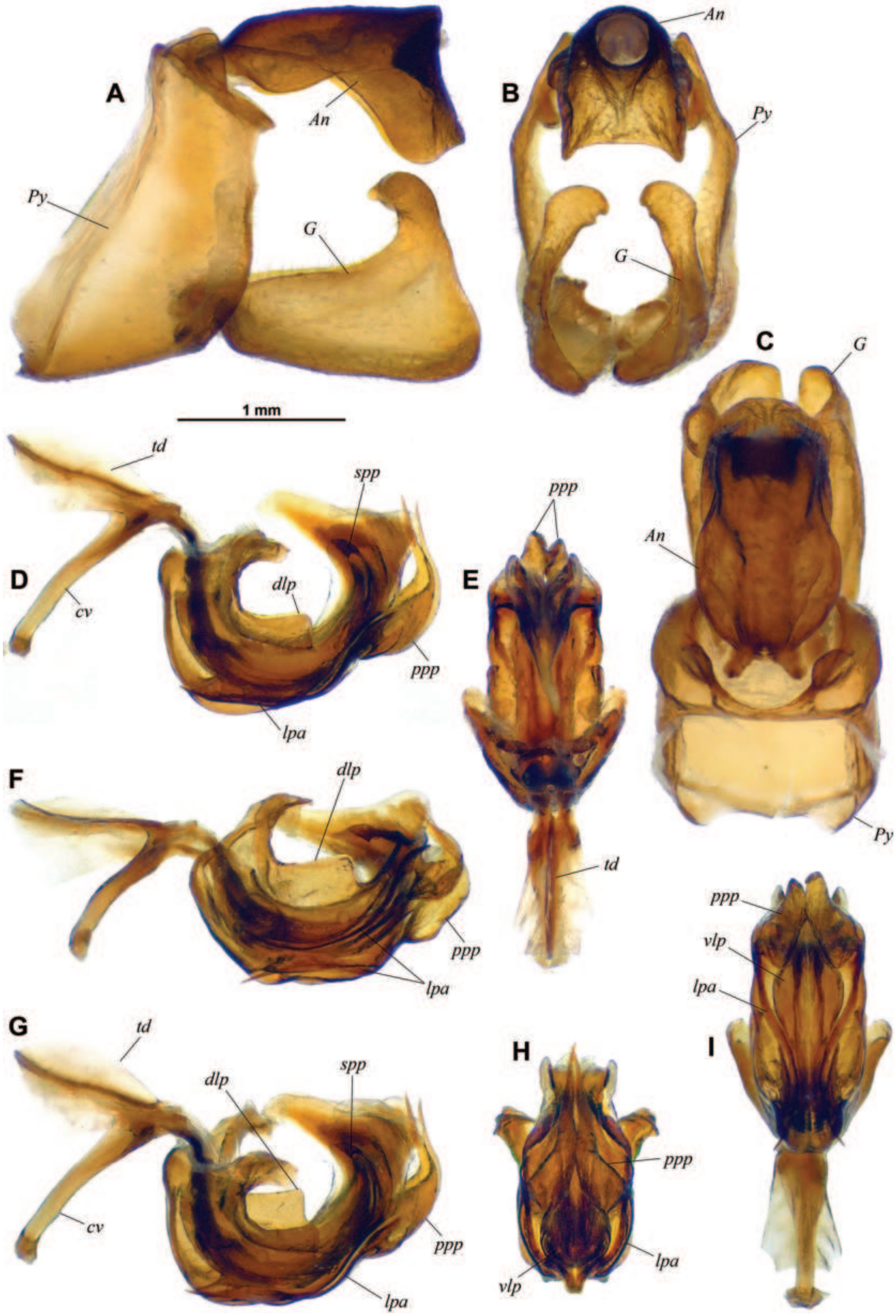

Figure 2. *Goniopsarites mientrunganus* Constant & Pham, sp. nov., holotype ♂, terminalia **A–C** pygofer, gonostyli and anal tube **A** lateral **B** caudal **C** dorsal **D–I** aedeagus, phallobase and connective **D** left lateral **E** dorsal **F** lateroventral **G** laterodorsal **H** caudal **I** ventral. *cv* = connective; *dlp* = dorsal laminate process of periandrium; *lpa* = lateral process of aedeagus; *ppp* = posterior process of periandrium; *spp* = sclerotized process of phallus; *td* = tectiductus; *vlp* = ventral lobe of periandrium.

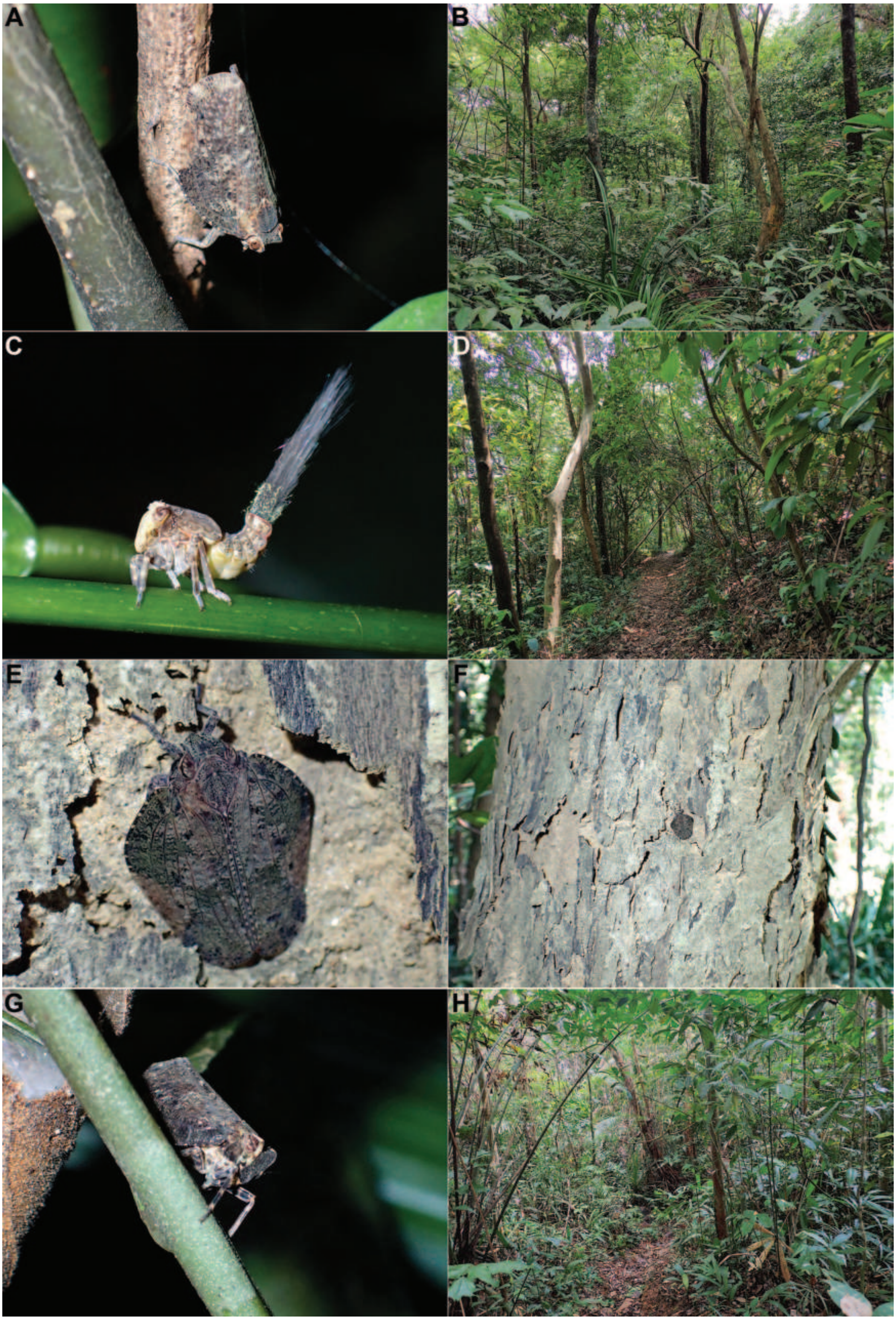

Figure 3. *Goniopsarites mientrunganus* Constant & Pham, sp. nov., in nature and habitat **A–C** Bach Ma National Park, low altitude, 15 May 2023 **A** adult on stem **B** habitat **C** nymph **D–F** Bach Ma National Park, Pheasant Trail, 20 May 2023 **D** habitat **E** adult on tree trunk **F** idem, general view **G, H** Phong Dien District, CCRR, 23 May 2023 **G** adult on stem **H** habitat.

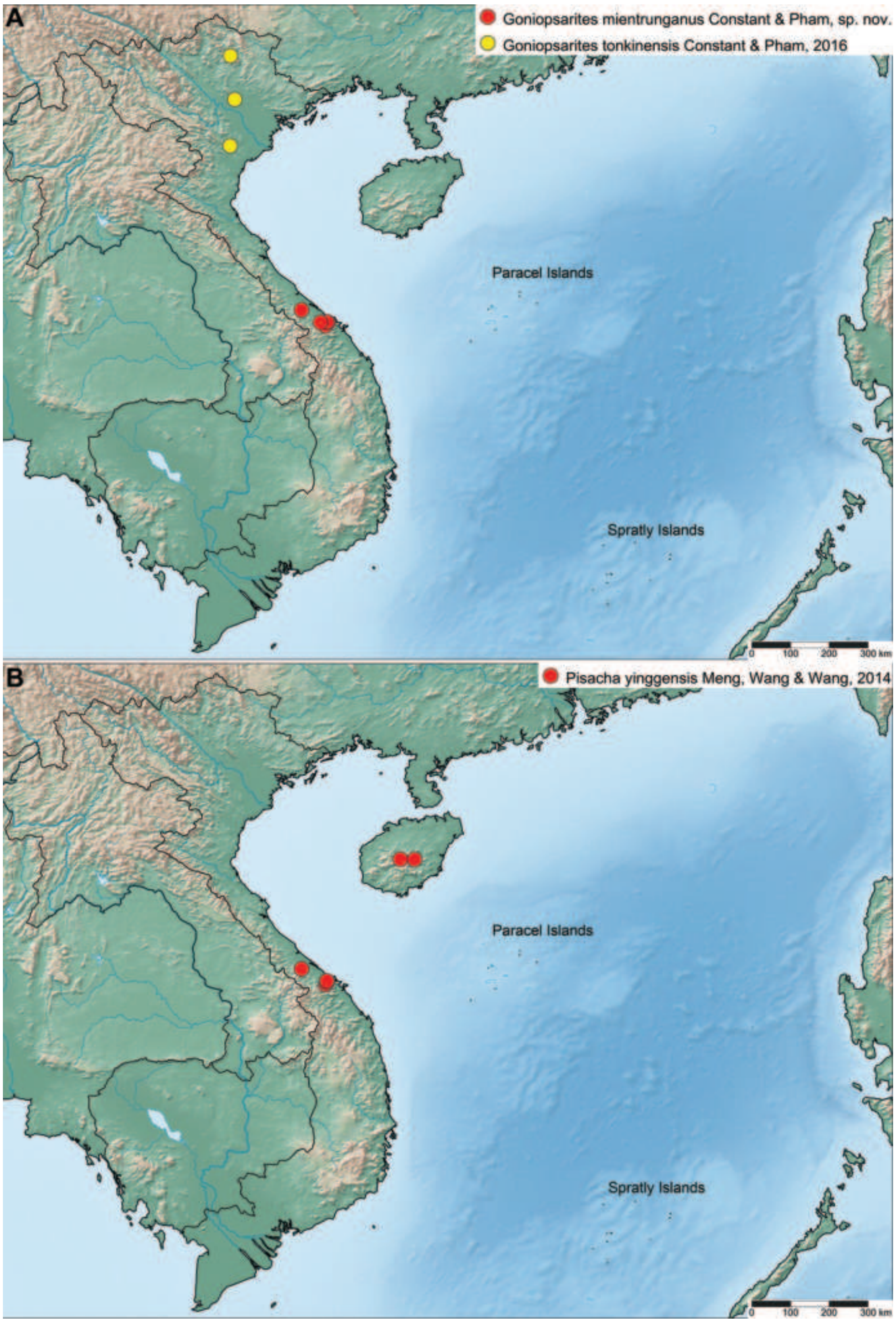

Figure 4. Distribution maps **A** *Goniopsarites* species in Vietnam **B** *Pisacha yinggensis* Meng, Wang & Wang, 2014.

laminate process (*dlp*) running dorsally in basal half, abruptly terminated at right angle at midlength. Ventral lobe of periandrium (*vlp*) elongate, lanceolate in distal portion in ventral view, with sides rounded. Phallus membranous, large, with pair of curved, sclerotized processes (*spp*) directed cephalodorsad before apex; strongly, angularly projecting posterodorsad; apex narrowing, directed anteriorly, and curved ventrally. Connective (*cv*) with well-developed, elongate tectiductus (*td*) showing complete, broadly rounded dorsal crista.

Note. The female genital structures were checked and found to be similar to those of *G. fronticonvexus*, as well as to these of *G. tonkinensis*, and, as it is the case in most nogodinids that we have observed so far, female genitalia do not help with species identification. The indentation in middle of the hind margin of sternum VII is always present but was found to vary in depth between the specimens of *G. mientrunganus* sp. nov. that we have in hand (Fig. 1G).

Etymology. The species epithet *mientrunganus* refers to the region where the new species was discovered: Central Vietnam, "Miền Trung" in Vietnamese.

Biology. The specimens were found sitting on stems of bushes (Fig. 3A, C, G) or on tree trunks (Fig. 3E, F), in subtropical evergreen forest (Fig. 3B, D, H) at the junction of the Northern Vietnam lowland rain forests, Southern Vietnam lowland rain forests, and Southern Annamites montane rain forests ecoregions, at rather low altitude (150–600 m). Some nymphs (Fig. 3C) were observed in May 2023 together with adult specimens.

Distribution. Vietnam, Thua Tinh-Hue Province, Bach Ma National Park, and Phong Dien district, CCRR (Fig. 4A).

Genus *Pisacha* Distant, 1906

Pisacha Distant, 1906: 391. Type species: *Pisacha naga* Distant, 1906, by original designation.
Soaemis Jacobi, 1915. Nomen nudum.
Soaemis Jacobi, 1916: 311. Type species: *Soaemis encaustica* Jacobi, 1916, by original designation. Synonymized by Ishihara (1965: 207).

Distribution. Southern China (Chongqing, Guangdong, Hainan, Sichuan, Zhejiang); India (Assam); Taiwan; North and Central Vietnam.

Species included.

P. baculiformis Meng, Wang & Wang, 2014 – China: Zhejiang.
P. balteiformis Meng, Wang & Wang, 2014 – Vietnam: Ninh Binh Province.
P. encaustica (Jacobi, 1916) – Taiwan.
P. falcata Meng, Wang & Wang, 2014 – China: Chongqing, Sichuan.
P. kwangsiensis Chou & Lu, 1977 – China: Guangxi.
P. naga Distant, 1906 – India: Assam.
P. yinggensis Meng, Wang & Wang, 2014 – China: Hainan; Vietnam: Thua Thien-Hue Province.

Pisacha yinggensis Meng, Wang & Wang, 2014
Figs 4B, 5

Pisacha yinggensis Meng, Wang & Wang, 2014: 93, figs 38–41, 56–69, 115, 120.

Material examined. Vietnam • 1 ♂; Thừa Thiên-Huế Province; Phong Dien District, CCRR; 16°30'27"N, 107°16'05"E; 23 May 2023; alt. 350–400m; J. Constant & L. Semeraro leg.; I.G.: 34.640; RBINS • 1 ♂, 2 ♀♀; Thừa Thiên-Huế Province, Bach Ma National Park, near ranger station; 16°08'37"N, 107°49'36"E; 18 May 2023; alt. 300–600 m; J. Constant & L. Semeraro leg.; VNMN_ E000.017.003 • Thừa Thiên-Huế Province, Bach Ma National Park; 16°12'N, 107°52'E; 12–17 Jul. 2011; J. Constant & J. Bresseel leg.; I.G.: 31.933; RBINS • 1 ♀; Thừa Thiên-Huế Province,

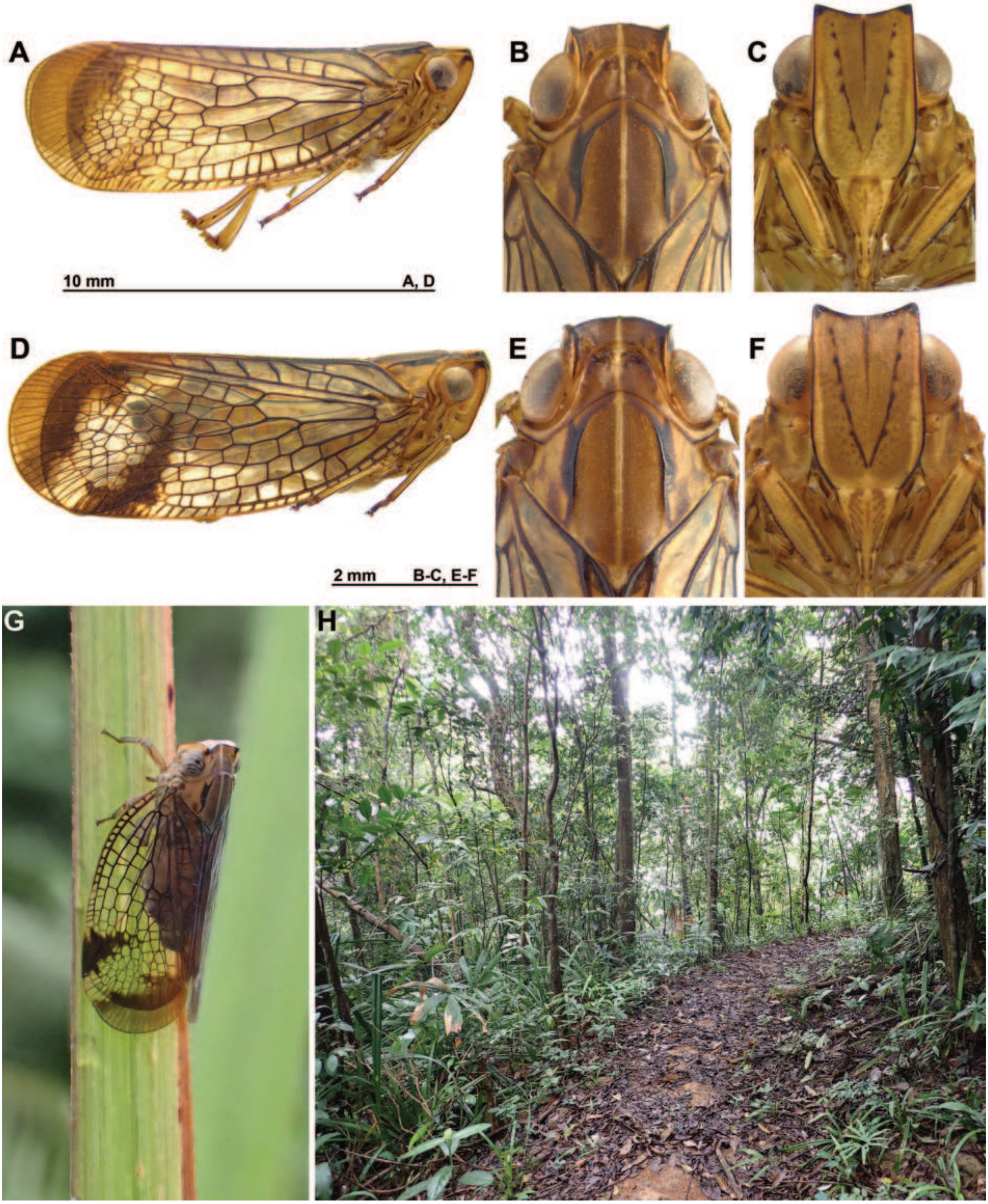

Figure 5. *Pisacha yinggensis* Meng, Wang & Wang, 2014, from Bach Ma National Park, Pheasant Trail, 10–20 May 2023 **A–C** male **A** lateral **B** head and thorax, dorsal **C** frons, perpendicular **D–F** female **D** lateral **E** head and thorax, dorsal **F** frons, perpendicular **G** adult female in nature **H** habitat.

Bach Ma National Park; summit; 16°11'18"N, 107°50'56"E; 11–21 May 2023; alt. 1300–1400 m; J. Constant & L. Semeraro leg.; I.G.: 34.640; RBINS • 1 ♂, 1 ♀; Thừa Thiên-Huế Province, Bach Ma National Park, Pheasant trail; 16°13'38"N, 107°51'20"E; 10–20 May 2023; alt. 500–600 m; J. Constant & L. Semeraro leg.; I.G.: 34.640; RBINS • 2 ♀♀; same collection data as for preceding; VNMN_ E000.017.004 • 1 ♂; same collection data as for preceding; 29 Mar. 2021; Malaise trap; V.T. Trung leg.; VNMN_ E000.017.005 • 1 ♀; Thừa Thiên-Huế Province; Phong Dien District, CCRR; 16°30'27"N, 107°16'05"E; 23 May 2023; 350–400m; Trung T. Vu leg.; VNMN_ E000.017.006.

Notes. The specimens from Central Vietnam show obvious sexual dimorphism, with the tegmina of the females marked with a contrasting, incomplete, dark brown to black band at the distal 2/3 of its length, and a broad, oblique area of the same colour, or slightly paler, along the apical margin (Fig. 5D, G). These dark markings on the tegmina are weakly visible or absent in males (Fig. 5A). The markings of the head and thorax, however, are similar in both sexes (Fig. 5B, C, E, F).

Biology and distribution. The specimens were found sitting on leaves or stems on the lower vegetation (Fig. 5G), in subtropical evergreen forest (Fig. 5H) in at the junction of Northern Vietnam lowland rain forests, Southern Vietnam lowland rain forests, and Southern Annamites montane rain forests ecoregions, at altitude from 300 to 1,400 m. In China, the species is recorded from the Hainan Island monsoon rain forests ecoregion.

The species was previously only recorded from Hainan Island, China (Meng et al. 2014). It is here recorded for the first time from the mainland, in Central Vietnam (Fig. 4B).

Discussion

The present work adds two species of Nogodinidae to the fauna of Vietnam, including one species described as new. This leads to a total of 13 species for the country. As a comparison, 10 species are known from China (Bourgoin 2023). The new records also greatly extend the Vietnamese distribution of the genera *Goniopsarites* and *Pisacha* to the south but leave a gap of over 500 km without any records of these genera in the northern half of Central Vietnam.

In Phong Dien District, VNMN is conducting an ambitious project of forest restoration at the Centre for Conservation of Vietnam Natural Resources and Rescue of Animals and Plants, not far from the forest where *G. mientrunganus* Constant & Pham, sp. nov. and *P. yinggensis* were found. As already recently mentioned for a new species of Tropiduchidae, *Connelicita phongdienensis* Constant & Pham, 2023, the return of such planthopper species in this area in the future would be a great indicator of a successful project (Constant et al. 2023).

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Conceptualization, J.C. and T.-H.P.; Funding acquisition, T.-H.P. and J.C.; Investigation, J.C.; Methodology, J.C. and T.-H.P.; Project administration, T.-H.P., C.V.C.L. and J.C.; Field work, J.C., T.-H.P., C.V.C.L., T.T.V., H.T.T.N.; Field logistics, T.-H.P., C.V.C.L., T.T.V., H.T.T.N.; Supervision, J.C. and T.-H.P.; Validation, J.C. and T.-H.P.; Writing – original draft, J.C.; Writing – review and editing, J.C., T.-H.P., C.V.C.L., T.T.V., H.T.T.N. All authors have read and agreed to the published version of the manuscript.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Research Article

A new North American species of *Etainia* (Lepidoptera, Nepticulidae), feeding on *Arbutus* and *Arctostaphylos* species (Ericaceae)

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Abstract

Etainia thoraceleuca van Nieukerken, Epstein & Davis, **sp. nov.** is the second native American species of *Etainia* Beirne, 1945, and the second known *Etainia* species feeding on Ericaceae. The species is known from light-collected adults in the USA (California, Arizona) and Canada (Ontario). These were linked via DNA barcodes to larvae that make short leafmines on *Arbutus* and *Arctostaphylos* species, then continue feeding in stems and branches, causing damage in nurseries and planted trees in Sonoma and Marin Counties, California. The holotype was accidentally reared from *Arbutus arizonica*, without observing the damage. Life history and damage are described in detail. Damage in *Arctostaphylos uva-ursi* found in Washington State probably belongs to *E. thoraceleuca*, which is a sister species to the European *E. albibimaculella* (Larsen, 1927).

Key words: Arizona, California, Canada, insect damage, leafmines, stem mines, taxonomy, United States

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Introduction

Trees of the genus *Arbutus* are popular as planted trees for landscaping and gardening in western North America; this applies both to the native Pacific madrone (*A. menziesii* Pursh) as well as to the European Strawberry tree (*A. unedo* L.) and the cultivar *Arbutus* ‘Marina’, which is of obscure hybrid origin, probably from European stock (San Marcos Growers 2023). Especially the latter is frequently planted as street trees, for example, in San Francisco (Martin et al. 2016). Several Lepidoptera are known as leafminers of *Arbutus*, especially the heliozelid *Coptodisca arbutiella* Busck, 1904 and the gracillariid *Marmara arbutiella* Busck, 1903, which are common on Pacific madrone (Hunt et al. 1992; Eiseman 2022). In 2014 nurseries in Marin County, California reported unknown damage on *Arbutus*, causing leaf spots and dieback of shoots (Zwart 2017). This damage was first investigated by the late Steven Seybold (University of California - Davis), Drew Zwart, and SVS, who eventually sent larval samples to EvN. DNA barcoding matched these to an undescribed species of *Etainia* (Nepticulidae) that had been known for some time from adults collected at light, and one specimen that was accidentally reared by D.L. Wagner from material collected on *Arbutus arizonica* by R.S. Wielgus in 1987.

The Nepticulidae are a medium–large family of very small moths, of which the majority make leafmines as larvae. Globally around 1000 species are known, and 97 named species occur in North America, but many are still unnamed (van Nieukerken et al. 2016; van Nieukerken and Eiseman 2023).

The genus *Etainia* Beirne, 1945 is one of the smaller nepticulid genera with only 17 named species from Asia, Europe, Africa, and North America (van Nieukerken et al. 2016; Yagi and Hirowatari 2017) and around five undescribed species known in collections. The genus has also been known under the preoccupied name *Obrussa* Braun, 1915 or as a subgenus of *Ectoedemia* Busck, 1907. It is one of the few genera of which none of the species make the typical nepticulid leafmines but rather feed in shoots, buds, or fruits. Known hosts belong to Sapindaceae: *Acer* and Ericaceae, but the hosts for most species are still unknown. The hitherto only known native North American species, *E. ochrefasciella* (Chambers, 1873), feeds in petioles and buds of sugar maple (*Acer saccharum* Marshall) and its subspecies (Kulman 1967). The European *E. sericopeza* (Zeller, 1839), now a widespread alien in North America, feeds in summer in the keys (samaras) of Norway maple, *A. platanoides* L., and in winter also in a similar fashion as *E. ochrefasciella* (Jäckh 1951; Emmet and Johnson 1977). In North America it has also been reported to mine petioles of the host in summer (Felt 1930).

The European *E. albibimaculella* (Larsen, 1927) feeds on bearberry (or kinnikinnick), *Arctostaphylos uva-ursi* (L.) Spreng., and makes mines that start in the leaf but then immediately enter the shoots (Adamczewski 1947). The specimen of the new species, taken in Almonte, Ontario, in an area where bearberry is common, was first misidentified as *E. albibimaculella*, which as a result was wrongly recorded as Holarctic and Canadian (van Nieukerken et al. 2016; van Nieukerken 2018).

Adults in the genus *Etainia* can be best recognized by the long apodemes on the dorsal surface of the valvae in the male genitalia (e.g. Fig. 7). More apomorphies and general descriptions are provided by van Nieukerken (1986, 2020), van Nieukerken and Johansson (1990), Puplesis and Diškus (1996), van Nieukerken and Laštůvka (2002), Yagi and Hirowatari (2017), and Shin et al. (2022).

We here describe the new species and compare it with congeners and other similar North American species. The other two North American species were previously treated by Wilkinson and Scoble (1979).

Material and methods

Material

We list here material without coordinates, more detailed specimen data are provided in GBIF dataset https://doi.org/10.15468/espa8k.

Abbreviations for depositories, etc.(often combined with catalog numbers)

BIN Barcode Index Number (Ratnasingham and Hebert 2013);
BIOUG Biodiversity Institute of Ontario, University of Guelph, ON, Canada;

BOLD Barcode of Life Data Systems (http://www.barcodinglife.com/);
CASENT California Academy of Sciences, Entomology, San Francisco, CA, USA;
CSCA California State Collection of Arthropods, Sacramento, CA, USA;
CNC Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, ON, Canada;
EMEC Essig Museum of Entomology, Berkeley, CA, USA;
MZH Luomus, Finnish Museum of Natural History, Helsinki, Finland;
RMNH Naturalis Biodiversity Center, Zoological collections, Leiden, The Netherlands;
USNM National Museum of Natural History, Smithsonian Institution, Washington DC, USA.

Methods

Adults were usually collected at light by various collectors. The holotype was reared accidentally. SVS collected adults by setting five-gallon *Arbutus* 'Marina' (bush) trap plants out nearby infected trees from 2900 Wild Turkey Run, in the Bennett Valley area south of Santa Rosa, California. Once trap plants showed symptoms of infestation, they were transported back to a holding area, where the plants had plastic funnels constructed around their bases (0.013 mm clear polycarbonate sheeting cut and glued into a 68 cm tall funnel, with a top opening of 46 cm and a bottom opening of 25 cm). Nets measuring 175 cm × 71 cm were constructed using a Singer model 4423 sewing machine, of white organdy (JoAnn Fabrics and Crafts, Rohnert Park, CA), white polyester thread, and cinched with black 4 mm diameter parachute cord. These nets were placed over the entire plant and funnel assembly in April of 2020 and checked twice weekly.

Larvae were collected by cutting off ends of symptomatic branches of various hostplants and dissecting them using a scalpel under a Leica MZ75 stereomicroscope. Larvae were teased from their tunnels with a pin, and frozen before shipment to CDFA labs, or alternatively kept in ethanol 80%.

Pupae were recovered from the duff within the adult enclosures (above) and later from beneath heavily infested plants in the landscape. Cocoons were found about 5 cm beneath the surface of the duff, usually sandwiched between fragments of two dead leaves to which they were lightly attached.

We further added data obtained from observation platforms iNaturalist, BugGuide, and Barcode of Life Data Systems.

Morphology

Genitalia were prepared according to standard procedures—those by DRD using Canada balsam as embedding medium, those by EvN usually including DNA extraction—and using Euparal as embedding medium; see earlier papers (van Nieukerken 1985; van Nieukerken et al. 2010). Larval slides were prepared in the same way.

Measurements

Measurements of genitalia were obtained from digital images, using calibrated scaling in the Zeiss AxioVision software; we used a 20× objective for male genitalia and 10× or 20× for female genitalia. Capsule length was measured from vinculum to middle of pseuduncus; valva length from tip of posterior process to ventral edge, excluding the sublateral process; phallus length was measured along the sclerotized tube, from tip, excluding carinae. Total corpus bursa length was measured from where the ductus bursae widens into the corpus bursae to anterior edge of bursa. Genitalia measurements are rounded off to the nearest 5 μm. Forewing length was measured from tip of fringe to attachment on thorax, with a Zeiss SV11 stereomicroscope at a magnification of 20×. Antennal segment counts include scape and pedicel; they were counted on photographs or directly under the same stereo microscope. Larval measurements of potential 2nd, 3rd, and 4th instars, mounted on slides, were from San Rafael, California (Figs 22, 23, 26) (S. Seybold, see below) and those measured from ethanol by MEE were 1st to 4th instars (n = 21) and from San Rafael and Sonoma, California (Figs 18–21, 24, 25, 27, 28; see below).

Photographs

Photographs of moths were made with an AxioCam MRc 5 digital camera attached to a motorized Zeiss SteREO Discovery V12, using the Module Extended Focus and Zeiss AxioVision software to prepare a picture in full focus from a Z-stack of ca 10–40 individual photos. Genitalia were photographed with an MRc 5 camera on a manually operated Zeiss Axioskop H, without using extended focus. Photographs were edited with Adobe Photoshop (various versions), avoiding changes to the real object, but backgrounds were cleaned of excess debris and artifacts by using the healing brush and clone tools; tone and contrast are adjusted, and some sharpening was used. Larvae in fluid, as well as dry cocoons, pupal skin, and a parasitoid, were photographed with a Leica MZ 16 using LAS IV Z-stack, as above, and scanning electron microscopy of the larvae was done using a Vega 3 Tescan with normal vacuum; the samples were sputter-coated with gold palladium.

DNA barcoding

Our methodology has been described in other papers (van Nieukerken et al. 2012; Doorenweerd et al. 2015, 2016). We present a neighbor-joining tree, with KP2 distances, of the selected taxa, made with tools provided by BOLD Systems (Ratnasingham and Hebert 2007). The DNA barcode data as used here are given in detail in the public BOLD dataset DS-ETAARB (*Etainia* Arbutus) (https://doi.org/10.5883/DS-ETAARB), including GenBank accession numbers.

Hostplants

Hostplant names follow Catalogue of Life (Hassler 2023) and the Flora of North America (Parker et al. 2009; Sørensen 2009). The larvae were recovered from various manzanita species (*Arctostaphylos*). Given the large number of species in the genus, particularly in California, we did not attempt to identify the species of hostplant, but some of the cited observations do include species identifications. See Parker et al. (2009) for more information. Where species names are provided, we cannot guarantee that all species identifications are fully correct.

Results

Etainia thoraceleuca **van Nieukerken, Epstein & Davis, sp. nov.**
https://zoobank.org/C483BF94-3D5F-4AFE-9336-40FFEDAD37C3

Etainia albibimaculella; van Nieukerken et al. 2016: 145; van Nieukerken 2018: 32 [North American, Canadian records, misidentification].

Type material. ***Holotype*****.** United States • ♂; Arizona, Cochise Co., Huachuca Mts., Miller Canyon; 31.4248, −110.26; 5,200' [1585 m]; 19.iii.1987; larva collected with *Arbutus arizonica*; R. S. Wielgus leg.; emerged 24.v.1987 [reared by D.L. Wagner], DLW Lot: 87C4.5; Genitalia slide EvN4950; USNM01850751.

Paratypes (13♂, 6♀). United States **– Arizona** • 1♂; Cochise Co., Ash Canyon, Huachuca Mts.; 5100' [1550 m]; 6.x.1979; P.M. Jump leg.; Genitalia slide USNM16408; USNM01850740 • 1♂; Yavapai Co., 20 km W. Prescott, Yavapai CG [Campground]; 9.vi.1997; oak-juniper-pine; H.W. van der Wolf leg.; Genitalia slide EvN5492; RMNH.INS.25492. **– California:** 1♂ (abdomen missing); Contra Costa Co., Walnut Creek; 14.x.1961; J. Powell leg.; USNM01850749 • 1♂; Del Norte Co., Grassy Flat Campground, 3 mi. [4.8 km] W Patrick's Creek; 2.x.1968; P.A. Opler leg.; at light; Genitalia slide USNM20961; USNM01850741 • 1♂; Lake Co., Pogie Point, Lake Pillsbury; 28–29.viii.1973; J. Powell leg.; at light; Genitalia slide DRD3151; USNM01850742 • 1♂; Los Angeles Co., San Gabriel Mts., San Gabriel Canyon, Red Box Canyon Road; 31.viii.1974; black lite; D.C. Frack leg.; USNM01850743 • 1♂; Madera Co., O'Neals; 26.iv.2015; V. + M. Albu leg.; Genitalia slide EvN4998; RMNH.INS.24998 • 1♂ (abdomen missing); Medocino Co., South of Piercy; 9.viii.1971, 10.viii.1971; R.H. Leuschner leg.; USNM01850750 • 1 ♂; same collecting data; EMEC752122 • 1♂; Riverside Co, San Jacinto Mts, Keen Camp; 4,500' [1370 m]; 31.viii.1974; D.C. Frack leg.; black lite; Genitalia slide USNM20877; USNM01850744 • 1♂; San Bernardino Co., Wild Horse Canyon, Rt. 2, 0.7 mi. [1.13 km] W Jct. Rt. 138; 4,800' [1465 m]; 21.vi.1974; D. Frack leg.; black lite; Genitalia slide DRD3403; USNM01850745 • 1♀; same collecting data; 23.vii.1975; Genitalia slide DRD3401; USNM01850746 • 1♂ [in ethanol]; San Diego Co., San Dieguito River Valley Conservancy, Site 1 (Volcan Mtn); 24.viii.2013; Joshua Kohn leg.; T, Upland, Malaise trap; Genitalia slide EvN4941; BIOUG08839-B12 • 2♀; Santa Barbara Co., 1 mi. NE San Marcos Pass; 1500' [460 m]; 7.vii.1965; J. Powell leg.; Genitalia slide USNM17493; EMEC1744182, EMEC1744183 • 1♀; Santa Barbara Co., 2 mi. [3.2 km] W Los Prietos; 7.ix.1969; P. Opler leg.; at light; Genitalia slide DRD3330; USNM01850747 • 1♀; Siskiyou Co., Happy Camp; 8.vii.1958; J. Powell leg.; at light; Genitalia slide DRD3329; USNM01850748 • 1♂; Siskiyou Co., 8 km SW Mount Shasta, Castle Lake; 12.viii.1992; H.W. van der Wolf leg.; Genitalia slide EvN4951; RMNH.INS.24951 • 1♀; Yuba Co., Marysville Buttes [Sutter Buttes]; 2.v.1928; H.H. Keifer leg.; CASENT8568092.

Non-type material examined, adults. Canada – **Ontario** • 1♀; Ottawa, 40 km W, Almonte; 7.ix.1992; Kauri Mikkola leg.; alvar, ad lucem; Genitalia slide EvN4138; RMNH.INS.24138; MZH.

Non-type material examined, larvae. United States **– California** • 9 larvae in ethanol; Marin Co., 400 Deer Valley Rd., San Rafael, Smith Ranch Homes; 15.iii.2017; S.J. Seybold, S. Swain leg.; ex collected stems and leaves, Marina strawberry tree, Arbutus × 'Marina' (*Arbutus unedo* × *A. andrachne*); RMNH.

INS.31006, 31007, 31012–15 • 20 larvae (3–4th instar); same collection data; 11.iv.2017; S.J. Seybold leg.; ex collected stems and leaves Marina strawberry tree; CSCA • 2 larvae; same collection data; from native *Arbutus menziesii*; RMNH.INS.31008, 31009 • 2 larvae on slide (barcoded); Sonoma Co., 2900 Wild Turkey Run, near intersection of Bennett Valley Road and Savannah Trail; 855 ft [260 m]; 15.iii.2017; S.J. Seybold, S. Swain leg.; ex collected stems and leaves, manzanita, *Arctostaphylos* spp. (broad leaf); slides RMNH.INS.31005.P, RMNH.INS.31010.P • 1 larva in ethanol; same collection data; RMNH.INS.31011 • 28 larvae in ethanol; same collection data; Marina strawberry tree, Arbutus × 'Marina', (*Arbutus unedo* × *A. andrachne*); RMNH • 6 larvae in ethanol; same collection data; from manzanita, *Arctostaphylos* spp.; RMNH • 4 larvae (1–2nd instar); 257 Perkins Street, Sonoma; 11.iv.2017; S.J. Seybold leg.; collected leaves Marina strawberry tree; CSCA.

Non-type material examined, leafmines. possibly of *E. thoraceleuca*. United States **– Washington** • vacated mines; Washington, Chelan Co., Wenatchee National Forest, Entiat summit Road; 12.vii.2010; E.J. van Nieukerken leg.; EvN2010017; low *Pinus ponderosa* forest on ridge, leafmines on *Arctostaphylos uva-ursi*; RMNH.INS.42859.

Additional online records – adults. Canada **– Ontario** • 1♂, 1♀; Lambton Co., Port Franks; 21.viii.2021, 25.ix.2020; K. H. Stead leg.; BIOUG62319-H05, BIOUG74608-E04 (BOLD).

United States **– Arizona** • 1 adult; Cochise Co., Sierra Vista Southeast. Miller Canyon Upper Parking; 17.v.2022; Jim Eckert; https://www.inaturalist.org/observations/142023215. – **California** • 1 adult; San Diego Co., San Marcos; 31.vii.2018; Greg Smith leg.; https://bugguide.net/node/view/1568125 • 1 adult; Santa Clara Co., Silicon Valley, Stanford Academic Reserve; 5.vi.2021; Jen and Hilary Bayer leg.; Malaise trap; BIOUG92695-A02 (BOLD) • 1 adult; Tulare Co., Ash Mountain; 06.vii.2018; Graham Montgomery leg.; https://bugguide.net/node/view/1569217.

Additional online records – leafmines. United States – **California** • Colusa Co., various localities; mines on *Arctostaphylos manzanita*; 27.ii.2020, 4–5.ii.2021, 27, 28.iii.2021; K. Schneider leg.; https://www.inaturalist.org/observations/72384123, https://www.inaturalist.org/observations/72335843, https://www.inaturalist.org/observations/72447513, https://www.inaturalist.org/observations/39306497, https://www.inaturalist.org/observations/69086879, https://www.inaturalist.org/observations/69119629 • Contra Costa Co., Mount Diablo State Park; leafmines on *Arctostaphylos manzanita* subsp. *laevigata*; 8.ii.2020; Ken-Ichi Ueda leg.; https://www.inaturalist.org/observations/38489869 • Los Angeles Co., Claremont, California Botanic Garden; 2 leafmines on *Arctostaphylos insularis*; Steven Kurniawidjaja leg.; https://www.inaturalist.org/observations/150883693 • Los Angeles Co., La Cañada Flintridge, Descanco Gardens; 2 leafmines on *Arbutus*; Steven Kurniawidjaja leg.; https://www.inaturalist.org/observations/155422286 • Marin Co., Santa Venetia, leafmine on unidentified host; 28.i.2020; Krissa Klein leg.; https://www.inaturalist.org/observations/38138633 • Modoc Co., FR-73, 0.1 road mi W Householder Reservoir entrance road; leafmines on *Arctostaphylos manzanita*; 17.v.2021; K. Schneider leg.; https://www.inaturalist.org/observations/79232102, https://www.inaturalist.org/observations/79232103 • San Diego Co., 31.iii.2019; leafmines on *Arctostaphylos rainbowensis*; James Bailey leg.; https://www.inaturalist.org/observations/21914712 • San Diego Co., Cleveland National Forest; 11.xi.2021; leafmines on *Arctostaphylos*; Jorge Ayón leg.; https://www.inaturalist.org/observations/100888480.

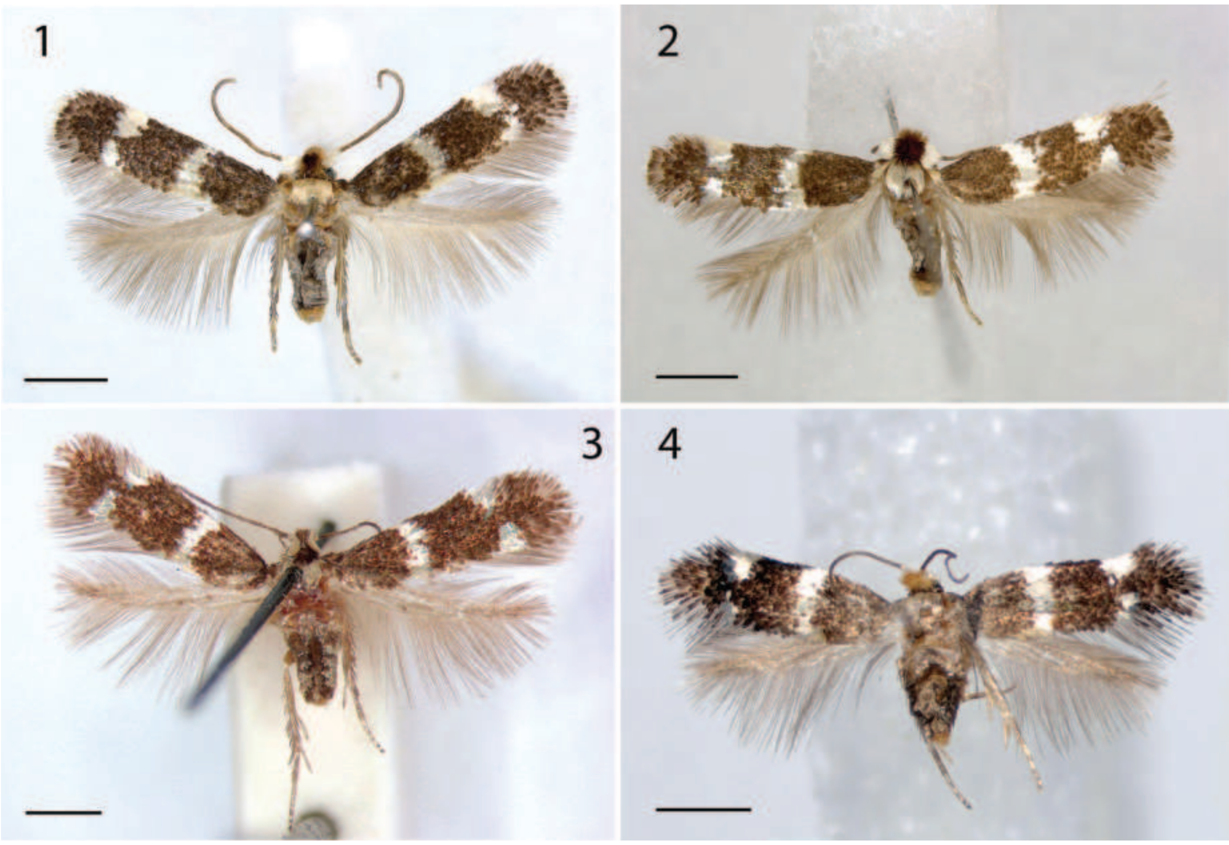
Diagnosis. *Etainia thoraceleuca* is easily recognized by the combination of a white thorax and the silver markings: a fascia and costal plus dorsal spot. Some *Stigmella* species have a similar pattern, but can be recognized by the distinct collar, comprising lamellar scales. Most similar are some species of *Acalyptris*, including the eastern *A. thoracealbella* (Chambers, 1873). This species has the pattern not so silvery, the antennae are paler, and the wings are narrower; moreover, the distribution does not seem to overlap much, but genitalia should be checked when in doubt. The male genitalia are characteristic of the genus *Etainia* by the valval apodemes, absent uncus, and structure of the phallus; it differs from *E. ochrefasciella* and *E. sericopeza* by the different shapes of the valva and gnathos, and the latter are very wide in *E. sericopeza* and very narrow in *E. ochrefasciella*. The female genitalia differ especially by the different structure of tergite 8.

Description. Male (Figs 1, 2). Forewing length 2.6–3.2 mm (2.9 ± 0.2, 7), wingspan 5.8–7.0 mm. Head: frontal tuft ferruginous, mixed with fuscous on frons, almost black on vertex, ferruginous in Canadian specimens, collar inconspicuous, comprising ferruginous or fuscous hair-scales. Scape and pedicel cream white. Flagellum fuscous, antenna with 49–57 segments (51.3 ± 2.9, 6), ratio to forewing length 16–19 (17.8 ± 1.4, 6) segments/mm. Thorax creamy white, tegulae either white or concolorous with forewing, forewing shining fuscous, pattern silvery white, consisting of a fascia at 1/3, and opposite costal and dorsal spots at 2/3, terminal fringe white beyond distinct fringe line, underside dark fuscous, no androconial scales present. Hindwing grey, a row of costal bristles behind frenulum, underside grey. Abdomen grey brown, genitalia with ochreous vestiture.

Female (Figs 3, 4). Forewing length 2.6–3.4 mm (3.0 ± 0.3, 6), wingspan 5.9–7.8 mm. Antenna with 41–49 segments (43.5 ± 3.7, 6), ratio to forewing length 8–11 segments/mm. As male, but frontal tuft completely ferruginous in Canadian specimens. Hindwing with costal bristles.

Male genitalia (Figs 5–11). Capsule length 435–660 μm (544.0 ± 79.8, 6), 1.3–1.6× as long as wide. Vinculum large, anteriorly truncate, posteriorly with U-shaped excavation. Tegumen produced into triangular, pointed pseuduncus, uncus absent. Gnathos with median lobe relatively broad at base, pointed at tip, length less than twice its width. Valva length 200–320 μm (255.9 ± 38.2, 6), relatively narrow, curved and tapering slightly to an abruptly down-curved apex; dorsal apodeme greatly elongate, sharply curved, and smooth; transtilla transverse bar straight, rather long, sublateral processes distinct, about half length of transverse bar. Phallus 325–460 μm (405.5 ± 49.0, 6), 2.9–3.4× as long as wide; apically ending in a long tongue-shaped process dorsally, and a pair of ventral pointed carinae; vesica with the following sclerotizations: basally an H-shaped sclerotization, followed by a distinct striate cathrema and an indistinct complex sclerotized structure, ending in a single large pointed cornutus protruding from the phallus.

Female genitalia (Figs 12–17). Abdominal end broadly rounded, anal papillae a narrow band with more than 50 setae in total; T8 with pointed posterior margin; on T8 three transverse broken rows with groups of socketed setae, posteriorly two connected groups of ca 21–25 setae each; medially two widely separate groups of 12–13 setae at either side; anteriorly two groups of ca 14–17 setae. Anterior apophyses widely separate, with curved tips; posterior apophyses straight. T7 with medial indentation in posterior margin. Corpus bursae total length ca 710–855 μm. Ductus bursae with a paired sclerotized structure near cloaca and group of small spines laterally, more anteriorly;



Figures 1–4. *Etainia thoraceleuca*, adult habitus **1** male Holotype AZ, genitalia slide EvN4950 **2** male, CA, Siskiyou Co., genitalia slide EvN4951, RMNH.INS.24951 **3** female, CA, Santa Barbara Co., San Marcos Pass, 7.vii./1965 **4** female, Canada, ON, Ottawa, genitalia slide EvN4138. Scale bars: 1 mm.

corpus bursae with paired elongate reticulate signa, usually different in length, longest 520–550 µm; ca 10–12 cells wide, shortest 360–425 µm, ca 10–17 cells wide. Ductus spermathecae with 2 indistinct convolutions.

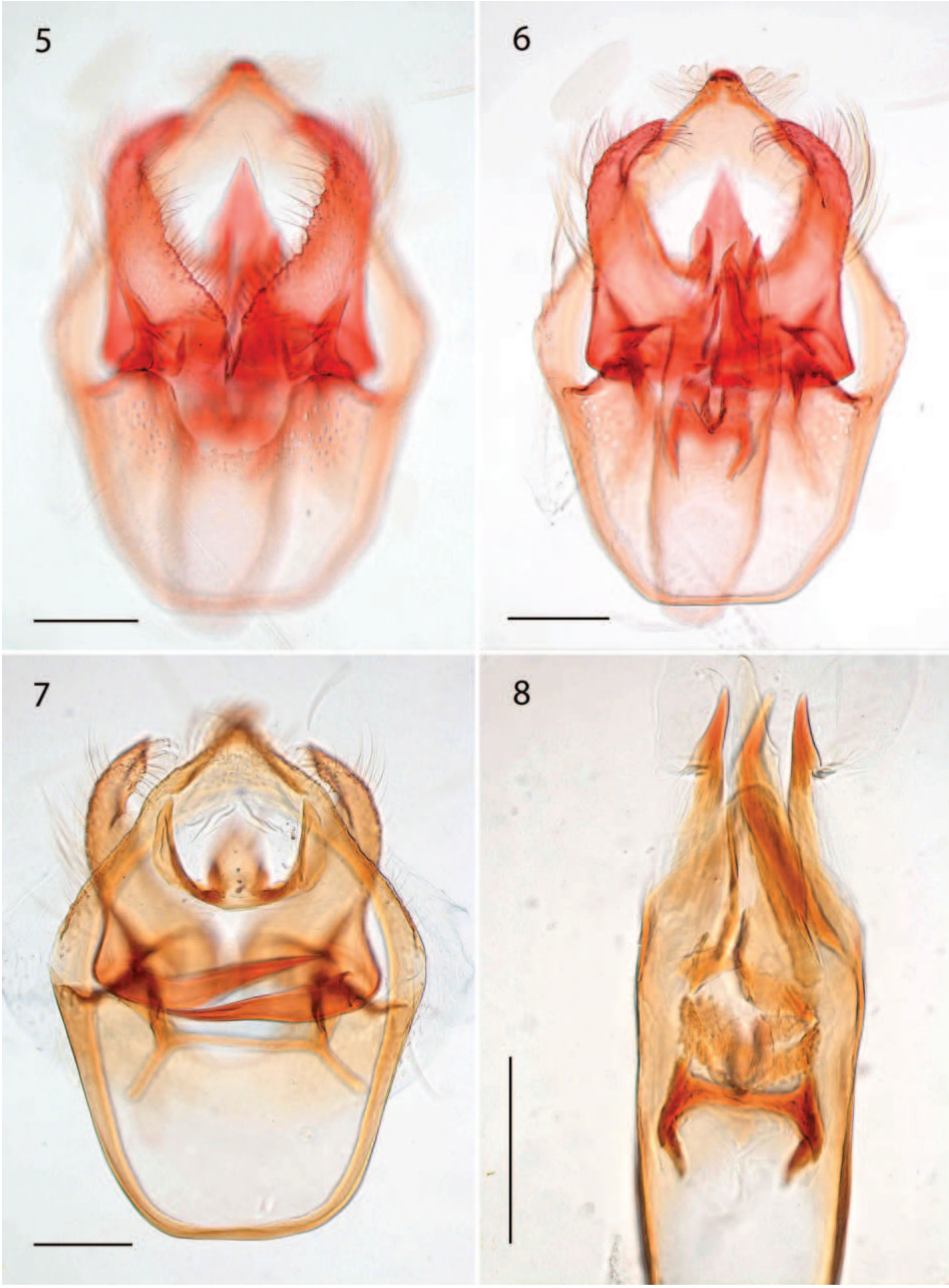
Egg. In the few examples seen on leaf underside, the usual domed egg scale of Nepticulidae. When the mine develops, the egg is more or less in the center of the leaf spot.

Larva (Figs 18–40, 45–52). First instar: head-capsule width 0.24 mm, length 0.27 mm, (overall length 2.78 mm) (n = 1), Second instar: head-capsule width 0.33–0.36 mm, length 0.35–0.37 mm, (overall length 4.21–4.59 mm) (n = 3); Third instar: Head-capsule width 0.47–0.48 mm, length 0.42–0.47 mm, (overall length 1.71–2.06 mm) (n = 6); Final (fourth) instar: head-capsule width 0.44–0.56 mm, length 0.41–0.53 mm, (overall length 2.63–4.71 mm) (n = 11).

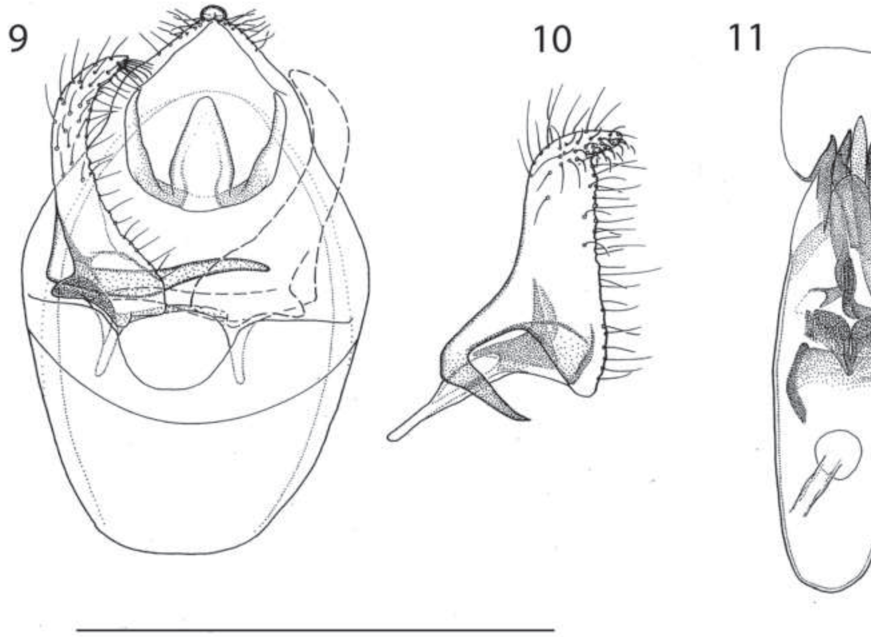
Pupa (skin) (Figs 56, 57). 2.2 mm long, 0.9 mm wide.

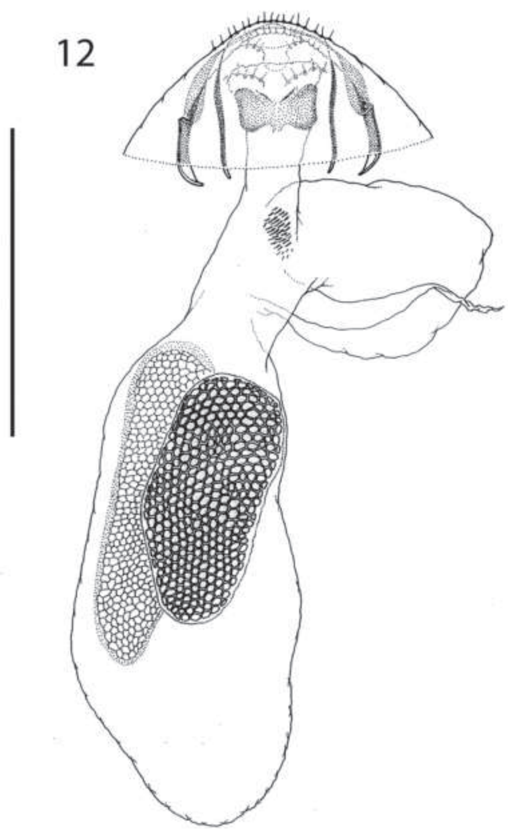
Cocoon (Figs 53–55). Yellow-brown and ovoid, 2.5–3.1 mm long and 1.5 mm wide. Emergence slit about half the length along the narrow periphery.

Biology. Hostplants. Ericaceae: *Arbutus arizonica* (A. Gray) Sarg. (Arizona madrone), *Arbutus menziesii* Pursh (Pacific madrone), *Arbutus × andrachnoides* Link 'Marina', (Marina strawberry tree, possibly *Arbutus unedo* L. × *A. andrachne* L.), *Arctostaphylos canescens* Eastw. (Eiseman 2022), *Arctostaphylos ?glauca* Lindl., *Arctostaphylos insularis* Greene & Parry (Island manzanita), *Arctostaphylos manzanita* Parry (Manzanita), *Arctostaphylos manzanita* subsp. *laevigata* (Eastw.) Munz, *Arctostaphylos pungens* Kunth (Eiseman 2022), *Arctostaphylos rainbowensis* J. E. Keeley & Massihi, most likely also *Arctostaphylos uva-ursi* (L.) Spreng. (Bearberry).



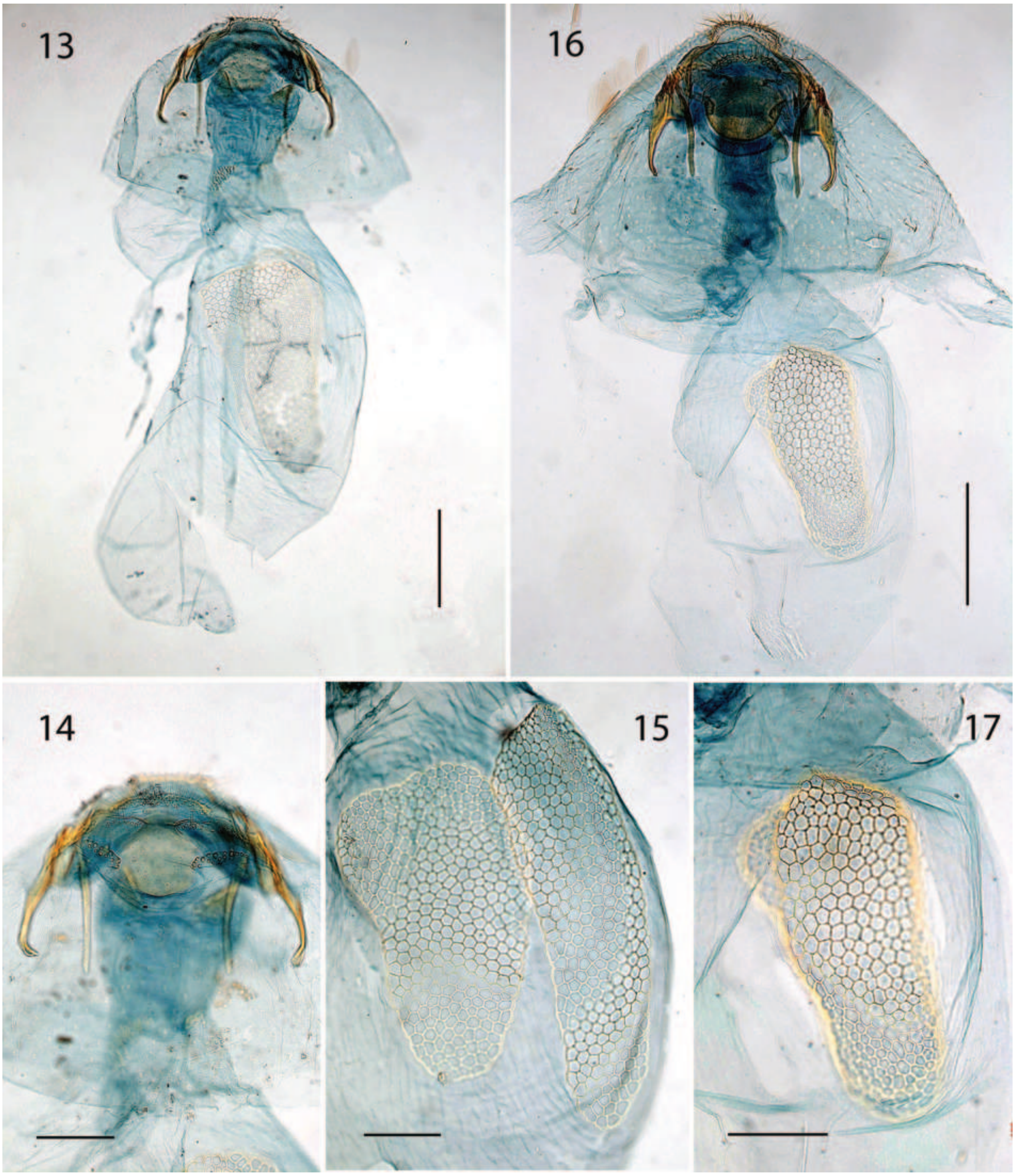
Figures 5–8. *Etainia thoraceleuca*, male genitalia **5, 6** holotype, AZ, genitalia slide EvN4950, respectively more ventrally and more dorsally focused **7, 8** CA, genitalia slide EvN4951, capsule, focused at valval processes and separate detail of phallus. Scale bars: 100 μm.





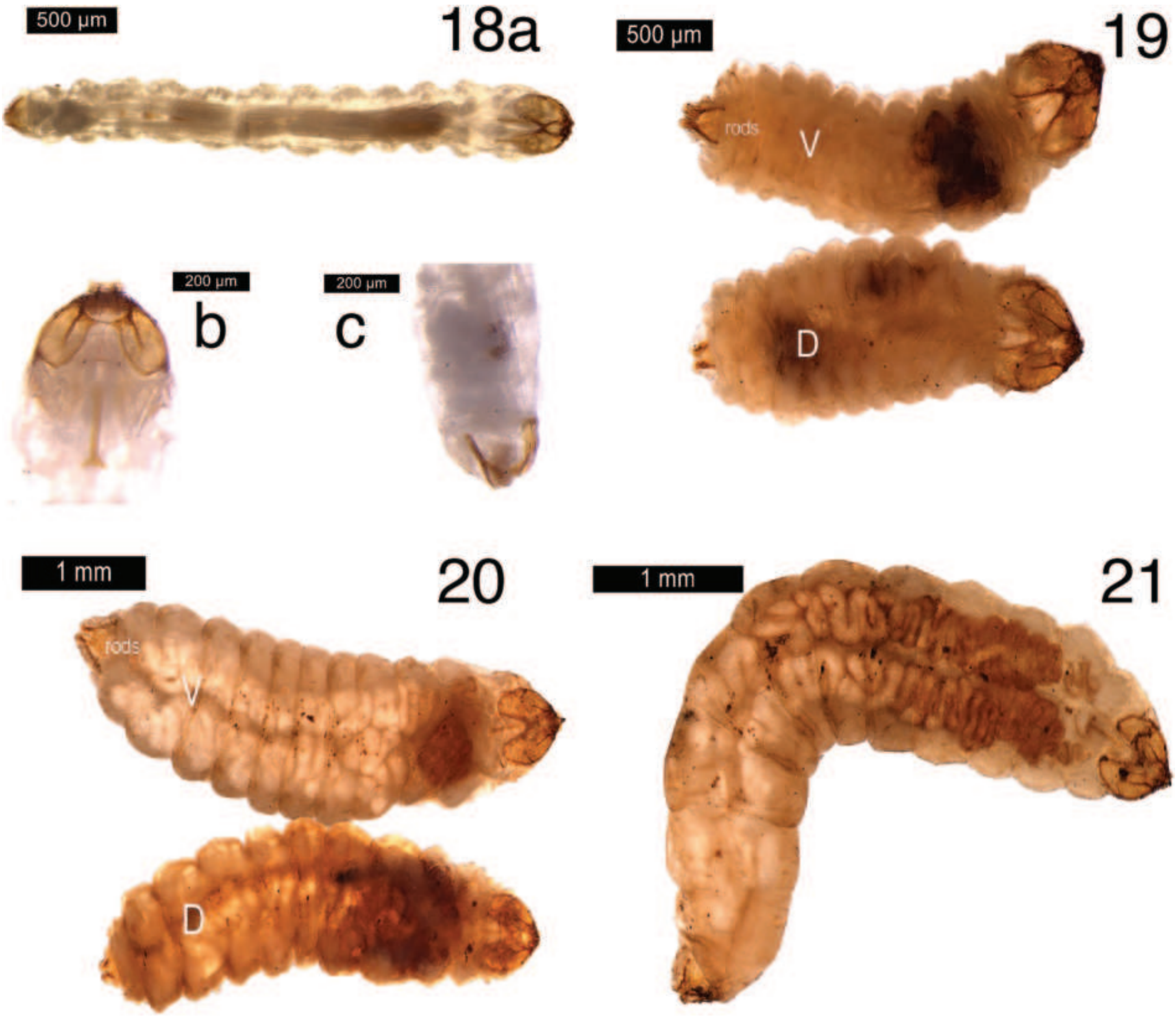
Figures 9–12. *Etainia thoraceleuca*, genitalia **9, 10** male genitalia slide USNM20877, phallus omitted, right valva illustrated separately, internal view **11** phallus, genitalia slide USNM20961 **12** female genitalia, genitalia slide USNM17493. Scale bars: 0.5 mm.

Life cycle. Eggs are apparently laid singly on the underside of leaves in late summer to early fall, where they remain quiescent for several weeks. In late fall, the larvae hatch and begin burrowing into leaf tissue. On the oviposition site there develops a red to black stained leaf spot; from there the larvae make a thin, linear mine running along the lateral and midveins of the hostplants' leaves,



Figures 13–17. *Etainia thoraceleuca*, female genitalia **13, 14** CA, genitalia slide DRD3401, with detail of terminal segments, dorsally **15** CA, genitalia slide DRD3329, detail signa **16, 17** ON, genitalia slide EvN4138, with detail of signa. Scale bars: 200 µm (**13, 16**); 100 µm (**14, 15, 17**).

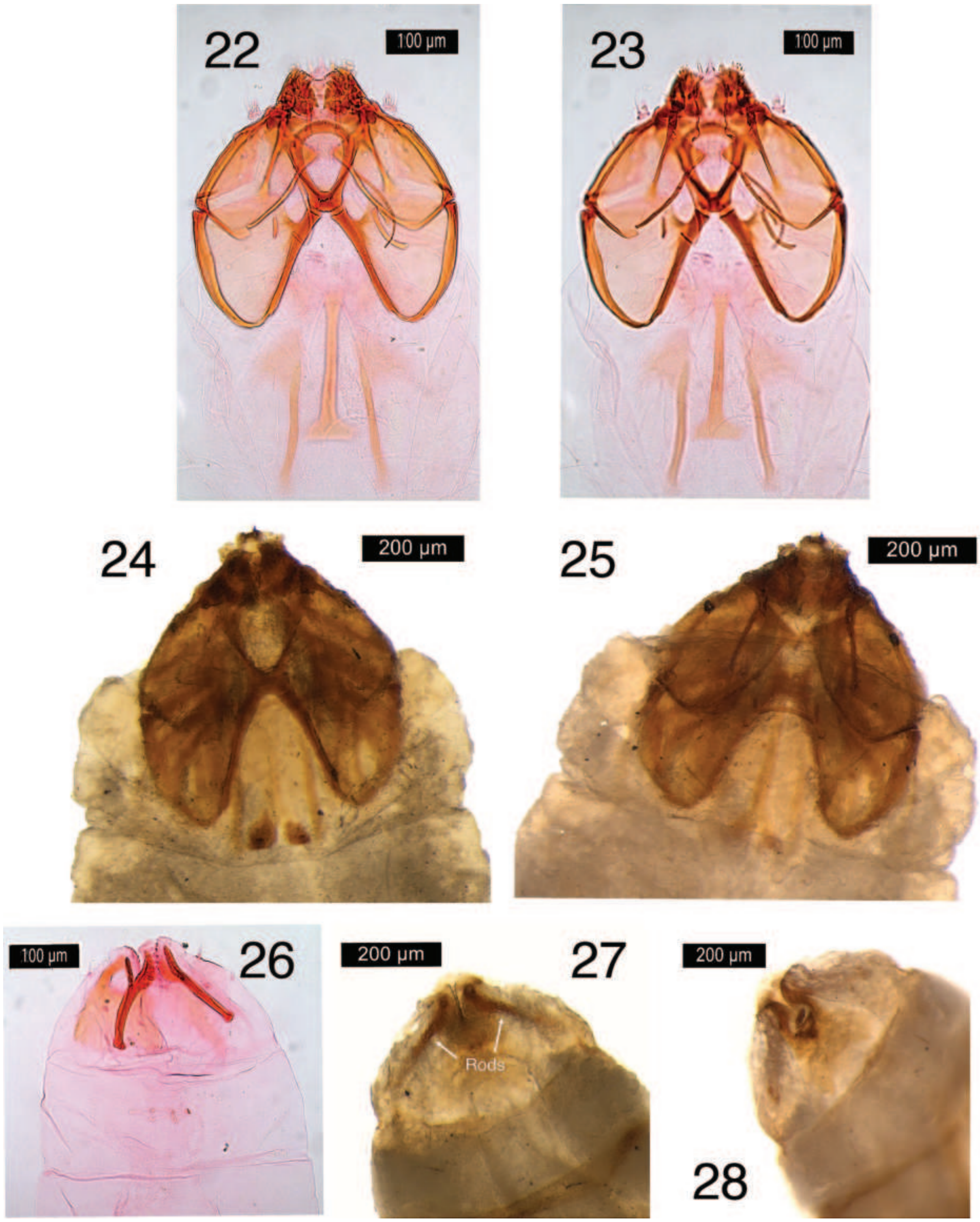
often very straight or sometimes with a few loops; the frass line is central and almost completely fills the gallery; the mined area soon turns red to black. Larvae continue burrowing through the petiole and into subtending twigs where they mine phloem tissues. After feeding in the twig cambium for several months, larvae bore their way out of the twigs and drop into the leaf litter beneath the plant. The exit holes are little slits in the twig epidermis, resembling those of other



Figures 18–21. Larval whole body of *Etainia thoraceleuca* **18** first instar: **a** whole larva posterior (L) to anterior (R), dorsal view **b** close up head (ventral view) **c** close up posterior (dorsal view) **19** second instar (dorsal and ventral) **20** third instar (dorsal and ventral) **21** fourth instar (ventral-lateral).

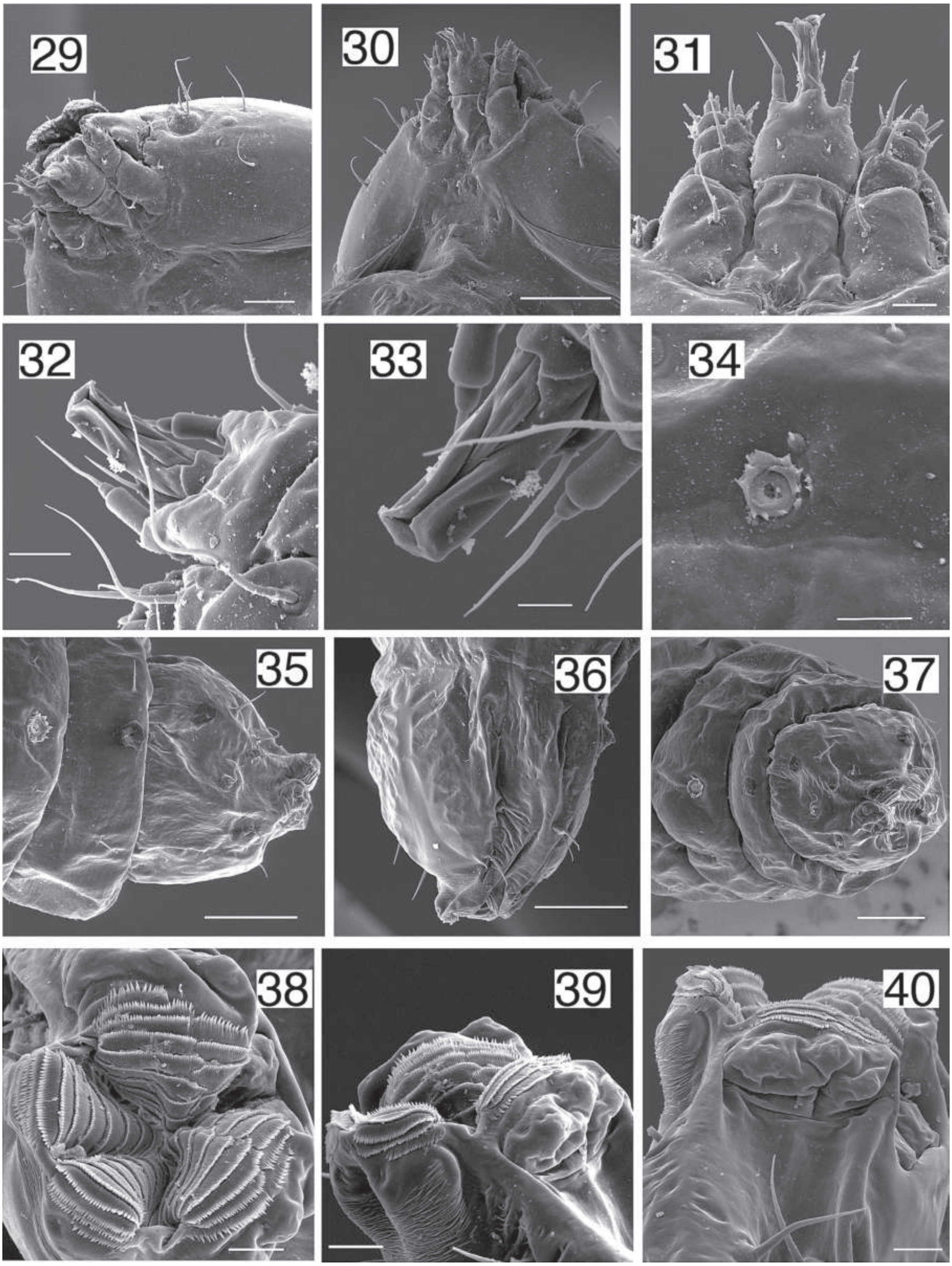
nepticulids. On California's north coast, this occurs from April to May. Larvae pupate in the duff, tying dead leaves and perhaps other organic material together with bright-saffron to orange silken cocoons. Pupation is complete by June with most adult moths emerging early to mid-May in 2019 and 2020. Moths were found between 26 April and 14 October, which may indicate two annual generations, or a rather irregular emergence of adults. Adults are usually found at light.

Damage details (Figs 41–44). Initial damage symptoms appear as inconspicuous black spots on the hostplant leaf blade, caused by a larva tunneling in a wandering circular pattern (Fig. 41). The circles gradually enlarge until the larva encounters a lateral leaf vein. The larva then normally follows the lateral vein down to the midvein, through the petiole (Figs 41–44). Damage by the larvae can be seen on the undersides (and sometimes the top) of the leaf as a thin but conspicuous red to black line marking the tunnel. Sometimes a larva will follow the lateral vein to the edge of the leaf, and then circle toward the leaf center until it again finds a lateral vein. Once the larva reaches the thicker tissues of the petiole and begins boring into the twig's cambial tissues the line gradually disappears.

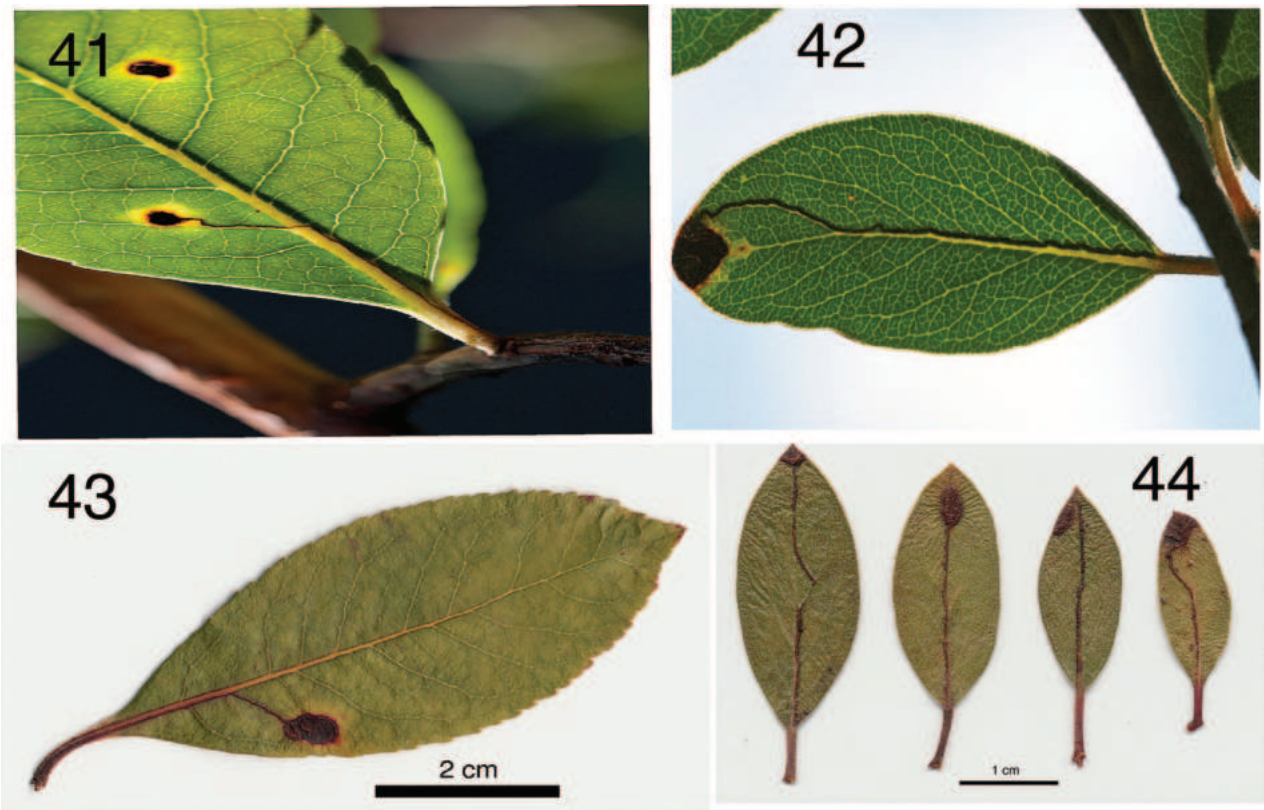


Figures 22–28. Larval head and posterior end of *Etainia thoraceleuca* **22, 23** head capsule of instar 3? in slide, dorsal (**22**) and ventral (**23**) view, RMNH.INS.31005.P (DNA barcoded larva) **24, 25** head of instar, untreated larva, dorsal (**24**) and ventral (**25**) view **26–28** posterior segments **26** in slide RMNH.INS.31005.P **27** ventral **28** dorsal.

Twig bark excision with a scalpel will reveal substantial feeding damage in the cambium. Undamaged leaves of *Arbutus* normally last at least one season, sometimes a few months more (Berner and Law 2016: table 2). All hostplants observed so far dropped their damaged leaves before the end of their first season.



Figures 29–40. *Etainia thoraceleuca*, larva, scanning electron microscopy [scale bars = μm] **29** early instar head ventro-lateral **30** early instar head ventral **31** early instar labium with spinneret, labial palps and maxillae with palps, ventral **32** mid instar dorsal spinneret and labial palps **33** mid instar dorsal spinneret **34** early instar spiracle A4 **35** mid instar A8-A10 lateral **36** mid instar lateral A10 **37** mid instar A8–A10 posterior lateral **38** early instar rows of spines in anal opening A10 **39** early instar ventral A10 **40** early instar lateral ventral A10. Scale bars: 100 μm (**30, 35–37**); 50 μm (**29, 31**); 20 μm (**32, 34, 38–40**); 10 μm (**33**).

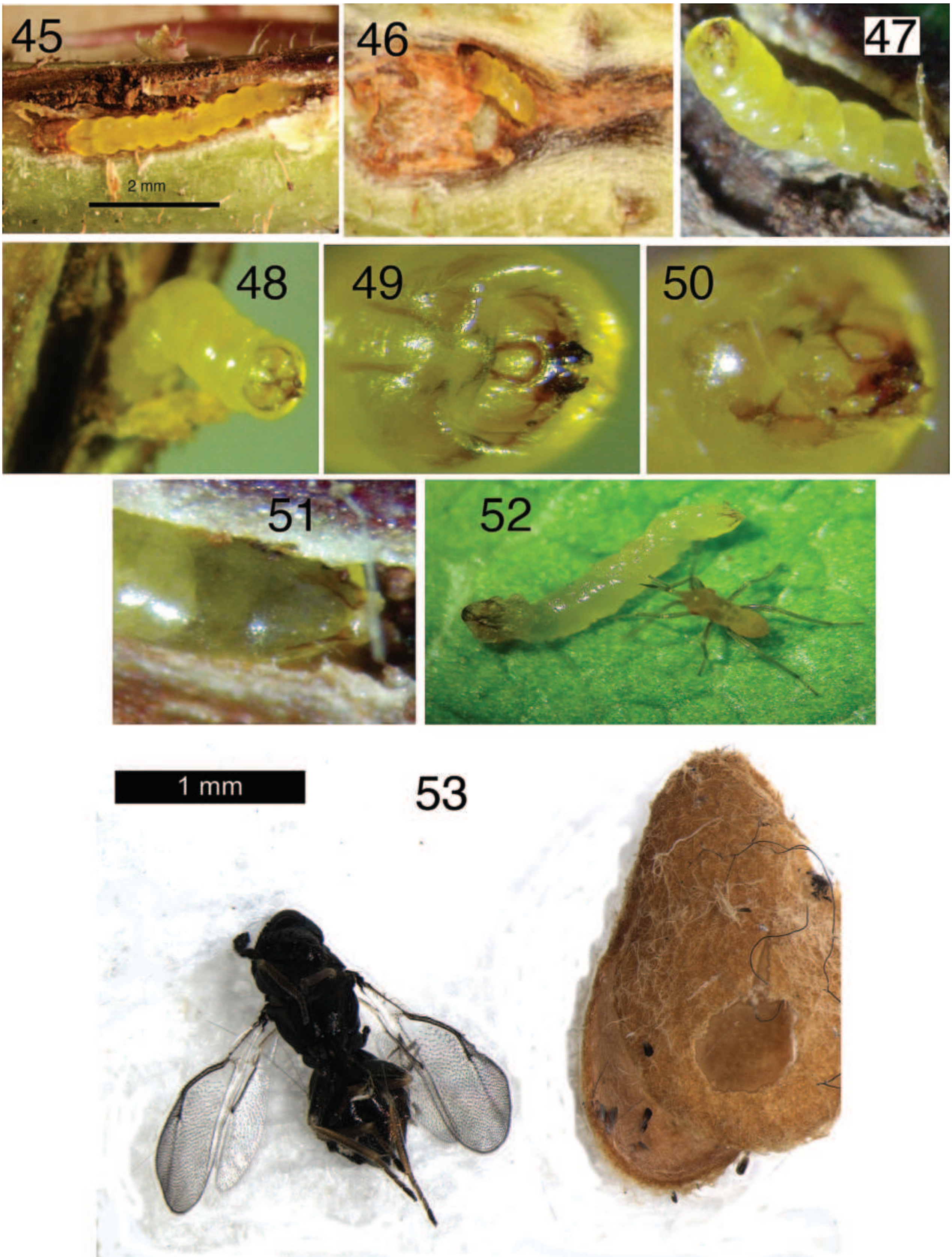


Figures 41–44. Leafmine damage caused by *Etainia thoraceleuca* **41** Marin Co., CA: S. Swain, leafmine on Marina strawberry tree, *Arbutus* × 'Marina' **42** CA: Sonoma Co., S. Swain, leafmine on manzanita, *Arctostaphylos* spec. **43** CA: San Diego Co., S.J. Seybold, MA Siefker, coll., leafmine on Marina strawberry tree, *Arbutus* × 'Marina' **44** CA: Marin Co., S.J. Seybold, coll., mines on stems and leaves from manzanita, *Arctostaphylos* spec.

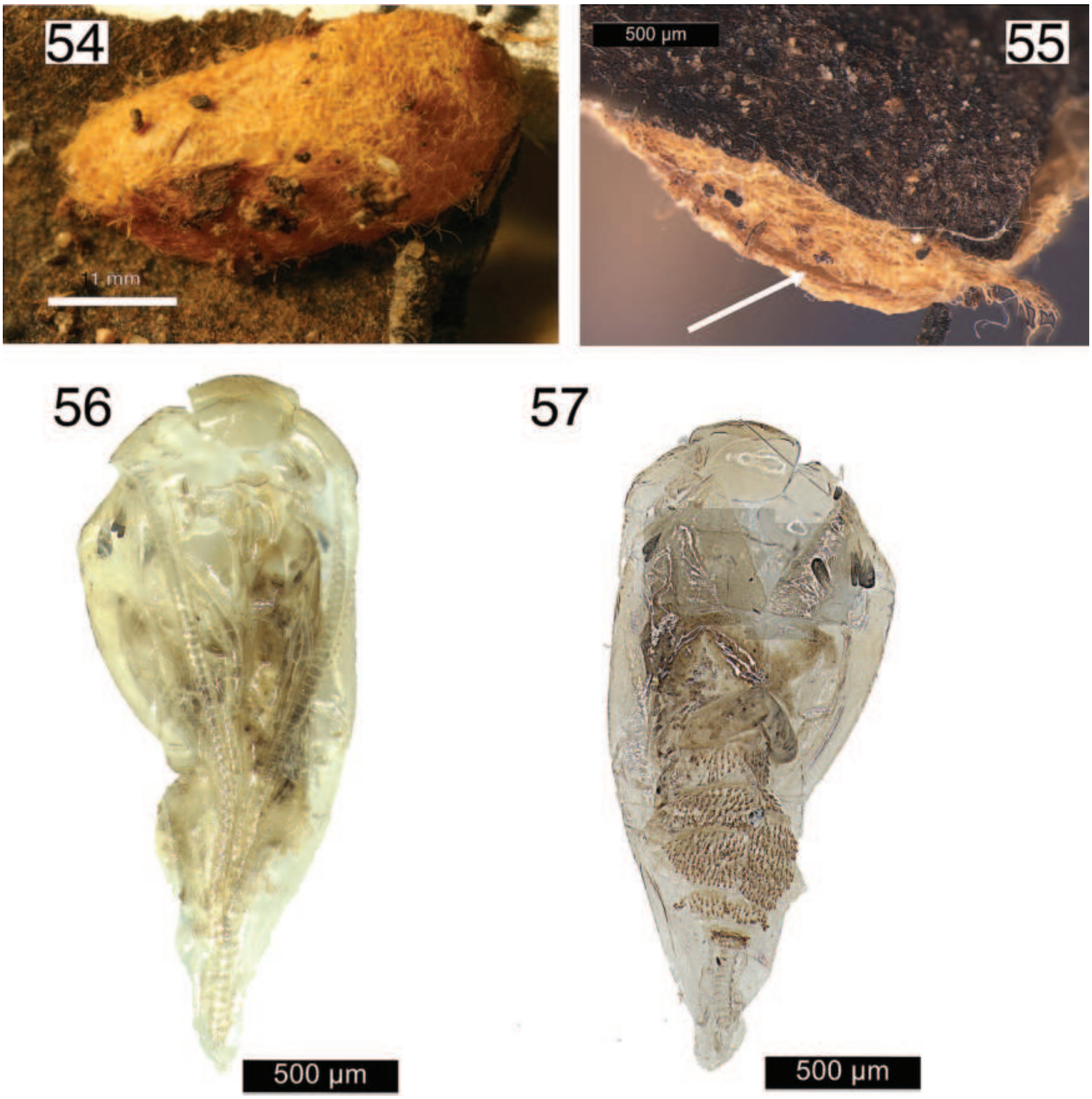
As larvae from many leaves migrate into subtending twigs to feed, their numbers and associated damage become concentrated, damaging the cambium to such an extent that the distal portions of the twig are frequently killed. These branches wilt and die rapidly, leaving the wilted end of the twig to droop, shrivel, and then harden into a shepherd's crook. Even when twigs are not killed, the bark splits and callus tissue will form on the twigs, disfiguring and sometimes distorting it. In severe cases, young *Arbutus* 'Marina' trees have been killed, and older trees rather severely disfigured, with less than 50% live canopy remaining. Damage to native manzanita and madrone does not appear to be as severe.

Parasitoids. As might be expected for a moth in its native range, parasitoid wasp pupae have been found inside the mines on occasion. One Chalcidoidea parasitoid (most likely Eulophidae, Entedoninae, C. Eiseman pers. comm.) emerged in summer 2023 from cocoons from Sonoma (near Napa Co.) found by SVS on 11 May 2023; it made a circular exit hole on a broad cocoon surface (Fig. 53). A moth emerged from another cocoon from the same date and location during the same summer.

Distribution (Figs 58, 59). Most records are from California, where *E. thoraceleuca* has been found over much of the coastal ranges of California and collected from Del Norte County in the extreme northwestern part of the state to as far south as San Diego County, in adjacent Oregon (leafmines, Josephine Co., Rough and Ready Botanical Wayside, 42.0959, −123.6831; C. Eiseman pers. comm.), in Arizona in the Huachuca mountains (type locality), Chiricahua



Figures 45–53. Active larvae of *Etainia thoraceleuca* boring in woody stems of Marina strawberry tree, *Arbutus* × 'Marina' from CA: Marin Co. unless otherwise mentioned **45–46** CA: Sonoma Co., S. Swain **47–50** open stem with larval head, dorsal view **51** larva in stem with anal rods visible **52** larva, removed from stem, attacked by a mirid nymph **53** Chalcidoid parasitoid, most likely Eulophidae: Entedoninae and cocoon of *Etainia thoraceleuca* with exit hole of parasitoid.



Figures 54–57. Cocoons (54–55) and pupal skin (56–57) of *Etainia thoraceleuca*.

mountains (leafmines on *A. pungens*, Cochise Co., Cave Creek Canyon, Cathedral Vista Trail, 31.8866, −109.1721, C. Eiseman pers. comm.; illustrated by Eiseman 2022), Yavapai County, and three specimens from Ontario, Canada. Leafmines collected in Washington State also probably belong to this species.

DNA barcodes (Fig. 60). We have DNA barcodes from eleven specimens, four larvae and seven adults: seven full barcodes belonging to BIN BOLD:ACK1467 with an average KP2 distance of 0.39%, and a maximum distance of 0.83%, and three barcodes of the Canadian specimens belonging to BIN BOLD:AEO1837 (no variation) at a distance of 1.5% to the nearest Californian sequence (Fig. 58). Unfortunately, we failed to amplify COI from the holotype.

The identical barcodes of adults and larvae undoubtedly show that the described larvae and damage belong to the same species as the adults.

Remarks. The specimens from Canada differ in having a completely orange head and in their female genitalia; in both specimens the signa are almost equal length, 360 µm. In a Californian female specimen one of the three rows of setae on T8 seems to be missing. The genitalia of the male Canadian specimen could

Figures 58–59. Distribution of *Etainia thoraceleuca* **58** in North America **59** in Oregon, California and Arizona.

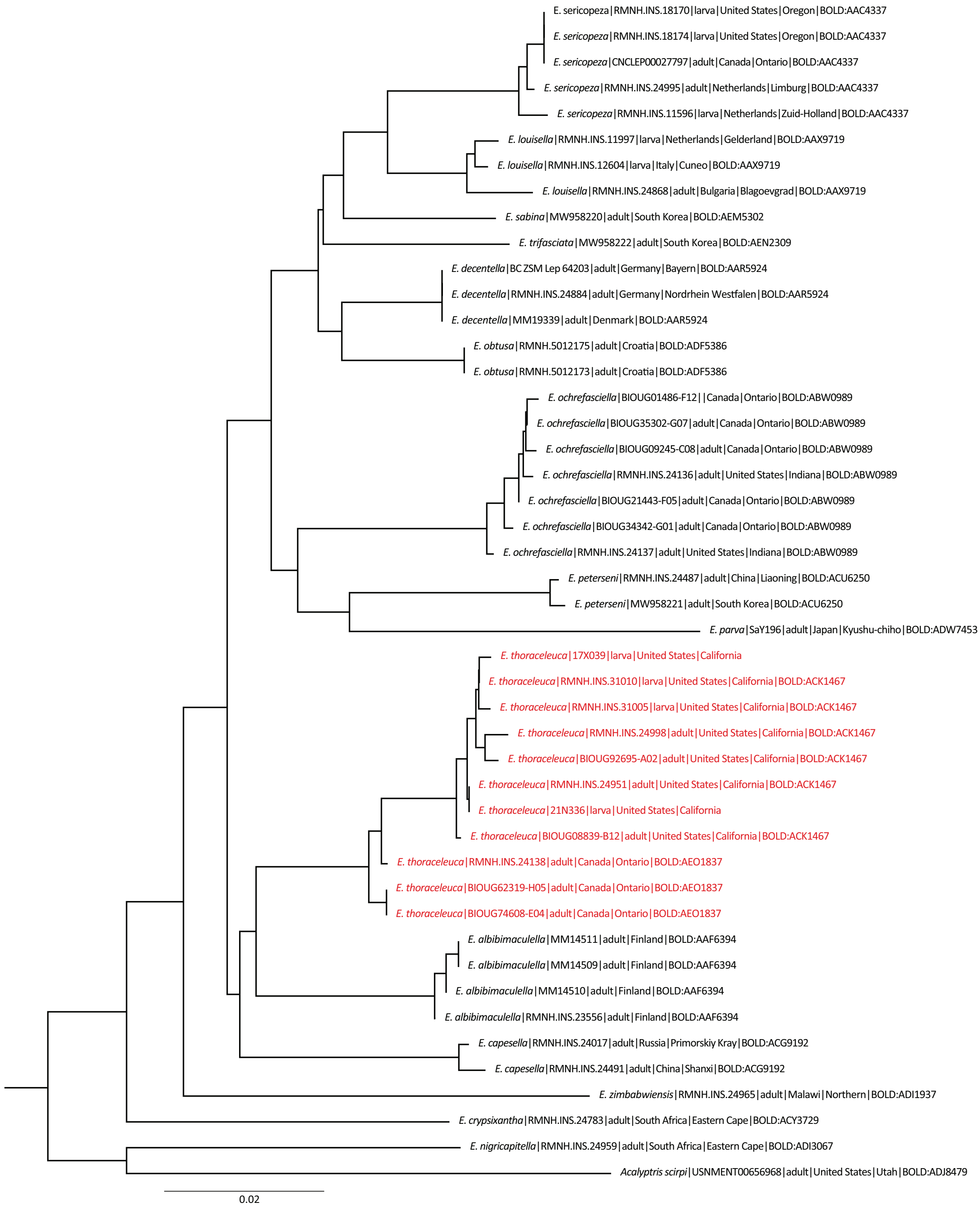


Figure 60. Neighbor-joining tree of DNA barcodes (mt gene COI-5P) of *Etainia* species, using the Kimura distance model. *Acalyptris scirpi* (Braun, 1925) is used as outgroup. Labels show species name, Sample ID, life stage, Country, State or Province and BIN (Barcode Identification Number).

not yet be examined. For now, we consider the Canadian specimens as belonging to the same species, but further study and material is required to evaluate the possibility of hidden diversity.

Etymology. The specific name, *thoraceleuca*, a noun in apposition, is derived from the Greek noun *thorax* (breastplate) and adjective *leukos* (white), referring to the characteristic white thorax.

Discussion

Phylogeny

In a maximum-likelihood analysis of Nepticulidae based on a maximum of eight genes (to be published elsewhere), *E. thoraceleuca* groups with *E. albibimaculella* and the eastern Palearctic *E. capesella* (Puplesis, 1985) as sistergroup to all other Holarctic representatives of *Etainia*, which are probably all associated with *Acer* (Sapindaceae). The grouping of *E. albibimaculella* and *E. capesella* was also observed earlier (Doorenweerd et al. 2016), and since both *E. thoraceleuca* and *E. albibimaculella* feed on Ericaceae, it may indicate that *E. capesella* is also an Ericaceae feeder.

The sister-group relationship between *E. thoraceleuca* and *E. albibimaculella* may suggest a scenario where the common ancestor invaded North America from Asia, where it continued on the same hostplant, *Arctostaphylos uva-ursi* and from there invaded the mountains in the West and expanded its host range to include the abundant other Ericaceae hostplants already present.

Distribution

The three Canadian records, far away from most records from the western USA, suggest that the species may have a continuous distribution with the northern *Arctostaphylos uva-ursi*, which has a very wide distribution throughout Canada and the northern and western United States. It is remarkable, however, that this relatively large and conspicuous nepticulid has not been recorded anywhere else in Canada, and also not in the extensive Canadian Malaise trapping programs (Hebert et al. 2016). In fact, *E. thoraceleuca* has only been collected twice in a Malaise trap, the specimens cited here as BIOUG08839-B12 from San Diego County and BIOUG92695-A02 from Santa Clara County. The apparent rarity is comparable to that of the European *E. albibimaculella*, for which records outside Finland and Sweden are extremely rare (van Nieukerken and Johansson 1990; Roweck and Savenkov 2002; Mazurkiewicz 2007; Kopp 2010; Nel et al. 2020), despite the likewise large distribution of bearberry in Europe and Asia.

Hostplant relationships

The genera *Arbutus* and *Arctostaphylos* are closely related and grouped in the subfamily Arbutoideae (Kron et al. 2002), and many insect species share these genera as hosts. This is also the case for several leafminers: *Coptodisca arbutiella*, *Marmara arbutiella*, *Coleophora glaucella* Walsingham, 1882, *Epinotia nigralbana* (Walsingham, 1879), *Epinotia terracoctana* (Walsingham, 1879), and an undescribed *Stigmella* species (Eiseman 2022). The oligophagy of *Etainia thoraceleuca* thus follows this common pattern. It should be searched for on *Arbutus xalapensis* in New Mexico and Texas and is likely to be found on many more *Arctostaphylos* species.

Impact

As *Etainia thoraceleuca* is indigenous in California, its occurrence on cultivated plants was to be expected and by itself not of much concern. In some cases, however, the damage made by the insect can become a nuisance, but the use of the neonicotinoid imidacloprid in many nurseries (personal communications to SVS) has probably prevented this from becoming problematic. This, however, is in no way a plea to use these pesticides against this insect, as the damage caused by neonicotinoids to insects, especially bees, is too well known (Pisa et al. 2021). It is better to allow the native parasitoids and predators to do their work. Care should, however, be taken to avoid distributing infested plant material outside the native area, to avoid the possibility that *E. thoraceleuca* could become established elsewhere and might become invasive.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Morphological study adults: EvN, DRD, Morphological study immatures: ME, EvN, Fieldwork, study of biology: SVS, Data compilation, writing: EvN, ME, SVS.

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Data availability

The data that support the findings of this study are available in the main text and in datasets https://www.gbif.org/dataset/42e8fdc3-bcff-45ba-b318-605173ab1f04 and https://doi.org/10.5883/DS-ETAARB.

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Research Article

Four new species of the genus *Xynobius* Foerster (Hymenoptera, Braconidae, Opiinae) from South Korea

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Abstract

Four new species, *Xynobius azonius* **sp. nov.**, *X. brevifemora* **sp. nov.**, *X. duoferus* **sp. nov.**, and *X. stipitoides* **sp. nov.**, are described and illustrated, and one species *X. geniculatus* (Thomson, 1895) is newly reported from South Korea. *Xynobius geniculatus* (Thomson, 1895) is redescribed and illustrated, and a new combination, *Xynobius* (*Stigmatopoea*) *cubitalis* (Fischer, 1959), **comb. nov.** is suggested. An identification key to the *Xynobius* species known from South Korea is provided.

Key words: Description, identification, key, parasitoid, Republic of Korea

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Introduction

The large and cosmopolitan subfamily Opiinae Blanchard, 1845 consists of derived koinobiont cyclostome wasps, with approximately 2,100 described valid species to date (Yu et al. 2016). Members of the Opiinae are koinobiont endoparasitoids of dipterous larvae, of which some are agricultural pests such as leaf miners and fruit feeders. Therefore, their opiine parasitoids might be valuable for biological control (Wharton 1997; Ovruski et al. 2000; Delrio et al. 2005; Wahyuni et al. 2017). The taxonomy of the Opiinae is still subject to much discussion and fluctuation because of their intermediate characters. The number, validity, and systematic placement of several genera is not yet finalised, and debates exist regarding the classification of certain genera, such as *Opius* Wesmael, 1835 and *Eurytenes* Foerster, 1863 (e.g., Wharton 1987, 1988, 1997; Wharton and Norrbom 2013) and some new genera (e.g., van Achterberg 2023). Papp (1981a, 1989, 1992) reported *Xynobius tenuicornis* (Thomson, 1895), *X. japanus* (Fischer, 1963), *X. caelatus* (Haliday, 1837), and *X. comatus* (Wesmael, 1835) from North Korea, and the national species list of Korea (National Institute of Biological Resources (NIBR), 2019) lists five species, including *X. rudis* Wesmael, 1835. However, *X. rudis* belongs to a different genus, viz., *Neopius* Gahan, 1917 according to Sheng et al. (2019). In addition, the reported species *Apodesmia sapporanus* (Fischer, 1963) belongs to the genus *Xynobius* (Han et al. 2023) and should be included in this review.

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We treat *Xynobius* Foerster, 1863 as a valid genus separate from *Opius* following Li et al. (2013) and van Achterberg (2023). We report five *Xynobius* species, four new to science and one newly recorded in South Korea. An identification key to the Korean *Xynobius* is provided with descriptions and illustrations of the new species.

Materials and methods

Specimens of *Xynobius azonius* sp. nov., *X. duoferus* sp. nov., and *X. stipitoides* sp. nov. were collected by using a net to sweep the herbal vegetation, while those of *X. brevifemora* sp. nov. and *X. geniculatus* were collected in a Malaise trap. All specimens were preserved in 70% alcohol. For identification of the subfamily Opiinae, see van Achterberg (1990, 1993, and 1997); for references to the classification of the Opiinae, see Yu et al. (2016).

Morphological terminology follows van Achterberg (1988, 1993), including the abbreviations for the wing venation. Measurements were taken as indicated by van Achterberg (1988); for the length and the width of a body part the maximum length and width is taken, unless otherwise indicated. The length of the mesosoma is measured from the anterior border of the mesoscutum to the apex of the propodeum and of the first tergite from the posterior border of the adductor to the medio-posterior margin of the tergite.

Observations, photographic images, and descriptions were made either with a LEICA DMC2900 digital camera or with a LEICA M205 C microscope (Leica Geosystems AG). The photos were stacked with Helicon Focus v. 7 software (Helicon Soft, Kharkiv, Ukraine) After stacking, illustrations were created using Adobe Photoshop CS5.1.

The holotype of *Xynobius duoferus* sp. nov. is deposited in the National Institute of Biological Resources (**NIBR**) at Incheon and the specimen of *X. geniculatus* (Thomson, 1895) is deposited in the Korea National Arboretum (**KNA**) at Pocheon. The remaining holotypes are deposited in the Kunsan National University (**KSNU**) at Gunsan.

Systematics

Genus *Xynobius* Foerster, 1863

Xynobius Foerster, 1863: 235. Type species (by original designation): *Xynobius pallipes* Foerster, 1863 (= *Opius caelatus* Haliday, 1837).

Aclisis Foerster, 1863: 267. Type species (by original designation): *Aclisis isomera* Foerster, 1863 (= *Opius caelatus* Haliday, 1837). Synonymised by Fischer (1972).

Holconotus Foerster, 1863: 259 (not Schmidt-Göbel, 1846). Type species (by original designation): *Opius comatus* Wesmael, 1835). Synonymised by van Achterberg (2004).

Aulonotus Ashmead, 1900: 368 (new name for *Holconotus* Foerster). Type species (by original designation): *Opius comatus* Wesmael, 1835). Synonymised by Tobias and Jakimavičius (1986).

Eristernaulax Viereck, 1913: 362. Type species (by original designation): *Eristernaulax leucotaenia* Viereck, 1913). Synonymised by van Achterberg (2004).

Stigmatopoea Fischer, 1984: 610, 611 (as subgenus of *Opius* Wesmael), 1998: 25 (key to species); Wharton, 1988: 356; 2006: 338 (as subgenus of *Eurytenes* Foerster, 1863; possible paraphyly in *Xynobius*). Type species (by original designation): *Opius macrocerus* Thomson, 1895. Synonymised by van Achterberg (2004).

Xynobiotenes Fischer, 1998: 23 (as subgenus of *Eurytenes* Foerster, 1863). Type species (by original designation): *Opius scutellatus* Fischer, 1962. Synonymised by Li et al. (2013).

Diagnosis. Hypoclypeal depression distinct and ventral margin of clypeus above upper level of mandibular condyles (Figs 6, 20, 34, 48, 58, 70); mandible without acute basal lamella; notauli complete (Fig. 32) or largely absent except a pair of short anterior impressions (Figs 4, 16, 57); medio-posterior depression variable, often present (Figs 4, 32, 45, 57, 67); precoxal sulcus distinct and no sternaulus; vein r of fore wing more or less angled with vein 3-SR and distinctly shorter than vein 2-SR (Figs 2, 14, 30, 43, 55, 65); pterostigma either narrowed apically or parallel-sided to slightly widened apically (subgenus *Stigmatopoea*: Figs 55, 65); dorsope distinct (Figs 5, 9, 22, 25, 26, 37, 45, 46, 50, 51, 57, 58, 68, 69).

Distribution. Cosmopolitan.

Biology. Koinobionts endoparasitoids of mining dipterous larvae (species of the genus *Agromyza* Fallen, 1810; Agromyzidae), or of fruit-infesting larvae (species of the genera *Euliea* Walker, 1835, and *Trypeta* Meigen, 1803; Tephritidae).

Key to Korean species of the genus *Xynobius* Foerster

The number of included species for Korea is based on the list by Yu et al. (2016), the Korean species list (NIBR 2019), and this study; only *X. cubitalis* (Fischer, 1959) is included as a new combination.

1 Pterostigma subparallel-sided and more or less widened apically (Figs 43, 65); subgenus *Stigmatopoea* Fischer, 1986 .... **2**

– Pterostigma elliptical or triangular, narrowed apically (Figs 2, 14, 30, 55); subgenus *Xynobius* Foerster, 1863 .... **3**

2 Propodeum finely and weakly rugose; medio-posterior depression of mesoscutum round; face weakly punctate and rugose; length of hind femur 6–7× its width; third and following metasomal tergites without pale bands..................................... ***X.* (*S.*) *cubitalis* (Fischer, 1959), comb. nov.**

– Propodeum mainly coarsely rugose; medio-posterior depression of mesoscutum sublinear; face densely punctate; length of hind femur 4.7× its width; third and following metasomal tergites with pale transverse bands [notauli present up to middle of mesoscutum and narrowly crenulate; vein SR1 of fore wing 2.7× longer than vein 3-SR; first tergite subparallel-sided and nearly twice longer than its apical width] ....***X.* (*S.*) *stipitoides* Han & van Achterberg, sp. nov.**

3 Vein m-cu of fore wing antefurcal or interstitial [rarely in *X. sapporanus*; see couplet 10] **4**

– Vein m-cu of fore wing postfurcal **7**

4 Scutellum smooth; face conspicuously setose (Figs 20, 21, 27)............... **5**

– Scutellum entirely sculptured; face inconspicuously setose **6**

5 Notauli absent on mesoscutal disc; pronope absent; antenna of ♀ with 40 segments; middle lobe of mesoscutum largely glabrous; face punctate; medio-posterior depression of mesoscutum absent [occiput smooth with setae; all femora robust; wing rather infuscated; mesosoma except metapleuron and propodeum orange-brown] .... ***X.* (*X.*) *brevifemora* Han & van Achterberg, sp. nov.**

– Notauli at least present on anterior half of mesoscutal disc; pronope present; antenna of ♀ with 22–24 segments; middle lobe of mesoscutum evenly setose; face smooth; medio-posterior depression of mesoscutum present, round [propodeum reticulate-rugose] .... ***X.* (*X.*) *comatus* (Wesmael, 1835)**

6 Scutellum densely rugose; occiput punctate; antenna with 41–50 segments [notauli complete and narrowly crenulate; middle lobe of mesoscutum faintly punctate; medio-posterior depression of mesoscutum round and surrounding area rugulose; pronotal side extensively rugose expect dorsally; ventral margin of clypeus concave] .... ***X.* (*X.*) *caelatus* (Haliday, 1837)**

– Scutellum coarsely punctate; occiput smooth or with some fine punctures; antenna with 50–54 segments.................... ***X.* (*X.*) *japanus* (Fischer, 1963)**

7 Antenna of ♀ with white subapical band; second metasomal tergite striate-rugose medially [first tergite with straight longitudinal striae; notauli complete and narrowly crenulate; mesoscutum largely smooth and sparsely setose medially; antenna with two dark apical segments]........... .... ***X.* (*X.*) *duoferus* Han & van Achterberg, sp. nov.**

– Antenna of ♀ without white subapical band and dark brown to brownish subapically; second tergite smooth or finely striate **8**

8 First metasomal tergite 1.7–2.2× longer than its apical width; second tergite more or less finely striate; antenna with 28–31 segments [frons, vertex and entire occiput blackish brown; propodeum smooth or only carinate] .. .. ***X.* (*X.*) *tenuicornis* (Thomson, 1895)**

– First tergite 1.3–1.5× longer than its apical width; second tergite smooth; antenna with 35–44 segments... **9**

9 Precoxal sulcus smooth [malar sulcus distinct and deep; antenna with 38–44 segments; area below pterostigma with brownish patch, rarely obsolescent; second submarginal cell of fore wing long; second metasomal tergite bicoloured (dark brown and with a pale yellowish patch medially); hind tarsus pale yellowish or ivory; apex of hind femur dark brown] ....***X.* (*X.*) *geniculatus* (Thomson, 1895)**

– Precoxal sulcus sculptured... **10**

10 Antenna with 39–42 segments; area below pterostigma with a large Y-shaped dark brownish patch; notauli largely impressed on mesoscutal disc [vertex and mesoscutum conspicuously setose; vein m-cu of fore wing variable, usually postfurcal; medio-posterior depression of mesoscutum elongated; propodeum and first tergite coarsely rugose] .... ***X.* (*X.*) *sapporanus* (Fischer, 1963)**

– Antenna with 35 segments; area below pterostigma subhyaline; notauli absent on mesoscutal disc [malar sulcus absent; 5th–7th tergites yellow posteriorly without dark brown band; vein r and 2-SR of fore wing ~ 0.7 and 2.5× as long as vein m-cu, respectively] .... ***X.* (*X.*) *azonius* Han & van Achterberg, sp. nov.**

Xynobius azonius **Han & van Achterberg, sp. nov.**
https://zoobank.org/C76FAE32-149D-4742-91E2-F2D577AE2215
Figs 1–12

Type material. ***Holotype*.** ♀ (KSNU), "South Korea: Amnam, Seo-gu, Busan, 35°04'48.6"N, 129°00'59.2"E, 14.v.2020, SW [= collected by sweeping], Hyojoong Kim leg., KSNU".

Diagnosis. Antennal segments of ♀ ~ 35 and subapical segments dark brown; frons laterally and temple in dorsal view black; eye 1.6× longer than temple in dorsal view (Fig. 7); precoxal sulcus coarsely crenulate (Fig. 3); notauli absent on mesoscutal disc; pterostigma elliptical (Fig. 2); veins r and 2-SR of fore wing ~ 0.7 and 2.5× as long as vein m-cu, respectively; fore wing subhyaline; first metasomal tergite ~ 1.4× longer than its apical width (Fig. 5); second tergite smooth; fifth-seventh metasomal tergites yellow posteriorly, without apical dark brown band; ovipositor sheath short and comparatively robust (Fig. 10).

Description. Female; length of body nearly 2.9 mm, of fore wing 3.0 mm.

***Head*.** Antenna with 35 segments and 1.1× as long as body (Fig. 12); third segment of antenna 2× longer than wide, as long as fourth segment of antenna; eye 1.6× longer than temple in dorsal view (Fig. 7); stemmaticum shiny and smooth; vertex shiny, smooth and moderately setose posteriorly; frons with depression medially and remainder shiny and smooth; face shallowly punctate and densely setose (Fig. 6); median keel present up to between antennal sockets; clypeus 2.3× wider than its maximum height; clypeus smooth and densely setose, protruding in lateral view; hypoclypeal depression present; malar sulcus absent; occipital carina absent medio-dorsally; mandible twisted, triangular in lateral view and gradually widened basally.

***Mesosoma*.** Mesosoma 1.4× longer than its height (Fig. 3); pronope elliptical and deep (Figs 4, 7); propleuron largely smooth and propleuron flange protruding posteriorly (Fig. 3); mesopleuron largely shiny and smooth, but precoxal sulcus crenulate, wide and reaching epicnemial area; epicnemial area distinctly crenulate; pronotal side largely smooth with crenulate groove anteriorly and posteriorly; mesopleural sulcus crenulate; anterior groove of metapleuron crenulate; metapleuron coarsely rugose and densely setose; notauli absent on disc of mesoscutum, except deep and crenulate impressions anteriorly (Fig. 4); mesoscutum shiny, smooth and sparsely setose along imaginary notaulic courses and around medio-posterior depression; scutellum shiny, smooth and rather convex; medio-posterior depression of mesoscutum round; scutellar sulcus crenulate, medium-sized; propodeum sparsely setose with short medio-longitudinal carina anteriorly, transverse carinae, areola, and remainder area shiny and smooth (Figs 4, 8, 9); inside of areola of propodeum reticulate-rugose.

***Wings*.** Fore wing (Fig. 2): pterostigma elliptical and narrowed apically; vein 1-M curved; vein 1-SR+M slightly sinuate; vein 3-SR angled with vein r, converged with vein 2-M and 1.6× longer than vein 2-SR; vein 2-SR straight and oblique; vein SR1 straight; r: 3-SR: SR1 = 5: 21: 41; vein m-cu postfurcal; vein CU1b medium-sized; first subdiscal cell closed. Hind wing: vein m-cu pigmented and curved basally; vein 1r-m 0.5× as long as vein 1-M; vein 2-M only pigmented.

***Legs*.** Hind femur 3.9× longer than its maximum width (Fig. 11).

Figure 1. *Xynobius azonius* Han & van Achterberg sp. nov., holotype, ♀, habitus, lateral.

Metasoma. First metasomal tergite 1.4× longer than its apical width (Fig. 9); first tergite slightly widened apically, dorsal carinae converging medially and its surface with longitudinal striate; dorsope distinctly developed (Figs 5, 9); second metasomal suture superficially indicated dorsally (Fig. 5); second tergite shiny and smooth with a pair of oblique depressions anteriorly; following tergites shiny, smooth, with subposterior row of setae; setose part of ovipositor sheath 0.3× as long as first metasomal tergite (Figs 1, 10).

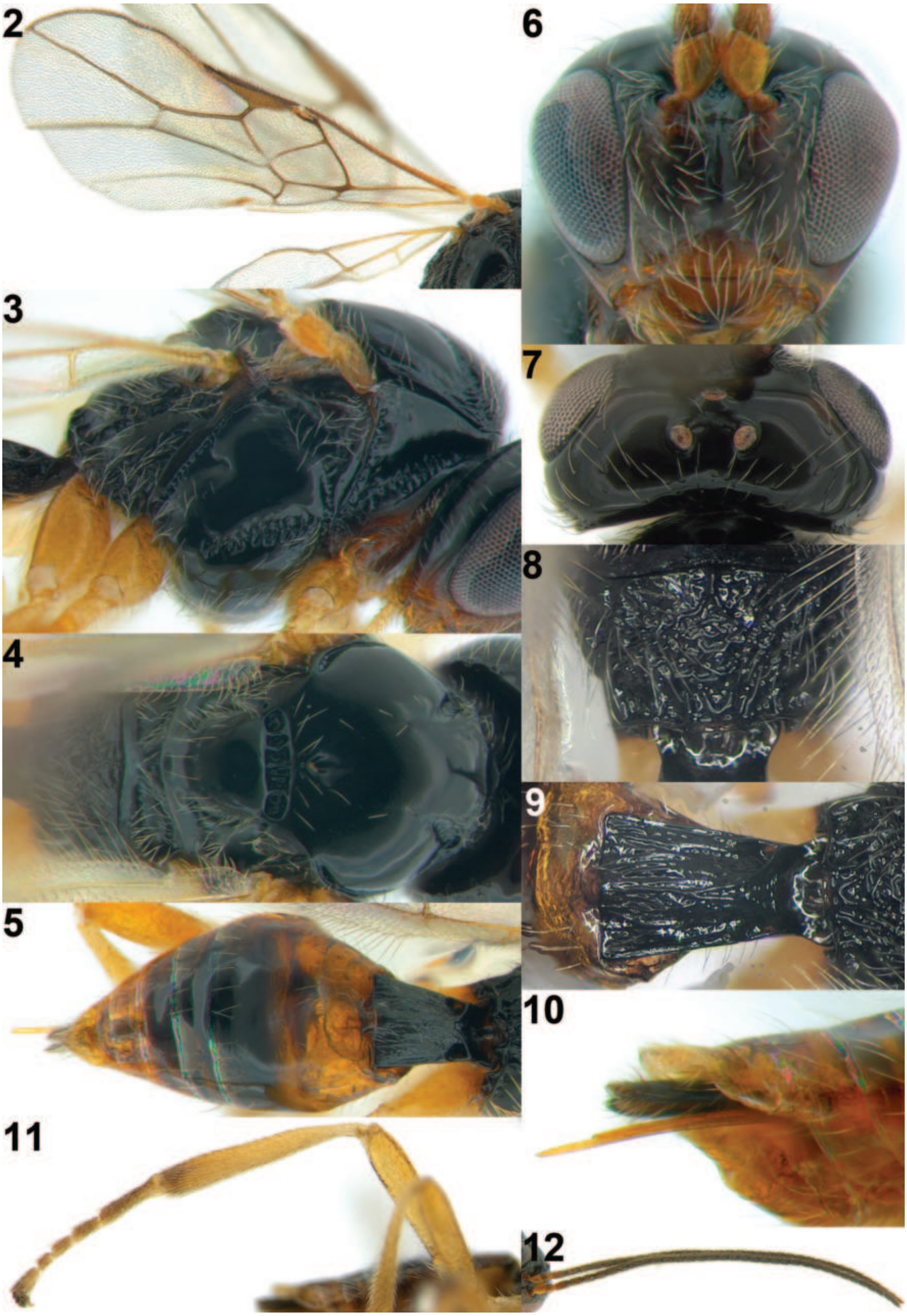
Colour. Body, black; scape of antenna, clypeus, mandible, propleuron, second, sixth, and seventh tergites brown; flagellar segments of antenna, hind tibia, and tarsus dark brown; remainder of legs and palpi pale yellowish; pterostigma and vein of wings greyish brown; wings subhyaline.

Distribution. South Korea.

Biology. Unknown.

Etymology. The new species is named for not having the isolated dark brown bands on the fourth–seventh tergites as in the similar *X. polyzonius* (Wesmael, 1835); "a" is Greek for not and "zone" is Greek for girdle or band.

Remarks. This species runs to the genus *Xynobius* Foerster because of the dorsope at the base of the first tergite, vein 3-SR of the fore wing distinctly longer than vein 2-SR, the mandible more or less twisted medially, symmetrical basally and its second tooth hardly or not visible in lateral view, the hypoclypeal depression distinctly developed and the propleuron without oblique carina (van Achterberg 2023). However, it does not run well in the key by Tobias (1998) by having the notauli reduced (absent on mesoscutal disc and only a pair of crenulated impressions anteriorly), the mesoscutum smooth and sparsely setose, the medio-longitudinal carina and areola on the propodeum (with inner area of



Figures 2–12. *Xynobius azonius* Han & van Achterberg sp. nov., holotype, ♀ **2** wings **3** mesosoma, lateral view **4** mesosoma, dorsal view **5** metasoma, dorsal view **6** head, anterior view **7** head, dorsal view **8** propodeum, dorsal view **9** 1st metasomal tergite, dorsal view **10** ovipositor and sheath, latero-ventral view **11** hind leg **12** antenna.

areola coarsely rugose), the first metasomal tergite comparatively stout (1.3× longer than its apical width) and the smooth and yellowish brown second tergite. Actually, the new species is similar to *X. polyzonius* (Wesmael, 1835) from which is differs by having ~ 35 antennal segments (♀: 24–31 in *X. polyzonius*), frons laterally and temples in dorsal view black (yellowish brown); veins r and 2-SR of fore wing ~ 0.7× and 2.5× as long as vein m-cu, respectively (0.5× and 1.6×, respectively) and fifth–seventh metasomal tergites without dark brown apical band (isolated bands present).

Xynobius brevifemora **Han & van Achterberg, sp. nov.**
https://zoobank.org/4679E4C0-BF7C-437B-80C0-70530160D032
Figs 13–28

Type material. ***Holotype*.** ♀ (KSNU), "South Korea: 290-2 Singwan-dong, Gunsan, Jeonbuk prov., 35°56'34"N, 126°40'45"E, 14.–30.v.2016, MT [= Malaise trap], Hyojoong Kim leg., KSNU".

Diagnosis. Apical third of antenna dark brown or black (Fig. 23); eye 2.4–2.7× longer than temple in dorsal view; middle lobe of mesoscutum largely glabrous and strongly shiny (Fig. 16); scutellum slightly convex; fore wing at most slightly infuscated (Fig. 14); pterostigma gradually narrowed apically, triangular; hind tarsus largely dark brown or brown (Fig. 28); first tergite approximately as long as wide apically (Fig. 26); second metasomal tergite smooth; setose part of ovipositor sheath 0.3× as long as fore wing, 2.2× first tergite and 1.4× hind tibia; all femora robust (Fig. 13); mesosoma except metapleuron and propodeum orange brown.

Description. Female; length of body 4.0 mm, of fore wing 3.9 mm.

***Head*.** Antenna with 40 segments and 1.1× as long as body; third segment of antenna 1.9× longer than its width (Fig. 23); area between antennal sockets rugose; eye 2.7× longer than temple in dorsal view (Fig. 21); vertex and stemmaticum shiny, smooth and moderately setose; frons finely punctate and densely setose (Fig. 20); face punctate and densely short setose; clypeus 2.8× wider its maximum height (Fig. 20); ventral margin of clypeus slightly concave and sparsely setose; hypoclypeal depression present; length of maxillary palp nearly as long as height of head; malar sulcus absent; occipital carina absent dorsally; mandible triangular in lateral view, hardly twisted and gradually widened basally (Fig. 27).

***Mesosoma*.** Mesosoma 1.3× longer than its height; pronope absent (Fig. 21); pronotum with indistinctly crenulated groove posteriorly; mesopleuron largely shiny and smooth, but precoxal sulcus oblique and moderately crenulate; epicnemial area crenulate ventrally, remaining area smooth (Fig. 15); pronotal side largely smooth except crenulated groove anteriorly and posteriorly; mesopleural sulcus smooth; anterior groove of metapleuron crenulate; metapleuron coarsely punctate and sparsely setose posteriorly (Fig. 15); notauli absent on disc of mesoscutum but as a pair of short and deep impressions present anteriorly; mesoscutum shiny, smooth and with few setae, middle lobe largely glabrous (Fig. 16); medio-posterior depression of mesoscutum absent; scutellar sulcus narrow and crenulate (Fig. 16); scutellum largely shiny and smooth, rather flat in lateral view; propodeum sparsely setose with

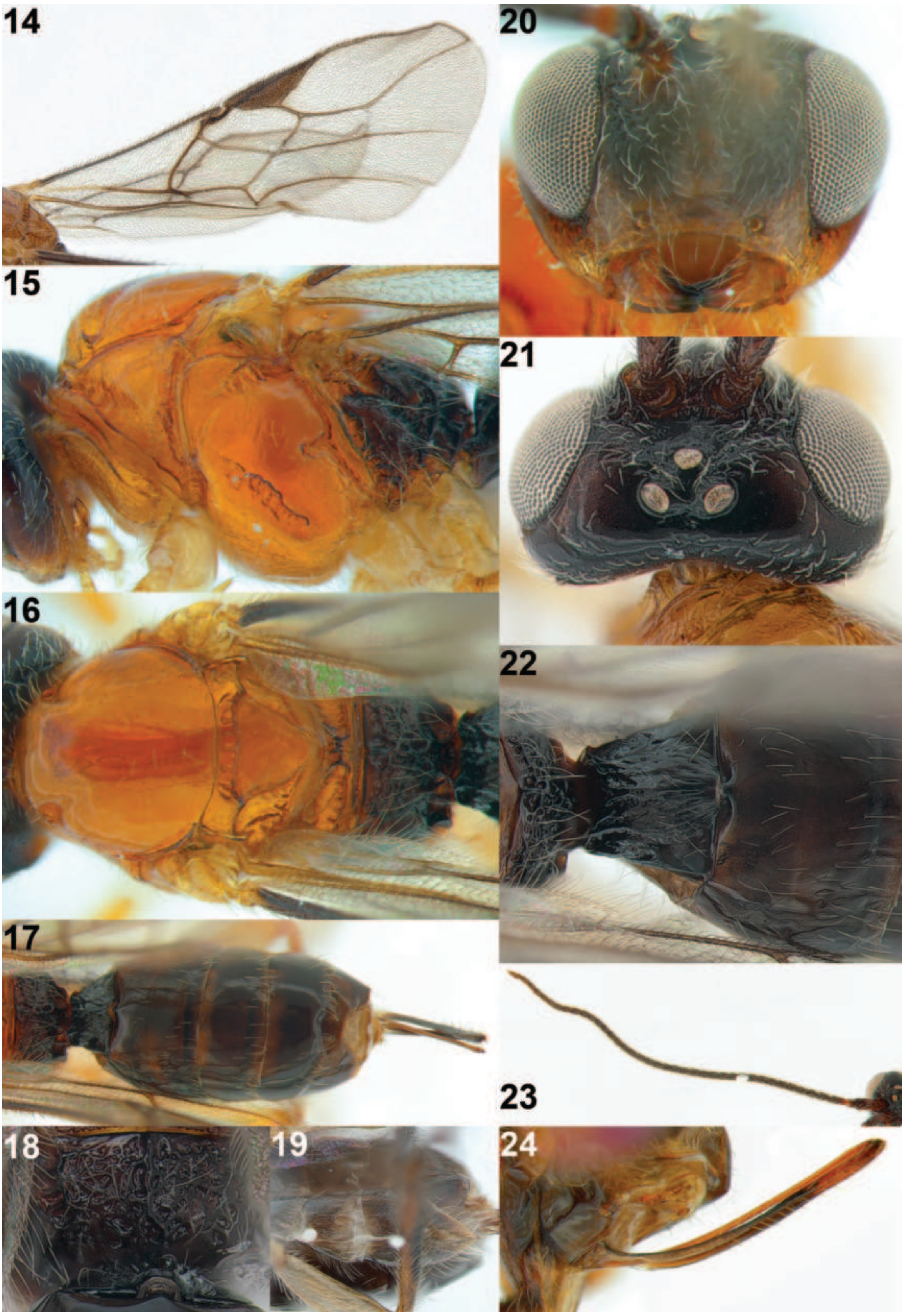
Figure 13. *Xynobius brevifemora* Han & van Achterberg, sp. nov., holotype, ♀, habitus, lateral.

long medio-longitudinal carina connected to two longitudinal carinae posteriorly forming reversed Y posteriorly, no transverse carina and remaining area coarsely rugose (Figs 16–18).

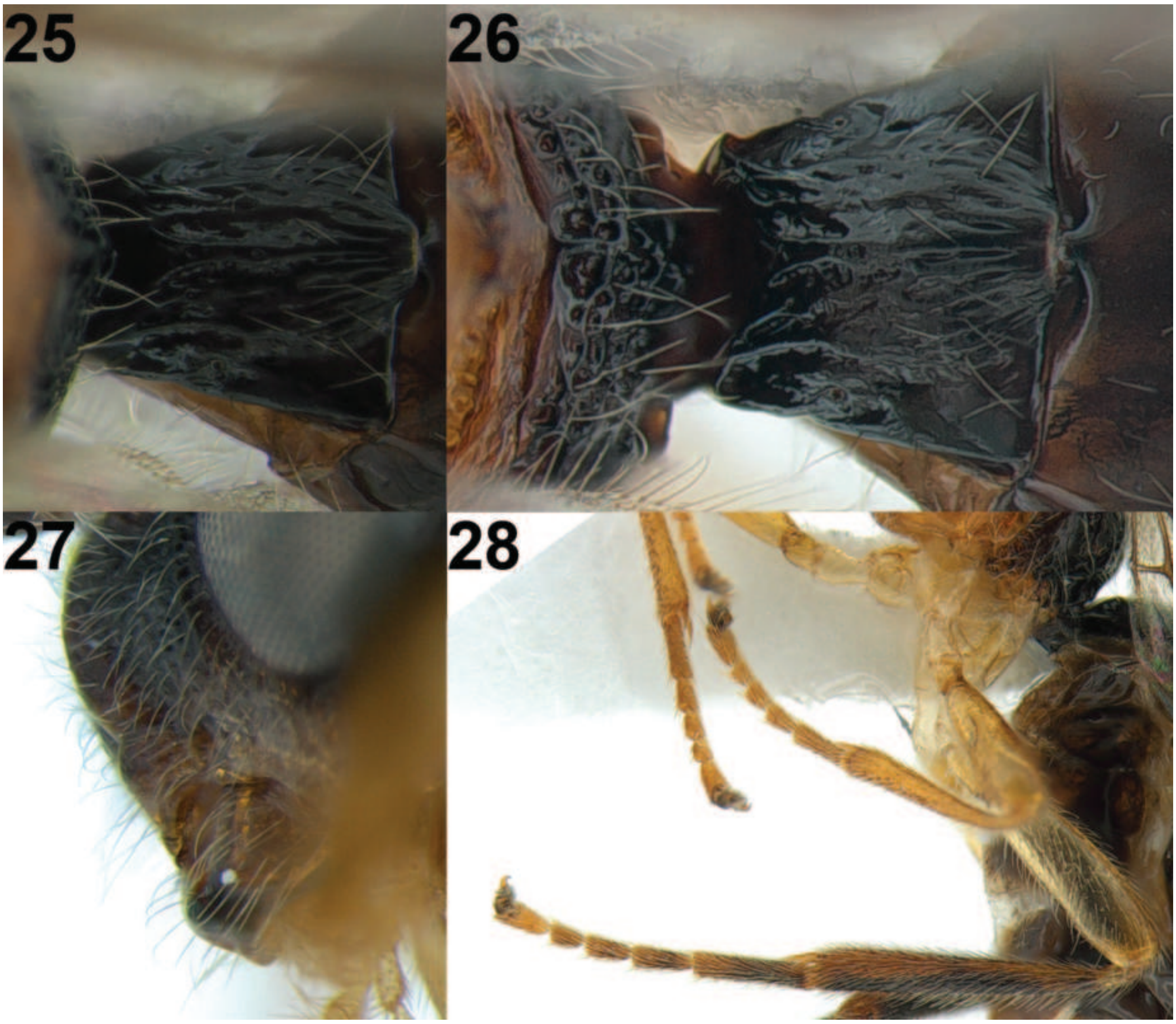
***Wings*.** Fore wing (Fig. 14): pterostigma wide, triangular and narrowed apically ending before level of vein r-m; vein r nearly 0.6× longer than vein 2-SR; vein 1-SR+M sinuate; vein 3-SR sublinear with vein r, parallel with vein 2-M and 1.8× longer than vein 2-SR; vein 2-SR almost straight; vein SR1 curved upward, ~ 2.0× longer than vein 3-SR; vein 1-M curved; second submarginal cell narrow; r: 3-SR: SR1 = 5: 13: 25; vein m-cu distinctly antefurcal, converging to vein 1-M posteriorly; first subdiscal cell transverse; vein CU1b short. Hind wing (Fig. 14): vein m-cu absent; vein 1r-m 0.5× as long as vein 1-M; vein 2-M only pigmented.

***Legs*.** Hind femur 3.4× longer than its maximum width (Fig. 28).

***Metasoma*.** Length of first metasomal tergite 1.1× its apical width; first tergite gradually widened apically and its surface with longitudinal striae medially, and remaining area shiny and smooth (Figs 22, 25, 26); dorsope present and surrounded by strongly curved dorsal carinae (Figs 22, 25, 26); second metasomal suture indistinctly indicated dorsally (Fig. 22); second tergite shiny and smooth except a pair of droplet-shaped impressions anteriorly; second tergite 0.6× as long as third tergite in dorsal view; following tergites shiny, smooth and moderately setose posteriorly (Fig. 17); hypopygium 0.4× as long as metasoma, rather acute apically and reaching apex of metasoma (Fig. 19); setose part of ovipositor sheath ~ 2.2× longer than first tergite and 0.3× as long as fore wing (Figs 13, 24).



Figures 14–24. *Xynobius brevifemora* Han & van Achterberg, sp. nov., holotype, ♀ **14** wings **15** mesosoma, lateral view **16** mesosoma, dorsal view **17** metasoma, dorsal view **18** propodeum, dorsal view **19** hypopygium, ventral view **20** head, anterior view **21** head, dorsal view **22** 1st–3rd metasomal tergites, dorsal view **23** antenna **24** ovipositor and its sheath, lateral view.



Figures 25–28. *Xynobius brevifemora* Han & van Achterberg, sp. nov., holotype, ♀ **25** 1st metasomal tergite, dorsal view **26** 1st metasomal tergite, dorso-posterior view **27** mandible, lateral view **28** hind leg, lateral view.

***Colour*.** Body generally blackish to dark brown (Fig. 13); face and temple ventrally, mesoscutum, scutellum, metanotum, pronotum, mesopleuron, and ovipositor yellowish brown to orange (Figs 15, 16); palp, tegulae, legs (except hind tibia dorsally and tarsus) pale brown; narrowed band on fourth–sixth tergites anteriorly (Fig. 17) and apical segments of antenna brown; pterostigma and veins of wings dark brown.

Distribution. South Korea.

Biology. Unknown.

Etymology. Named after the robust and comparatively short femora of the new species (Figs 13, 28); *brevis* is Latin for short.

Remarks. The new species has a rather shallow dorsope bordered with strongly curved dorsal carinae basally, vein r much shorter than vein 2-SR and a large hypoclypeal depression; therefore, it belongs to the genus *Xynobius*. It has the reduced notauli (absent on mesoscutal disc and only distinctly impressed anteriorly), glabrous middle lobe of mesoscutum, a long medio-longitudinal carina on propodeum with two diverging longitudinal carinae posteriorly and remainder coarsely rugose, the short second submarginal cell of fore wing, median keel present between antennal sockets, second metasomal tergite relatively shorter than third tergite and relatively long setose part of ovipositor sheath. In the key by Tobias (1998), it runs to the subgenus *Psyttalia* Walker sensu Tobias by having two diverging medio-longitudinal carinae posteriorly on propodeum, short second metasomal tergite (0.7× as long as third metasomal tergite) and indistinctly indicated second metasomal suture. This new species is superficially similar to *P. spectabilis* van Achterberg, 2016, because they share the reduced medio-posterior depression of mesoscutum, vein r of fore wing sublinear with vein 3-SR, mesosoma yellowish brown to orange (except propodeum and metapleuron blackish to dark brown), pterostigma of fore wing distinctly triangular and reduced vein m-cu of hind wing. The new species has the dorsope present and dorsal carinae on first metasomal tergite not united (dorsope absent but dorsal carinae strong in its basal half and with depressed area below in *P. spectabilis*), ventral margin of clypeus strongly convex (slightly convex in *P. spectabilis*), median keel on frons between antennal sockets present (keel absent and frons behind antennal sockets rugose in *P. spectabilis*), with two longitudinal carinae on propodeum and partly coarsely rugose (smooth in *P. spectabilis*) and obtuse apex of hypopygium (acute apex in *P. spectabilis*). In the key by Fischer (1972), it runs to the subgenus *Phlebosema* Fischer, and to *Opius fischeri* Papp, 1981. However, *O. fischeri* has no medio-longitudinal carinae on the propodeum (medio-longitudinal carina present in the new species), reduced median keel between antennal sockets (present), third segment of antenna more than 3.0× longer than its width (1.9× longer than its width), first metasomal tergite smooth (striate medially) and relatively short setose part of ovipositor sheath (~ 2.7× longer than first tergite).

Among the described Korean and Chinese species of *Xynobius*, the new species is similar to *X. gracilitergum* (Fischer, 1990) and *X. sulciferus* (Papp, 1967) because of sharing the slightly convex scutellum, length of eye 1.6–2.7× temple in dorsal view, vein m-cu of fore wing antefurcal (but slightly so in *X. sulciferus*), wing membrane at most slightly infuscated and second metasomal tergite smooth. *Xynobius brevifemora* differs from both by having no medio-posterior depression of mesoscutum (present in both species), first tergite approximately as long as its apical width (1.7–2.2× in both species), setose part of ovipositor sheath ~ 1.4× longer than hind tibia (shorter than length of hind tibia in both species), femora robust (femora more slender in both species) and mesosoma (except metapleuron and propodeum) orange-brown (black in both species).

Xynobius duoferus Han & van Achterberg, sp. nov.

https://zoobank.org/7F8C078F-94F4-4D71-BB49-3DB46F8C947E
Figs 29–41

Type material. ***Holotype*.** ♀ (NIBR), "South Korea: Jangam Cave, Pyeongchang-gun, Gangwon prov., 37°23'54.2"N, 128°25'24.2"E, 11.vii.2020, SW [= collected by sweeping], Hyojoong Kim leg., KSNU".

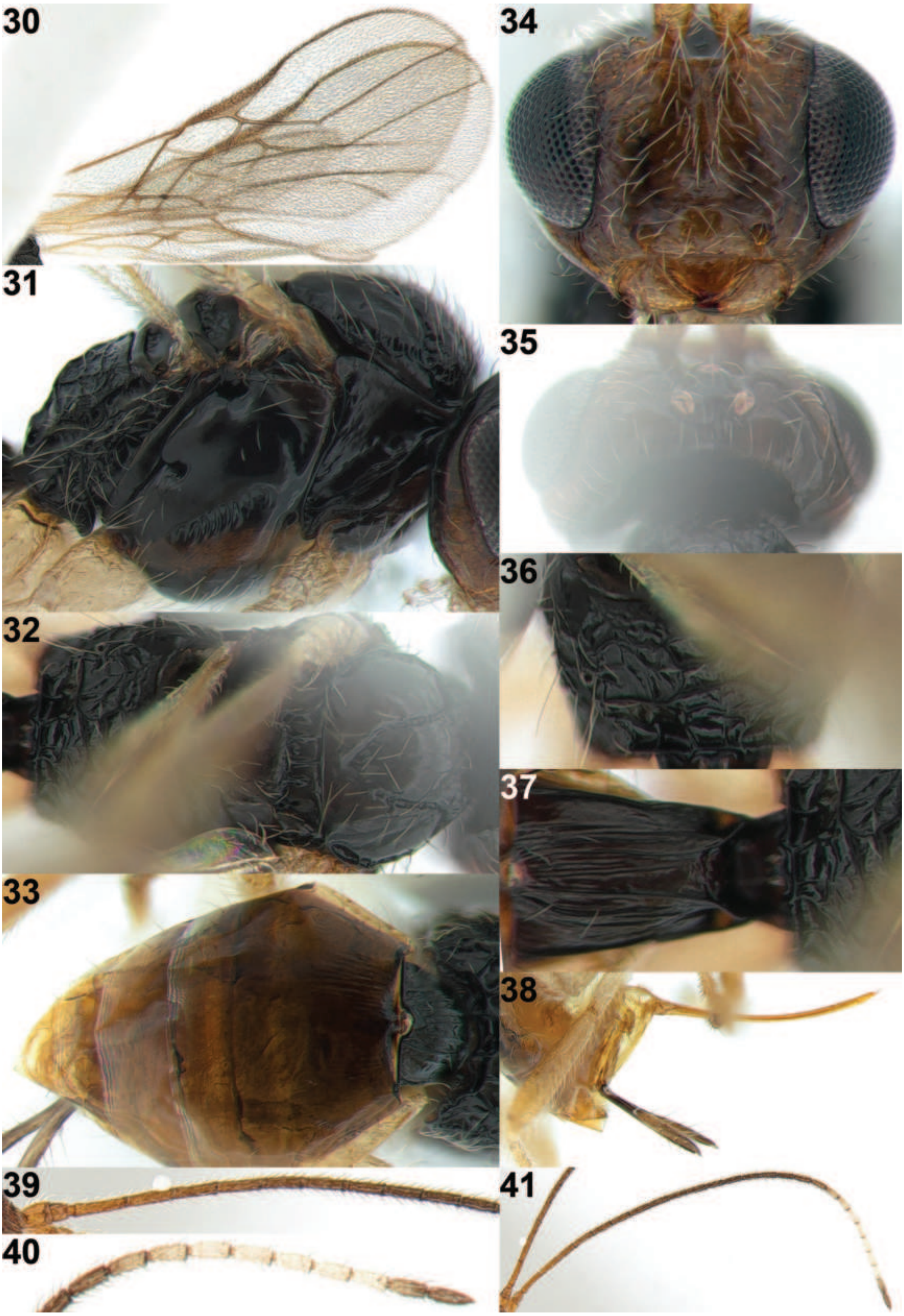
Diagnosis. Dorsope distinct (Fig. 37); first metasomal tergite with straight longitudinal striae; notauli complete and narrowly crenulate (Fig. 32); mesoscutum largely smooth and sparsely setose medially; second tergite striate-rugose medially; 20th to 26th antennal segments of ♀ white followed by two dark apical segments.

Figure 29. *Xynobius duoferus* Han & van Achterberg, sp. nov., holotype, ♀, habitus, lateral.

Description. Female; length of body 2.0 mm, of fore wing 2.5 mm.

***Head*.** Antenna with 28 segments and 1.6× longer than body; third segment of antenna 5.8× longer than wide and 1.1× longer than fourth segment (Figs 39, 41); depression of frons present near antennal sockets (Fig. 34); eye ~ 2.5× longer than temple in dorsal view (Fig. 35); frons and vertex smooth, glabrous and moderately setose; face largely shiny, smooth and densely setose, but granulate latero-dorsally; median keel present; clypeus twice wider than its maximum height (Fig. 34); clypeus semi-circular, moderately setose, and ventral margin of clypeus straight and above upper level of condyles of mandible; hypoclypeal depression present; length of maxillary palp nearly 0.9× as long as height of head; malar sulcus absent; occipital carina absent dorsally; mandible triangular in lateral view, hardly twisted and gradually widened basally (Fig. 34).

***Mesosoma*.** Mesosoma 1.4× longer than its height; pronotal side largely smooth and smooth groove present along its ventral margin; propleuron smooth and sparsely setose, without transverse carinae; mesopleuron largely smooth and sparsely setose antero-dorsally and postero-ventrally, but precoxal sulcus oblique, medium-sized and densely crenulate; epicnemial area smooth (Fig. 31); mesopleural sulcus smooth; anterior groove of metapleuron smooth; metapleuron reticulate-rugose and moderately setose (Fig. 31); notauli complete on disc of mesoscutum and narrowly crenulate; mesoscutum smooth, largely glabrous but middle lobe sparsely setose (Fig. 32); medio-posterior depression of mesoscutum round and shallow; scutellar sulcus wide and crenulate (Fig. 32); scutellum largely smooth and glabrous, rather flat in lateral view and protruding above level of mesoscutum; propodeum rugose with long medio-longitudinal carina, transverse carinae, and areola, remainder of propodeum largely smooth (Figs 32, 36).



Figures 30–41. *Xynobius duoferus* Han & van Achterberg, sp. nov., holotype, ♀ **30** wings **31** mesosoma, lateral view **32** mesosoma, dorsal view **33** metasoma, dorsal view **34** head, anterior view **35** head, dorsal view **36** propodeum, dorsal view **37** 1st metasomal tergite, dorsal view **38** ovipositor and its sheath, lateral view **39** basal part of antenna **40** apical part of antenna **41** antenna.

Wings. Fore wing (Fig. 30): pterostigma triangular and rather directly narrowed apically; vein 1-SR+M almost straight; vein 3-SR sublinear with vein r, converging with vein 2-M and 1.6× longer than vein 2-SR; vein 2-SR almost straight; vein SR1 straight, 2.0× longer than vein 3-SR; vein 1-M straight; r: 3-SR: SR1 = 5: 40: 84; vein m-cu distinctly postfurcal, converging to vein 1-M posteriorly and angled with vein 2-M; first subdiscal cell transverse and closed; vein CU1b present. Hind wing (Fig. 30): vein m-cu absent; vein 1r-m 0.8× as long as vein 1-M; vein 2-M pigmented.

Legs. Hind femur 4.5× longer than its maximum width (Fig. 29).

Metasoma. First metasomal tergite 1.5× longer than its apical width; first tergite gradually widened apically and its surface densely longitudinally striate postero-medially, and remainder of tergite shiny and smooth (Fig. 37); dorsope present and surrounded by strongly curved dorsal carinae (Fig. 37); second metasomal suture absent dorsally (Fig. 33); second tergite striate-rugose medially except a pair of droplet-shaped impressions anteriorly; following tergites shiny, smooth and moderately setose posteriorly (Fig. 33); setose part of ovipositor sheath ~ 1.2× longer than first tergite and 0.1× as long as fore wing (Fig. 38).

Colour. Body generally brown to black (Fig. 29); entire head, transverse band below the precoxal sulcus, tarsi, inside of dorsope, and first and second tergites dorsally dark brown; legs, remaining tergites, ovipositor, and basal segments (1^{st}–6^{th}) of antenna brown; palp pale yellowish or white; apical segments (20^{th}–26^{th}) of antenna white to white-brown; pterostigma and veins of wings pale brown; wings subhyaline.

Distribution. South Korea.

Biology. Unknown.

Etymology. Name derived from *duo* (Latin for two) and *-fero* (suffix in Latin meaning carrying or having), because of the two apical dark antennal segments.

Remarks. This species runs to *Xynobius notauliferus* Li & van Achterberg, 2013 in the key by Li et al. (2013). It differs by having the length of maxillary palp 0.9× height of head (1.4× in *X. notauliferus*), face smooth, but granulate latero-dorsally (smooth), clypeus twice wider than high (1.6× wider than its maximum height), first metasomal tergite 1.5× longer than its apical width (length 1.3×), antenna of ♀ with two apical antennal segments dark brown (6 or 7 such segments), pterostigma directly narrowed distally (gradually narrowed) and outer side of hind femur without brownish patch (with patch).

Xynobius stipitoides **Han & van Achterberg, sp. nov.**

https://zoobank.org/D7935E14-BA59-4F89-93F6-419D42EAB220
Figs 42–53

Type material. ***Holotype.*** ♀ (KSNU), “South Korea: Forahn house, Ongpo-ri, Hallim, Jeju, Jeju Island, 33°12'51.1"N, 126°15'04.0"E, 16.v.2019, SW [= collected by sweeping], Hyojoong Kim leg., KSNU”.

Diagnosis. Pterostigma slightly widened apically (Fig. 43); maxillary palp 1.5× longer than height of head; notauli present up to middle of mesoscutum and narrowly crenulate, mesoscutum medio-posteriorly and scutellum punctate (Fig. 45); precoxal sulcus oblique and moderately crenulate medially (Fig. 44);

vein SR1 of fore wing 2.7× as long as vein 3-SR; first tergite subparallel-sided and nearly twice longer than its apical width (Fig. 51); second tergite shiny and smooth (Fig. 46); setose part of ovipositor sheath slightly shorter than first tergite (Fig. 52); hind tibia (except ivory base) and tarsus dark brown.

Description. Female; length of body 5.9 mm, of fore wing 4.6 mm.

***Head*.** Antenna with 48 segments and 1.2× as long as body; third segment 3.5× longer than its width and 0.9× as long as fourth segment (Fig. 52); eye 1.7× longer than temple in dorsal view (Fig. 48); temple smooth and moderately setose; vertex, stemmaticum and frons shiny and smooth; face densely punctate and setose but granulate dorso-laterally; median keel present on face (Fig. 47); width of clypeus 1.9× its maximum height; clypeus punctate and protruding anteriorly in lateral view (Figs 42, 49); ventral margin of clypeus above upper level of condyli of mandibles and densely setose; hypoclypeal depression rather deep (Fig. 47); maxillary palp 1.5× longer than height of head; malar sulcus rather deep and curved anteriorly in lateral view (Figs 42, 49); occipital carina protruding dorsally in lateral view; interrupted dorso-medially (Fig. 48); mandible twisted and triangular in lateral view and gradually widened basally (Fig. 49).

***Mesosoma*.** Mesosoma 1.4× longer than its height (Fig. 44); pronope absent (Figs 45, 48); propleuron flange largely smooth and protruding posteriorly with oblique carina (Fig. 44); mesopleuron largely shiny and smooth, but precoxal sulcus oblique and moderately crenulate medially; epicnemial area crenulate ventrally, remaining area smooth; pronotal side largely smooth except crenulated groove anteriorly and ventrally; mesopleural sulcus crenulate and narrowed dorsally; anterior groove of metapleuron narrow and crenulate; metapleuron flange distinctly protruding ventrally (Fig. 44); metapleuron reticulate-rugose and moderately setose posteriorly and remainder of metapleuron smooth; notauli present anteriorly up to middle of mesoscutum and narrowly crenulate, medio-posteriorly mesoscutum densely punctate and with setae (Fig. 45); medio-posterior depression of mesoscutum sublinear, shallow and surroundings distinctly punctate; scutellar sulcus wide, distinctly and densely crenulate; scutellum sparsely punctate and setose medially, posteriorly densely punctate and rather flat in lateral view; propodeum shiny and densely setose medially with long medio-longitudinal carina and indistinctly transverse carina medially (together cross-shaped) and remaining area mainly coarsely rugose (Figs 45, 50).

***Wings*.** Fore wing (Fig. 43): pterostigma narrow, elongated, sublinear and slightly widened apically, ending after level of vein r-m (Fig. 43); vein r 0.4× longer than vein 2-SR; vein 1-SR+M sinuate; vein 3-SR angled with vein r, parallel with vein 2-M and 1.5× longer than vein 2-SR; vein 2-SR slightly curved upward; vein SR1 curved upward, 2.5× longer than vein 3-SR; vein 1-M straight; first subdiscal cell rather transverse; r: 3-SR: SR1 = 5: 16: 42; vein m-cu distinctly postfurcal; vein CU1b completely present. Hind wing: vein m-cu absent; vein 1r-m 0.6× as long as vein 1-M; vein 2-M incompletely pigmented.

***Legs*.** Hind femur 4.7× longer than its maximum width (Fig. 53); hind leg long and densely setose.

***Metasoma*.** Length of first metasomal tergite ~ 2.0× its apical width (Fig. 51); first tergite slightly widened medially and parallel-sided posteriorly, setose, dorsal carinae converging to short medio-longitudinal carina at basal third and

Figure 42. *Xynobius stipitoides* Han & van Achterberg, sp. nov., holotype, ♀, habitus, lateral.

remaining area reticulate-rugose; dorsope distinct (Figs 45, 46, 50, 51); second metasomal suture absent dorsally (Fig. 46); second tergite shiny and smooth with a pair of impressions anteriorly; following tergites shiny, smooth and moderately setose posteriorly; setose part of ovipositor sheath 0.8× and 0.1× as long as first tergite and fore wing, respectively (Figs 42, 52, 43).

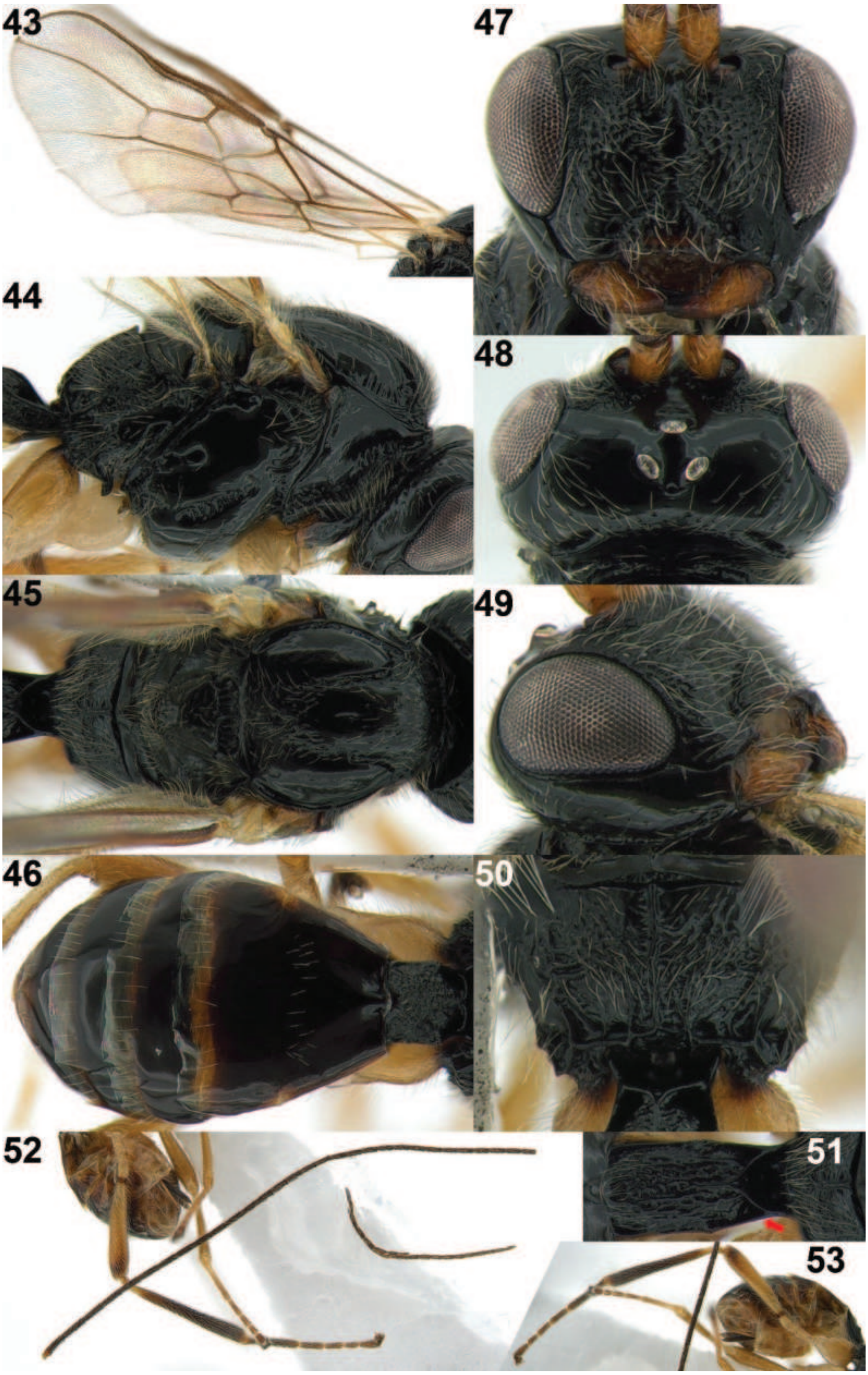
***Colour*.** Body generally black; antenna, ovipositor sheath, and tibia, tarsus, and femur of hind leg dark brown (Figs 52, 53); antennal sockets, ventral margin of clypeus, mandibles, and legs (Figs 52, 53; except hind tibia and tarsus) brownish yellow; palpi and tegulae pale yellowish; ovipositor, narrowed band on third–sixth tergites posteriorly and spot of second tergite latero-posteriorly, yellowish brown (Fig. 46); pterostigma and veins of wings greyish brown.

Distribution. South Korea

Biology. Unknown.

Etymology. Name is a combination of the specific name *stipitatus* and *oides* (Latin for resembling) because the new species is similar to *Opius stipitatus* Tobias.

Remarks. This species has a distinct dorsope, ventral margin of clypeus above upper level of mandibular condyles and a large hypoclypeal depression; therefore, it belongs to the genus *Xynobius*. It has a curved malar suture in lateral view, reduced notauli (narrowly crenulated anteriorly and absent on posterior half of mesoscutal disc), largely shiny and smooth mesoscutum except some punctures anteriorly and around medio-posterior depression, elliptical depression medio-posteriorly on middle lobe of mesoscutum, a long medio-longitudinal carina with indistinct transverse carina on propodeum, and hind leg with long, evenly and conspicuous setae. In the key by Tobias (1998), it runs to *Opius* (*Xynobius*) *stipitatus* Tobias, 1998 (Figs 65–75), by having the scutellum sculptured, the mesoscutum largely smooth and the pterostigma more or less widened apically. However, it differs by having the narrowly crenulated notauli up to middle of



Figures 43–53. *Xynobius stipitoides* Han & van Achterberg, sp. nov., holotype, ♀ **43** wings **44** mesosoma, lateral view **45** mesosoma, dorsal view **46** metasoma, dorsal view **47** head, anterior view **48** head, dorsal view **49** head, lateral view **50** propodeum, dorsal view **51** 1st metasomal tergite, dorsal view **52** antenna **53** hind leg and ovipositor, lateral view. The red arrow points to the dorsope.

mesoscutum (notauli absent on mesoscutal disc in *O.*(*X.*) *stipitatus*, except for shallow depressions at imaginary notaulic courses), middle lobe of mesoscutum shallowly punctate and densely setose medio-posteriorly (smooth and glabrous), precoxal sulcus crenulated (precoxal sulcus smooth), groove on pronotal side narrowly crenulated and without setae ventrally (crenulated groove rather wide and densely setose ventrally), propodeum with long medio-longitudinal carina and indistinct transverse carina medially (with short medio-longitudinal carina, coarse transverse carinae and indistinct areola), length of first metasomal tergite ~ 2.0× its apical width (1.3× longer than its apical width), dorsal carinae forming a short medio-longitudinal carina on first tergite (longitudinal carinae remain separated), and third–sixth tergites with distinct brown band posteriorly (only third tergite with obsolescent brown band posteriorly). Among the Chinese species it shares the shape of the pterostigma, the setose and punctate medio-posterior area of the mesoscutum, the antenna of ♀ with ~ 48 segments, and the largely punctate face (except for the smooth medial ridge) with *Xynobius rugosulcus* (Wu & Chen, 2005), comb. nov. (it was described as *Eurytenes rugosulcus* but it lacks the typical derived venation of *Eurytenes* s. str.). The new species differs by having the posterior half of the notauli reduced (notauli nearly complete in *Xynobius rugosulcus*), middle lobe of mesoscutum shallowly punctate and densely setose medio-posteriorly (with a pair of grooves parallel to notauli), scutellum punctate medially (scutellum smooth medially), face coarsely and more densely punctate submedially (finer and sparsely punctate submedially), precoxal sulcus distinctly crenulated (precoxal sulcus slightly punctate), propodeum with long medio-longitudinal carina and indistinct transverse carina medially (with coarse transverse carinae and areola, and without medio-longitudinal carina), vein m-cu of hind wing absent (vein m-cu of hind wing as an unpigmented fold), and length of first metasomal tergite 1.9× its apical width (1.6× longer than its apical width).

***Xynobius geniculatus* (Thomson, 1895)**

Figs 54–64

Opius geniculatus Thomson, 1895: 2179.
Opius (*Nosopoea*) *geniculatus*: Fischer 1972: 282–284; Papp 1981b: 44–59.
Opius (*Allotypus*) *geniculatus*: Tobias and Jakimavičius 1986: 63.
Opius albicoxis Marshall, 1898: 236; Fischer 1967: 143 (as synonym of *O. geniculatus* Thomson), 1972: 282.

Material examined. 1 ♀ (KNA), "South Korea: DMZ Botanical Garden, Mandae-ri, Haean, Yanggu, Gangwon prov., 38°15'09.3"N, 128°06'40.6"E, 17.x.2017–17.xi.2017, MT [= Malaise trap]".

Diagnosis. Antennal segments of ♀ 38–44; area below pterostigma with brownish patch (Figs 54, 55), rarely obsolescent; precoxal sulcus smooth; mesoscutum largely glabrous, but middle lobe sparsely setose, notauli absent on disc, only anteriorly deeply impressed and medio-posterior depression distinct; pterostigma triangular; vein M+CU1 of fore wing largely sclerotised (Fig. 55); second metasomal tergite bicoloured (dark brown and with a pale yellowish patch medially); hind tarsus (except telotarsus) pale yellowish or ivory; second submarginal cell of fore wing long (Fig. 55); area around medio-posterior

Figure 54. *Xynobius geniculatus* (Thomson), ♀, habitus, lateral.

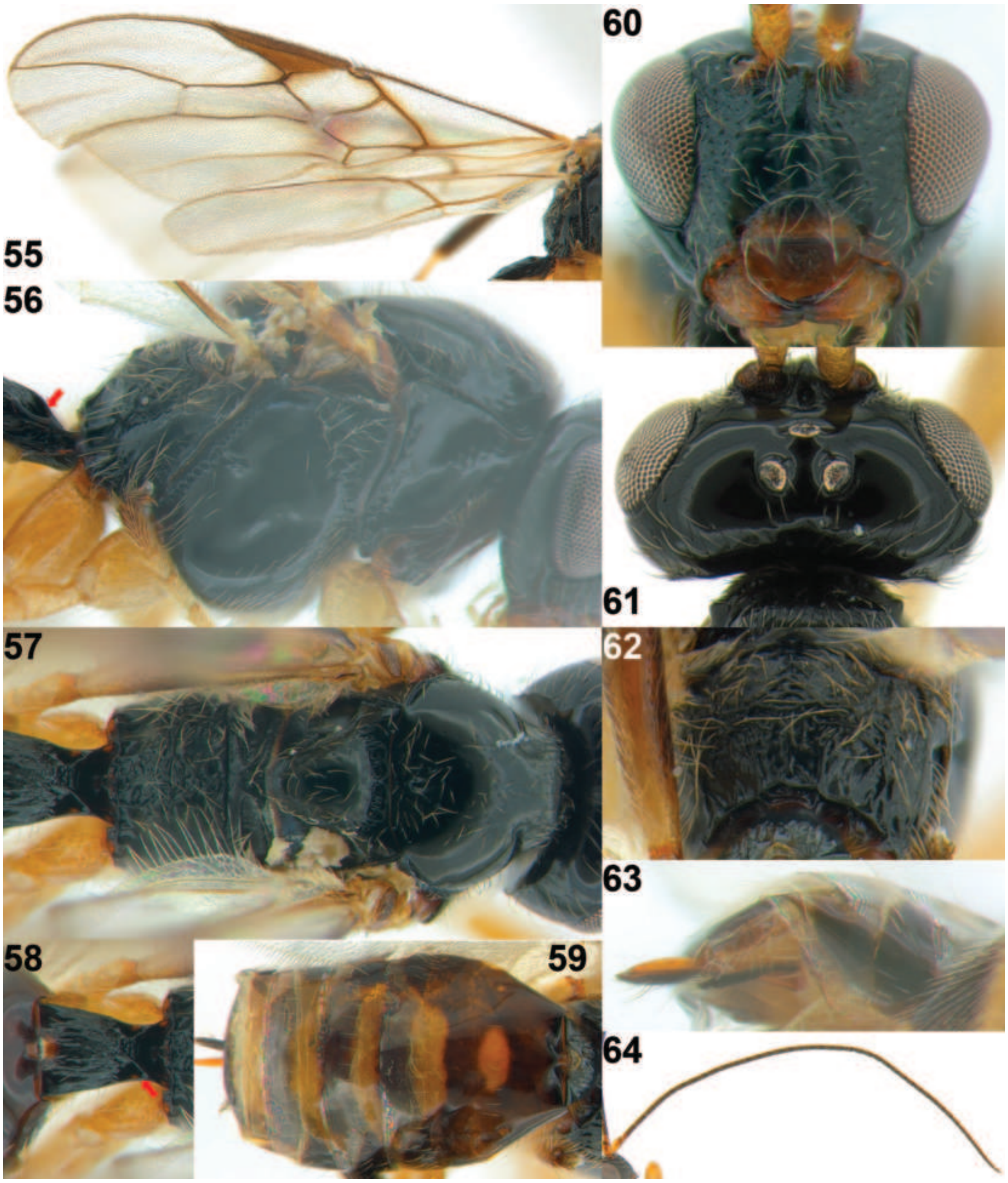
depression of mesoscutum finely punctate or punctulate; at least apex of hind femur dark brown; no pronope; setose part of ovipositor sheath 0.6× as long as first metasomal tergite.

Re-description. Female; length of body 3.6 mm, of fore wing 4.1 mm.

***Head*.** Antenna with 44 segments and 1.5× as long as body (Fig. 64); third segment of antenna 2.6× longer than wide, ~ 1.1× longer than fourth segment of antenna; eye 2× longer than temple in dorsal view (Fig. 61); stemmaticum shiny and smooth; vertex shiny, smooth and moderately setose posteriorly; frons with depression medially and remainder shiny and smooth; face densely punctate and setose, median keel present up to between antennal sockets (Fig. 60); clypeus 2.4× wider than its maximum height; clypeus punctate and moderately setose, rather flat in lateral view; hypoclypeal depression present; malar sulcus straight; occipital carina absent medio-dorsally; mandible slightly curved apically, triangular in lateral view and gradually widened basally.

***Mesosoma*.** Mesosoma 1.5× longer than its height (Fig. 56); pronope absent (Figs 57, 61); propleuron largely smooth and propleuron flange present posteriorly (Fig. 56); mesopleuron largely shiny and smooth, including narrow precoxal sulcus; epicnemial area distinctly crenulate; pronotal side largely smooth with crenulated groove anteriorly and posteriorly; mesopleural sulcus crenulate; anterior groove of metapleuron crenulate; metapleuron largely shiny, smooth and moderately setose along grooves; notauli absent on disc of mesoscutum (Fig. 57); mesoscutum shiny, smooth and densely setose medially; scutellum slightly punctate and setose; medio-posterior depression of mesoscutum round; scutellar sulcus distinctly crenulate, medium-sized and curved; propodeum moderately setose with short medio-longitudinal carina anteriorly, indistinct transverse carina and areola, remainder of propodeum shiny and largely rugose (Figs 57, 62).

***Wings*.** Fore wing (Fig. 55): pterostigma triangular with dark spot below pterostigma; vein 1-SR+M sinuate; vein 3-SR angled with vein r, parallel with

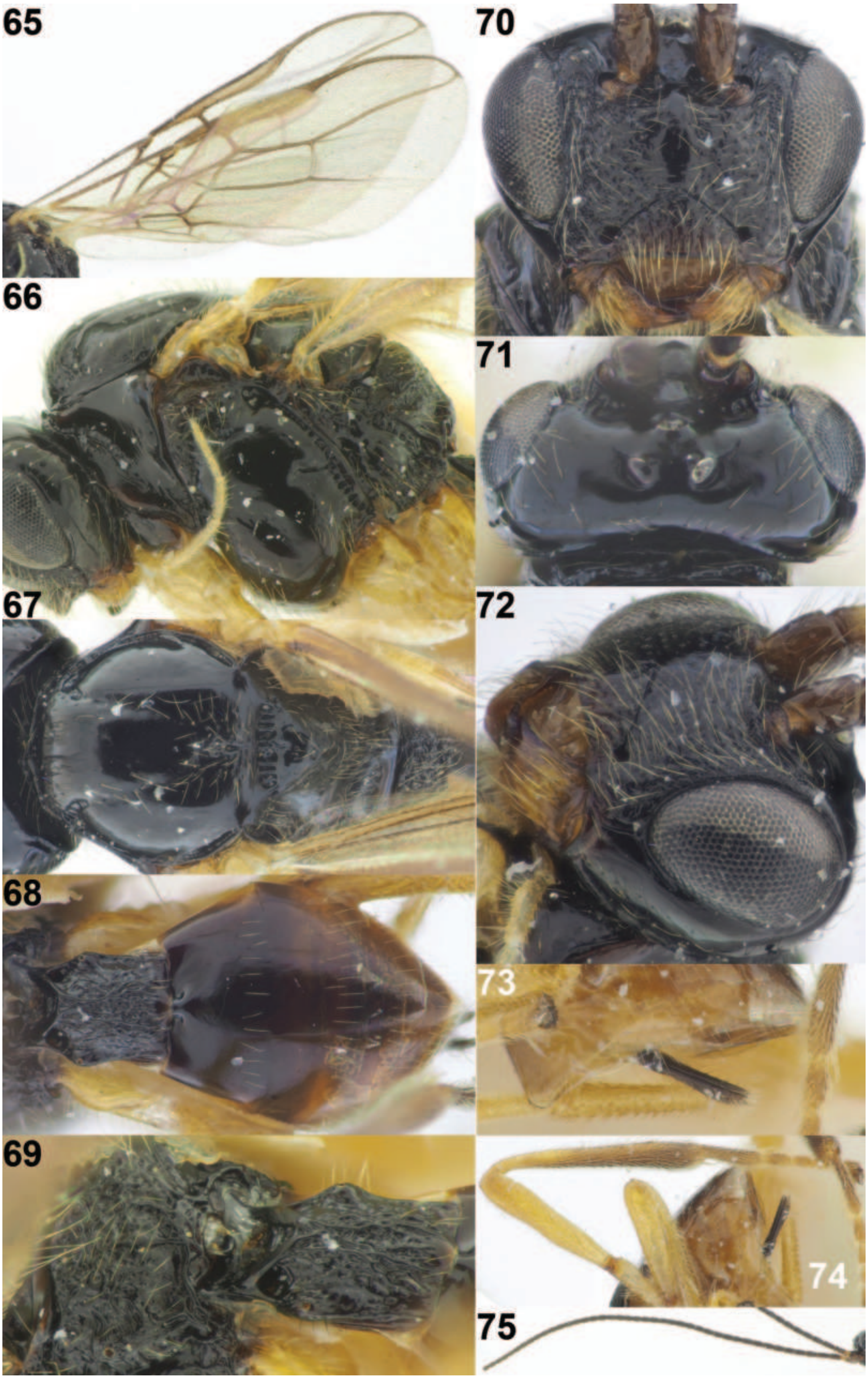


Figures 55–64. *Xynobius geniculatus* (Thomson), ♀, South Korea **55** wings **56** mesosoma, lateral view **57** mesosoma, dorsal view **58** 1st metasomal tergite, dorsal view **59** metasoma, dorsal view **60** head, anterior view **61** head and pronotum, dorsal view **62** propodeum, dorsal view **63** ovipositor and sheath, latero-ventral view **64** antenna. The red arrow indicates the dorsope.

vein 2-M and ~ 2× longer than vein 2-SR; vein 2-SR straight and oblique; vein SR1 curved upward, nearly 1.8× longer than vein 3-SR; r: 3-SR: SR1 = 5: 46: 84; vein m-cu postfurcal; second submarginal cell elongated; vein CU1b medium-sized. Hind wing: vein m-cu pigmented and curved basally; vein 1r-m 0.6× as long as vein 1-M; vein 2-M pigmented.

Legs. Hind femur 4.6× longer than its maximum width (Fig. 54).

Metasoma. First metasomal tergite 1.3× longer than its apical width (Fig. 58); first tergite slightly widened apically and its surface with longitudinal striae medially and remaining area shiny and smooth; dorsope distinct (Figs 57, 58);



Figures 65–75. *Xynobius stipitatus* (Tobias), holotype, ♀, Russia **65** wings **66** mesosoma lateral **67** mesosoma dorsal **68** metasoma dorsal **69** propodeum and 1st metasomal tergite latero-dorsal **70** head anterior **71** head and pronotum dorsal **72** head latero-anterior **73** ovipositor sheath lateral **74** hind leg **75** antenna. Photographs: Konstantin Samartsev.

second metasomal suture indistinctly indicated (Fig. 59); second tergite shiny and smooth, with a pair of oblique depressions anteriorly; second and following tergites shiny, smooth, with transverse band of setae posteriorly; setose part of ovipositor sheath 0.6× as long as first metasomal tergite and nearly 0.07× as long as fore wing (Fig. 63).

***Colour*.** Body black (Fig. 54); clypeus ventrally, mandible, and ovipositor brown; flagellar segments of antenna, femur, and tibia of hind leg and tarsal claw dark brown; scape of antenna, pterostigma, vein of wings and spot below pterostigma, tegulae, and remainder of legs brown; palpi pale yellowish; posterior band of third–sixth metasomal tergites brown or yellowish brown.

Distribution. South Korea (new record), Europe, Eastern/Western Palearctic region.

Biology. Parasitoid of *Trypeta immaculata* (Macquart, 1835) and *Stemonocera cornuta* (Scopoli, 1771) (Tephritidae) (Yu et al. 2016).

Remarks. This species runs in the key by Tobias (1998) to *Opius geniculatus* Thomson, because of having the distinct medio-posterior depression of mesoscutum, smooth precoxal sulcus, distinct hypoclypeal depression, vein m-cu of fore wing weakly postfurcal, hind femur 4.6× longer than its width, antenna with 44 segments, pterostigma short and triangular, mesoscutum rather densely setose, vein 3-SR of fore wing twice longer than vein 2-SR, a brownish spot below pterostigma and brownish band posteriorly at third–sixth metasomal tergites.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Data availability

All of the data that support the findings of this study are available in the main text.

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