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RESEARCH ARTICLE

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Melitid amphipods from the Gulf of Thailand, with a description of *Dulichiella pattaniensis*, a new species

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Abstract

Two species of melitid amphipod were collected from the Gulf of Thailand. *Dulichiella pattaniensis* is new to science, and *Melitalati latiflagella* Ren & Andres, 2012 has not been previously reported from Thai Waters. *Dulichiella pattaniensis* is characterized by male gnathopod 2 distolateral crown with 4 spines; pleonite/urosomite formula 7-7-7-5-6-2; pereopod 5-7 dactylus with 2 accessory spines. This combination of characters has not been recorded previously in the *Dulichiella.* The characters of the specimens are described and illustrated. All specimens are deposited in the Princess Maha Chakri Sirindhorn Natural History Museum, Prince of Songkla University, Thailand.

Keywords

Crustacea, Amphipoda, Melitidae, *Dulichiella pattaniensis*, Gulf of Thailand, taxonomy

Introduction

Melitid amphipods most commonly occur in coastal and freshwater areas. Thailand has a variety of aqueous habitats including coral reefs, seagrass beds, and mangrove forests, but only one melitid amphipod, *Rotomelita longipropoda* Wongkamhaeng et al., 2013 was described. In this study, we describe a new melitid species *Dulichiella pattaniensis* sp. n., and our observations of *Melita latiflagella* Ren & Andress, 2012, which has not been previously reported in Thai Waters. Figures and descriptions of both species are provided.

Materials and methods

Amphipods were collected from some settlement plates in an artificial reef in Ban Pak Bang Ta Wa, Pattani Bay and from sediment of Lower Songkhla Lake (Figure 1). The sites were visited at low tide and amphipods were collected using a 20×20 cm Ekman grab from the subtidal zone. The amphipod specimens were sorted out and fixed in formalin for 1 week and then stored in 70% alcohol. In the laboratory, the specimens were transferred from alcohol into glycerol for study. Drawing was accomplished using a drawing tube attached to an Olympus CH30 light microscope. The pencil drawings were scanned and digitally inked using a WACOM bamboo CTH-970 graphics board following the method described in Coleman (2003). The following abbreviations are used: A, antenna; G, gnathopod; HD, head; LL, lower lip; MD, mandible; MX, maxilla; MP, maxilliped; P, pereopod; Pl, pleopod; T, telson; U, uropod; UR, urosome; UL, upper lip; r, right; l, left; ♂, male; ♀, female. Specimens of different species were deposited into the Prince of Songkla University Zoological Collection (PSUZC).

Results

Systematics

Melitidae Bousfield, 1973

Dulichiella Stout, 1912

http://species-id.net/wiki/Dulichiella
Figures 2–9

Diagnosis. (Lowry and Springthorpe 2007) Head anteroventral corner with several long, slender setae. Antenna 1 longer than antenna 2. Maxilla 1 inner plate long, narrow, tapering distally, with 2 well developed apical plumose setae. Maxilla 2 inner plate with oblique setal row. Gnathopod 2 male, asymmetrical, significantly unequal in size; palm in larger slightly obtuse; those of female equal in size. Pereopods 5–7 distal articles strongly to weakly setose; dactylar ungues with accessory spines. Pereopods 6 and 7 in

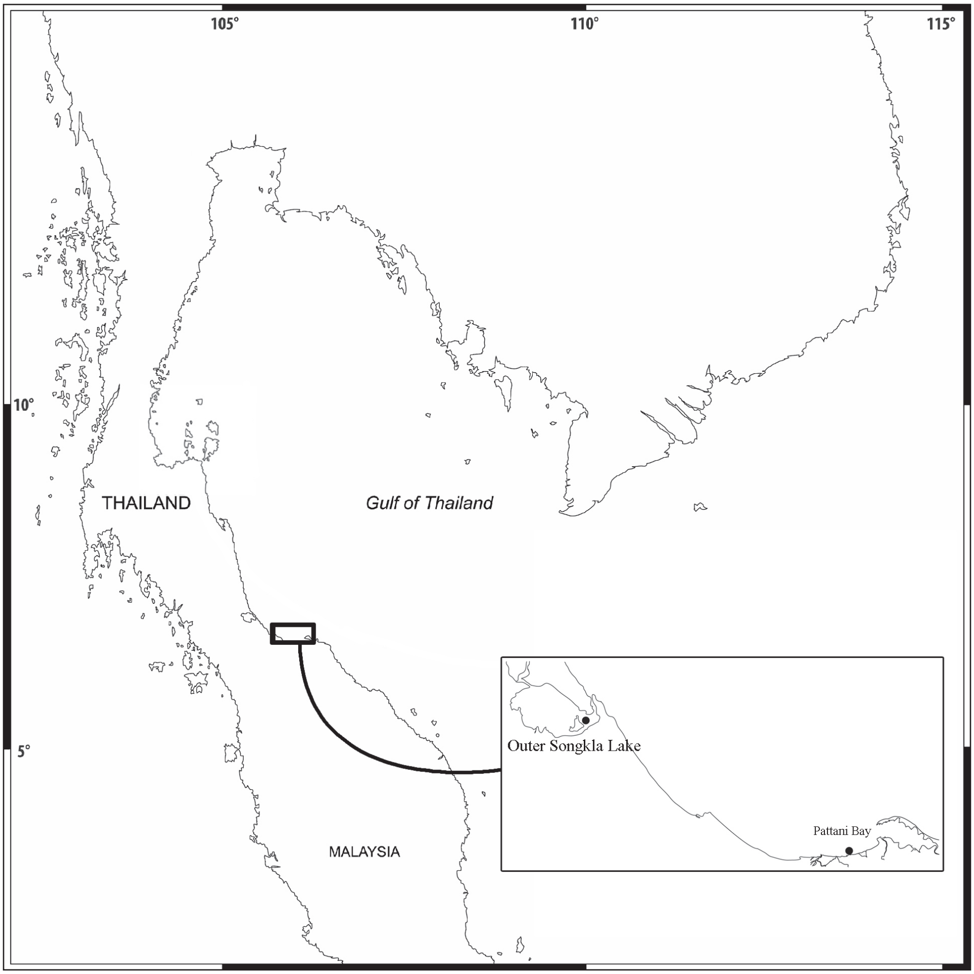

Figure 1. Map of the sampling area.

males with bunches of long slender setae. Pereopod 7 basis in female fully expanded. Pleonites dorsally serrate. Uropod 3 inner ramus scale-like; outer ramus 4 to 5× longer than wide, 2-articulate. Telson deeply cleft, lobes tapering distally to an acute point.

Typespecies. *Dulichiella spinosa* Stout, 1912 (type by monotypy).

Species composition. *Dulichiella appendiculata* Say, 1818; *Dulichiella australis* Haswell, 1879; *Dulichiella celestun* Paz-Rios & Ardisson, 2014; *Dulichiella cotesi* Giles, 1890; *Dulichiella cuvettensis* Appadoo & Myers, 2005; *Dulichiella fresnellii* (Audouin, 1826); *Dulichiella guinea* Lowry & Springthorpe, 2007; *Dulichiella lecroyae* Lowry & Springthorpe, 2007; *Dulichiella oahu* Lowry & Springthorpe, 2007; *Dulichiella pacifica* Lowry & Springthorpe, 2005; *Dulichiella pattaniensis* sp. n.; *Dulichiella spinosa* Stout, 1912 (type species); *Dulichiella takedai* Tomikawa & Komatsu; *Dulichiella terminos* Lowry & Springthorpe, 2007; *Dulichiella tomioka* Lowry & Springthorpe, 2007; *Dulichiella tulear* Lowry & Springthorpe, 2007.

Dulichiella pattaniensis sp. n.

http://zoobank.org/212F51D8-E32A-4601-9E04-88292FBEB989
http://species-id.net/wiki/Dulichiella_pattaniensis

Type material. Holotype. ♂, THAILAND, Lower Gulf of Thailand, Pattani Bay (6°51'55"N, 101°10'7"E), artificial reef (associated with coral settlement plate), 1 September 2010, Puttapreecha, R., PSUZC-CR-0192. Allotypes, ♀ collected with holotype; PSUZC-CR-0193; Paratype, collected with holotype (PSUZC-CR-0194 (5♂; 5♀)).

Description. Based on male holotype. Body length 6.3 mm (from tip of rostrum to apex of telson). *Body* compressed, subcylindrical. *Head*, lateral cephalic lobe truncate, anteroventral corner with setae, eyes round. *Antenna 1*, setiferous, ratios of peduncular articles 1–3 4:5:1; peduncular article 1 with 3 ventromarginal robust setea and distoventral setae; accessory flagellum with 5 articles, last article reduced; primary flagellum 16-articulate (possibly regenerating in this specimen), flagellum can be 25-articulate (observed from additional material). *Antenna 2*, Antenna 2 setiferous, peduncular article 2 cone gland not reaching end of article 3; article 5 subequal to 4, flagellum 9-articulate.

Upper lip, (labrum) distally rounded. *Lower lip*, inner lobes well developed, pubescent. *Mandible*, both similar, left incisor 3 dentates, right incisor 4 dentate; left and right lacinia mobilis armed with 3 and 4 dentates respectively; palp slender with marginal setae, article 1 smooth, article 3 slightly longer than article 2. *Maxilla 1*, inner plate narrow with 2 apical plumose setae; outer plate with 8 apical serrate robust setae; palp 2-articulate, article 1 with 3 distal setae, article 2 with 4 apical robust setae and 4 apical setae. *Maxilla 2*, inner plate with mediofacial row of 29 setae and 14 apical plumose setae; outer plate broader than inner plate, distally setose. *Maxilliped*, inner plate borad, with 6 plumose marginal setae; outer plate margin with 11 conate robust setae, terminal with 4 plumose setae; palp 4-articulate, article 2-3 with marginal setae, article 4 tapering with fine marginal setae.

Pereon. *Gnathopod 1* subchelate, smaller than gnathopod 2; coxa anterodistal corner not produced, posteroventral corner notch present, anterior margin straight; length ratio of articles from basis to dactylus 10: 3:4:7:5: 3; basis slender; merus–propodus setose; palm slightly convex, defined by posterodistal corner, without posterodistal robust setae. *Gnathopod 2* sexually dimorphic; left and right gnathopods unequal in size; coxa posteroventral corner notch present; (larger) length ratio of article from basis to dactylus 8:1:3:1:10:11; propodus distolateral corner crown with 4 rounded spines, palm straight, posterodistal corner produced, upturned, fit with dactylus; dactylus apically blunt; (smaller) subchelate; length ratio of article from basis to dactylus 9:3:4:6:6:4; merus with sharp posteroventral spine; carpus subequal to propodus; palm straight, without posteroventral spine. *Pereopod 3–4* alike. *Pereopod 5* basis posterior margin straight, posteroventral corner rounded; carpus and propodus sparsely setose; dactylus unguis anterior margin with accessory spines. *Pereopod 6–7* alike, basis, merus, carpus, propodus with long marginal setae. *Pereopod 6* basis posterior margin straight,

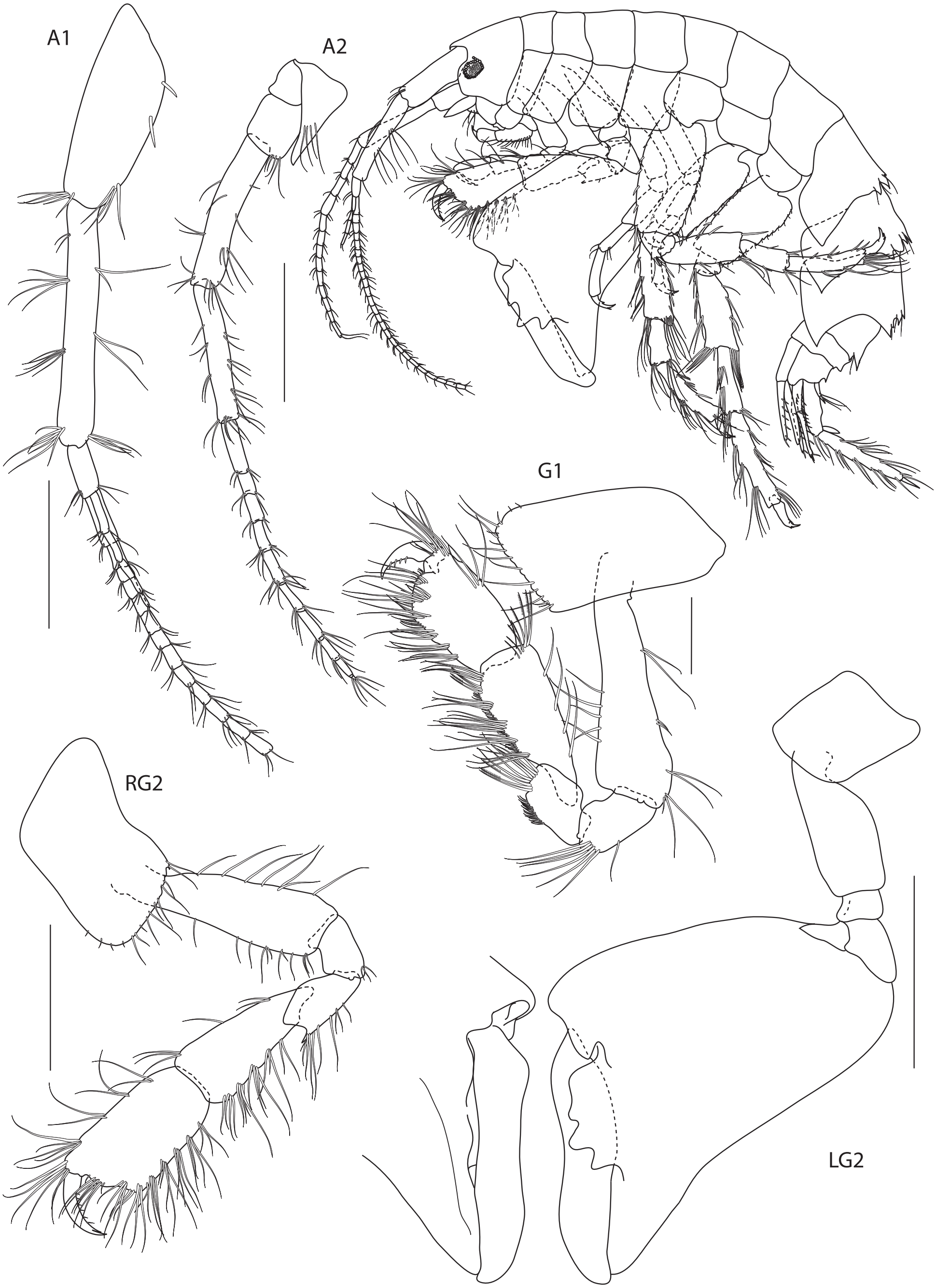

Figure 2. *Dulichiella pattaniensis* sp. n. holotype, male, (PSUZC-CR-00192), 6.3 mm. Pattani Bay, Lower Gulf of Thailand. All scale bars represent 0.5 mm.

Figure 3. *Dulichiella pattaniensis* sp. n. paratype, male, (PSUZC-CR-00194), Pattani Bay, Lower Gulf of Thailand. All scale bars represent 0.5 mm.

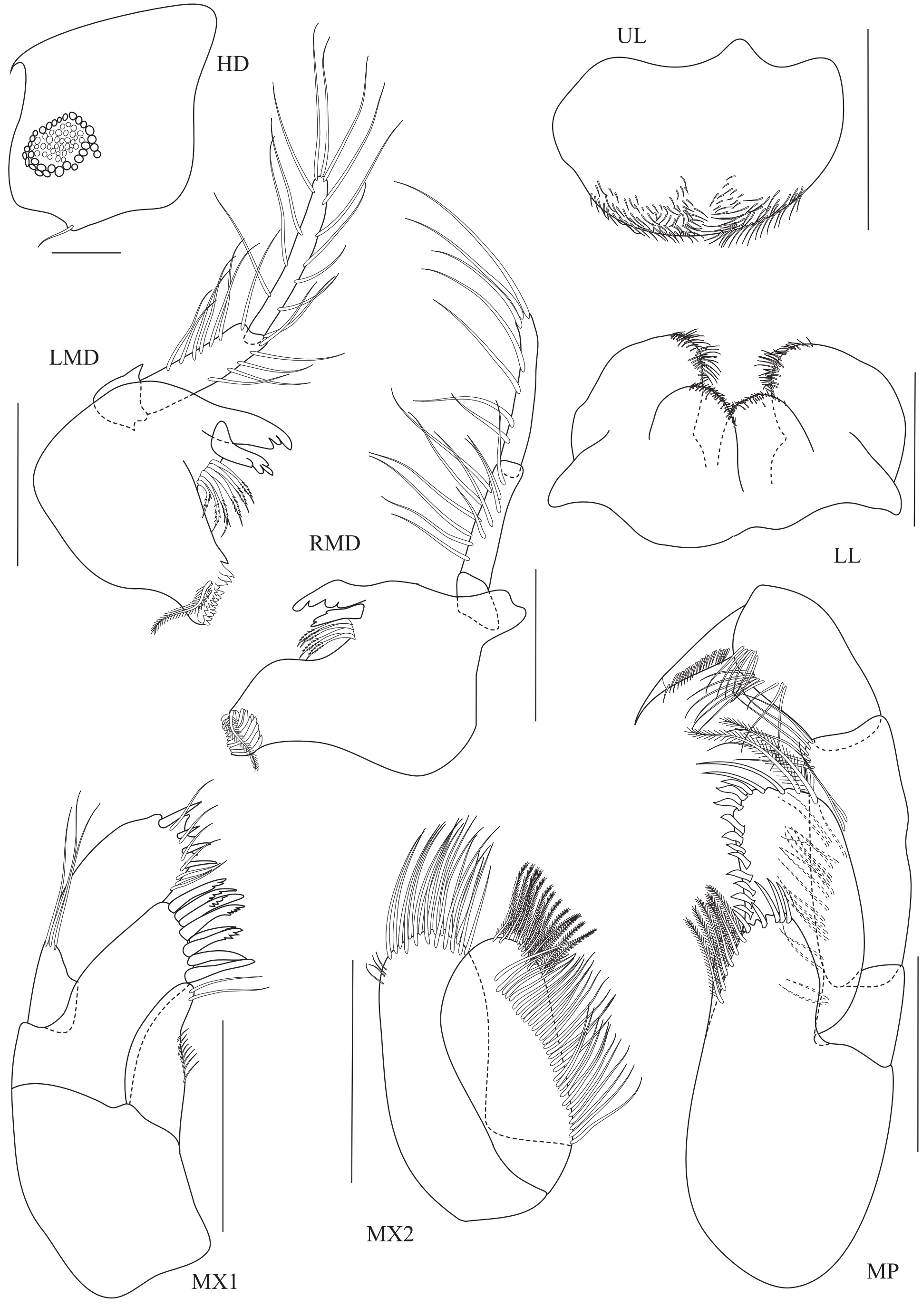

Figure 4. *Dulichiella pattaniensis* sp. n. paratype, male, (PSUZC-CR-00194), Pattani Bay, Lower Gulf of Thailand. The scale bars for U1-U3, PL1-3 represent 0.5 mm, but 0.2 mm for T.

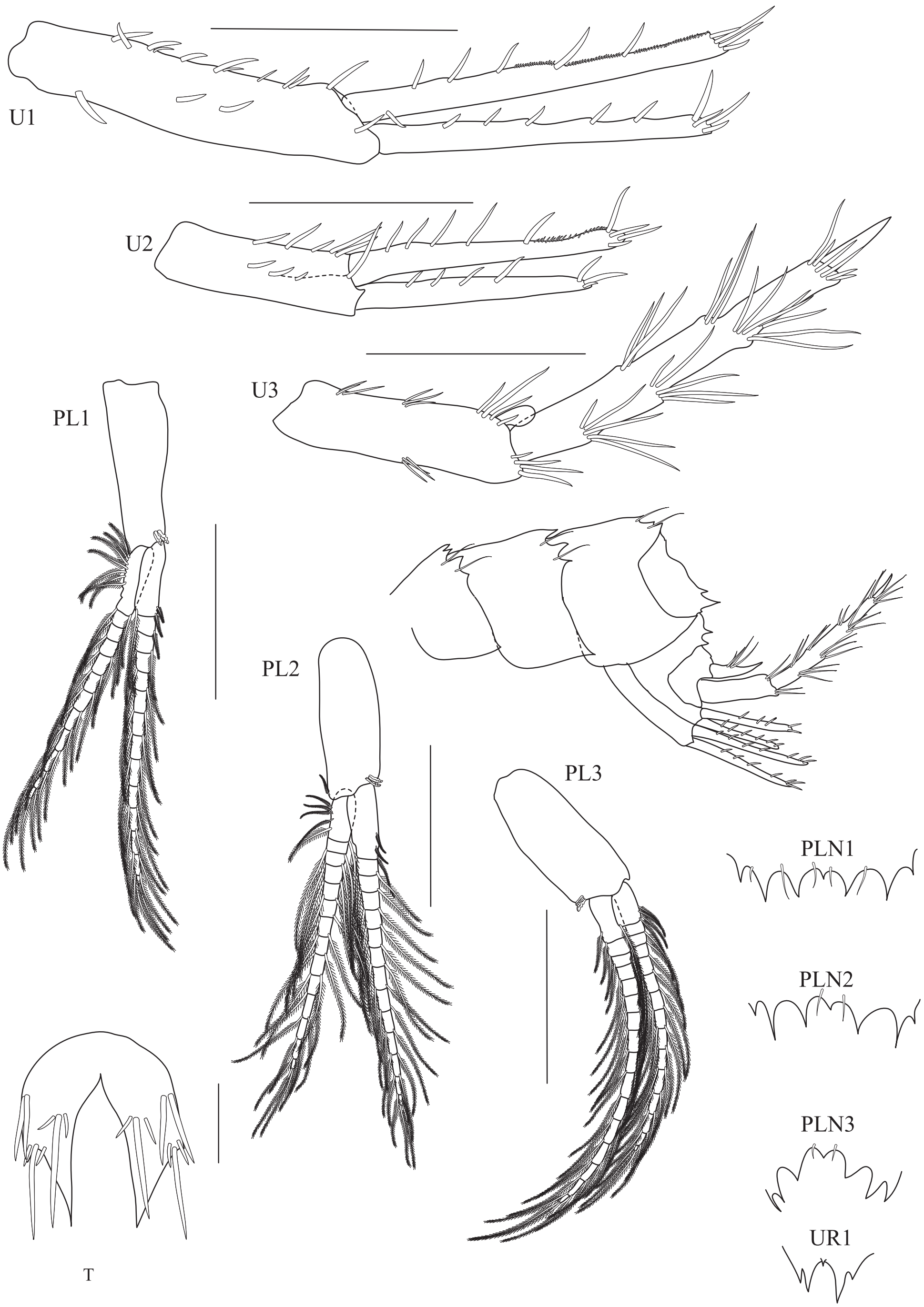

Figure 5. *Dulichiella pattaniensis* sp. n. paratype, male, (PSUZC-CR-00194), Pattani Bay, Lower Gulf of Thailand. All scale bars represent 0.5 mm.

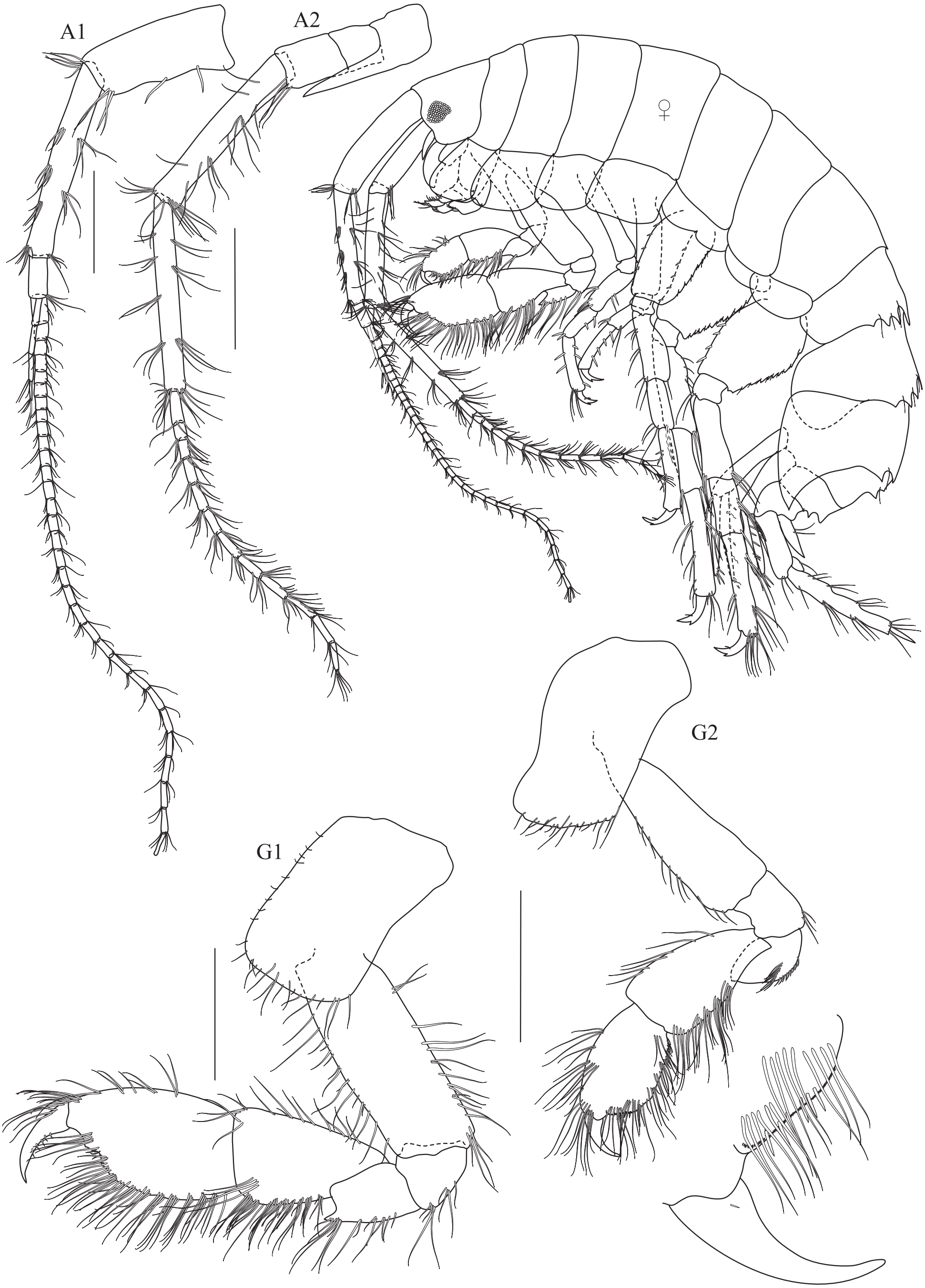

Figure 6. *Dulichiella pattaniensis* sp. n. allotype, female, (PSUZC-CR-00193), Pattani Bay, Lower Gulf of Thailand. All scale bars represent 0.5 mm.

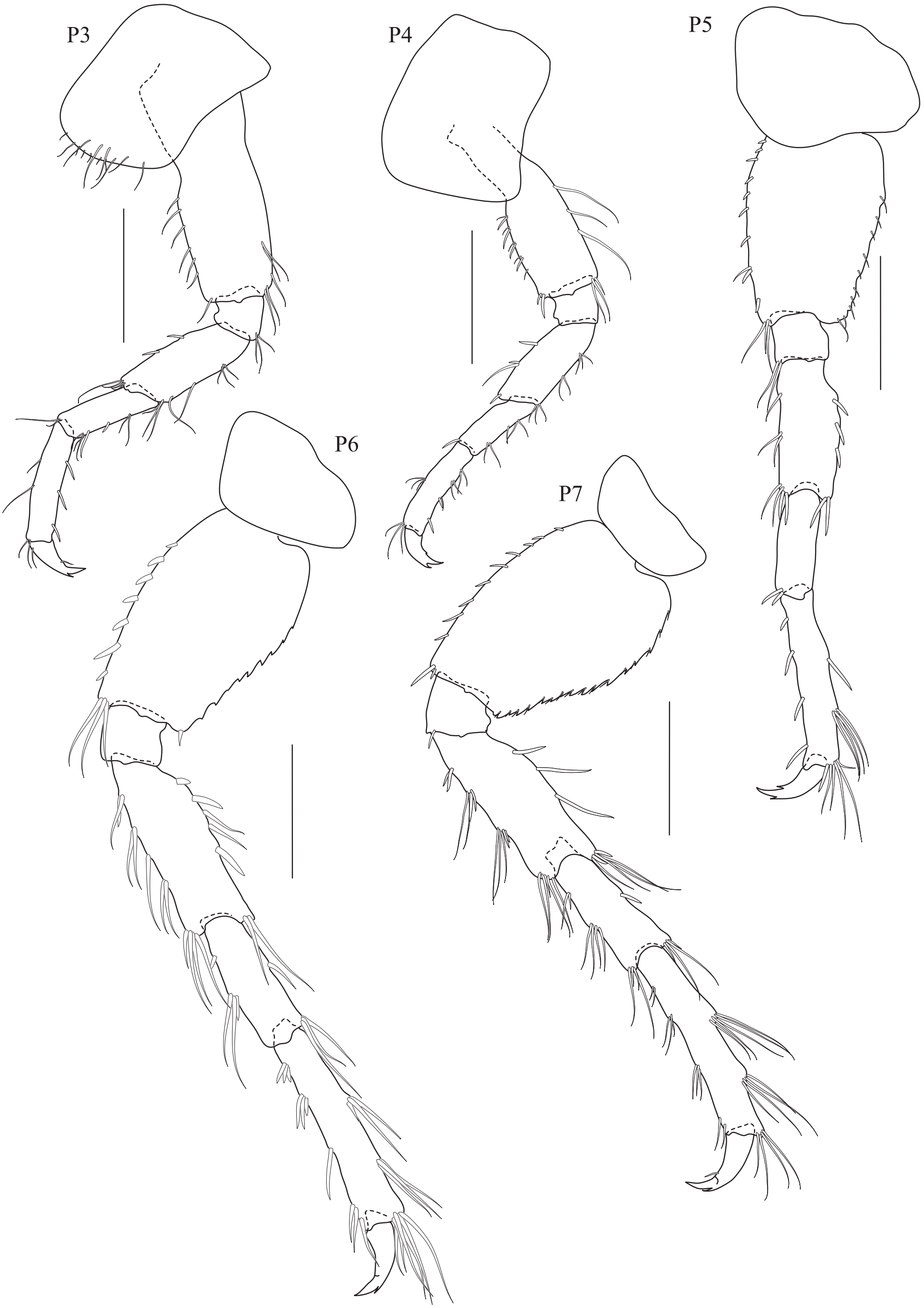

Figure 7. *Dulichiella pattaniensis* sp. n. allotype, female, (PSUZC-CR-00193), Pattani Bay, Lower Gulf of Thailand. All scale bars represent 0.5 mm.

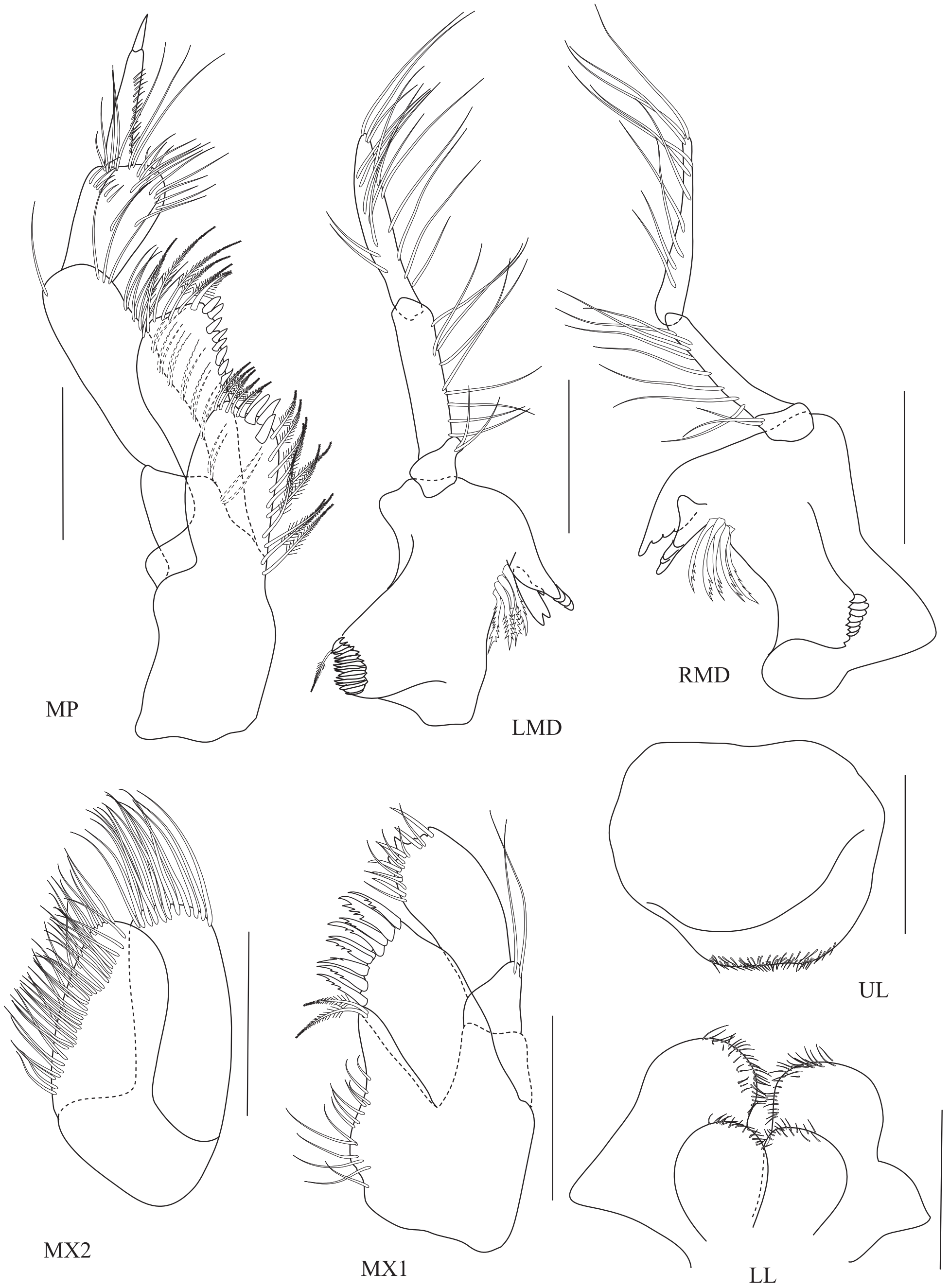

Figure 8. *Dulichiella pattaniensis* sp. n. allotype, female, (PSUZC-CR-00193), Pattani Bay, Lower Gulf of Thailand. All scale bars represent 0.2 mm.

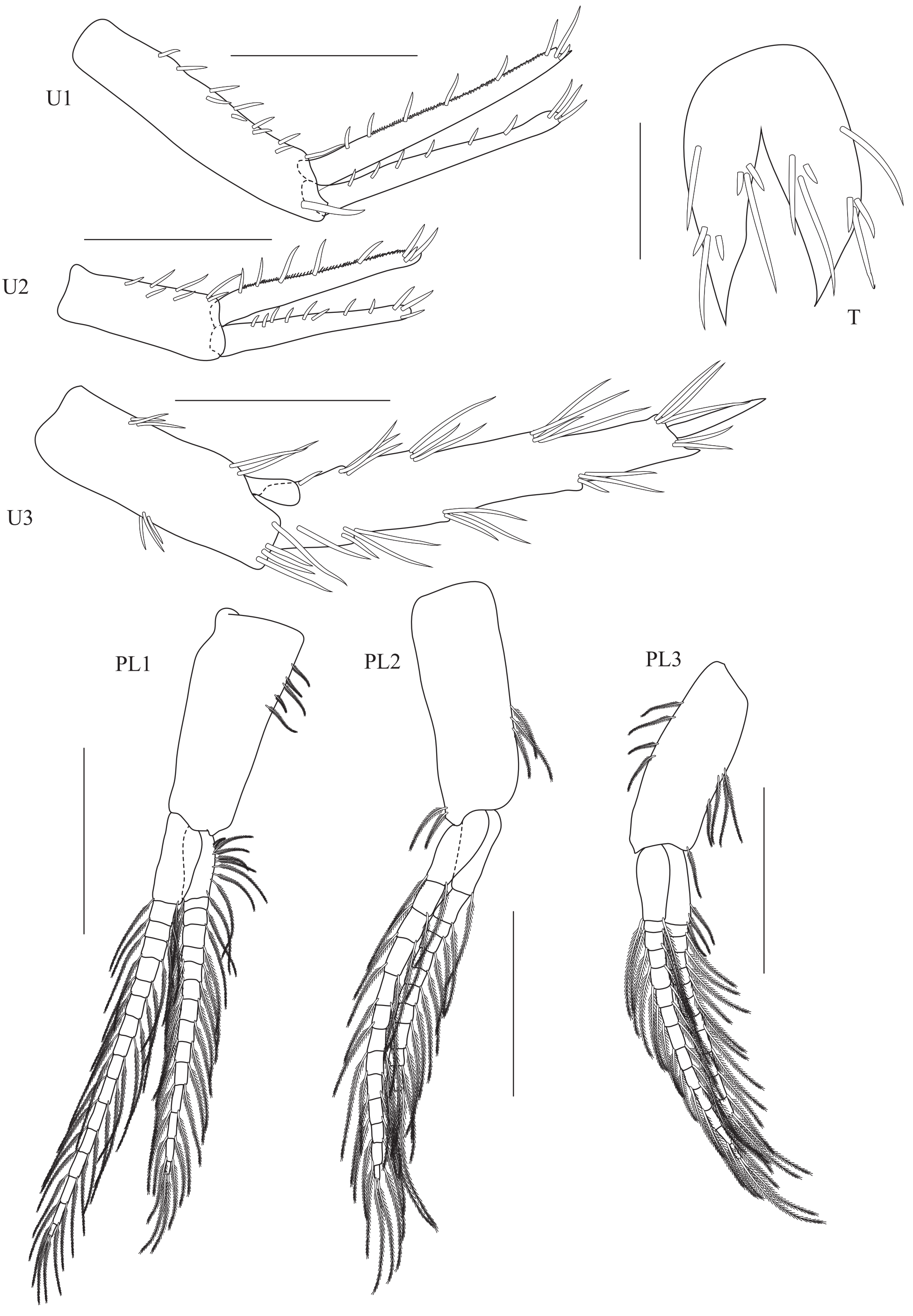

Figure 9. *Dulichiella pattaniensis* sp. n. allotype, female, (PSUZC-CR-00193), Pattani Bay, Lower Gulf of Thailand. Scale bars for U1-U3, PL1-3 represent 0.5 mm, but 0.2 mm for T.

Table 1. A summary of the diagnostic characteristicsthat serve to distinguishclosely related *Dulichiella* species.

	accessory flagellum	**lateral cephalic lobe**	**male large G2 distolateral crown**	**male G1 coxa anterior margin**	**male G1 carpus: propodus**	**male G2 dactylus**	**pereopod 3–4 dactyli**	**pereopod 6-7**	**pleonite/ urosome formular**	**epimera 3 posteroventral margin**
D. pattaniensis	5 articles	truncate	with 4 spines, fourth spine not well developed	straight	>	overlapping into palm posterodistal corner	with 2 accessory spines	with bunch of long setae on merus carpus and propodus	7-7-7-5-6-2	smooth
D. appendiculata	5 articles	truncate	with 4 spines, fourth spine not well developed	concave	=	fitting into palm posterodistal corner	with 2 accessory spines	with bunch of long setae on basis merus carpus and propodus	7-7-7-5-4-2	smooth
D. cotesi	3 articles	truncate	with 3 spines	straight	=	fitting into palm posterodistal corner	with 1 accessory spine	with bunch of long setae on merus carpus and propodus	7-7-7-5-6-2	smooth
D. cuvettensis	4 articles	truncate	with 4 spines, fourth spine not well developed	straight	>	overlapping into palm posterodistal corner	with 1 accessory spine	with bunch of long setae on carpus and prooodus	7-7-7-5-4-2	serrate
D. fresnellii	4 articles	truncate	with 4 spines, fourth spine not well developed	concave	>	overlapping into palm posterodistal corner	with 2 accessory spines	with bunch of long setae on carpus and prooodus	7-7-7-5-4-2	smooth
D. guinea	5 articles	truncate	with 4 spines, fourth spine well developed	straight	=	fitting into palm posterodistal corner	with 1 accessory spine	with bunch of long setae on basis merus carpus and propodus	7-7-7-5-4-2	smooth
D. lecroyae	4 articles	rounded	with 4 spines, fourth spine well developed	straight	>	fitting into palm posterodistal corner	with 1 accessory spine	with bunch of long setae on carpus and prooodus	7-7-7-5-4-2	smooth
D. oahu	4 articles	truncate	with 3 spines	straight	=	fitting into palm posterodistal corner	with 2 accessory spines	with bunch of long setae on carpus and prooodus	7-7-7-5-6-2	smooth
D. pacifica	4 articles	truncate	with 4 spines, fourth spine well developed	straight	=	fitting into palm posterodistal corner	with 1 accessory spine	with bunch of long setae on carpus and prooodus	7-7-7-5-4-2/6-2	smooth
D. takedai	4 articles	truncate	with 4 spines, fourth spine well developed	straight	>	overlapping into palm posterodistal corner	with 2 accessory spines	with bunch of long setae on merus carpus and propodus	7-6-7-5-4-2	serrate
D. tulear	no data	truncate	with 3 spines	convex	<	fitting into palm posterodistal corner	with 1 accessory spine	without bunch of long setae	7-7-7-5-6-2	serrate

minutely castelloserrate; dactylus unguis anterior margin with accessory spines. *Pereopod 7* basis posterior margin straight, with posterior margin minutely castelloserrate, posteroventral corner; dactylus unguis anterior margin with accessory spines.

Pleon. Pleonite/urosomite dorsal spine formula (7-7-7-5-6-2). *Pleonites 1–3* with dorsal setae. *Epimera 1–3* posteroventral margin without spines above posteroventral corner. *Epimeron 3* posterior margin smooth, posteroventral corner with strongly produced acute. *Urosomite 1* with spine at midline, no medial gape. *Urosomite 2* with dorsal setae. *Urosomite 3* with dorsal setae, with 2 dorsal spines. *Uropod 3* inner ramus scale-like, much shorter than outer ramus; outer ramus much longer (more than 2× length) than peduncle, 2-articulate. *Telson* with dorsal robust setae.

Female. (sexually dimorphic characters). Length, 7.4 mm. Gnathopod 1 coxa 4 anterodistal corner not produced, posteroventral corner notch present, anterior margin excavated. Gnathopod 2 equal, coxa subrectangular, palm crenulated, oblique with setae on margins. Pereopod 7 basis expanded, posterior margin slightly convex.

Etymology. This species is named after the type locality.

Remarks. *Dulichiella pattaniensis* sp. n., with pleonite/urosome formular of 7-7-7-5-6-2 has only *D. cotesi*, *D. oahu*, *D. pacifica* and *D. tulear* that share this characters. This new species can be distinguished from *D. cotesi*, *D. oahu* and *D. tulear* by having male gnathopod 2 (large) with 4 spines on distolateral crown while those three species have 3 spines. *D. pattaniensis* differs from *D. pacifica* in the following: the male large gnathopod 2 has a fourth spine on its distolateral crown that is not well developed vs. its well-developed fourth set of spines. The male gnathopod 1 has carpus longer than its propodus vs. a carpus subequal to its propodus. Pereopods 3-4 have a dactyli with 2 accessory spines vs. 3-4 dactyli with 1 accessory spine.

The new species also has four spines on the distolateral crown of the male gnathopod 2. Only 7 species, *D. appendiculata*, *D. cuvettensis*, *D. celestun*, *D. fresnellii*, *D. guinea*, *D. lecroyae*, *D. pacifica* and *D. takedai* share this distinct character. *D. pattaniensis* can be distinguished from amphipods by having pleonite/urosome formular of 7-7-7-5-6-2 while *D. appendiculata*, *D. cuvettensis*, *D. fresnellii*, *D. lecroye* and *D. pacifica* pleonite/urosome formula 7-7-7-5-4-2, *D. guinea* 9-9-7-5-4-2 and *D. celestun* 9-9-9-5-6-2. Moreover, *D. pattaniensis* differs from *D. cuvettensis*, *D. guinea* and *D. lecroyae* by having 2 accessory spines on pereopods 3-4 dactyli vs. 1 accessory spine. A summary of these distinguishing characters are given in Table 1.

Melita Leach, 1841

Melita latiflagella Ren & Andress, 2012

http://species-id.net/wiki/Melita_latiflagella

Figures 10, 11

Material examined. Lower Gulf of Thailand, Songkhla Lake (09°18'39.5"N, 99°46'46.4"E), 1 Feb 2012, Wongkamhaeng, K. PSUZC-CR-0191. (10♂; 10♀).

Figure 10. *Melita latiflagella* male (PSUZC-CR-000191) 4 mm. Outer Sonkhla Lake, lower Gulf of Thailand. All scale bars represent 0.2 mm.

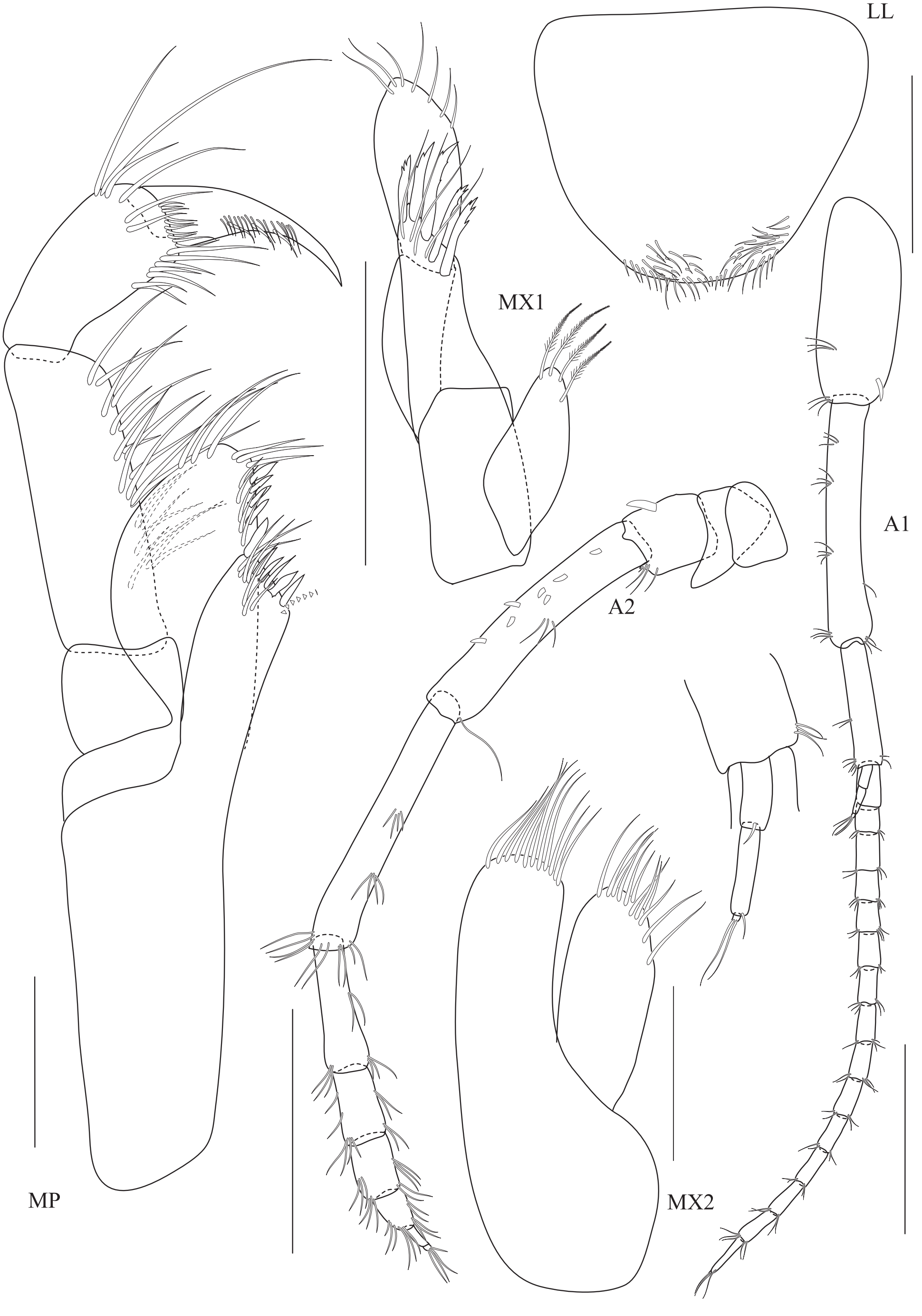

Figure 11. *Melita latiflagella* male (PSUZC-CR-000191) 4 mm. Outer Sonkhla Lake, lower Gulf of Thailand. All scale bars represent 0.2 mm.

Type locality. Hainan province, China Sea.

Description. *Head*. Lateral cephalic lobe smooth. *Antenna 1* peduncular article 1 longer than article 2, posterior margin with 2 marginal robust setae and 1 ventrodistal robust seta; flagellum with 19 articles, accessory flagellum 2 articles. *Antenna 2* gland cone not reaching to the end of article 3; flagellum with 5 articles. *Lower lip* inner lobes well developed, outer lobes pubescent. *Maxilla 1* inner plate with 3 terminal plumose setae. *Mandibular palp* article 2 subequal to article 1.

Pereon. *Gnathopod 1* coxa anteroventral corner slightly produced, posteroventral corner expanded; merus-propodussetose; carpus longer than propodus; propodus transverse, venterodistal corner produced, without defining robust seta on anteroventral corner; dactylus overlapping palm. *Gnathopods 2* merus posterodistal corner produced; carpus naked; propodus 3 × of carpus length, palmar margin oblique, serrated, longer than hind margin, with 2 robust setae, posterodistal corner produced with a robust seta; dactylus fit with palmar margin. *Pereopod 3* coxa subrectangular. *Pereopod 4* similar to pereopod 3; coxa distally expanded. *Pereopod 5 and 6* basis posterior margin rounded. *Pereopod 7* basis posterior margin straight.

Pleon. *Epimera 1–3* rounded. *Pleonite 1–3* dorsally smooth. *Uropod 1* peduncle with venterodistal spine, bearing marginal robust setae, both rami with a row of marginal robust setae. *Uropod 2* peduncle shorter than rami; rami subequal. *Telson* cleft each half with 2 apical robust setae.

Remarks. Ren and Andres (2012) described the China Sea residing *Melita latiflagella*as having an antenna 2 that is long and extended. The specimens from this study are similar to those of Ren's, but smaller in size with a total length of 3 mm as opposed to 5 mm.

Distribution. China Sea and Songkhla Lake (current study).

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RESEARCH ARTICLE

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Three new bamboo-feeding species of the genus *Symplanella* Fennah (Hemiptera, Fulgoromorpha, Caliscelidae) from China

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Abstract

Three new species of the Oriental caliscelid planthopper genus *Symplanella* Fennah, *S. hainanensis* **sp. n.**, *S. recurvata* **sp. n.** and *S. zhongtua* **sp. n.**, are described and illustrated from South China. A checklist and a key to species of genus *Symplanella* are provided.

Keywords

Fulgoroidea, bamboo planthopper, morphology, Oriental region, taxonomy

Introduction

The genus *Symplanella* was erected by Fennah (1987) based on specimens from Burma (type species: *Symplanella breviceps* Fennah, 1987) and was placed in the subtribe Augilina of the tribe Ommatidiotini of the family Issidae. Recently, the genus was transferred to the family Caliscelidae by Gnezdilov and Wilson (2006) when they reviewed the family Caliscelidae. Zhang and Wang (2009) reviewed the species of *Symplanella* from China and described one new species, *S. unipuncta* Zhang & Wang, 2009, and proposed one new combination, *S. brevicephala* (Chou, Yuan & Wang, 1994) (transferred from *Symplana* Kirby). To date, only three species, *S. brevicephala* (China: Yunnan), *S. breviceps* (Burma: Dawna Hills) and *S. unipuncta* (China: Hainan), are included in the genus *Symplanella*.

In this paper three new species of the genus *Symplanella* are described and illustrated from South China (Guangdong, Guangxi, Hainan and Yunnan). The generic characteristics are redefined. A checklist and a key to known species of *Symplanella* are provided.

Materials and Methods

Terminology follows Fennah (1987) and Chan and Yang (1994). Dry specimens were used for the descriptions and illustrations. External morphology was observed under a stereoscopic microscope and characters were measured with an ocular micrometer. Measurements are given in millimeters; body length is measured from the apex of the head to the apex of the forewing in repose. The genital segments of the examined specimens were macerated in 10% KOH, washed in water and transferred to glycerine. Illustrations of the specimens were made with a Leica MZ 12.5 stereomicroscope. Photographs were taken with a Leica D-lux 3 digital camera. The digital images were then imported into Adobe Photoshop 8.0 for labeling and plate composition. The type specimens and material examined are deposited in the Institute of Entomology, Guizhou University, Guiyang, China (IEGU).

Taxonomy

Symplanella Fennah, 1987

http://species-id.net/wiki/Symplanella
Figs 1–36

Symplanella Fennah, 1987: 244; Zhang and Wang 2009: 176.

Type species. *Symplanella breviceps* Fennah, 1987, by original designation.

Diagnosis. Vertex (Figs 3, 15, 27) with anterior margin angular or rounded, posterior margin angulately concave, disc distinctly depressed, without median carina. Frons (Figs 5, 17, 29) with median carina and submedian carinae, longer in middle line than widest part, widest at level of second segment of antennae. Clypeus with median carina. Pronotum as broad as or broader than head including eyes; lateral carinae strongly diverging laterad. Mesonotum without carina, almost twice as broad as long. Forewing (Fig 6) long and narrow, 4.00–4.71 times as long as broad; Sc+R and M united in basal fifth, Sc+R forking close to nodal transverse line; three or four subapical cells and seven to nine apical cells; M with three or four branches. Hindwing broad triangular, venation as shown in Fig. 7. Post-tibia with one spine laterally, six apically; basal and second metatarsal segments toothless and ventrally pilose. Abdomen exceptionally elongate, narrow sternites chevron-shaped. Genital styles narrow and long or short and oval. Aedeagus fused with connective, both forming V-shaped or Y-shaped; aedeagal shaft long, simple, phallobase slender lobe-like or reduced.

Distribution. Oriental Region (China and Burma).

Checklist of species of *Symplanella* Fennah, 1987

Symplanella brevicephala (Chou, Yuan & Wang, 1994); China (Yunnan).
Symplanella breviceps Fennah, 1987; Burma (Dawna Hills).
Symplanella hainanensis sp. n.; China (Hainan).
Symplanella recurvata sp. n.; China (Guangdong and Guangxi).
Symplanella unipuncta Zhang & Wang, 2009; China (Hainan).
Symplanella zhongtua sp. n.; China (Yunnan)

Key to species of genus *Symplanella* (male)

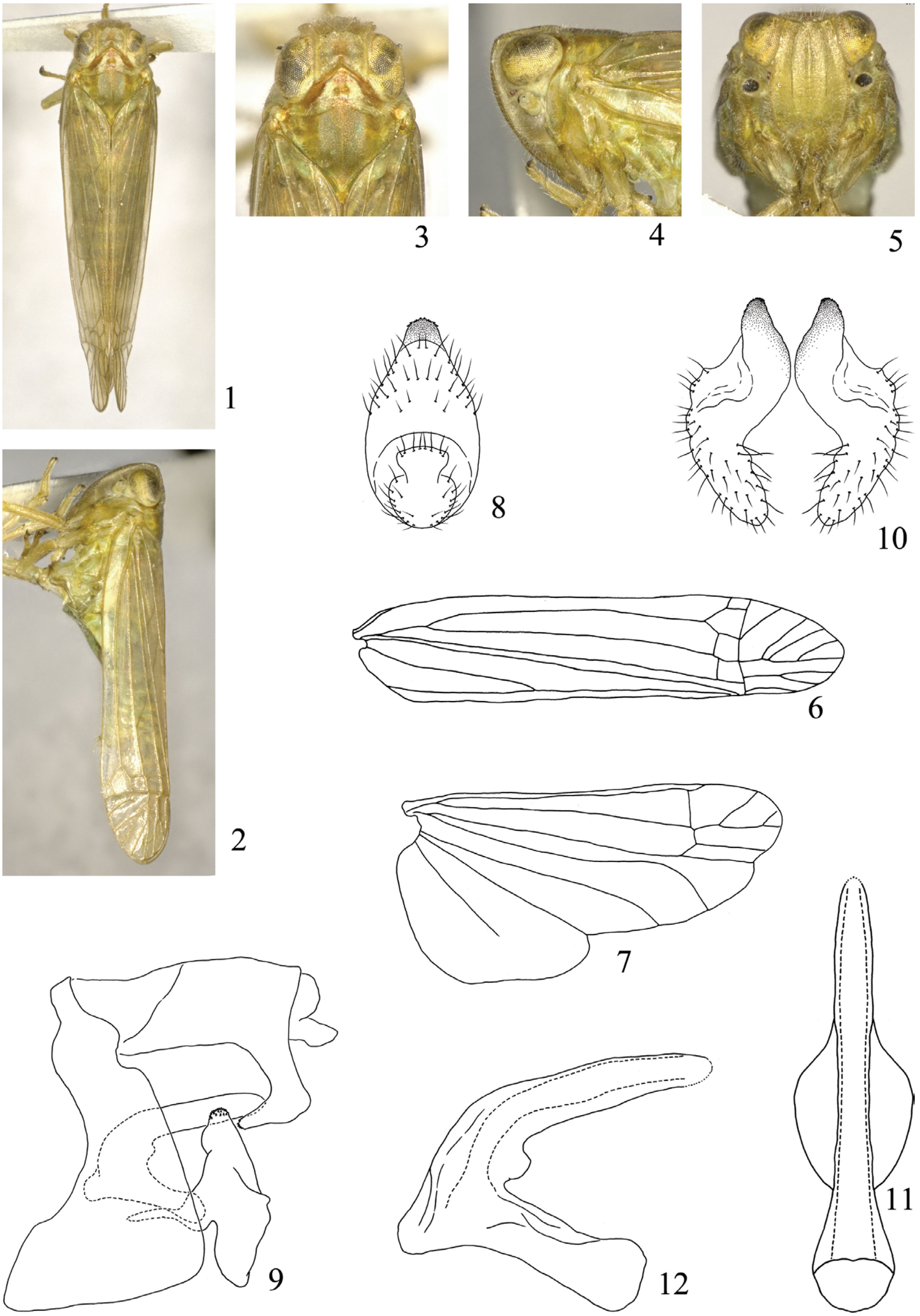
1 Frons and clypeus mostly blackish or dark brown (Figs 17, 29) **2**
– Frons and clypeus mostly yellowish green (Fig. 5)...................................... **4**
2 Head in lateral view with the apex acute (Fig. 16)........ ***S. hainanensis* sp. n.**
– Head in lateral view with the apex rounded (Fig. 28)................................. **3**
3 Frons and clypeus mostly blackish brown (Fig. 29); pygofer with one stout process at middle (Fig. 32).. ***S. zhongtua* sp. n.**
– Frons and clypeus mostly dark brown; pygofer with one lobe-like process at dorsal posterior angle... ***S. brevicephala***
4 M of forewing with three branches; genital style long in posterior view, posterior margin broadly concave.. ***S. breviceps***
– M of forewing with four branches (Fig. 6); genital style short in posterior view (Fig. 10), posterior margin not concave or slightly convex (Fig. 9)...... **5**
5 Posterior margin of pygofer with one process.......................... ***S. unipuncta***
– Posterior margin of pygofer without process (Fig. 9)....... ***S. recurvata* sp. n.**

Symplanella recurvata sp. n.

http://zoobank.org/FA3249B6-4106-4928-9201-F444D3E76BED
http://species-id.net/wiki/Symplanella_recurvata
Figs 1–12

Measurements. Body length including forewing: male 5.78–5.98 mm (N = 6), female 6.15–6.25 mm (N = 12); forewing length: male 4.90–5.15 mm (N = 6), female 5.30–5.40 mm (N = 12).

Coloration. General color light yellowish brown with somewhat green. Ocelli reddish brown, eyes black brown. Antennae with one black spot at apex of second



Figures 1–12. *Symplanella recurvata* sp. n. **1** Male habitus, dorsal view **2** Male habitus, lateral view **3** Head and thorax, dorsal view **4** Head and thorax, lateral view **5** Face **6** Forewing **7** Hindwing **8** Male anal segment, posterior view **9** Male genitalia, lateral view **10** Styles, posterior view **11** Aedeagus, dorsal view **12** Aedeagus, lateral view.

segment. Central area of vertex and pronotum, base of mesonotum with somewhat pale yellowish red. Procoxae, mesocoxae, metapleura, abdominal sternites laterally and pregenital sternite of female fuscous.

Head and thorax. Vertex including eyes narrower than pronotum (0.86:1). Vertex shorter in middle line than broad at base (0.60:1). Frons 1.28 times longer in middle line than widest part. Pronotum slightly longer in middle line than vertex (1.21:1). Mesonotum 1.24 times as long as vertex and pronotum together in middle line. Forewing longer in middle line than broad at widest part (4.71:1). Hindwing longer in middle line than broad at widest part (2.01:1), venation as shown in Fig. 7.

Abdomen. Anal segment of male in posterior view (Fig. 8) nearly long oval, in lateral view (Fig. 9) with basal half parallel dorsally and ventrally, apical margin produced into stout process ventrally, which curves cephalad, apex acutely rounded. Pygofer in lateral view (Fig. 9) with dorsal margin distinctly shorter than ventral margin, posterior margin mostly straight, concave at dorso-posterior angle. Genital style in lateral view slender, dorsal and ventral angles acutely rounded, posterior margin slightly convex; in posterior view (Fig. 10) with dorsal and ventral apex acute and rounded, inner and outer margin sinuate. Aedeagus in dorsal view (Fig. 11) with shaft straight, simple, apex rounded; in lateral view (Fig. 12) curved at basal third, apical part straight, phallobase small, lobe-like. Connective in lateral view (Fig. 12) straight, fused with base of aedeagus forming V-shape; connective in dorsal view (Fig. 11) with both lateral margins swelled laterad.

Type material. Holotype: ♂, China: Guangdong, Guangzhou, Huanan Botanical Garden (23°08'N, 113°14'E), on bamboo (*Neosinocalamus* sp.), 22 Nov. 2006, X.-S. Chen; paratypes: 5 ♂♂, 11 ♀♀, data same as holotype; 1 ♀, Guangxi, Daxin, Encheng, 4 May 2009, H.-R. Li.

Host plant. Bamboo (*Neosinocalamus* sp.).

Distribution. South China (Guangdong and Guangxi) (Fig. 37).

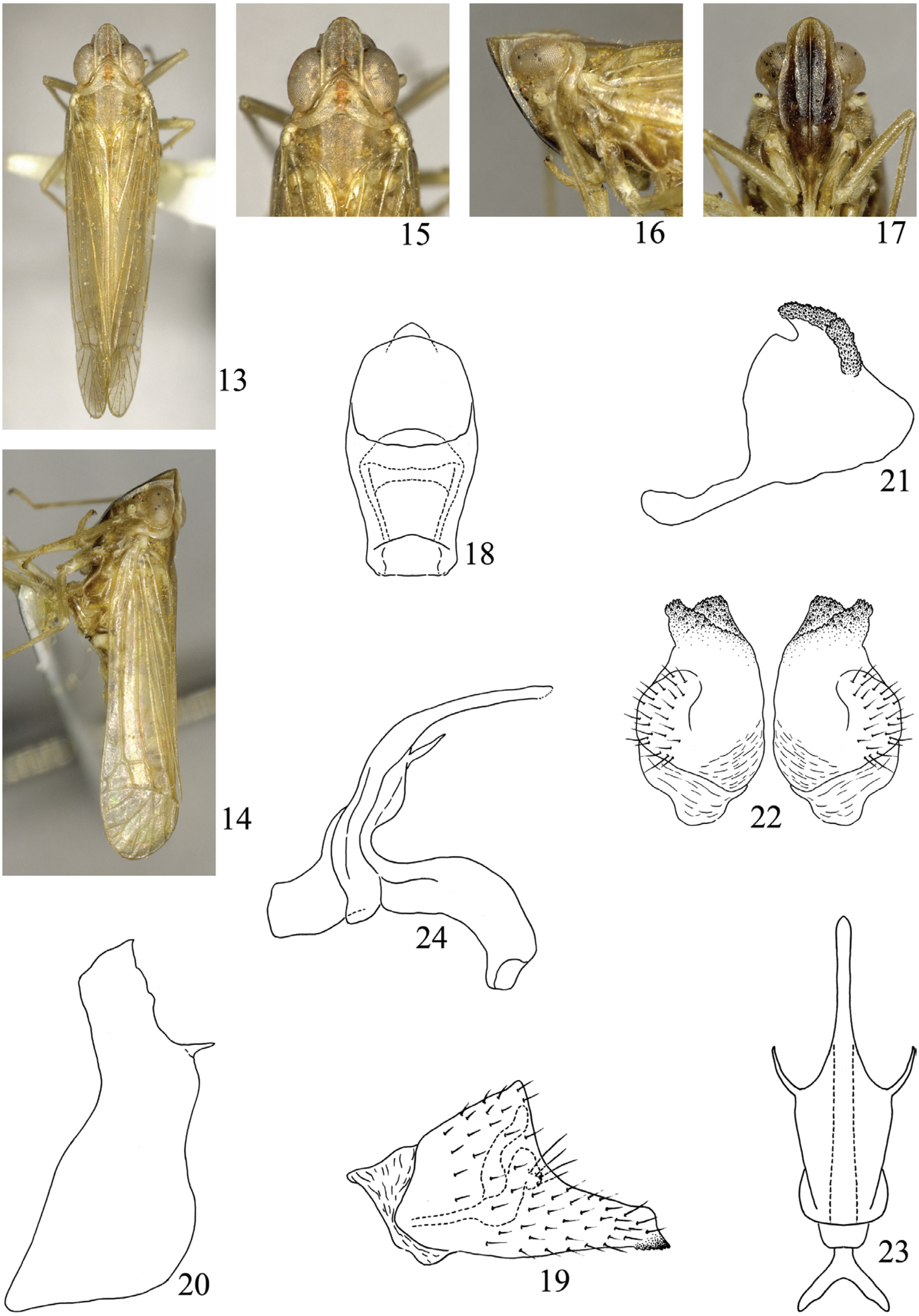
Remarks. This new species is closely related to *S. unipuncta* Zhang & Wang, 2009 but differs in: *i*) anal segment in lateral view with one stout process at apical margin ventrally, which curves cephalad apically (with one tooth-like process at middle of ventral margin in *unipuncta*); *ii*) posterior margin of pygofer without process (with one process in *unipuncta*); *iii*) aedeagus without process at base (with two long stout processes basally and ventrally, which as long as aedeagal shaft).

Etymology. The new species is named after the strongly recurved tip of the anal tube.

Symplanella hainanensis sp. n.

http://zoobank.org/C12B4D8F-BF4B-4939-977B-D13F7CEDDF9F
http://species-id.net/wiki/Symplanella_hainanensis
Figs 13–24

Measurements. Body length including forewing: male 5.45–5.62 mm (N = 2), female 6.00–6.30 mm (N = 8); forewing length: male 4.40 mm (N = 2), female 4.65–4.95 mm (N = 8).



Figures 13–24. *Symplanella hainanensis* sp. n. **13** Male habitus, dorsal view **14** Male habitus, lateral view **15** Head and thorax, dorsal view **16** Head and thorax, lateral view **17** Face **18** Male anal segment, dorsal view **19** Male anal segment, lateral view **20** Male pygofer, lateral view **21** Style, lateral view **22** Styles, posterior view **23** Aedeagus, dorsal view **24** Aedeagus, lateral view.

Coloration. General color dirty yellowish brown. Ocelli reddish brown, eyes black brown. Antennae with one black spot at apex of second segment. Frons and clypeus mostly dark brown. Central area of vertex and pronotum, base of mesonotum with somewhat pale yellowish red. Procoxae, mesocoxae, metapleura, abdominal sternites laterally and pregenital sternite of female, fuscous.

Head and thorax. Vertex including eyes as wide as pronotum. Vertex longer in middle line than broad at base (1.24:1). Frons 1.67 times longer in middle line than widest part. Pronotum shorter in middle line than vertex (0.74:1). Mesonotum 0.87 times as long as vertex and pronotum together in middle line. Forewing longer in middle line than broad at widest part (4.00:1).

Abdomen. Anal segment of male in dorsal view (Fig. 18) with median part slightly widened; in lateral view (Fig. 19) broad at basal half, abruptly narrowed at apical half, apex acute, with some micro teeth at apical ventral margin. Pygofer in lateral view (Fig. 20) with dorsal margin distinctly shorter than ventral margin, posterior margin sinuate, one finger-like process at dorsal third. Genital style in lateral view (Fig. 21) broad and rounded, dorsal margin concave, dorsal half of posterior margin mound-like, covered with a lot of micro teeth; in posterior view (Fig. 22) short and stout, mostly oval, dorsal angle forked, covered with a lot of micro teeth. Aedeagus in dorsal view (Fig. 23) with basal half broad, apical half abruptly narrowed, stick-like, each side with one spine-like process at widest part; in lateral view (Fig. 24) with base broad, narrowing apically, aedeagal shaft slightly curved ventrad. Connective in lateral view (Fig. 24) curved ventrad, fused with base of aedeagus, nearly forming Y-shape.

Type material. Holotype: ♂, China: Hainan, Diaoluoshan National Natural Reserve (18°47'N, 109°52'E), on bamboo, 9–12 Apr. 2009, X.-H. Hou; paratypes: 1 ♂, 8 ♀♀, data same as holotype.

Host plant. Bamboo.

Distribution. South China (Hainan) (Fig. 37).

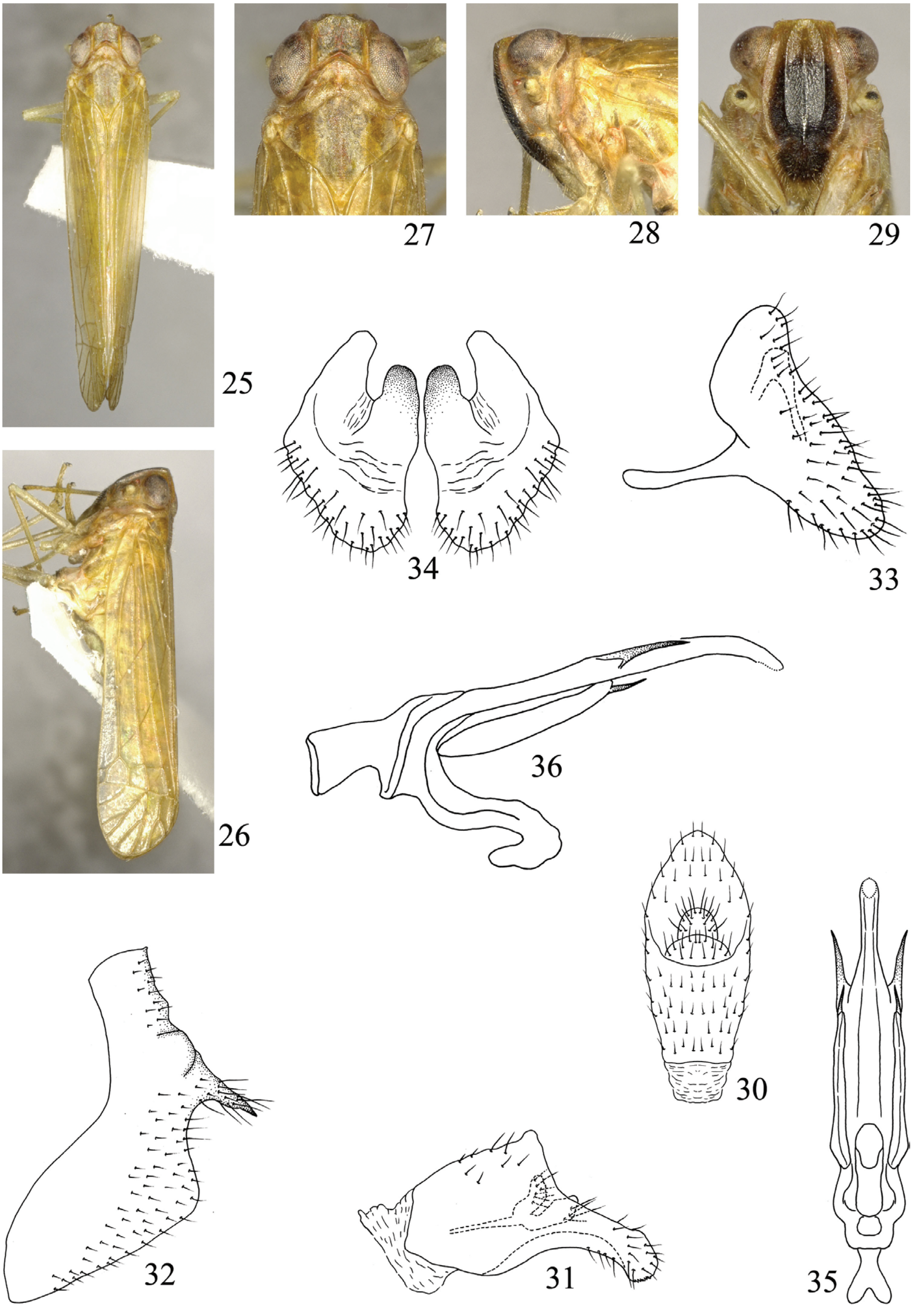
Remarks. This new species is similar to the type species from Burma, *S. breviceps* Fennah, 1987, but can be distinguished from the latter in: *i*) frons mostly dark brown (stramineous in *breviceps*); *ii*) vertex with anterior margin rounded (angulated in *breviceps*); *iii*) posterior margin of pygofer with one spinous process dorsally (absent in *breviceps*); *iv*) genital style in posterior view broad and short (narrow and long in *breviceps*).

Etymology. The new species is named after the type locality, Hainan Province, China.

Symplanella zhongtua sp. n.

http://zoobank.org/B8FADA9C-2202-4485-928A-E17811BB1A59
http://species-id.net/wiki/Symplanella_zhongtua
Figs 25–36

Measurements. Body length including forewing: male 6.10–6.35 mm (N = 4), female 6.30–6.50 mm (N = 2); forewing length: male 5.15–5.30 mm (N = 4), female 5.20–5.40 mm (N = 2).



Figures 25–36. *Symplanella zhongtua* sp. n. **25** Male habitus, dorsal view **26** Male habitus, lateral view **27** Head and thorax, dorsal view **28** Head and thorax, lateral view **29** Face **30** Male anal segment, dorsal view **31** Male anal segment, lateral view **32** Male pygofer, lateral view **33** Style, lateral view **34** Styles, posterior view **35** Aedeagus, ventral view **36** Aedeagus, lateral view.

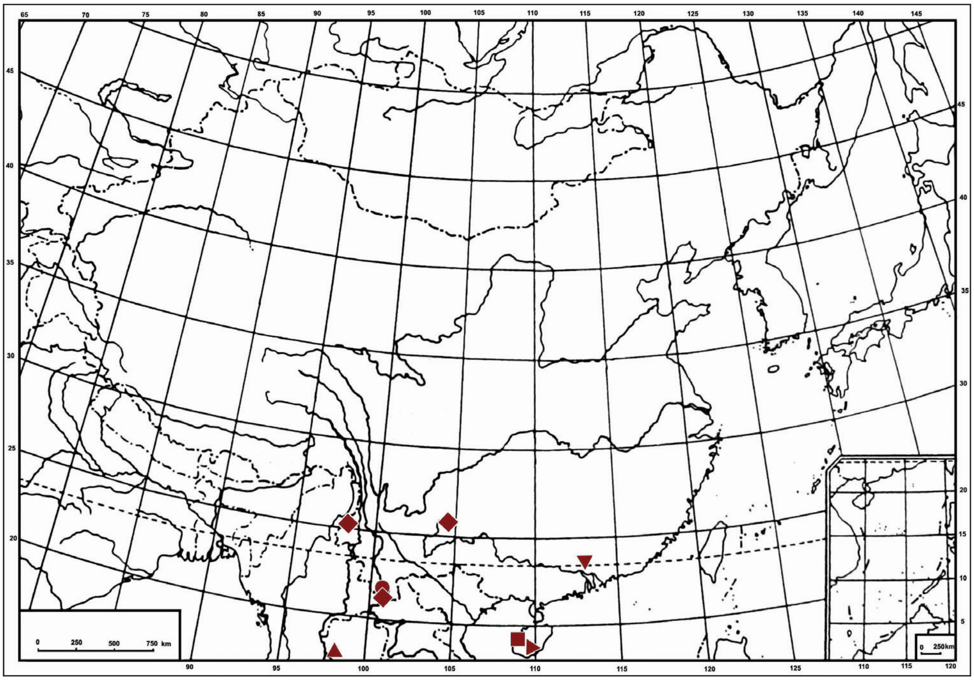


Figure 37. Geographic distribution of *Symplanella* species: *S. recurvata* sp. n. (▼); *S. brevicephala* (Chou, Yuan & Wang) (♦); *S. breviceps* Fennah (▲); *S. hainanensis* sp. n. (▶); *S. unipuncta* Zhang & Wang (■); *S. zhongtua* sp. n. (●).

Coloration. General color dirty yellowish brown. Ocelli reddish brown, eyes black brown. Antennae with one black spot at apex of second segment. Frons and clypeus mostly blackish brown. Central area of vertex and pronotum, base of mesonotum with somewhat pale yellowish red. Procoxae, mesocoxae, metapleura, abdominal sternites laterally and pregenital sternite of female fuscous.

Head and thorax. Vertex including eyes narrower than pronotum (0.98:1). Vertex shorter in middle line than broad at base (0.65:1). Frons 1.41 times longer in middle line than widest part. Pronotum as long in middle line as vertex. Mesonotum 1.45 times as long as vertex and pronotum together in middle line. Forewing longer in middle line than broad at widest part (4.45:1).

Abdomen. Anal segment of male in dorsal view (Fig. 30) long oval, widest at apical third, apical margin acutely convex; in lateral view (Fig. 31) with basal half broad, apical half abruptly narrowed, apex slightly swollen, which with some micro teeth at apical ventral margin. Pygofer in lateral view (Fig. 32) with dorsal margin distinctly shorter than ventral margin, posterior margin sinuate, with one stout spine-like process, directed caudo-ventrad. Genital style in lateral view (Fig. 33) with dorsal and ventral angles rounded, posterior margin sinuate; in posterior view (Fig. 34) short and broad, dorsal margin strongly concave, forcipate, inner and outer angles rounded. Aedeagus in ventral view (Fig. 35) with base mostly broad, apical third abruptly narrowed, stick-like, apical margin rounded, each side with one spine-like process; phallobase lobe-like, each with one small spine at apex; aedeagus in lateral view (Fig. 36) with base slightly broad, apical part mostly straight and slender, apical third slightly curved ventrad; phallobase slender, beanpod-like. Connective in lateral view (Fig. 36) narrow and slender, apical half reflexed ventrad and cephalad.

Type material. Holotype: ♂, China: Yunnan, Xishuangbanna, Menglun (21°55'N, 101°13'E), on bamboo, 28 July 2011, W.-B. Zheng and Z.-M. Chang; paratypes: 3 ♂♂, 2 ♀♀, data same as holotype.

Host plant. Bamboo.

Distribution. Southwest China (Yunnan) (Fig. 37).

Remarks. This new species is similar to *S. brevicephala* (Chou, Yuan & Wang, 1994), but can be distinguished by: *i*) frons and clypeus mostly black (dark brown in *brevicephala*); *ii*) posterior margin of male pygofer having one stout spinous process at middle, directed ventro-caudad (having one stout tooth-like process dorsally, directed dorso-caudad in *brevicephala*); *iii*) genital style in lateral view dorso-apical angle broadly rounded (acutely rounded in *brevicephala*); *iv*) aedeagal shaft mostly straight (S-shaped in *brevicephala*).

Etymology. The name is derived from transliteration of the Chinese "zhongtu", meaning posterior margin of male pygofer having one stout spinous process at middle.

Discussion

Diversity of bamboo-feeding planthoppers. The current authors paid particular attention to the species of bamboo planthopper in field research and collected large quantities of specimens in the past twelve years. A number of new taxa or new records were found and some of them have been published (Chen and Yang 2010). Based on the literature and the result of field work, the species diversity of Chinese bamboo-feeding planthoppers is very abundant and more than 84 species (in 18 genera) feed exclusively on Bambusoideae (Che et al. 2009; Chen and Yang 2010; Hou and Chen 2010a, b, c; Chen and Zhang 2011; Yang and Chen 2011; Chang and Chen 2012; Zhang and Chen 2013). They mostly are members of the family Delphacidae (78 species in 15 genera), Caliscelidae (three species in two genera), Cixiidae (two species in one genus) and Tropiduchidae (one species in one genus). The genus *Symplanella* with three known species and three new species described in this paper, represents the second bamboo-feeding genus in the tribe Augilini after *Pseudosymplanella* Che, Zhang & Webb, 2009 (Che et al. 2009).

Host plant. As a result of our field research, five species of *Symplanella* from China were found feeding exclusively on bamboo. Unfortunately, no more other information on host plant is available except for *S. recurvata* collected on *Neosinocalamus* sp..

Distribution. Based on the literature and the result of field work, five described species within *Symplanella* are distributed in southern China (Chou et al. 1994; Zhang and Wang 2009; this paper) and *S. breviceps* Fennah, 1987 occurring in Burma (Fennah 1987) (Fig. 37). It seems that the members of the genus *Symplanella* are restricted to the Oriental region.

Acknowledgements

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DATA PAPER

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AnthWest, occurrence records for wool carder bees of the genus *Anthidium* (Hymenoptera, Megachilidae, Anthidiini) in the Western Hemisphere

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Abstract

This paper describes AnthWest, a large dataset that represents one of the outcomes of a comprehensive, broadly comparative study on the diversity, biology, biogeography, and evolution of *Anthidium* Fabricius in the Western Hemisphere. In this dataset a total of 22,648 adult occurrence records comprising 9657 unique events are documented for 92 species of *Anthidium*, including the invasive range of two introduced species from Eurasia, *A. oblongatum* (Illiger) and *A. manicatum* (Linnaeus). The geospatial coverage of the dataset extends from northern Canada and Alaska to southern Argentina, and from below sea level in Death Valley, California, USA, to 4700 m a.s.l. in Tucumán, Argentina. The majority of records in the dataset correspond to information recorded from individual specimens examined by the authors during this project and deposited in 60 biodiversity collections located in Africa, Europe, North and South America. A fraction (4.8%) of the occurrence records were taken from the literature, largely California records from a taxonomic treatment with some additional records for the two introduced species. The temporal scale of the dataset represents collection events recorded between 1886 and 2012. The dataset was developed employing SQL server 2008 r2. For each specimen, the following information is generally provided: scientific name including identification qualifier when species status is uncertain (*e.g.* "Questionable Determination" for 0.4% of the specimens), sex, temporal and geospatial details, coordinates, data collector, host plants, associated organisms, name of identifier, historic identification, historic identifier, taxonomic value (*i.e.*, type specimen, voucher, etc.), and repository. For a small portion of the database records, bees associated with threatened or endangered plants (~ 0.08% of total records) as well as specimens collected as part of unpublished biological inventories (~17%), georeferencing is presented only to nearest degree and the information on floral host, locality, elevation, month, and day has been withheld. This database can potentially be used in species distribution and niche modeling studies, as well as in assessments of pollinator status and pollination services. For native pollinators, this large dataset of occurrence records is the first to be simultaneously developed during a species-level systematic study.

Keywords

Anthophila, Apoidea, bees, invasive species, North America, South America, pollinators, biodiversity, floral hosts

Project details

Project title: Wool carder bees of the genus *Anthidium* (Hymenoptera: Megachilidae, Anthidiini) in the Western Hemisphere

Personnel: Terry Griswold (author), Victor H. Gonzalez (author), Harold Ikerd (database manager, author).

Funding: National Science Foundation grants DEB-0742998 and DBI-0956388.

Study area description: The database covers a wide range of ecosystems found in both North and South America, from -62° to 79° in latitude and -174° to -22° in longitude. A large portion of the records in North America are from xeric regions (Great Basin, Colorado Plateau, Mojave, Sonoran, and Chihuahuan Deserts) and Mediterranean California, while those from South America are mostly from the xeric regions on the flanks of the Andes (Figs 1, 2). No records for *Anthidium* are known from the Caribbean islands. Much of the data set comes from general bee collecting. Additional material in western United States comes from multi-year intensive, systematic bee faunal studies in protected landscapes.

While the majority of species of *Anthidium* occupy a small number of ecoregions (< 5), some species such as *A. tenuiflorae* Cockerell are widespread, occurring in as many as 41 ecoregions. Many *Anthidium* have distributions that include critical, endangered, or vulnerable, as well as relatively stable or intact, ecoregions (Table 1) based on WWF (World Wild Fund for Nature) designations (Olson and Dinerstein 2002). Known distributions for 16 species are largely or entirely within critical or endangered ecoregions with at least 90% of collection records from such designated areas. An additional 22

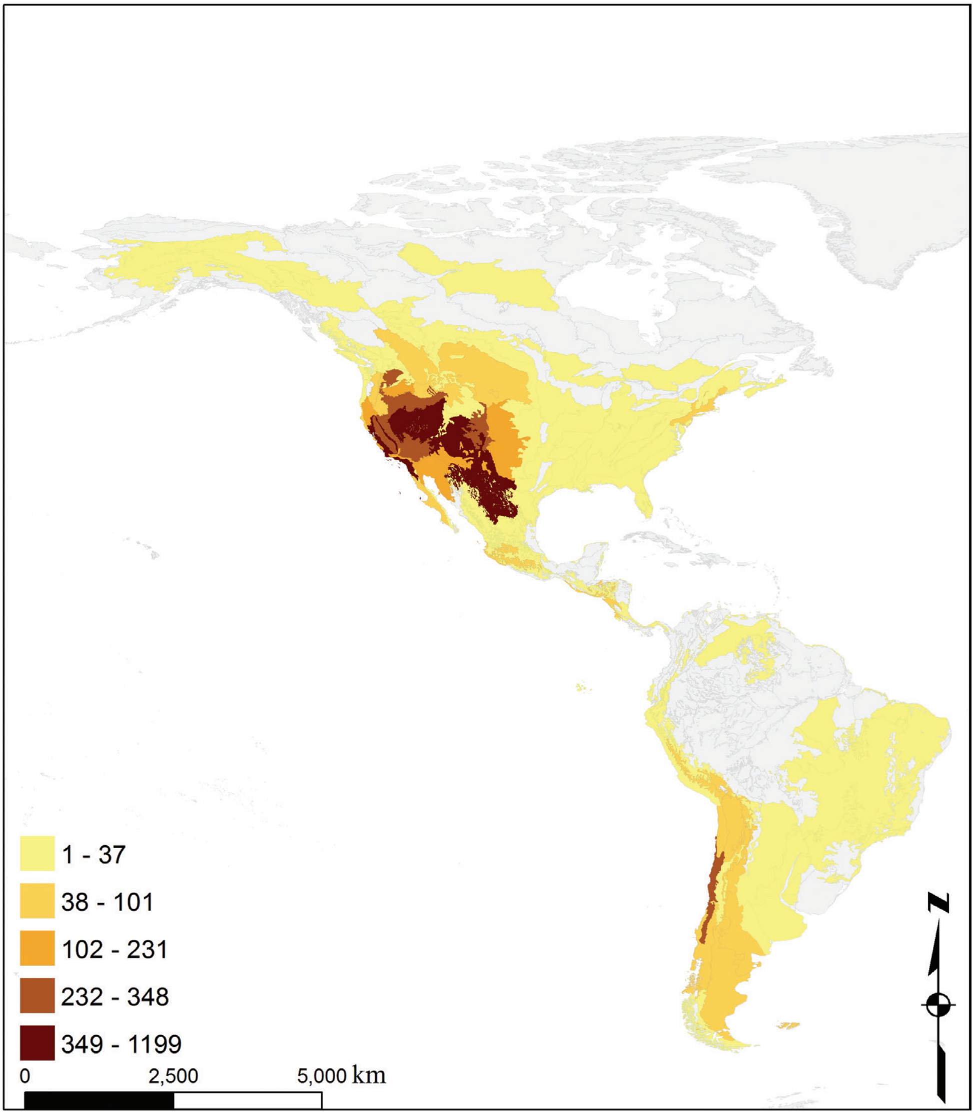

Figure 1. Collecting intensity of *Anthidium* by ecoregion in the Western Hemisphere. Number of collection events defined as unique date and latitude and longitude combinations per each WWF ecoregion (Olson et al. 2001). The 10 ecoregions with the highest number of events were: Great Basin shrub steppe, 1199; California coastal sage and chaparral, 930; Colorado Plateau shrublands, 782; California interior chaparral and woodlands, 768; Chihuahuan desert, 648; Mojave desert, 348; Sierra Nevada forests, 317; Chilean matorral, 314; Colorado Rockies forests, 303; and California Central Valley grasslands, 296.

species had at least 90% of collection records from within vulnerable ecoregions. Few native *Anthidium* spanned both Nearctic and Neotropic Realms (8.8%).

Design description: The purpose of this dataset is to make available data associated with bees of the genus *Anthidium* in the Western Hemisphere. The dataset was devel-

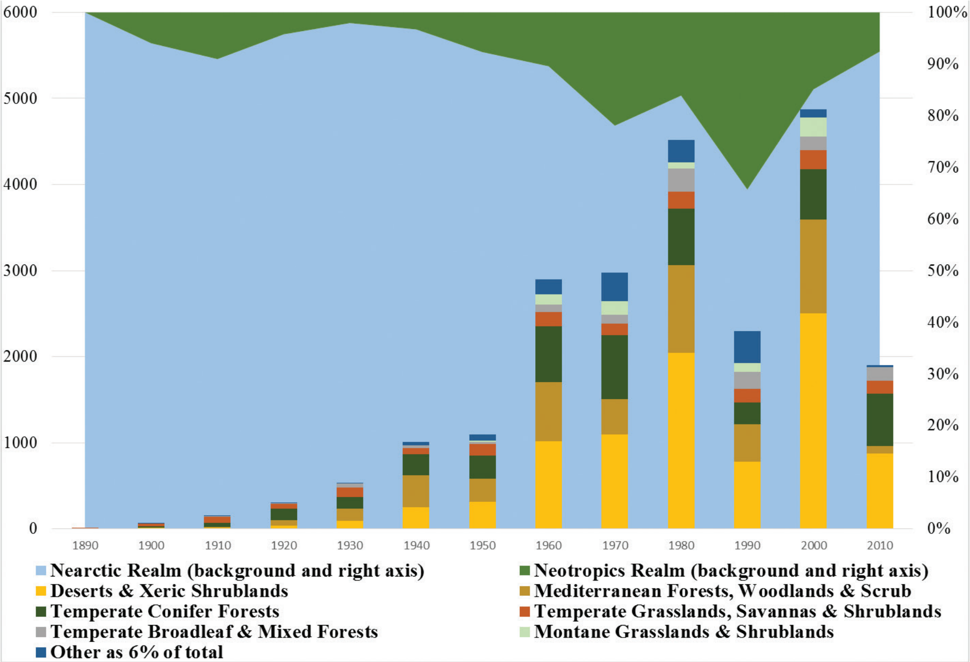

Figure 2. Collection intensity across decades by WWF Biomes and Realms. The following biomes comprised less than 3% each and were combined: Tropical and Subtropical Coniferous Forests, Tropical and Subtropical Dry Broadleaf Forests, Tropical and Subtropical Moist Broadleaf Forests, Tropical and Subtropical Grasslands, Savannas and Shrublands, Mangroves, Boreal Forests/Taiga, Rock and Ice, Tundra, and Flooded Grasslands and Savannas.

oped during the course of a species-level revision of the genus (Gonzalez and Griswold 2013). Most records come from specimens deposited in the first author's host institution or acquired on loan from multiple bee depositories, primarily in North America, but some from South American and European institutions (Fig. 3). Permitting issues limited access to some South American institutions. All such specimens were identified by V.H. Gonzalez and/or T. Griswold. Additional California records from Grigarick and Stange (1968) were captured for all species whose taxonomic concept was not modified in Gonzalez and Griswold (2013). Subsequent to identification, individual specimens were processed by a team of assistants at the USDA-ARS Bee Biology & Systematics Laboratory (BBSL). Individual specimens were entered into the US National Pollinating Insects Database (USNPID) using data entry forms where each specimen received a unique identifier (see below). These forms used authority files for bees, locations, collectors and plants. Where locations were not already georeferenced in the database they were georeferenced using Google Earth™ (http://earth.google.com/) or GEOlocate (http://www.museum.tulane.edu/geolocate/). Georeferencing used the form of decimal latitude and longitude in the WGS84 datum. Where georeferencing in the form of UTMs; township, range and section; or degree-minute-seconds was present

Table 1. Distribution and relative abundance of species of *Anthidium* by ecoregions in the Western Hemisphere. For a particular species, abundance on WWF designated ecoregion status was estimated as the percentage of specimen records occurring in those ecoregions over the total number of specimen records of that species.

Species	# of Ecoregions	# of specimens	Ecoregion Status		
			Critical or Endangered (%)	Vulnerable (%)	Relatively Stable or Intact (%)
A. adelphum	3	48	2	2	96
A. adriani	3	19	100	0	0
A. alsinai	1	1	0	100	0
A. andinum	4	10	20	80	0
A. anurospilum	3	22	0	18	82
A. atacamense	4	18	6	17	78
A. atrifrons	26	985	42	19	39
A. atripes	16	471	6	38	56
A. atripoides	3	127	0	0	100
A. aymara	4	13	23	69	8
A. aztecum	3	11	100	0	0
A. banningense	19	370	65	13	22
A. cafayate	3	4	0	100	0
A. calchaqui	3	8	0	100	0
A. chamelense	4	17	100	0	0
A. chilense	8	947	96	1	3
A. chubuti	6	15	67	0	33
A. clypeodentatum	25	177	45	18	37
A. cochimi	11	88	7	47	47
A. cockerelli	13	1169	1	6	93
A. collectum	16	730	47	50	4
A. colliguayanum	3	54	96	0	4
A. cuzcoense	2	8	88	13	0
A. dammersi	7	333	0	4	95
A. danieli	2	8	88	0	13
A. danunciae	1	5	0	100	0
A. decaspilum	5	34	24	3	74
A. deceptum	5	112	0	86	14
A. duomarginatum	6	210	8	0	92
A. edwardsii	15	369	63	31	6
A. edwini	3	13	92	0	8
A. emarginatum	14	505	40	7	53
A. espinosai	5	47	15	2	83
A. formosum	19	167	51	15	34
A. friesei	8	183	4	91	4
A. funereum	12	174	15	39	46
A. gayi	7	502	93	2	5
A. hallinani	9	137	93	7	0
A. igori	1	5	0	100	0
A. illustre	16	539	42	42	16

Species	# of Ecoregions	# of specimens	Ecoregion Status		
			Critical or Endangered (%)	Vulnerable (%)	Relatively Stable or Intact (%)
A. insignissimum	2	13	31	69	0
A. jocosum	14	422	15	15	69
A. kolla	2	9	0	100	0
A. labergei	2	38	0	95	5
A. larocai	1	1	0	100	0
A. latum	5	11	27	73	0
A. luizae	1	1	0	100	0
A. maculifrons	39	522	80	19	1
A. maculosum	35	1356	55	24	22
A. macushi	4	32	0	94	6
A. manicatum	23	635	53	3	44
A. mapuche	4	44	89	0	11
A. masunariae	1	2	100	0	0
A. meloi	1	5	0	100	0
A. michenerorum	4	16	94	0	6
A. mormonum	32	1612	51	15	35
A. multispinosum	1	1	0	100	0
A. neffi	1	1	100	0	0
A. nigerrimum	4	6	17	50	33
A. oblongatum	7	163	96	4	0
A. paitense	1	7	0	100	0
A. pallidiclypeum	8	181	14	34	52
A. palliventre	9	396	66	32	2
A. palmarum	17	984	7	12	81
A. parkeri	11	187	93	7	0
A. paroselae	9	563	0	3	97
A. penai	2	26	100	0	0
A. peruvianum	3	23	0	91	9
A. placitum	22	1034	30	19	51
A. platyfrons	1	3	0	0	100
A. porterae	18	982	41	31	27
A. psoraleae	7	17	88	0	12
A. quetzalcoatli	7	38	95	0	5
A. rafaeli	2	9	0	100	0
A. rodecki	6	411	21	1	79
A. rodriguezi	14	74	96	4	0
A. rozeni	1	1	0	100	0
A. rubripes	11	76	9	70	21
A. sanguinicaudum	4	8	13	88	0
A. schwarzi	9	104	12	61	28
A. sertanicola	1	1	0	100	0
A. sonorense	10	77	3	12	86
A. sparsipunctatum	4	90	3	97	0
A. spatulatum	2	41	2	0	98
A. tarsoi	1	2	0	100	0

Species	# of Ecoregions	# of specimens	Ecoregion Status		
			Critical or Endangered (%)	Vulnerable (%)	Relatively Stable or Intact (%)
A. tenuiflorae	41	1189	37	22	42
A. toro	2	65	0	22	78
A. utahense	29	2409	39	49	12
A. vigintiduopunctatum	9	41	24	76	0
A. vigintipunctatum	4	30	3	97	0
A. weyrauchi	1	11	0	100	0

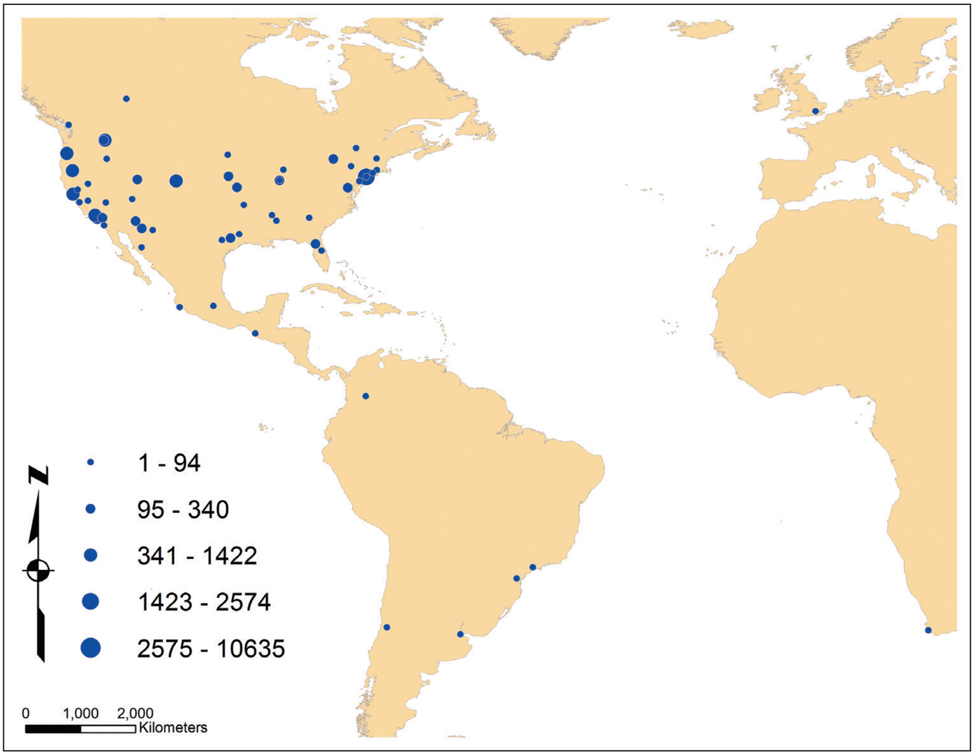

Figure 3. Location of 60 insect collections with number of specimens of *Anthidium* examined.

on the specimen label, these were transformed, but the original label georeferencing was captured in the location authority files. Records were analyzed geospatially using ArcGIS and WWF Biotic Regions. Twenty-two records (<0.1%) were excluded from biotic regions analysis due to questionable identification and/or label data.

Databasing processes for the USNPID have evolved over the 25 years since initiation. Processing, originally considered as too costly, has since been incorporated into the databasing process. Verbatim label data capture originally only for holotypes, was expanded first to loaned specimens and now to all retro-active data capture. When validity of entry fields is questioned, verbatim information is queried before pulling the specimen from the collection, saving both time and potential handling hazards.

Addition of that tracking data (*e.g.* date of record entry, date of record modification, logging of entry person) and use of authority tables were essential to data quality, yet amounted to negligible additional data capture costs.

The data underpinning the analysis reported in this paper are deposited at GBIF, the Global Biodiversity Information Facility, http://ipt.pensoft.net/ipt/resource.do?r=anthidium.

Taxonomic coverage

General taxonomic coverage description: The coverage of this dataset includes all 92 species of the bee genus *Anthidium* known to occur in the Western Hemisphere, including two that are introduced. *Anthidium* belongs to the tribe Anthidiini and is among the most diverse genera of the family Megachilidae. Based on the materials used in nest construction, anthidiines are broadly classed into two groups, carder bees and resin bees. While resin bees are generically diverse in the Western Hemisphere, *Anthidium* is the sole representative of carder bees in the Americas. As such this dataset documents all of a functional bee group for the Americas. The greatest number of data records are for two widespread western North American species, *A. utahense* Swenk (2409 records) and *A. mormonum* Cresson (1615 records) (Fig. 4).

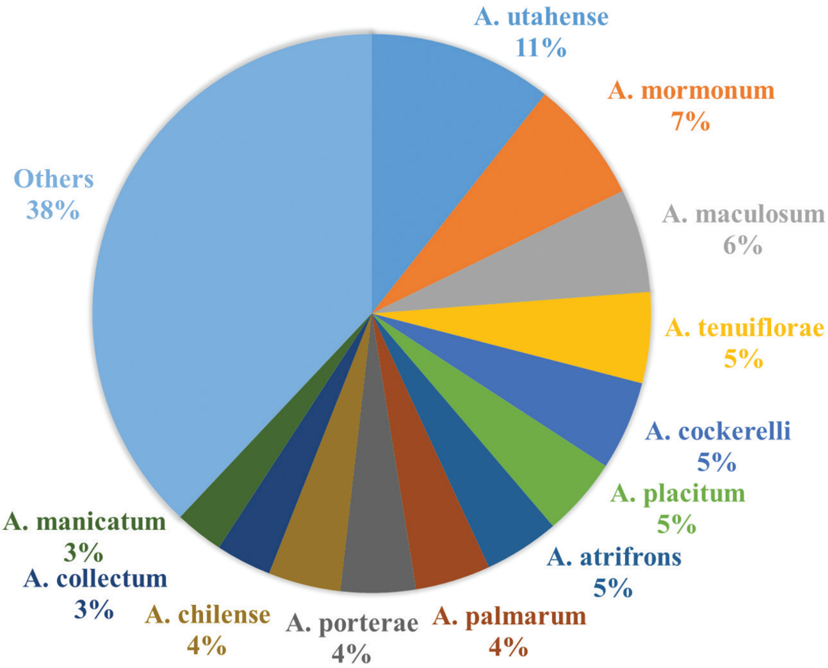

Figure 4. Percentage of specimen records per species of *Anthidium* in the AnthWest database. The category "Others" correspond to remaining species with specimen records accounting for less than 2%. All individual species shown except *A. chilense* are Nearctic.

Table 2. Species of *Anthidium* of the Western Hemisphere recorded from rare, threaten or endangered plants.

Plant species	Bee species	# of records
Asteraceae		
Erigeron rhizomatus Cronquist	*A. mormonum*	3
	A. duomarginatum	3
	A. maculosum	1
Cactaceae		
Sclerocactus mesae-verdae (Boissev. ex Hill & Salisb.) L.D. Benson	*A. emarginatum*	1
Pediocactus sileri (Boissev. ex Hill & Salisb.) L.D. Benson	*A. emarginatum*	1
Fabaceae		
Astragalus humillimus A. Gray	*A. dammersi*	2
Dalea formosa Torr.	*A. palmarum*	7

The species with the least number of records are *A. alsinai* Urban, *A. isabelae* Urban, *A. larocai* Urban, *A. luizae* Urban, *A. multispinosum* Gonzalez & Griswold, *A. neffi* Gonzalez & Griswold, and *A. rozeni* Urban, each represented by a single data record. Though these species are rare in collections, there is no knowledge whether they are rare in nature, though at least for *A. multispinosum*, it is likely that it has a restricted distribution. No *Anthidium* in the Western Hemisphere have formally been listed as threatened or endangered.

Anthidium are occasionally associated with rare, threaten or endangered plants. Only a handful of such associations with state and/or federally listed plant bee records are included in the dataset (Table 2). Published records provide georeference only to the nearest degree, and floral host, month and day fields will have information hidden.

All specimens in this dataset have been reviewed by the authors or are easily determined taxa that have been reviewed by experts in bee taxonomy (*e.g.*, John Ascher, for some AMNH material; A. A. Grigarick and L. A. Stange for California records in Grigarick and Stange 1968). Records with questionable determinations, label information or data have been withheld.

Taxonomic ranks

Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Hymenoptera
Family: Megachilidae
Genus: *Anthidium*
Common names: wool carder bees

Spatial coverage

General spatial coverage: This dataset includes species occurrences of bees in the genus *Anthidium* across the entire Western Hemisphere, from Alaska to southern Chile and southern Argentina, and from below sea level in Death Valley, California, USA, to 4700 m a.s.l. in Tucumán, Argentina. Within North America coverage is most complete for temperate regions, though diminishing diversity correlated with declining latitude cannot be ignored.

Coordinates

62° to 79° latitude and -174° to -22° longitude

Temporal coverage

Records in AnthWest span more than a century, from May 1886 to February 2012. The majority of the records are from the past four decades (Fig. 2). In temperate North America, here restricted to Canada and the United States, *Anthidium* is most active during the late spring and summer months; the majority of the records are for May through August. In alpine regions (> 3000m) the season is narrowed to May through September, but largely June through August, peaking in July.

Datasets

Dataset description: AnthWest is a result of a broadly comparative study on the diversity, biology, biogeography, and evolution of bees in the genus *Anthidium* in the Western Hemisphere. The dataset includes 22,648 occurrence records for 92 species of *Anthidium*, including two introduced species from Eurasia. Each record consists of the species name, locality, collector's name, collection date, latitude, longitude, host plants, associated organisms, name of identifier, taxonomic value (*i.e.*, type specimen, voucher, etc.), and repository. When coordinates for collection sites were not provided on the label, they were extracted using Google Earth™ (http://earth.google.com/) or GEOlocate (http://www.museum.tulane.edu/geolocate/). To guarantee the high quality of the data, most records in the dataset correspond to individual specimens examined by the authors during this project, representing 60 biodiversity collections in Europe, Africa, North and South America (Fig. 3). A small fraction (4.8%) of the occurrence records were extracted from the literature. Only literature records for which there was a high degree of certainty in the identification were included. The vast majority of these published records were taken from the rigorous study of California Anthidiini by Grigarick and Stange (1968). Their records were included for all *Anthidium* species except *A. atripes* and *A. emarginatum*, which in Gonzalez and Griswold (2013) are recognized as species complexes. The balance, 30 records of the introduced *A. manicatum* and *A. oblongatum* (Miller et al. 2002, Maier 2009, Tonietto and Ascher 2008), were included because these are distinctive species that could not be confused with any native species nor with each other.

As with most other bees, floral resources are essential for reproductive success of *Anthidium*. Floral records indicate a broad array of floral visitation based on the quarter (24%) of AnthWest records that include floral visits. While visitation includes 56 plant families and over 100 species, Fabaceae and Boraginaceae dominated the dataset, together accounting for 75% of the records (Fig. 5).

Analysis of plant records at the generic level similarly shows the dominance of Fabaceae and Boraginaceae; all top ten floral associations belong to these two families, but *Phacelia*, the most visited genus belongs not to Fabaceae but to Boraginaceae (Fig. 6).

Records for 34 name-bearing types of *Anthidium* are also included in the database.

Study extent: Because this dataset was developed as part of research that was focused on taxonomic revisionary work, sampling was not the focus of efforts; rather the data represents the aggregate of what we know about the distribution and behavior of *Anthidium* from existing material. Carder bees are diurnal, and are only active when temperatures are well above freezing and only during the growing season when floral resources are potentially available.

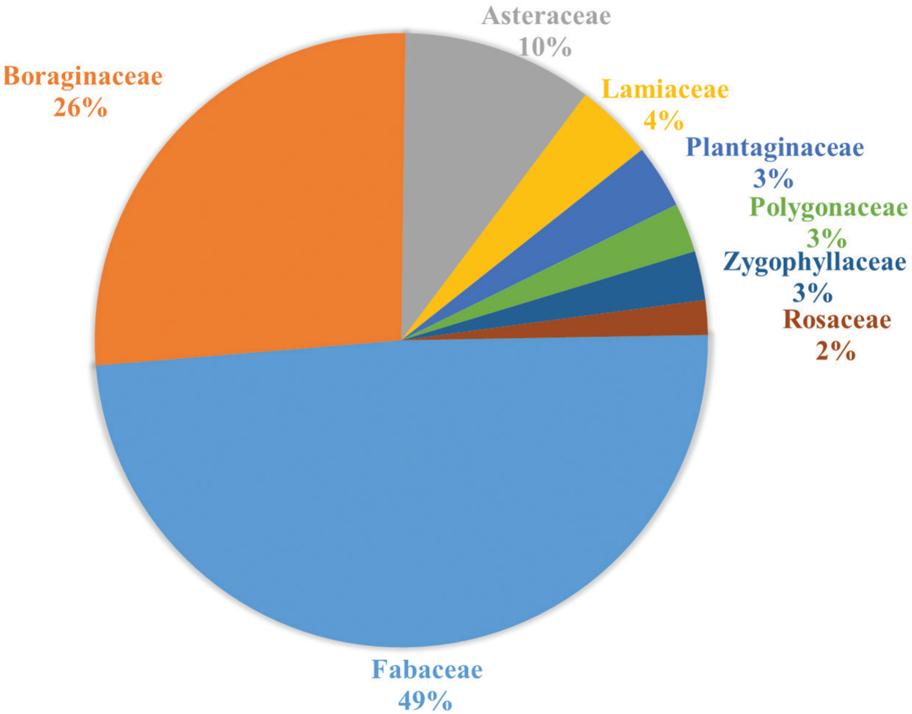

Figure 5. Plant families visited by *Anthidium* in the Western Hemisphere. Only families represented by at least 2% of the total 5358 floral visitation records in the database are shown.

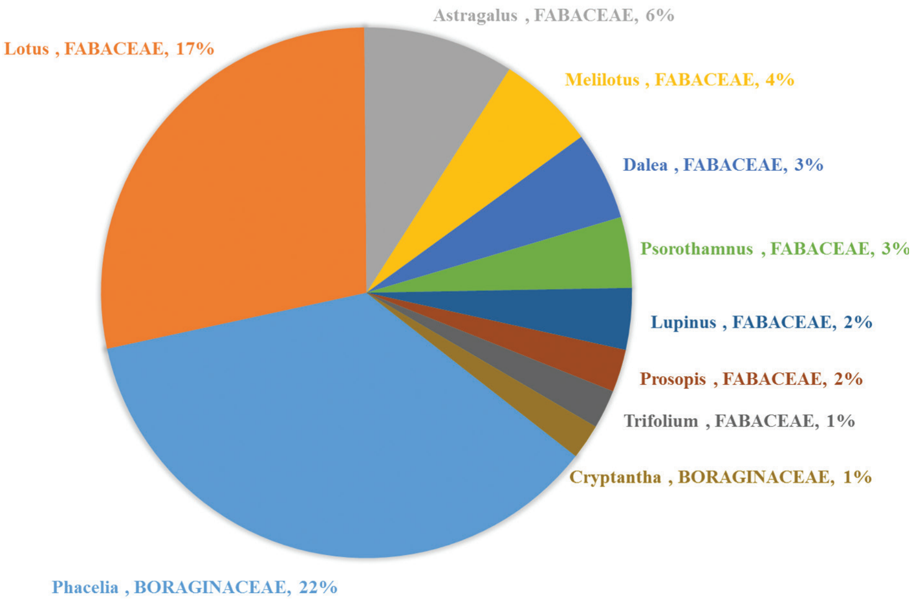

Figure 6. Percentage of plant records for the ten most visited plant genera (*n* = 5358 floral visitation records).

Sampling description: Specimen records captured in AnthWest are the result of: 1) non-systematic collections usually as part of general entomological collecting events or ones focused on bees in general; 2) standardized biodiversity surveys conducted by the USDA Pollinating Insects Research Unit using a combination of net and pan traps; 3) trap nest studies; and 4) specimens resulting from studies on pollination and reproductive biology of threatened or endangered plants.

Quality control: All individual specimens included in this dataset were examined during the course of the taxonomic revision using distribution maps and raw data following standardized protocols (Figs 7, 8). Records with questionable data on original insect labels were included in the dataset but distinguishable by notes in the DWC field "Identification Qualifier". These records were excluded from published distribution maps in the species-level revision of the genus (Gonzalez and Griswold 2013). A small fraction (4.8%) of the occurrence records were taken from the literature (see above), largely California records from a taxonomic treatment with some additional records for the two introduced species (*Anthidium manicatum* and *A. oblongatum*). These records are highlighted in the Darwin Core [DWC] fields "Associated References" and "Occurrence Remarks" as well as a denoted with a "PUB" prefix in the catalog number.

Step description: Two separate work flows were employed for data capture, which differed fundamentally on where in the process material was determined by the revisionary authors. Retroactive data capture (Fig. 7) incorporated loaned specimens, publication records, and previously non-databased specimens in the U.S. National Pollinating Insects Collection, all of which follows after the identification process. Publication records were treated similarly to retroactive data capture except each re-

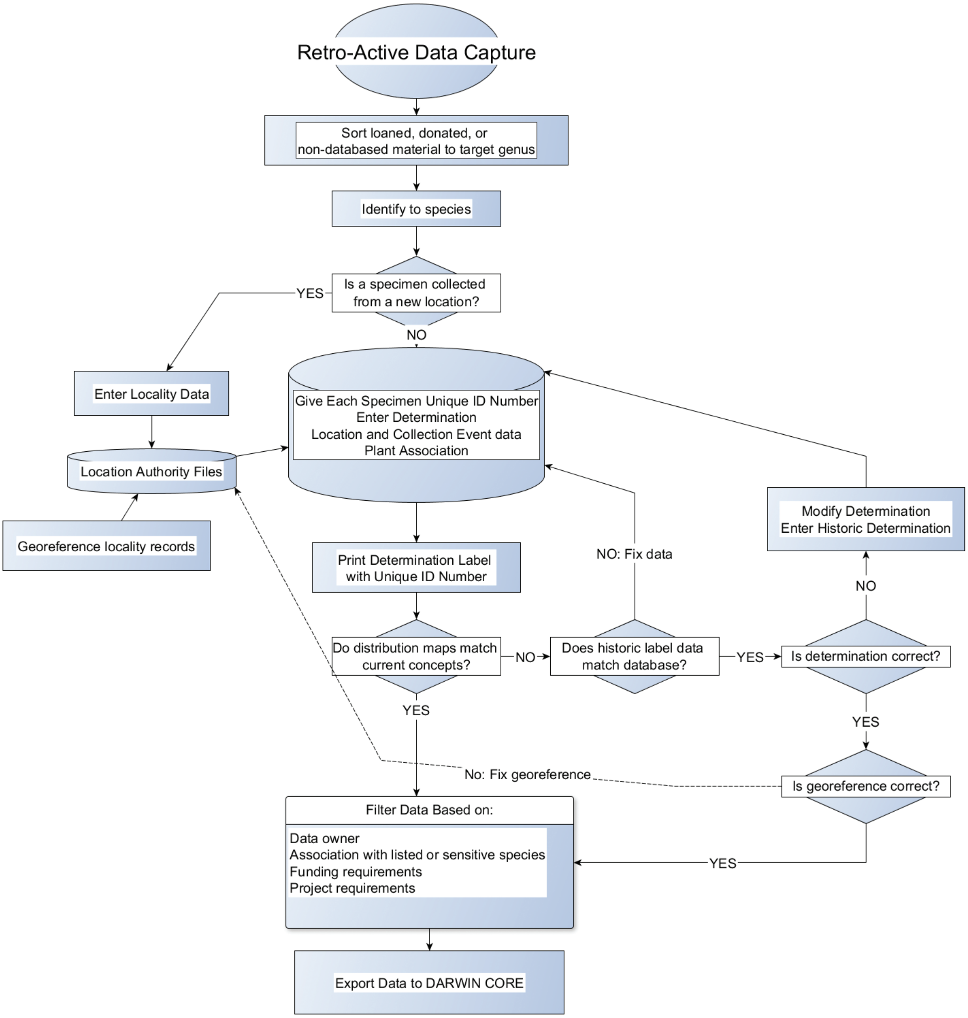

Figure 7. Flow chart for retroactive data capture of museum specimens.

cord represents a summation of males and females with identical collecting event data. Beginning in 2005, new specimen records (Fig. 8) were batch entered into the database for projects and opportunistic collection events alike. Specimen identification and subsequent update to the database occurred after record and event metadata had been entered. New specimen collections also had a work flow that resulted in a greater number of data quality checks by technicians and primary researchers.

Purpose: The purpose of this dataset is to make available data associated with bees of the genus *Anthidium* in the Western Hemisphere. The dataset was developed during the course of a species-level revision of the genus (Gonzalez and Griswold 2013). This dataset can potentially be used in species distribution and niche modeling studies, as well as in assessments of pollinator status and pollination services.

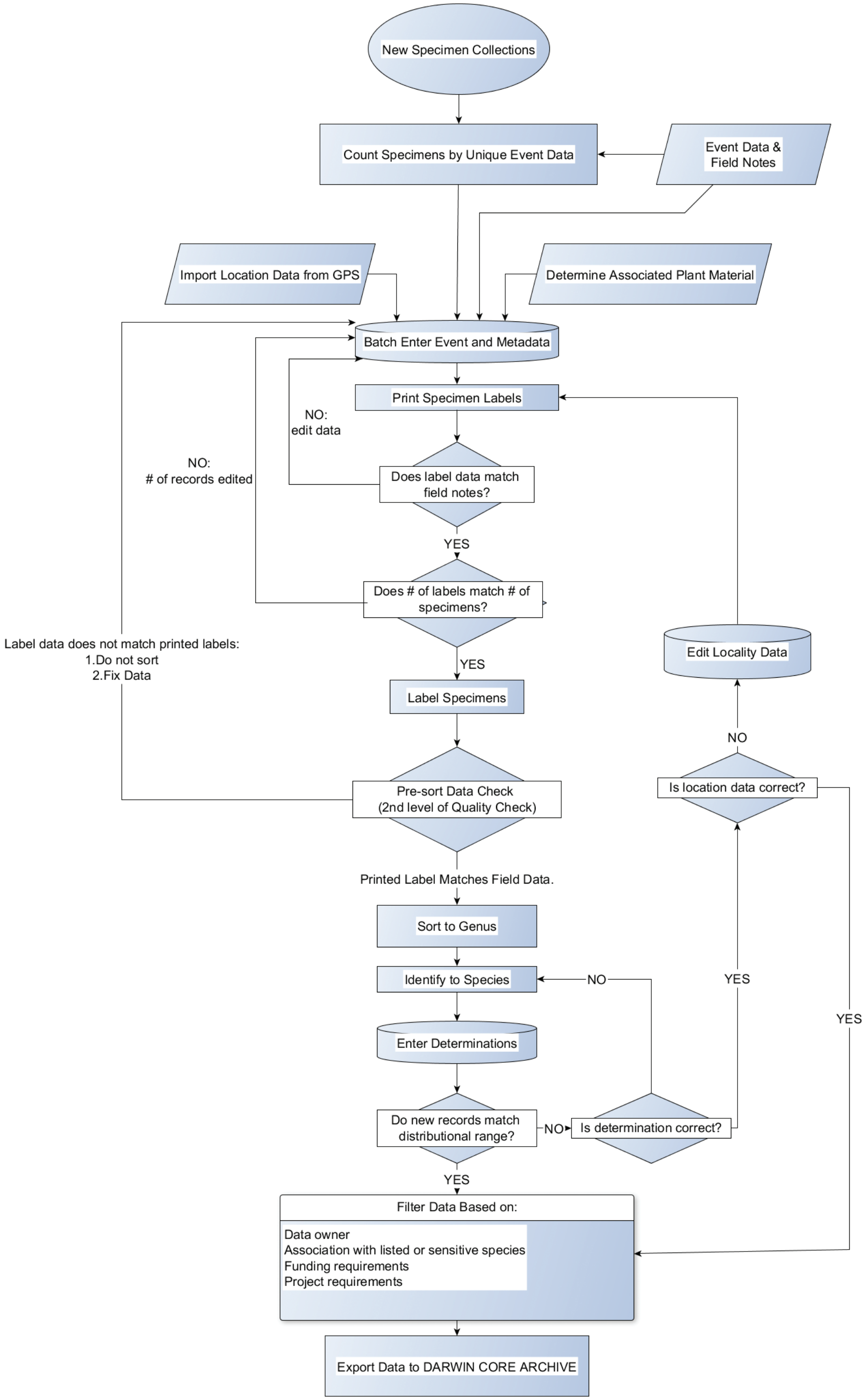

Figure 8. Flow chart for processing of new specimen samples.

IP Rights: Licenses of use: This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License. http://creativecommons.org/licenses/by-nc-sa/3.0/ Records highlighted in the Darwin Core [DWC] fields "rights" and "rightsholder" indicate specimens that have addition usage rights.

Collection Data: For all collections, including those not listed in the Global Registry of Biodiversity Repositories (www.grbio.org) the Institution code listed below is included in the DWC field "owner Institution Code".

AMNH	American Museum of Natural History, New York, New York, USA [2574 records]
ARDU	M. Arduser, Missouri Department of Conservation, St. Charles, Missouri [32 records]
ASUT	Arizona State University, Frank M.H. Natural History Museum, Tempe, Arizona, USA [145 records]
BBNP	Big Bend National Park, Big Bend, Texas, USA [7 records]
BBSL	USDA-ARS Bee Biology and Systematic Laboratory, Logan, Utah, USA [11123 records]
BNHM	British Natural History Museum, London, UK [19 records]
BYUC	Monte L. Bean Life Science Museum, Arthropod Collection, Provo, Utah, USA [105 records]
CAES	Connecticut Agriculture Experiment Station, New Haven, Connecticut, USA [30 records]
CAS	California Academy of Sciences, San Francisco, California, USA [637 records]
CEET	Colección de Insectos Asociados a Plantas Cultivadas en la Frontera Sur, El Colegio de la Frontera Sur, Tapachula, Chiapas, Mexico [1 record]
CIDA	College of Idaho, Museum of Natural History, Caldwell, Idaho, USA [25 records]
CNC	Canadian National Collection of Insects, Arachnids & Nematodes, Ottawa, Ontario, Canada [5 records]
CTMI	Central Texas Melittological Institute, Austin, Texas, USA [34 records]
CUIC	Cornell University Insect Collection, Ithaca, New York, USA [33 records]
DEVA	Death Valley National Park, Furnace Creek, California, USA [11 records]
DZUP	Departamento de Zoologia, Universidade Federal do Paraná, Curitiba, Brazil [16 records]
EBCC	Estación de Biología Chamela, Universidad Nacional Autónoma de Mexico, San Patricio, Jalisco, Mexico [24 records]
EMEC	Essig Museum of Entomology, University of California, Berkeley, California, USA [1173 records]
FCDA	Fresno County Department of Agriculture, Fresno, California, USA [3 records]
FMNH	Field Museum of Natural History, Chicago, Illinois, USA [7 records]
FSCA	Florida State Collection of Arthropods, Florida State University, Gainesville, Florida, USA [122 records]

GSENM	Grand Staircase-Escalante National Monument, Kanab, Utah, USA [12 records]
HNH_ent	Dartmouth College, Hanover, New Hampshire, USA [1 record]
INHS	Illinois Natural History Survey, Urbana, Illinois, USA [161 records]
LACM	Natural History Museum of Los Angeles County, Los Angeles, California, USA [1422 records]
MACN	Museo Argentino de Ciencias Naturales 'Bernardino Rivadavia', Buenos Aires, Argentina [36 records]
MEM	Mississippi Entomological Museum, Mississippi State University, Starkville, Mississippi, USA [6 records]
MEUC	Colección del Museo Entomológico Luis Peña, Departamento de Sanidad Vegetal, Universidad de Chile, Santiago, Chile [1 record]
SS; RR	Snelling and G.I. Stage personal collections; USA [9 records]
MZUSP	Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil [4 records]
NMNH	Smithsonian National Museum of Natural History, Washington, D.C., USA [340 records]
NVDA	Nevada State Department of Agriculture, Reno, Nevada, USA [17 records]
NYBG	New York Botanical Garden, New York, New York, USA [1 record]
OSAC	Oregon State Arthropod Collection, Corvallis, Oregon, USA [580 records]
PCYU	Packer's Apoidea Collection at York University, Toronto, Ontario, Canada [239 records]
PHIL	University of the Sciences in Philadelphia, Philadelphia, Pennsylvania, USA [32 records]
PINN	Pinnacles National Monument, Paicines, California, USA [6 records]
PMAE	Royal Alberta Museum, Edmonton, Alberta, Canada [12 records]
RUDZ	Rhodes University, Grahamstown, South Africa, [44 records]
SDNHM	San Diego Natural History Museum, San Diego, California, USA [94 records]
SDSU	Severin-McDaniel Insect Collection, South Dakota State University, Brookings, South Dakota, USA [48 records]
SEMC	Snow Entomological Museum, University of Kansas, Lawrence, Kansas, USA [246 records]
SFUC	Simon Fraser University, Burnaby, British Columbia, Canada [1 record]
SWRS	Southwestern Research Station, Portal, Arizona, USA [7 records]
TAMU	Texas A&M University Insect Collection, College Station, Texas, USA [101 records]
UAAM	University of Arkansas Arthropod Museum, Fayetteville, Arkansas, USA [4 records]
UAIC	University of Arizona Insect Collection, Tucson, Arizona, USA [150 records]
UCDC	R.M. Bohart Museum of Entomology, University of California, Davis, California, USA [658 records]
UCF	University of Central Florida Collection of Arthropods, Department of Biology, Orlando, Florida, USA [61 Records]

UCMC	University of Colorado Museum of Natural History, Boulder, Colorado, USA [762 records]
UCMS	University of Connecticut, Storrs, Connecticut, USA [38 records]
UCR	University of California, Riverside, California, USA [298 records]
UGCA	University of Georgia, Athens, Georgia, USA [68 records]
UNAB	Museo Entomológico, Departamento de Agronomía, Universidad Nacional de Colombia, Bogotá, Colombia [1 record]
UNAM	Museo de Zoología Alfonso L. Herrera, Facultad de Ciencias, Universidad Nacional Autónoma de México, Mexico [33 records]
UNSM	University of Nebraska State Museum, Lincoln, Nebraska, USA [111 records]
USON	Universidad de Sonora, Hermosillo, Sonora, Mexico [1 record]
WFBM	W.F. Barr Entomological Collection, University of Idaho, Moscow, Idaho, USA [639 records]
WSU	Maurice T. James Entomological Collection, Washington State University, Pullman, Washington, USA [110 records]
ZAVOR	Zavortink Private Collection, Davis, California, USA [14 records]

Specimen preservation method and curatorial units: Records represent pinned, dried adult individuals with attached label data stored in most cases in standard insect museum drawers preserved from dermestid damage by routine freezing of drawers at -20 C. Reviewed *Anthidium* specimens followed the basic process for Hymenoptera preservation and labeling outlined in Huber (1998). Newly collected BBSL specimens are given catalog numbers during initial labeling. Material sent for identification and loans were given unique catalog numbers after final identification and data entry.

Object name: Darwin Core Archive Wool carder bees of the genus *Anthidium* in the Western Hemisphere
Character encoding: UTF-8
Format name: Darwin Core Archive format
Format version: 1.0
Distribution: http://ipt.pensoft.net/ipt/archive.do?r=anthidium
Publication date of data: 2013-03-25
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RESEARCH ARTICLE

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Umashtanchaeviella plethotricha, a new genus and species of the family Tetracondylidae (Acari, Oribatida)

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http://zoobank.org/78453BDB-E029-4C45-925C-0E608B414DE0

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Abstract

A new genus of oribatid mites of the family Tetracondylidae, *Umashtanchaeviella* **gen. n.**, with type species *Umashtanchaeviella plethotricha* **sp. n.**, is proposed and described from forest litter, the Bu Gia Map National Park, southern Vietnam. The new genus is distinguishable from other otocepheoid genera by the presence of notogastral plethotrichy[1].

Keywords

Oribatida, Tetracondylidae, new genus, new species, Vietnam

Introduction

Tetracondylidae Aoki, 1961 (Acari, Oribatida, Otocepheoidea) is the large family of oribatid mites, comprising 24 genera, 3 subgenera, 297 species and 11 subspecies, which are distributed in the Pantropical and Subtropical regions (Subías 2004, online version 2014).

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[1] See van der Hammen (1980).

The main morphological characters of the subfamily Tetracondylinae were provided by Aoki (1961, 1967). The indentification keys to the many genera and species of tetracondylid mites were presented by Balogh and Balogh (1992, 2002, respectively).

During our studies of the oribatid mite fauna of Bu Gia Map National Park in southern Vietnam, we discovered a species of Tetracondylidae, representing as new genus, *Umashtanchaeviella* gen. n. and *Umashtanchaeviella plethotricha* sp. n.

Material and methods

Holotype (male) and paratype (male) of *Umashtanchaeviella plethotricha* sp. n. were obtained from southern Vietnam, Binh Phuoc Province, Bu Gia Map National Park, 12°11'N, 107°12'E, 601 m a.s.l., Dipterocarp forest (*Dipterocarpus costatus*), litter (sifting), 13.XI.2013 (collected by A.E. Anichkin and S.G. Ermilov). Specimens are stored in 70% ethanol (omit in tubes).

The soil litter was collected by taking 16 samples using a stainless frame (50 × 50 cm) and passed through a sifter with the mesh size 2 × 2 cm. The fine fraction was placed in a Winkler extractor with a collection bottle containing 100 ml with 75% ethanol. The extractions were conducted at room temperature for more than 20 days.

Holotype and paratype were mounted in lactic acid on temporary cavity slides for measurement and illustration. The body length was measured in lateral view, from the tip of the rostrum to the posterior edge of the ventral plate. The notogastral width refers to the maximum width in dorsal aspect. Lengths of body setae were measured in lateral aspect. All body measurements are presented in micrometers. Formula for leg setation is given in parentheses according to the sequence trochanter–femur–genu–tibia–tarsus (famulus included). Formula for leg solenidia is given in square brackets according to the sequence genu–tibia–tarsus. General terminology used in this paper follows that of Aoki (1965) and Norton and Behan-Pelletier (2009).

Description of a new genus and a new species

Family Tetracondylidae

Genus *Umashtanchaeviella* gen. n.

http://zoobank.org/091A7AA9-A6DE-4750-92AF-DB9B9D2887C6
http://species-id.net/wiki/Umashtanchaeviella

Diagnosis. Rostral, lamellar, interlamellar, notogastral and ventral setae setiform. Lateral prodorsal and lateral notogastral condyles of medium size, normally developed. Notogaster with 10 pairs of well developed setae and numerous plethotrichial setae. Ventral neotrichy absent (epimeral formula: 3–1–3–3; anogenital formula: 4–1–2–3). Pedotecta II rectangular. Adanal lyrifissures *iad* located nearly to the anal plates.

Type species. *Umashtanchaeviella plethotricha* sp. n.

Etymology. The specific name is dedicated to our colleague, the acarologist Dr. Umukusum Ya. Shtanchaeva (Universidad Complutense de Madrid, Madrid, Spain), for her extensive contributions to our knowledge of oribatid mites.

Remarks. *Umashtanchaeviella* gen. n. can clearly be distinguished from all the other genera of Otocepheoidea by the following apomorphic character: presence of strong (more 250 pairs) notogastral plethotrichy (versus notogastral plethotrichy absent).

The new genus is most similar to representatives of the genera *Hydroecocepheus* Corpuz-Raros, 1979 (see Corpuz-Raros 1979), *Neotrichocepheus* Hammer, 1973 (see Hammer 1973), *Trichocondyla* J. et P. Balogh, 1986 (see J. et P. Balogh 1986) (all three from Tetracondylidae), and *Megalotocepheus* (*Archegotocepheus*) Mahunka, 1988 (see Mahunka 1988), *Trichotocepheus* Aoki, 1965 (see Aoki 1965) (both from Otocepheidae) by presence of body neotrichy, however, it can be distinguished from the genera listed above by the localization (notogaster versus ventral side), number (more than 250 pairs versus less than 20 pairs) and morphology (short, thin versus normally developed) of neotrichial setae.

Umashtanchaeviella plethotricha sp. n.

http://zoobank.org/7EF674D2-0EAC-4E9F-9AFA-82ACC1782CD8
http://species-id.net/wiki/Umashtanchaeviella_plethotricha
Figures 1–7

Diagnosis. With character states of *Umashtanchaeviella* gen. n. as listed above. Body surface microfoveolate and microgranulate; surface of dorsal part of prodorsum, lateral sides of notogaster, anterior part of epimere I, anogenital region and anal plates tuberculate. Genital plates striate. Rostral, lamellar and interlamellar setae long, barbed. Bothridial setae with long stalk and short, weakly developed, lanceolate, head. Exobothridial setae short. Medial prodorsal and notogastral condyles absent; lateral prodorsal and notogastral condyles triangular. Ten pairs of notogastral setae setiform, barbed. More than 250 pairs of short, thin plethotrichial setae on notogaster. Epimeral and anogenital setae setiform, barbed. Adanal setae ad_1 shorter than ad_2, ad_3. Lyrifissures *iad* located in paraanal position. Formula for leg setae *u*: L–S–S–S.

Description. *Measurements*. Body length 614 (holotype), 630 (paratype); body width 348 (holotype), 365 (paratype).

Integument. Body color light brown. Body surface densely microfoveolate (diameter of foveolae less than 1) and microgranulate (granules elongate, length less than 1). Surface of dorsal part of prodorsum, lateral sides of notogaster, anterior part of epimere I, anogenital region and anal plates tuberculate (*tub*, diameter of tubercles up to 6). Genital plates with thin and numerous stria.

Prodorsum. Rostrum widely rounded. Costulae (*cos*) well developed, reaching the insertions of lamellar setae and protruding anteriad. Rostral (*ro*, 77–82), lamellar (*le*, 77–82) and interlamellar (*in*, 155–164) setae setiform, barbed. Bothridial

Figure 1. *Umashtanchaeviella plethotricha* sp. n., adult: dorsal view. Scale bar 100 µm.

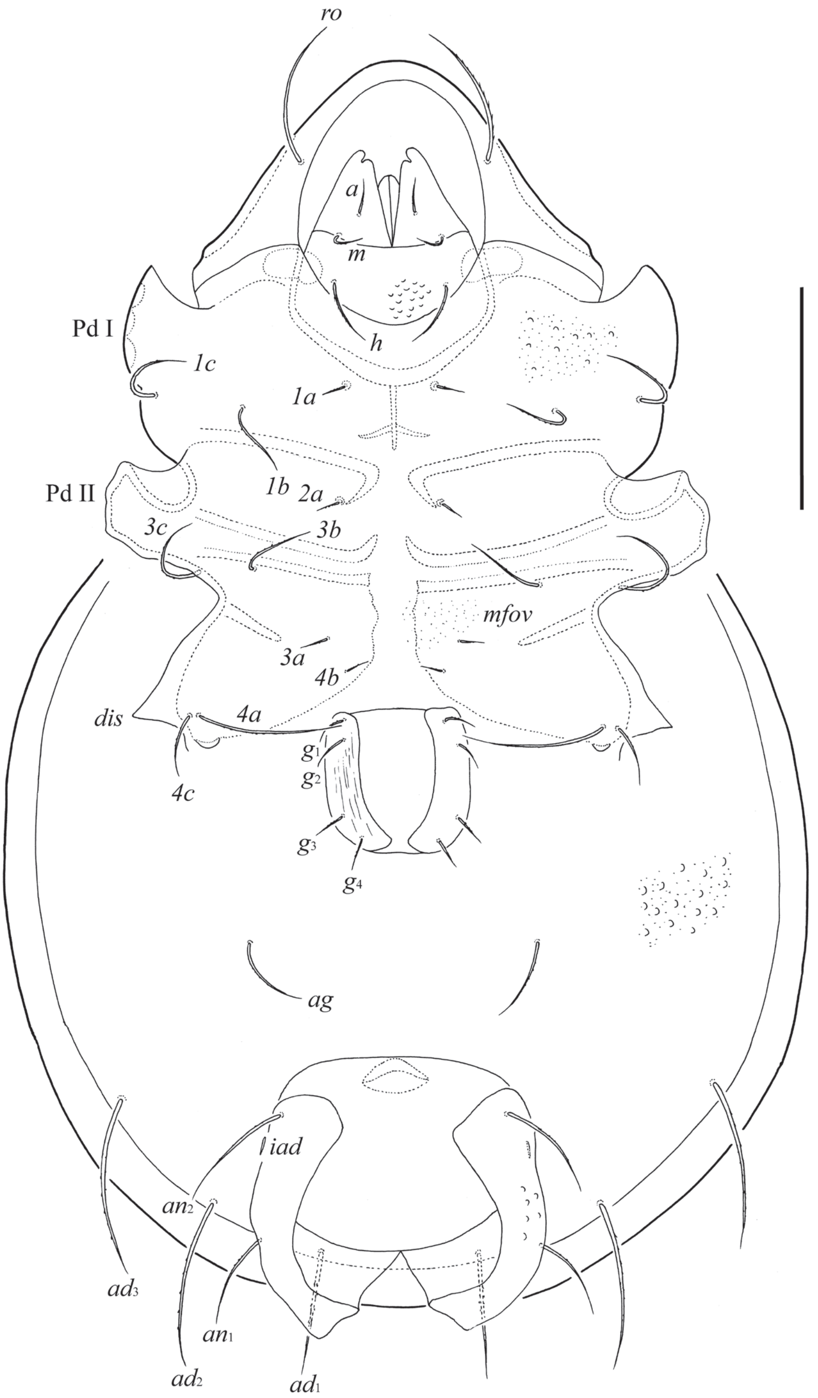
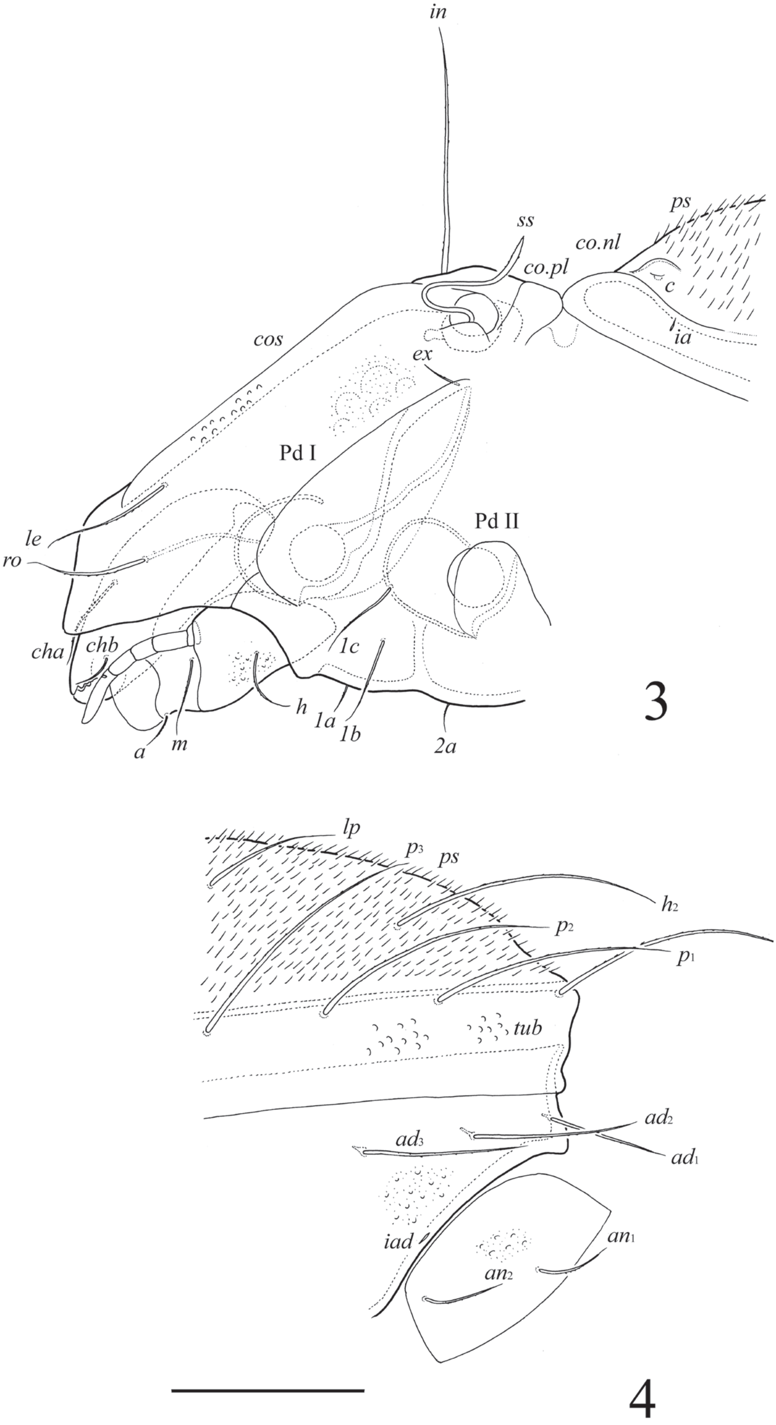
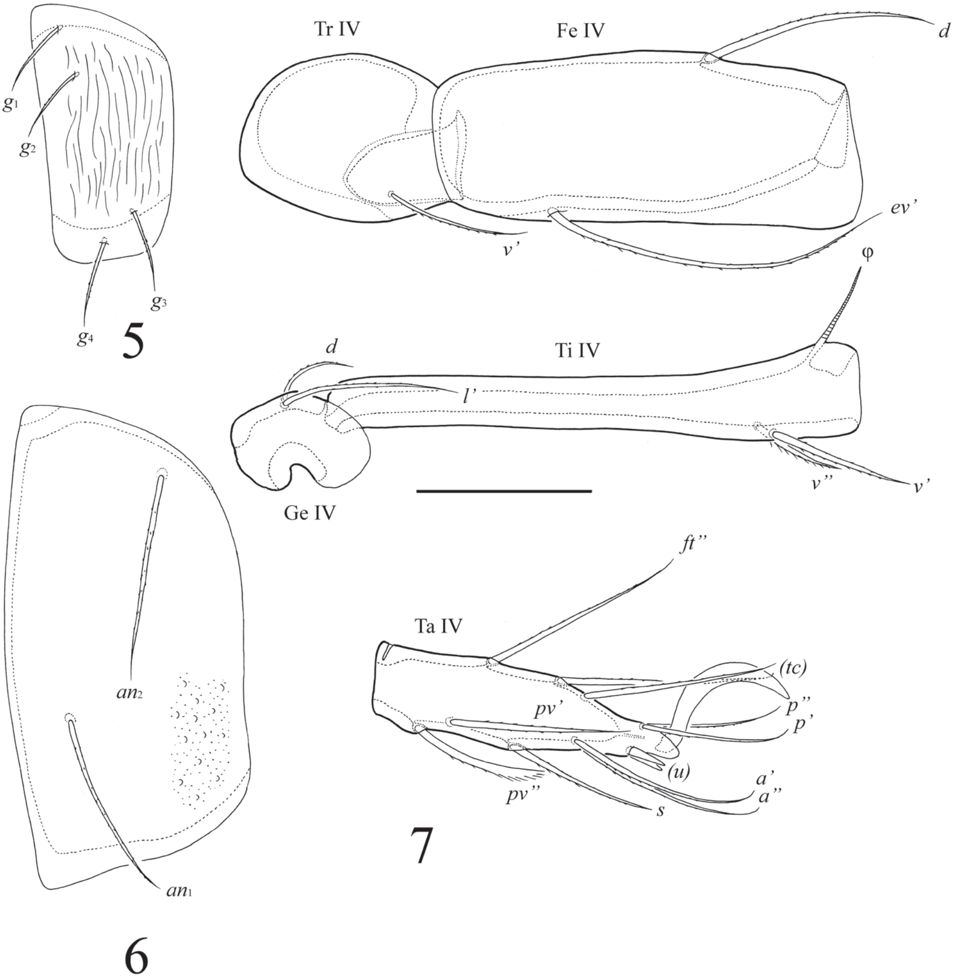


Figure 2. *Umashtanchaeviella plethotricha* sp. n., adult: ventral view (legs not shown). Scale bar 100 µm.



Figures 3–4. *Umashtanchaeviella plethotricha* sp. n., adult: **3** prodorsum and anterior part of notogaster, lateral view (palp setae not shown) **4** posterior view of notogaster, lateral view. Scale bar 100 µm.



Figures 5–7. *Umashtanchaeviella plethotricha* sp. n., adult: **5** genital plate, left **6** anal plate, left **7** leg IV, left, antiaxial view. Scale bar 50 μm.

setae (*ss*, 155–164) with long stalk and short, weakly developed, lanceolate, indistinctly barbed head. Exobothridial setae (*ex*) shortest (20), thin, slightly barbed. Medial prodorsal condyles absent. Lateral prodorsal condyles (*co.pl*) triangular, rounded distally.

Notogaster. Medial notogastral condyles absent. Lateral notogastral condyles (*co.nl*) large, triangular, rounded distally, connected to lateral prodorsal condyles. Notogaster has a normal complement of typical, identifiable setae, but with an underlying plethotrichy of minute setae. Ten pairs of notogastral setae well developed, setiform, barbed; medial setae *la*, *lm* shorter (73–86) and thinner than other setae (164–176). Distance between setae h_1–p_1 longer than p_1–p_2. Plethotrichial setae (*ps*, more 250 pairs) short (12), thin, straight, smooth, set on small tubercles (insertions of setae visible in high

Table 1. Leg setation and solenidia of adult *Umashtanchaeviella plethotricha* sp. n.

Leg	Trochanter	Femur	Genu	Tibia	Tarsus
I	*v’*	*d*, (*l*), *bv”*	(*l*), *v’*, σ	(*l*), (*v*), φ_1, φ_2	(*ft*), (*tc*), (*it*), (*p*), (*u*), (*a*), *s*, (*pv*), *e*, ω_1, ω_2
II	*v’*	*d*, (*l*), *bv”*	(*l*), *v’*, σ	*l’*, (*v*), φ	(*ft*), (*tc*), (*it*), (*p*), (*u*), (*a*), *s*, (*pv*), ω_1, ω_2
III	*l’*, *v’*	*d*, *l’*, *ev’*	*l’*, σ	(*v*), φ	(*ft*), (*tc*), (*it*), (*p*), (*u*), (*a*), *s*, (*pv*)
IV	*v’*	*d*, *ev’*	*d*, *l’*	(*v*), φ	*ft”*, (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*)

Roman letters refer to normal setae (*e* to famulus), Greek letters to solenidia. Single prime (‘) marks setae on anterior and double prime (“) setae on posterior side of the given leg segment. Parentheses refer to a pseudosymmetrical pair of setae.

magnification). Lyrifissures *ia*, *im* and opisthonotal gland openings (*gla*) distinct; *ip*, *ih*, *ips* indistinctly developed.

Gnathosoma. Morphology of subcapitulum, palps and chelicerae typical for most Tetracondylidae (for example, see Ermilov et al. 2010; Ermilov and Kalúz 2013). Subcapitulum longer than wide (139 × 86). Subcapitular setae setiform, slightly barbed; *a* (20) shorter than *m* and *h* (both 36–41). Adoral setae and their alveoli absent. Palps (86) with setation 0–2–1–3–8(+ω). Solenidion pressed to the palptarsus surface in medio-basal part and distal seta in distal part. Chelicerae (139) with two barbed setae; *cha* (49) longer than *chb* (24). Trägårdh’s organ distinct.

Epimeral and lateral podosomal regions. All apodemes (1, 2, sejugal, 3) well visible, Apodemes 4 absent. Epimeral setae setiform, slightly barbed. Setae *1a*, *2a*, *3a*, *4b* shortest (16–20); *4c* (36–41) and *1b*, *1c*, *3b*, *3c* (49) longer; *4a* longest (65–69). Pedotecta I (Pd I) and II (Pd II) well developed. Discidia (*dis*) triangular, pointed anteriorly.

Anogenital region. Four pairs of genital (g_1–g_4, 20–24), one pair of aggenital (*ag*, 41–45), three pairs of adanal (ad_1, 65; ad_2, ad_3, 90–94) and two pairs of anal (an_1, an_2, 49–57) setae setiform, barbed. Adanal setae ad_1 located in postanal position, ad_2, ad_3 in adanal position. Distance between setae ad_3–ad_3 longer than ad_2–ad_2 and ad_1–ad_1. Lyrifissures *iad* short, located in paraanal position.

Legs. Claw of each tarsus smooth. Tarsi without teeth. Formulae of leg setation and solenidia: I (1–4–3–4–16) [1–2–2], II (1–4–3–3–15) [1–1–2], III (2–3–1–2–15) [1–1–0], IV (1–2–2–2–12) [0–1–0]; homology of setae and solenidia as indicated in Table 1. Morphology of leg segments, setae and solenidia typical for Tetracondylidae (for example see Ermilov et al. 2010; Ermilov and Kalúz 2013). Leg setae *u* setiform (L-type) on tarsi I and thorn-like on tarsi II–IV (S-type).

Type deposition. The holotype is deposited in the collection of the Zoological Institute of the Russian Academy of Sciences, St. Petersburg, Russia; one paratype is in the collection of the Tyumen State University Museum of Zoology, Tyumen, Russia.

Etymology. The specific name *plethotricha* refers to the presence of plethotrichial setae on notogaster.

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A peculiar cave species of *Tomocerus* (Collembola, Tomoceridae, Tomocerinae) from Vietnam, with a discussion of the postantennal organ and prelabral chaetae in Tomocerinae

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Abstract

The first *Tomocerus* species with a postantennal organ (PAO) in the adult stage is described from Vietnam. *Tomocerus postantennalis* **sp. n.** differs from the other PAO-possessing tomocerid, *Tomolonus reductus* Mills, 1948, mainly in the morphology of PAO, the number of ocelli, the number of chaetae in trochantero-femoral organ and several features of the furca. The new species is placed in *Tomocerus* because of the presence of a toothlet on the outer basal mucronal tooth and the absence of the diagnostic character states of *Plutomurus* Yosii, 1956 and *Aphaenomurus* Yosii, 1956. Besides the presence of PAO, the new species is peculiar in having six prelabral chaetae, instead of four as in other *Tomocerus* species. The new species is similar to *Tomocerus folsomi* Denis, 1929 and *Tomocerus ocreatus* Denis, 1948 in the type of dental spines but different from them in the body colour, the relative length of antennae to body, the number of unguis inner teeth and the number of mucronal intermediate teeth.

Keywords

New species, Southeast Asia, taxonomy, *Tomocerus folsomi*, *Tomocerus ocreatus*, *Tomolonus*

Introduction

In Collembola, PAO is a paired organ located dorsally on the head, behind the antennae. It is probably a sensory organ of smell, humidity or temperature (Altner and Thies 1976). In some group, e.g. Onychiuridae and Neanuridae, PAO is morphologically diversified and highly important for taxonomy (Hopkins 1997). In contrast, most Entomobryomorpha have this organ poorly developed (e.g. Isotomidae) or absent (e.g. most Entomobryidae, Tomoceridae, Paronellidae and Cyphoderidae).

PAO in Tomocerinae was firstly recorded by Mills (1948) in a new genus and species, *Tomolonus reductus* Mills, 1948. Goto (1956) showed that PAO is present in the first instar of *Pogonognathellus longicornis* (Müller 1776) but disappears in subsequent instars. Christiansen (1964) claimed this organ did not always appear in all specimens of *Tomolonus reductus* and accordingly rejected the generic state of *Tomolonus*, but later studies (Yosii 1967, Rusek 1977) supported Mills' original position.

Until now, the only known species of Tomocerinae with PAO in the mature stage was *Tomolonus reductus*, from North America. The purpose of this paper is to describe a second species of this subfamily with well developed PAO, based on material from Vietnam.

Materials and methods

All type specimens were collected in caves with aspirators. After being photographed with a Jenoptik ProgRes C10+ camera mounted on a Leica MZ 16 stereomicroscope, specimens were cleared in lactic acid and mounted in Marc André II solution. The head, furca and legs were cut off from the trunk and mounted separately for detailed observation. The slide-mounted specimens were studied using a Leica DMLB microscope.

The pattern of dorsal cephalic chaetotaxy used here is modified from that Wang et al. (2013): the two posterior macrochaetae placed in the postocular area by these authors (Figure 2F in Wang et al. 2013) are here considered to belong instead to the posterior area. We follow Fjellberg (2007) for maxilla lamellae numbering and Christiansen (1964) for macrochaetotaxy. The dental spine formula follows that of Folsom (1913), in which the dental spines are arranged from basal to distal, with a slash indicating the separation between basal and medial subsegments and the Roman numerals referring to spines that are noticeably larger.

Abbreviations

Ant.: antennal segment; PAO: postantennal organ; Th.: thoracic segment; Abd.: abdominal segment. Institutional acronyms: NJAU, Nanjing Agricultural University, Nanjing, China; MNHN, Muséum national d'Histoire naturelle, Paris, France.

Taxonomy

Tomocerus postantennalis sp. n.

http://zoobank.org/D2015E75-AF28-4A47-9FC2-7AC6D0568FD4
http://species-id.net/wiki/Tomocerus_postantennalis
Figs 1–18

Type locality. Vietnam, Tuyen Quang Province: Na Hang, Khuoi Sung, Hang Khuoi Sung, in cave, 22.5013°N, 105.3649°E, 24 Dec. 2003, Louis Deharveng and Anne Bedos leg.

Type specimens. Holotype female and three paratype females on slides, labelled with collectors' sample number Vn0312-56. Deposited in MNHN (holotype and two paratypes) and NJAU (one paratype).

Description. Body length 3.4–4.3 mm. Body with diffuse dark pigment all over; Ant. II, base of Ant. III and ventral side of Ant. I darker than other parts of antenna; eye patches black and small; clypeus, antero-dorsal region and posterior margin of head darker than other parts of head; anterior half of trunk darker than posterior half; head and trunk with bilaterally symmetrical white pattern formed by numerous unpigmented patches (Fig. 1).

Antenna longer than body, Ant. IV lost, Ant. I:II:III ≈ 1.0:1.8:21.0, Ant. I and II dorsally scaled, Ant. III unscaled. Antennal chaetae poorly preserved and not studied. PAO oval, with thickened inner margin, its long axis as long as the diameter of anterior ocelli (Fig. 2). Ocelli 6+6, anterior two larger than others (Figs 2, 3). Prelabral chaetae 3+3; labral chaetotaxy 5, 5, 4, distal four chaetae stronger, anterior margin of labrum with four papillae (Fig. 4). Mandibular head asymmetrical, left mandible with four teeth, right mandible with five teeth, molar plate of left mandible distally with a cone-like tooth (Fig. 5). Basal teeth of maxillary lamella 5 prolonged, distinct beard absent (Fig. 6). Mentum (baso-lateral area of labium) with 5 smooth chaetae, other parts of labium not clearly seen. Cephalic dorsal chaetotaxy: anterior area 2, 2; interocular area 2, 0, macrochaetae absent along transverse medial line; postocular area 2+2; posterior area 1+1; posterior margin with about 30+30 short chaetae (Fig. 3). Head scaled both dorsally and ventrally.

Trochanteral-femoral organ with 1, 1 chaetae (Fig. 7); fore, middle and hind tibiotarsi ventrally with 6–7, 5, 5 spine-like chaetae (Fig. 8). Distal whorl of tibiotarsus with 11 chaetae, tenent hair thin and probably pointed (judging from its small socket), two small accessory chaetae beside tenent hair larger than pretarsal chaetae, sockets of two outer guard chaetae larger than tenent hair (Fig. 9). Unguis slender, with baso-internal ridging, two lateral teeth pointed, of moderate size; inner edge of unguis with one basal and one distal tooth, the distal tooth at about one third of the length of unguis from base. Unguiculus length 0.50–0.67 that of unguis, with one inner tooth larger than ungual teeth (Fig. 10). Scales present on all segments except pretarsus of all legs.

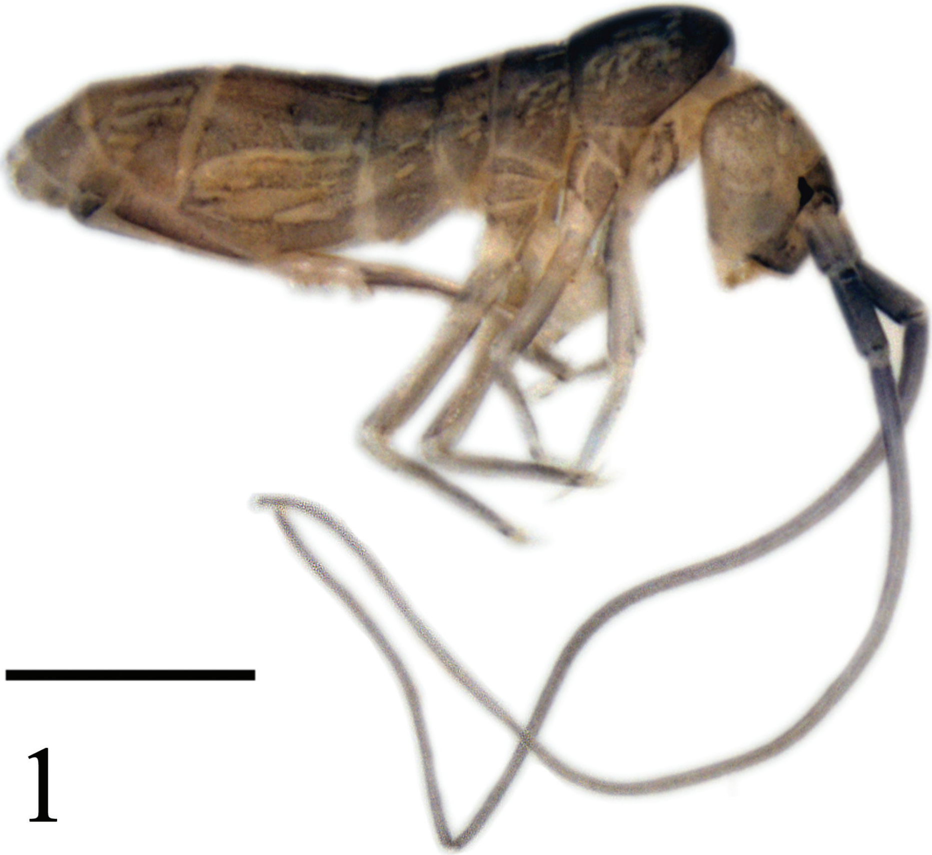
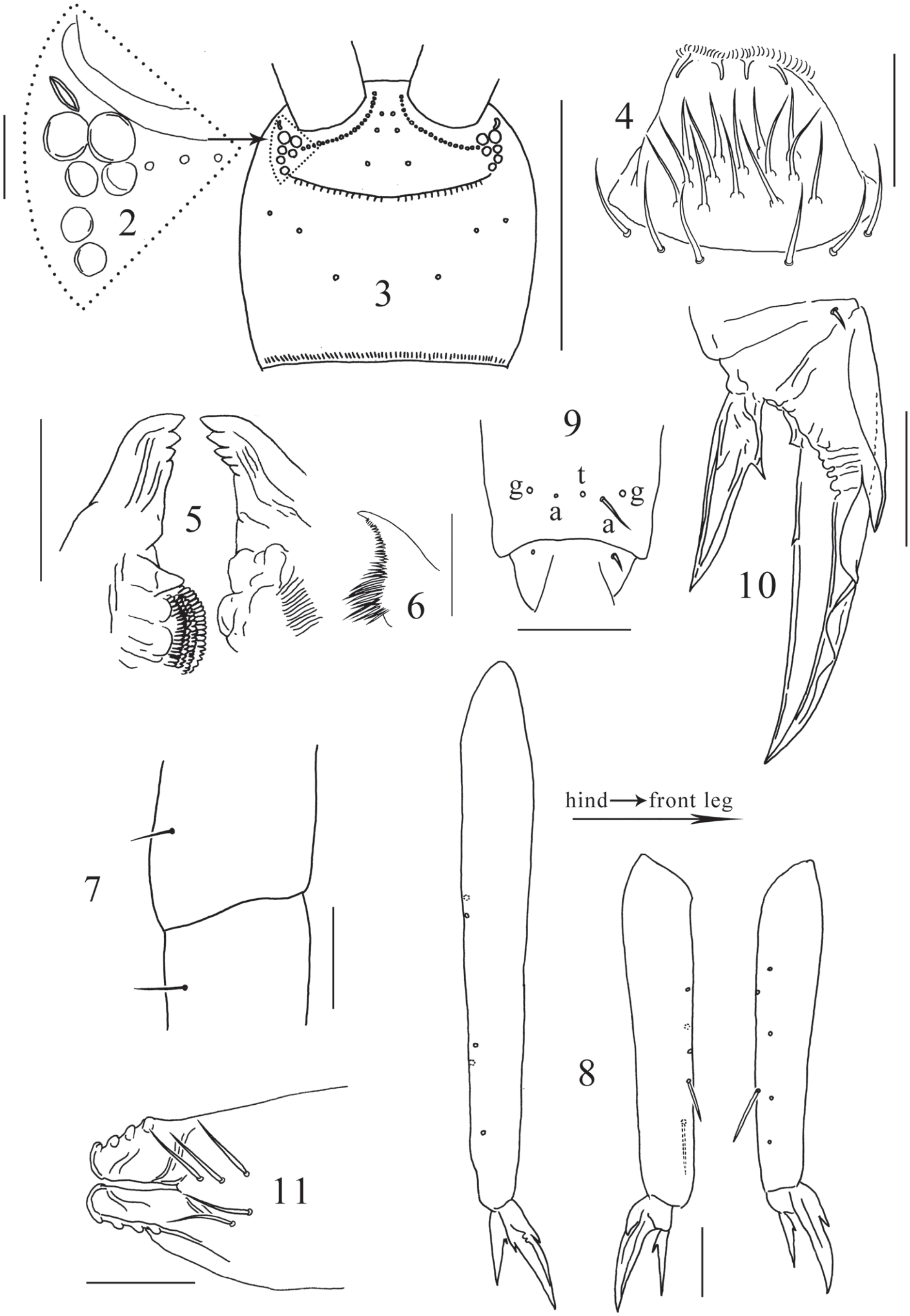


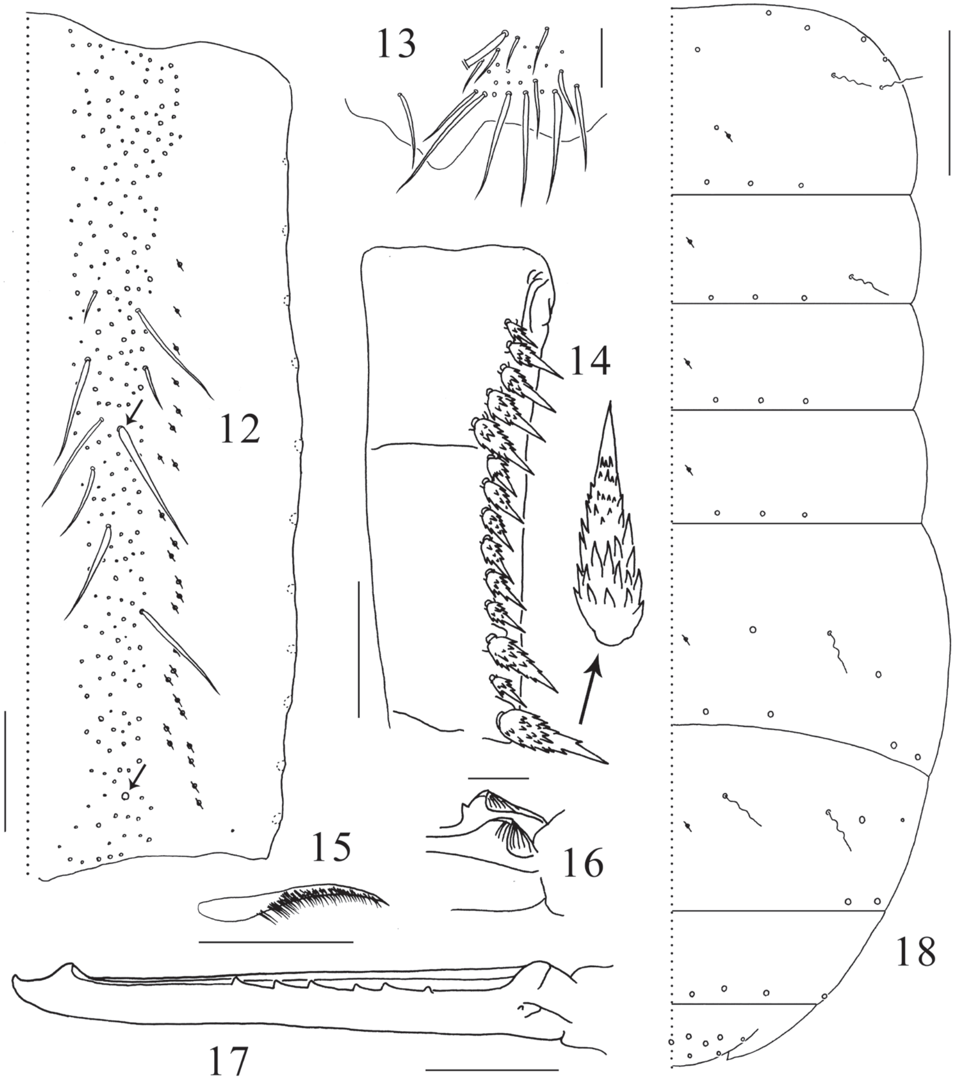
Figure 1. *Tomocerus postantennalis* sp. n. Appearance in alcohol. Scale bar: 1000 μm.

Ventral tube scaled both anteriorly and posteriorly, lateral flap unscaled. Each side of anterior face with ca. 50 chaetae, posterior face with ca. 90 chaetae, each lateral flap with ca. 60 chaetae; all chaetae smooth.

Tenaculum unscaled, with 4+4 teeth, anterior face with 5 small smooth chaetae (Fig. 11). Ratio manubrium:dens:mucro 3.3–4.0:4.8–5.4:1.0. Manubrium laterally with large scales and 11 chaetae, the proximal one chaeta small and smooth, the distal 10 chaetae enlarged and serrated; dorsal scales absent; each dorsal chaetal stripe with 250–300 smooth chaetae of different sizes, including 2+2 pointed prominent chaetae larger and straighter than other chaetae (arrowed in Fig. 12); 22–27 pseudopores on each side (Fig. 12); external corner chaetae as large as mesochaetae in the chaetal stripe (Fig. 13). Ventral side of manubrium covered only with scales. Dental spines formula 4–5/5–7, I, 1–2, I. Distal most spine strongest, about 0.1 times length of dens, sizes of the proximal spines increasing gradually from basal to distal. All spines compound, with numerous denticles of moderate size at basal half and smaller at distal half (Fig. 14). Dens internally divided into three subsegments, basally without outer strong



Figures 2–11. *Tomocerus postantennalis* sp. n. **2** PAO and ocelli **3** cephalic dorsal chaetotaxy **4** labrum **5** mandible **6** maxillary lamella five **7** trochanteral-femoral organ **8** tibiotarsus **9** anterior view of distal tibiotarsal chaetae (t: tenent hair, a: accessory chaetae, g: guard chaetae) **10** claw **11** tenaculum. Scale bars: **2, 7, 9, 10, 11**= 50 µm; **3**= 500 µm; **4, 5, 8**= 100 µm; **6**= 20 µm.



Figures 12–18. *Tomocerus postantennalis* sp. n. **12** dorsal face of manubrium (right side; prominent chaetae arrowed) **13** disto-dorsal chaetae on manubrium (left side) **14** dental spines (left side) **15** feathered chaeta on dens **16** basal teeth of left mucro **17** right mucro **18** body chaetotaxy. Scale bars: **12, 14**= 100μm; **13, 17**= 50 μm; **15, 16=** 21 μm; **18**= 400 μm. Large circles: macrochaetae; small circles: mesochaetae; wavy lines: bothriotricha; circles with a slash: pseudopores.

chaetae or inner pointed scales, dorsally with ordinary smooth chaetae and a longitudinal central stripe of feathered chaetae (Fig. 15) from base of middle subsegment to apex of distal subsegment between ordinary chaetae, ventrally covered with small oval scales. Mucro elongate and multi-setaceous; both basal teeth with proximal lamellae, outer basal tooth with a toothlet (Fig. 16); apical and subapical teeth subequal; two

Table 1. Discrimination of *Tomocerus postantennalis* sp. n., *T. ocreatus* and *T. folsomi* on the basis of the original descriptions and notes (Denis 1929, 1948).

Species	Body colour	Length of antennae	Unguis teeth	Shape of dental spines	Dental spines formula	Number of mucronal intermediate teeth
folsomi	yellowish with dark pigment along lateral margin of anterior terga	shorter than body	4–5	compound with very fine denticles	5–8/3–6, I, 1–2, I	6–7
ocreatus	pale	as long as body	5	compound with denticles of moderate size	3/3–4, II	8–9
postantennalis sp. n.	dark grey	longer than body	2	compound with denticles of moderate size	4–5/5–7, I, 1–2, I	5–7

dorsal lamellae beginning from subapical tooth, outer lamella ending in inner basal tooth, inner lamella ending freely beside inner basal tooth. Outer dorsal lamella with 5–7 subequal intermediate teeth (Fig. 17).

Macrochaetae distributed densely along anterior margin of Th. II (not drawn) and sparingly in posterior rows on terga. Th. II-Abd. V with 2,1/0,0,1,2,0 bothriotricha and 3,3/3,3,4,2,4 (3 central+1 lateral) posterior macrochaetae on each side; dorsal flap of Abd. VI with 13 macrochaetae (6+6 and 1 on middle line). Medial area of Th. II with two macrochaetae, the posterior one close to pseudopore; Abd. IV antero-laterally with one macrochaeta and one mesochaeta (Fig. 18). Most mesochaetae present at lateral margin of terga, especially from Abd. II to Abd. IV. Microchaetae uniformly distributed.

Etymology. Named with reference to the presence of the postantennal organ.

Remarks. *Tomocerus postantennalis* sp. n. is distinct from any other *Tomocerus* spp. in the presence of PAO and six prelabral chaetae. Besides, it is characterized by the unequal size of the ocelli, the lower number of cephalic macrochaetae and the reduction in the number of ungual inner teeth. Its compound dental spines are very similar to those of the Vietnamese species *Tomocerus ocreatus* Denis, 1948 and of the Chinese species *Tomocerus folsomi* Denis, 1929, which probably indicates a close phylogenetic relationship. The discrimination of these species is shown in Table 1.

Discussion

Most tomocerids have four prelabral chaetae, which is also common number in other groups of Entomobryomorpha. The taxonomic significance of the prelabral chaetae in Tomocerinae was firstly discovered by Yosii (1966, 1967), who described several *Plutomurus* species with more than four such chaetae. As far as we know, tomocerids other than *Tomocerus postantennalis* sp. n. with six or eight prelabral chaetae belong to two genera: *Plutomurus* (*P. grahami* Christiansen, 1980, *P. ehimensis* Yosii, 1956, *P.*

kawasawai Yosii, 1956, *P. gul* Yosii, 1966, *P. iwatensis* Yoshii, 1991, *P. ortobalaganensis* Jordana and Baquero, 2012, *P. kelasuricus* Martynova, 1969 and *P. marmorarius* Yosii, 1967) and *Lethemurus* Yosii, 1970 (*L. finitimus* Yosii, 1970). They all inhabit caves and most of them are eyeless, with the sole exception of *P. kelasuricus*, which has small ocelli. Although the function of prelabral chaetae is still unknown, the increased number of these chaetae appears to be a troglomorphic adaptation. The protruding prelabral chaetae probably provide a tactile sense in front of the mouthparts, and more prelabral chaetae may increase the sensitivity, which is important for living in darkness.

So far, only two species of Tomocerinae have the PAO developed in adults: *Tomolonus reductus* (Mills) and *Tomocerus postantennalis* sp. n. The former has the most reduced eyes of non-cave species (3+3) and lives in soil, while the latter has the maximum number of ocelli for the subfamily (6+6) and lives in a cave, where its eyes are useless because of darkness. PAO development in adult may therefore be assumed to compensate for deficient vision performance in both species. Under this assumption, we would expect PAO among other cave species of Tomocerinae, a presence difficult to detect given the inconspicuousness of the organ when present.

The PAO of *Tomocerus postantennalis* sp. n. is similar in shape to those of juvenile *Pogonognathellus longicornis* (Goto 1956) and some adult isotomids (Potapov 2001), but it differs from the compound PAO of *Tomolonus*, which is constituted of a small central vesicle and three larger tubercles (Mills 1948, Yosii 1967, Rusek 1977). Besides this structural difference, the PAO of *Tomocerus postantennalis* sp. n. is relatively larger than those of *Tomolonus reductus* and juvenile *Pogonognathellus longicornis*. The morphological differences in PAO between *Tomocerus postantennalis* sp. n. and *Tomolonus reductus* may reflect a functional difference or represent two evolutionary alternatives—enlargement of a simple organ or complication of a small organ, to enhance a similar function. In any case, the different PAOs in the two species are likely to be adaptive convergences rather than synapomorphies, since they are distantly related based on strong morphological differences.

Despite the presence of PAO, *Tomolonus* is more closely related to *Plutomurus*, since both have two posterior macrochaetae on the thoracic segments (Christiansen 1964, 1980, Jordana et al. 2012), a well developed trochanteral-femoral organ, strong outer basal chaetae on the dens and simple dental spines. The new species fits *Tomocerus* better than other genera because it has three posterior macrochaetae on the thoracic segments, poorly developed trochanteral-femoral organ, no strong dental chaetae and a toothlet on the outer basal tooth of the mucro.

The genus *Tomocerus* Nicolet, 1841 is so far poorly defined by a single character: the presence of a toothlet on the outer basal mucronal tooth, thus all species conforming to this criterion and lacking the diagnostic character of other genera have been assigned to this genus, resulting in a wider range of intrageneric diversity than in other genera. For instance, all types of dental spines from simple to strongly furcated can be found in *Tomocerus*, whereas in *Pogonognathellus*, *Plutomurus* and *Monodontocerus* the shape of dental spines are constant within genus. On the other hand, the single generic character is not exclusive for *Tomocerus* since *Aphaenomurus interpositus denticulatus* Yosii, 1956 and *Plutomurus vigintiferispina* Lee, 1974 also have a toothlet on the mucronal outer basal tooth. The situation of *Tomocerus* will remain problematic until a comprehensive and detail investigate is carried out.

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RESEARCH ARTICLE

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A new species in the genus *Amphipteryx* Selys, 1853 (Odonata, Amphipterygidae) from Pico Bonito National Park, Honduras

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Abstract

The Mesoamerican damselfly genus *Amphipteryx* includes four species: *Amphipteryx agrioides* (Mexico), *A. chiapensis* (Mexico), *A. meridionalis* (Honduras) and *A. nataliae* (Verapaz, Guatemala). We describe a fifth species, *Amphipteryx jaroli*, from the cloud forest in Pico Bonito National park, Honduras. Additionally we include an up to date key of all species in the genus for both sexes.

Resumen

El género Mesoamericano del zigóptero *Amphipteryx* incluye cuatro especies: *Amphipteryx agrioides*, (Mexico), *A. chiapensis* (Mexico), *A. meridionalis* (Honduras) y *A. nataliae* (Verapaz, Guatemala). Se describe una quinta especie, *Amphyterix jaroli*, localizada en ul bosque nublado del Parque Nacional Pico Bonito, Honduras. Adicionalmente se incluye una clave actualizada de todas las especies del género, tanto para machos como hembras.

Keywords
Zygoptera, cloud forest

Introduction

Central American cloud forests habitats are critically endangered ecosystems disappearing rapidly (Solorzano et al. 2003). While an estimated 80% of original lowland forest vegetation cover has already been lost or modified (Brooks et al. 2002), these hilltop and ridge forests have remained untouched for a long time, mostly due to difficult access. The growing pressure on remaining natural resources associated with increasing population now is also affecting cloud forests. The difficult access, once a protective trait, now works against an efficient conservation as it hampers data collection. Relatively little is known on the biodiversity in these habitats, but cloud forests are characterised by a high diversity and high endemicity. A recent overview of the 100 most irreplaceable places for biodiversity in the world (Saout et al. 2013) included the cloud forest in Pico Bonito National Park.

During a biodiversity survey of cloud forest in La Montaña de Corazal (Pico Bonito National Park) we discovered a new species of *Amphipteryx*. The genus *Amphipteryx* belongs to the monotypic family Amphypterygidae (Dijkstra et al. 2013). The two latest overviews of the species in this genus (González-Soriano and von Ellenrieder 2009; González-Soriano 2010) present illustrations and a key to all known species. The species from Pico Bonito NP has a close resemblance to *A. meridionalis*, the only other *Amphipteryx* currently recorded from Honduras. The new species differs by the bilobed lamellate processes on the prothorax. Here we describe this new species of *Amphipteryx* and update the keys for the separation of all species within the genus.

Materials and methods

Type material is deposited in the Royal Belgian Institute for Natural Sciences in Brussels Belgium (I.R.Sc.N.B.). Nomenclature follows Westfall and May (2006) for body morphology. All measurements are in mm; total length and length of abdomen for up to 10 specimens of each sex include cerci; means (in parenthesis) are given for more than two specimens. All drawings were made with the aid of a camera lucida coupled to a Nikon SMZ1500 stereoscope and are not to scale. Map represents distribution records from collections, and was created using QGIS 2.0. Abbreviations for structures used throughout the text are as follows: Fw: forewing; Hw: hindwing; pt: pterostigma; Ax: antenodal crossveins; Px: postnodal crossveins; S1–10: abdominal segments 1 to 10.

Results

Amphipteryx Selys, 1853

http://species-id.net/wiki/Amphipteryx

Amphipteryx Selys 1853: 66.

Type species. *Amphipteryx agrioides* Selys 1853, by original designation.

Other species included. *Amphipteryx chiapensis* González–Soriano 2010, *A. meridionalis* González-Soriano 2010, *A. nataliae* González-Soriano 2010.

General. *Amphipteryx* is the only genus in Amphipterygidae (Dijkstra et al. 2013). *Rimanella*, with its monotypic species *R. arcana* (Needham 1933), was formally included in Amphipterygidae but it was recently placed in its own monotypic family Rimanellidae (Dijkstra et al. 2013).

Distribution. *Amphipteryx* occurs at small mountain streams from Hidalgo Oaxaca, Puebla and Veracruz States, Mexico east into Guatemala and Honduras.

Biology. Adults perch with wings closed on vegetation overhanging water near seepages and small streams (González-Soriano 1991); larvae live in rough gravel and rapid-flow areas of small shallow creeks, and among leaf litter at lips of small waterfalls (Novelo-Gutiérrez 1995). With one exception (below) all Mexican populations are associated with tropical wet forests (i. e. cloud or tropical rain forests) and the same apparently is true for other Central American populations.

Key to males of *Amphipteryx*

This key is a modification of the one from González-Soriano (2010) and reference should be made to illustrations for other species in that paper.

1 Hind lobe of prothorax evenly curved with small disjunct lateral lobes forming small rounded lobes whose medial margins are bent anteriorly; cercus in dorsal view curved medially and armed with a blunt quadrate lobe along medial 0.40; paraproct slender, slightly surpassing cercus and with medially curved tip terminating in a single tooth; Hidalgo and Oaxaca States, Mexico .... ***A. agrioides***

1’ Hind lobe of prothorax with erect digit-like lateral lobes, or with middle lobe bent cephalad or posteriorly (Fig. 2D); cercus in dorsal view linear and lacking a blunt quadrate lobe along medial 0.40, paraproct dorso-ventrally flattened, as long as or considerably shorter than cercus and terminating in an angular to quadrate tip; Chiapas State, Mexico, Honduras and Guatemala **2**

2(1’) Hind lobe of prothorax continuous; raised lateral lobes vertical, semicircular, and continuous with smaller irregular shaped middle lobe; Honduras **3**

2’ Hind lobe of prothorax with erect digit-like lateral lobes; Chiapas State, Mexico, and Guatemala **4**

3(2) Scalariform tooth on cercus in mediodorsal view anteapical, medial margin of cercus gently concave; middle lobe of hind lobe of prothorax bilobed or with a v-shaped incision medially, bent cephalad, this structure as prominent as lateral lobes; Comayagua and Cortés Departments, Honduras .... ***A. meridionalis***

3’ Scalariform tooth on cercus in mediodorsal view at medial half, medial margin of cercus with ventro-medial lobe at basal third (Fig. 2A); middle lobe of hind lobe of prothorax entire, bent posteriorly and much smaller than erect wing-like lateral lobes (Fig. 2D); Atlantida Department, Honduras .... ***A. jaroli***

4(2’) Paraproct as long as cercus and terminating in an angular tip; erect lateral lobes of prothorax as long as interval between them; Guatemala .... ***A. nataliae***

4’ Paraproct considerably shorter than cercus and terminating in a quadrate tip; erect lateral lobes of prothorax much shorter than interval between them; Chiapas State, Mexico .... ***A. chiapensis***

Key to females of *Amphipteryx* (female of *A. chiapensis* unknown)

1 Hind lobe of prothorax evenly curved with lateral lobes forming small angulate lobes; Hidalgo and Oaxaca States, Mexico .... ***A. agrioides***

1’ Hind lobe of prothorax with erect digit-like lateral lobes, or with middle lobe bent cephalad or posteriorly (Fig. 2E); Chiapas State, Mexico, Honduras and Guatemala **2**

2(1’) Hind lobe of prothorax with a pair of small, isolated, erect digit-like lateral lobes converging posteriorly; Guatemala .... ***A. nataliae***

2’ Hind lobe of prothorax with erect lateral lobes continuous with middle lobe; Honduras **3**

3(2’) Middle lobe of hind lobe of prothorax bilobed or with a v-shaped incision medially, bent cephalad, this structure as prominent as lateral lobes; Comayagua and Cortés Departments, Honduras .... ***A. meridionalis***

3’ Middle lobe of hind lobe of prothorax entire, bent dorso-posteriorly and subequal in height to erect wing-like lateral lobes (Fig. 2E); Atlantida Department, Honduras .... ***A. jaroli***

Species description

Amphipteryx jaroli sp. n.

http://zoobank.org/DAE4DF4E-0E95-4A33-BA0C-5E02CE4EF531
http://species-id.net/wiki/Amphipteryx_jaroli
Figs 2A–E, 3A–E

Etymology. Named *jaroli* (noun in the genitive case), after our friend and guide through the cloud forest on our first expedition in Pico Bonito National Park (2012); Jarol Estrada. Jarol collected the first specimen of this species.

Type material. Total: 9 males (32.597/1-10, Coll. I.R.Sc.N.B.) and 1 female (32.597/10). Holotype: male (32.597/1), Honduras, Pico Bonito National Park., Montaña de Corazal, cloud forest, north of the small village Los Horcones in Northern Honduras. Basecamp was at 1640m (N15.556, W86.918), all collections were made in the vicinity from this location.

Description. Holotype dimensions: Fw 39,0mm; Hw 36,0mm; abdomen 46,0mm; total length 51,0mm . Head of male holotype with basal part of labium light cyan blue (Fig. 3D), labial palp and apex of mentum black, labrum and gena light cyan blue, mandible black except for well-defined pale yellow spot at base, large spot confluent with the genae on either side of antefrons, light cyan blue (Fig. 3A, C–D). Clypeus and midline of antefrons black, and most of the dorsal and posterior surfaces of the head, black, lateral area of antefrons light cyan blue; anterior portion of epicranium to epicranial furrow shiny black except for a small elongated yellow patch extending antero-laterally from each lateral ocellus (Fig. 3B); posterior portion of epicranium including postocular lobes, occipital bar, and rear of head matte black.

Prothorax black except for pale yellow anterior lobe and large lateral spot on either side of median lobe and below ventral margin of propleural suture (Fig. 3A, C–D); hind lobe (Figs 2D, 3A, C) with paired dorsal, upright, lamellate processes, which, in lateral view (Fig. 3C) are thin, and strongly erect, each anteriorly with pale yellow patch on distal half; distance between these lobes about twice the height of each lobe, middle lobe decumbent dorso-posteriorly and not as high as lateral lobes. Synthorax yellow green (Fig. 3A, C–D) with a broad mid-dorsal black stripe confluent with abbreviated broad black antehumeral stripe at upper half, its ventral portion acuminate, and not reaching mesinfraepisternum; this last with anterior half black, posterior half pale yellow green; side of thorax yellow green with three narrow lateral black stripes; one on middle of mesepimeron with its ventral portion expanding to mesinfraepisternum, its upper end along margin of antealar crest and meeting second (interpleural) stripe at upper posterior margin of metepimeron and ending antero-ventrally above metastigma; third thoracic stripe extending full length of posterior margin of metepimeron; venter of thorax pale. Coxae pale yellow washed with darker brown ventrally; legs blackish with bases and the inner, surfaces of the femora yellowish; armature and claws black. Wings hyaline; Ax Fw 8:9; Hw 8:8; Px Fw 31:28; Hw 23:27.

Abdomen black (Fig. 3A) with following parts yellow green: a narrow mid-dorsal line on S2–5, dorso-lateral spot on S1, a narrow dorso-lateral line on S2, a decreasingly smaller latero-basal spot on S3, S4 and S5, dorsum of S7–10 bright light blue dorsally (faded to brown due to postmortem affects), a thin mid-dorsal black line on S10, its postero-dorsal margin with a narrow median notch half as long as segment. Genital ligula with two dorsal and two ventral lobes, semi-hyaline with light brown patch at the base of the ventral lobes; semi-hyaline dorsal lobes about twice as long as ventral lobes, ending in elongate spatula shaped rounded tip; semi-hyaline ventral lobes ending in rounded tip. Cercus black, subequal to S10, robust, spinulose dorso-externally, in dorsal view fusiform with apex rounded, medial side with a well-developed scalariform tooth approximately halfway between apex and base (Fig. 2A, C), medial surface from tooth

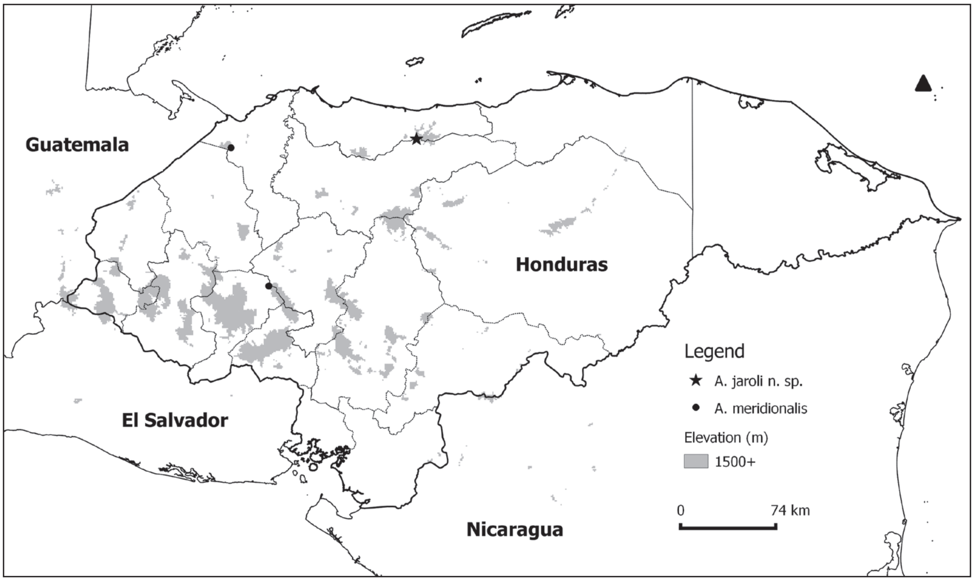

Figure 1. Occurrence records of the two species of *Amphipteryx* found in Honduras. Arrow indicates the North.

to base with a large robust ventro-medially directed lobe (Fig. 2A); medial surface from tooth to apex smooth, slightly convex; in lateral view cercus linear, with ventral surface dorsally arched exposing inner margin of tip of cercus (Fig. 2A). Paraproct subequal to cercus, its tip in lateral view directed dorsally (Fig. 2B), base in dorsal view inflated, paraproct tapering down, apex with quadrate tip pointing medio-dorsally (Fig. 2A, C).

Variation in paratypes. Males differ in extent of black on body and in shape of pronotal lobes. The narrow mesepimeral stripe in some is complete and connects with black ventrally on mesinfraepisternum, interpleural stripe may be broken into elongate spots and third thoracic stripe may be reduced. Normally the pronotal lobes are pale, but the size of this patch varies in some specimens, height and morphology of the pronotal lobes is also variable. In some animals the normally erect lobes gently dip anteriorly when viewed laterally. In one male, wings were slightly infumed.

Female similar to male but black markings on head, pro- and especially on synthorax reduced. Mid-dorsal black stripe narrower than in male, occupying less than 0.25 of each mesepisternum, asymmetrical hourglass pattern, with the narrowest part anterior, steadily widening posteriorly, ventral acuminate portion isolated, only attached to mid dorsal stripe through a narrow black line at the edge of the pterothorax, in dorsal view an acuminate fish hook shape, extends less than half length of mesepisternum. Pronotal lobes smaller and less pronounced compared to male.

Dimensions. Males (*n* = 25, including holotype; means in parentheses): Hw 34.0–37.5mm (35.9±1.0 mm); abdomen 39.5–43.0 mm (41.5±0.9 mm); total length 50.0–54.0 mm (52.1±1.0 mm). Females (*n* = 2): Hw 38.0 mm; abdomen 37.5 mm; total length 50.5 mm.

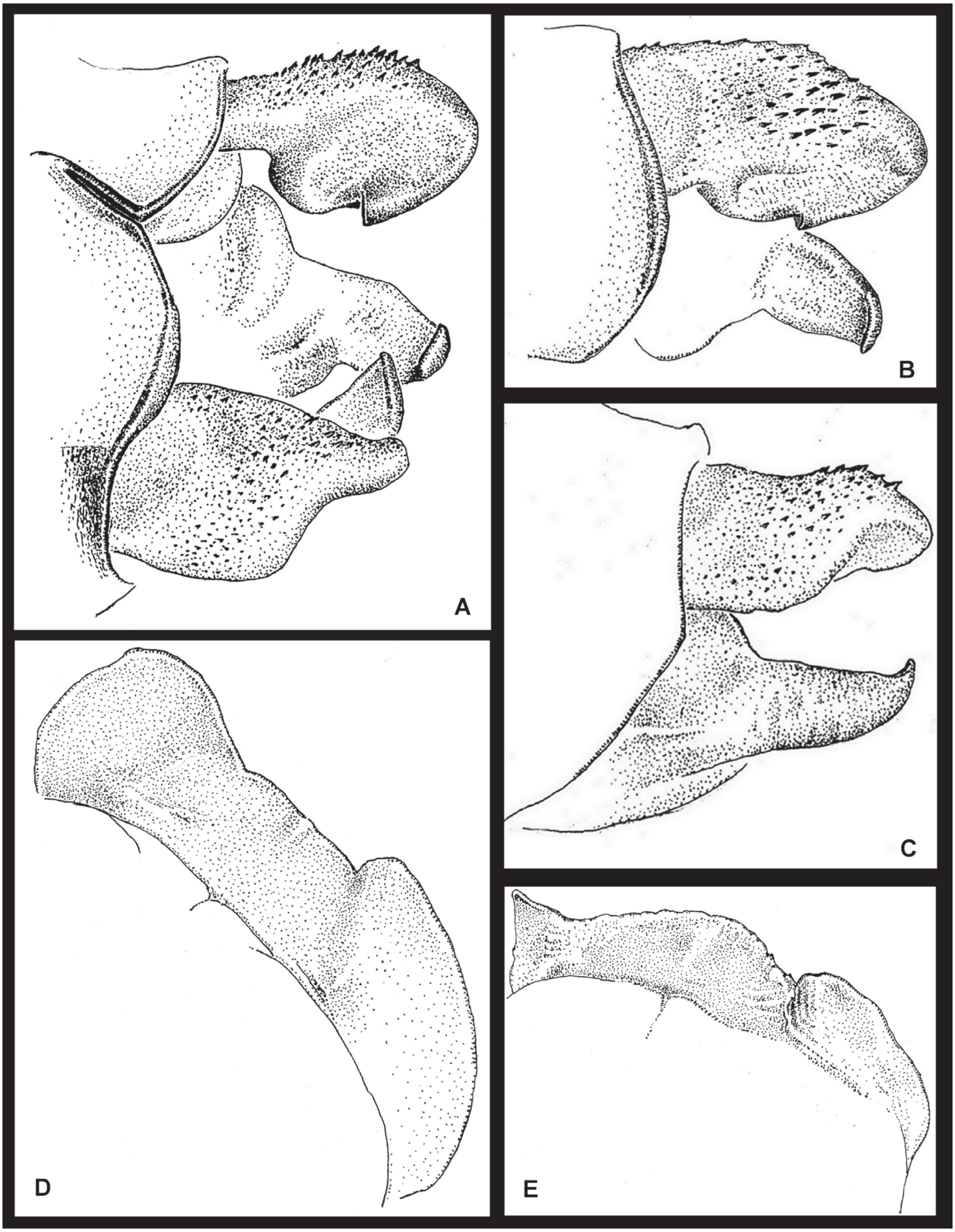

Figure 2. *Amphipteryx jaroli* (**A–E**), S10 holotype male dorso-lateral (**A**), ventro-lateral (**B**) and lateral (**C**) view. Holotype male posterior lobe of prothorax (**D**) and female posterior lobe of prothorax (**E**).

Distribution. Currently only known from Pico Bonito National Park, Honduras (Fig. 1). *Amphipteryx jaroli* was collected from three neighboring river catchments, all within a narrow elevational range (1611 to 1673 masl).

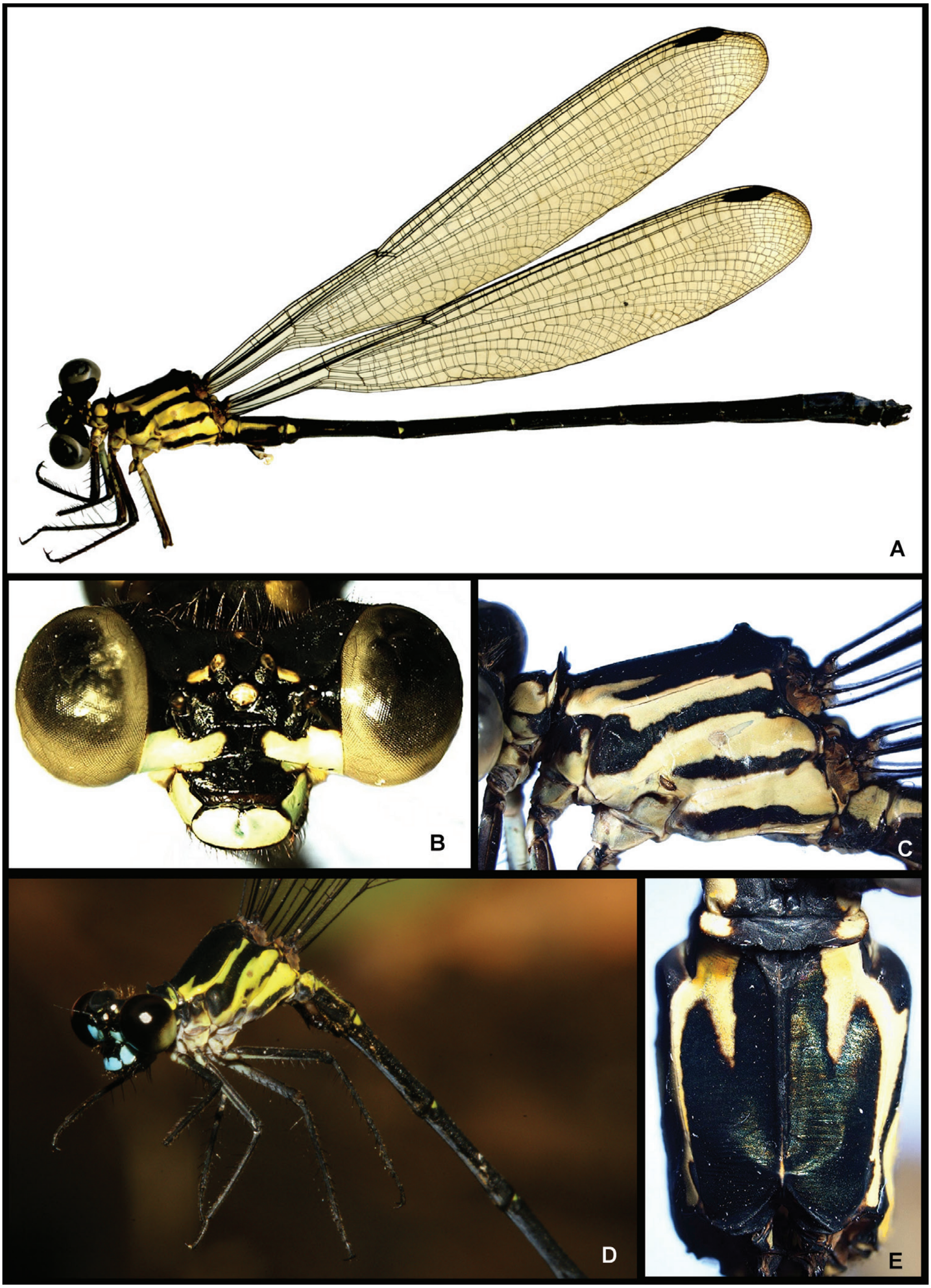

Figure 3. Images of *Amphipteryx jaroli* (**A–E**), whole male holotype dead and preserved (**A**), frontal view head (**B**), lateral pterothorax (**C**), life male in the field (**D**) and dorsal pterothorax (**E**).

Diagnosis. The structure of the pronotal lobes in lateral view, with the two large, straight lobes, separates this species from other species in the genus. Additionally, the male is separable based on the position of the well-developed scalariform tooth on the internal side of the cercus approximately halfway between apex and base. *Amphipteryx chiapensis*, *A. meridionalis* and *A. nataliae* have a well-developed scalariform anteapical tooth, *A. agrioides* has the scalariform tooth positioned more basally, but still closest to the apex (González-Soriano and von Ellenrieder 2009).

Discussion

The narrow elevational distribution of *Amphipteryx jaroli* is remarkable. The expedition departed from Los Horcones, a small village at an elevation of 289m, crossing the forest on a three day hike to a provisionary basecamp at an elevation of 1640masl. From basecamp daily excursions in all directions were completed and dragonflies collected. Despite the substantial altitudinal range crossed, this species was only collected from a narrow elevational range. Other *Amphipteryx* species are also cloud forest species as a rule occurring at mid-height elevation around medium sized rocky mountain rivers. A single *A. agrioides* was collected at 36m, but this seems to be an exception. *Amphipteryx agrioides* has been found as low as 650m in Pueblo State, Mexico.

Acknowledgments

We thank Rosser Garrison for his endless support and guidance on our first steps in the dragonfly world and most of all for the illustrations and images of the holotype that accompany this paper. Thanks also to Tim van Berkel for his enthusiasm and dedication during the expedition. Many thanks to Don Eduardo Cardoza, Rene Ordoñez, Don Faustino Del Cid, Maria Montufar for support in the field. MJ was supported by a “Back to Belgium” grant from the Belgian Science Policy (BELSPO) issued in 2010 and the Ralph Brown Award issued by the Royal Geographic Society in 2013.

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RESEARCH ARTICLE

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New tardigrade records for the Baltic states with a description of *Minibiotus formosus* sp. n. (Eutardigrada, Macrobiotidae)

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Abstract

In sixteen moss, lichen and mixed (moss/lichen) samples, collected from Estonia, Latvia and Lithuania, 291 specimens, 48 simplexes, including one exuvium with 6 eggs, and 8 free-laid eggs of eutardigrades were found. In total, 17 species, together with one new to science, were identified (all are new records for the Baltic states): *Astatumen bartosi*, *Diphascon* (*Adropion*) *prorsirostre*, *D.* (*Diphascon*) *bullatum*, *D.* (*D.*) *pingue pingue*, *D.* (*D.*) *recamieri*, *D.* (*D.*) *rugosum*, *Hypsibius convergens*, *H. dujardini*, *H.* cf. *scabropygus*, *Isohypsibius ronsisvallei*, *I. sattleri*, *Macrobiotus harmsworthi harmsworthi*, *M. hufelandi hufelandi*, *Milnesium asiaticum*, *Milnesium tardigradum tardigradum*, *Minibiotus formosus* **sp. n.** and *Paramacrobiotus richtersi*. The new species is most similar to *Minibiotus gumersindoi*, but differs from it mainly by the presence of two types of cuticular pores, the absence of a triangular or pentagonal arrangement of pores above a single large pore on legs, the presence of granulation on all legs and a different macroplacoid length sequence. In this paper we also provide photographs and morphometrics of *H.* cf. *scabropygus*.

Keywords

Estonia, Europe, *Hypsibius* cf. *scabropygus*, Latvia, Lithuania, new species, Tardigrada

Introduction

The Baltic States, i.e. Estonia, Latvia and Lithuania, are located on the eastern coast of the Baltic Sea, and fall within the Palearctic ecozone (Holt et al. 2012). The topography of the three countries is dominated by lowlands with the highest peaks at *ca.* 300 m asl. The temperate climate is intermediate between maritime and continental. Even though the phylum Tardigrada is cosmopolitan and currently comprises *ca.* 1,200 species (Degma et al. 2013), so far only six tardigrade taxa have been reported from the Baltic States. Specifically, two from Estonia: *Eremobiotus alicatai* (Binda, 1969) and *Isohypsibius* cf. *marcellinoi* (Binda & Pilato, 1971), two from Latvia: *Paramacrobiotus richtersi* group and *Macrobiotus hufelandi* group and two from Lithuania: *Macrobiotus* sp. and *Ramazzottius* sp. (Šatkauskienė and Vosyliūtė 2010, Zawierucha and Kaźmierski 2012, Ziemelis et al. 2012).

In this study we report seventeen tardigrade species, which are all new records for the Baltic States. Moreover, one of these species is also new to science. The new species belongs to the genus *Minibiotus* R.O. Schuster, 1980, that until 1988 contained only a single species, *Minibiotus intermedius* (Plate, 1888). In 1988 Pilato and Claxton (1988) described *Minibiotus maculartus*, and within the last decade fourteen new *Minibiotus* species have been described. Several species have also been transferred to *Minibiotus* from the genus *Macrobiotus* based on characters defined by Claxton (1998) and later supplemented by Guidetti et al. (2007) (Michalczyk and Kaczmarek 2003a, Pilato et al. 2003, Michalczyk and Kaczmarek 2004, Guil and Guidetti 2005, Michalczyk et al. 2005, Pilato and Lisi 2006b, Li et al. 2008, Fontoura et al. 2009a, b, Rossi et al. 2009, Meyer and Hinton 2009, Meyer and Domingue 2011, Meyer et al. 2011 Meyer 2012). Currently, the total number of *Minibiotus* species amounts to as many as forty seven.

In addition to the description of the new species, we also provide morphometric data and photographs of *Hypsibius* cf. *scabropygus*, a rare species that belongs to a large group of hypsibiids with at least partially sculptured dorsal cuticle and pharynx with two macroplacoids and without the microplacoid.

Material and methods

Sixteen moss, lichen and mixed (moss/lichen) samples from trees, soil and stones were collected from 15 localities in Estonia, Latvia and Lithuania between the 29 April and the 5 May 2012 by the third author (more details below). Samples were collected and examined for tardigrades using standard methods (see Dastych 1980). After extraction, animals were mounted on microscope slides in Hoyer's medium. All specimens were examined measured and photographed using Phase Contrast Microscopy (PCM) or Scanning Electron Microscopy (SEM). In total 358 specimens (including 47 simplexes), one exuvium with 6 eggs, and 8 free-laid eggs were examined.

All measurements are given in micrometers [µm]. Structures were measured only if their orientation was appropriate. Body length was measured from the anterior extremity to the end of the body, excluding the hind legs. Buccal tube length and the level of the stylet support insertion point were measured according to Pilato (1981). Buccal tube width was measured as the external diameter at the level of the stylet support insertion point. Lengths of the claw branches were measured from the base of the claw to the top of the branch including accessory points for *Minibiotus* and according to Beasley et al. (2008) for *Hypsibius*. The *pt* ratio is the ratio of the length of a given structure to the length of the buccal tube expressed as a percentage (Pilato 1981). Macroplacoid length sequence is given according to Kaczmarek et al. (2014b), i.e. macroplacoids are listed from the shortest to the longest and their relative sizes are denoted with appropriate inequality, approximation and/or equality signs (<, ≤, ≈, =). Morphometric data were handled using the 'Macrobiotoidea' ver. 1.1 template available from the Tardigrada Register (www.tardigrada.net/register, Michalczyk and Kaczmarek 2013).

For species identification and differentiation, keys in Claxton (1998), Fontoura and Pilato (2007), Kaczmarek et al. (2011), Michalczyk et al. 2012a, b and Ramazzotti and Maucci (1983), and original descriptions and redescriptions (Ehrenberg 1859, Ramazzotti 1959, 1962, Horning et al. 1978, Bertolani and Rebecchi 1993, Dastych 1988, 1990, Binda and Pilato 1992, Michalczyk and Kaczmarek 2004, Michalczyk et al. 2005, Miller et al. 2005, Fontoura et al. 2009a, b, Meyer and Hinton 2009, Meyer et al. 2011) as well as for insertion of the stylet muscles Pilato (2013) were used. Tardigrade taxonomy is presented according to Marley et al. (2011). Only specimens determined to species level are provided in the list of species (we omitted all specimens determined only to the species group level, e.g. the *hufelandi* group or the *oberhaeuseri* group). In the species list Roman numbers indicate sample codes (see sampling localities) and Arabic numbers indicate the number of specimens, exuvia/simplexes and eggs.

Raw data underlying the description of *Minibiotus formosus* sp. n. are deposited in the Tardigrada Register (Michalczyk and Kaczmarek 2013) under www.tardigrada.net/register/0012.htm.

Sampling localities

I. 56°03'08"N; 24°24'10"E, *ca.* 33 m asl: Lithuania, Panevėžys county, Pasvalys district municipality, along the road E67, 0.5 km before the turning to Pasvalys, moss from tree and soil (slide code: LT 2422), date: 29.04.2012.

II. 55°25'59"N; 24°13'32"E, *ca.* 59 m asl: Lithuania, Kaunas county, Kėdainiai district municipality, Truskava city, near a church, lichens from tree and moss from soil (slide code: LT 2423), date: 29.04.2012.

III. 55°17'12"N; 23°58'57"E, *ca.* 30 m asl: Lithuania, Kaunas county, Kėdainiai district municipality, Kėdainiai city, Kranto II street; moss from wall (slide code: LT 2424), date: 29.04.2012.

IV. 55°17'13"N; 23°58'56"E, *ca.* 30 m asl: Lithuania, Kaunas county, Kėdainiai district municipality, Kėdainiai city, Paeismilgio street; moss from stone (slide code: LT 2425), date: 29.04.2012.

V. 55°43'35"N; 24°21'30"E, *ca.* 62 m asl: Lithuania, Panevėžys county, Panevėžys district municipality, Panevėžys city, Garden Street near Holy Trinity Rector; moss from tree (slide code: LT 2440), date: 05.05.2012.

VI. 56°38'53"N; 23°43'18"E, *ca.* 7 m asl: Latvia, Zemgale region, Jelgava municipality, Jelgava city, City Park; moss from soil (slide code: ŁO 2426), date: 29.04.2012.

VII. 57°10'33"N; 24°50'32"E, *ca.* 45 m asl: Latvia, Vidzeme region, Sigulda municipality, Gutmana Cave in the Gauja National Park; moss from rocks (slide code: ŁO 2427), date: 30.04.2012.

VIII. 56°23'55"N; 24°07'33"E, *ca.* 25 m asl: Latvia, Zemgale region, Bauska municipality, along Road No P103, 0.5 km from Saulaine; lichens from tree (slide code: ŁO 2428) date: 29.04.2012.

IX. 57°09'55"N; 24°51'03"E, *ca.* 73 m asl: Latvia, Vidzeme region, Sigulda municipality, Turaida city, Turaida Castle; moss from stone (slide code: ŁO 2430), date: 30.04.2012.

X. 56°54'32"N; 24°08'45"E, *ca.* 10 m asl: Latvia, Riga Region, boundary of Ķekava municipality, along road no A2; moss from tree (slide code: ŁO 2431), date: 30.04.2012.

XI. 57°09'59"N; 24°50'59"E, *ca.* 91 m asl: Latvia, Vidzeme region, Sigulda municipality, Sigulda city, Sigulda Castle; moss from stone (slide code: ŁO 2432), date: 30.04.2012.

XII. 56°41'22"N; 23°47'43"E, *ca.* 4 m asl: Latvia, Zemgale region, Ozolnieki municipality, Ozolnieki city, about 100 m from the Ozolnieki Lake; moss from soil (slide code: ŁO 2433), date: 29.04.2012.

XIII. 57°45'43"N; 24°20'59"E, *ca.* 3 m asl: Latvia, Vidzeme region, Salacgriva municipality, Salacgriva city; moss from soil, near the beach (slide code: ŁO 2434), date: 01.05.2012.

XIV. 59°10'44"N; 24°30'06"E, *ca.* 59 m asl: Republic of Estonia, Harju county, Kernu Parish municipality, Road No 4, moss from tree (slide code: ES 2420), date: 04.05.2012.

XV. 59°10'44"N; 24°30'06"E, *ca.* 59 m asl: Republic of Estonia, Harju county, Kernu Parish municipality, Road No 4, moss from tree (slide code: ES 2421), date: 04.05.2012.

XVI. 58°48'47"N; 24°24'46"E, *ca.* 32 m asl: Republic of Estonia, Rapla County, Märjamaa municipality, forest near Konuvere village, moss from tree (slide codes: ES 2487), date: 29.04.2012.

Results

Taxonomic accounts of species found in the study

Phylum: Tardigrada (Spallanzani, 1777)
Class: Eutardigrada Richters, 1926
Order: Apochela Schuster, Nelson, Grigarick and Christenberry, 1980
Family: Milnesiidae Ramazzotti, 1962
Genus: *Milnesium* Doyère, 1840

Milnesium asiaticum Tumanov, 2006

Localities and specimen numbers. XV: 1 specimen.

Remarks. Our specimen corresponds perfectly to the original description. *Milnesium asiaticum* was originally described from Kirghizstan and subsequently found in the Svalbard archipelago (Tumanov 2006, Kaczmarek et al. 2012).

Milnesium tardigradum tardigradum Doyère, 1840

Localities and specimen numbers. VIII: 31 specimens (including 6 simplexes) + 1 exuvium with 6 eggs.

Remarks. Specimens correspond perfectly with the redescription by Michalczyk et al. (2012a, b). This species was reported from many localities throughout the World, however records prior to Michalczyk et al. (2012a, b) need to be verified. So far, all confirmed localities are exclusively European (Michalczyk et al. 2012a, b).

Order: Parachela Schuster, Nelson, Grigarick & Christensen, 1980
Superfamily: Hypsibioidea Pilato, 1969 (in Marley et al. 2011)
Family: Hypsibiidae Pilato, 1969
Subfamily: Diphasconinae Dastych, 1992
Genus: *Diphascon* Plate, 1888
Subgenus: *Diphascon* (*Diphascon*) Pilato, 1987

Diphascon (*Diphascon*) *bullatum* Murray, 1905

Localities and specimen numbers. XIII: 1 specimen.

Remarks. Specimens correspond well with the limited original description (Murray 1905) and also with later descriptions (Argue 1974 and Dastych 1980, 1988). This species is very similar to *D.* (*D.*) *patanei* (Binda & Pilato, 1971) and, as suggested by Dastych (1988), these two species could be synonymous. Thus, to clarify the taxonomic status of *D.* (*D.*) *patanei*, a re-description of *D.* (*D.*) *bullatum* is necessary based on material from *locus typicus* in Scotland (the type material probably does not exist) (Dastych 1988).

Diphascon (*Diphascon*) *pingue pingue* (Marcus, 1936)

Localities and specimen numbers. XV: 11 specimens.

Remarks. Although we have found only 11 specimens, we were confident in identifying them to *D.* (*D.*) *pingue* because they corresponded perfectly to the partial redescriptions by Pilato and Binda (1997/1998, 1999) and we also identified them with the key by Fontoura and Pilato (2007). The species belongs to the *pingue* group and has been previously recorded from numerous localities throughout the World, however the majority of records should be verified based on the modern taxonomy (Pilato and Binda 1997/1998, 1999). Currently, exclusively verified localities of this species are only from Europe and North America (Pilato and Binda 1997/1998).

Diphascon (*Diphascon*) *recamieri* Richters, 1911

Localities and specimen numbers. XV: 1 specimen.

Remarks. The species has previously been found in many localities, mostly in the Holarctic (McInnes 1994).

Diphascon (*Diphascon*) *rugosum* (Bartoš, 1935)

Localities and specimen numbers. II: 3 specimens.

Remarks. The species has previously been found in many localities in the Holarctic (McInnes 1994).

Genus: *Diphascon* Pilato, 1987

Subgenus *Diphascon* (*Adropion*) *prorsirostre* Thulin, 1928

Localities and specimen numbers. XIV: 2 specimens, XV: 2 specimens.

Remarks. The species has been previously found in many localities, mostly in the Holarctic (McInnes 1994).

Subfamily: Hypsibiinae Pilato, 1969
Genus: *Hypsibius* Ehrenberg, 1848

Hypsibius convergens (Urbanowicz, 1925)

Localities and specimen numbers. IX: 6 specimens (including 2 simplexes).

Remarks. Belonging to the cosmopolitan *convergens-dujardini* complex of species (McInnes 1994, Miller et al. 2005, Kaczmarek and Michalczyk 2009a, Kaczmarek et al.

2014a), *H. convergens* used to be considered cosmopolitan, but it is most likely a complex of very similar (possibly also cryptic) species found throughout the world. The original *H. convergens* description no longer conforms to modern standards and therefore a redescription is required. Nevertheless, the examined specimens correspond perfectly with the original description and the *H. convergens* characteristics reviewed by Miller et al. (2005).

Hypsibius dujardini **(Doyère, 1840)**

Localities and specimen numbers. XIV: 2 specimens (including 1 simplex), XV: 5 specimens.

Remarks. *H. dujardini* belongs to the cosmopolitan *convergens-dujardini* complex of species (McInnes 1994, Miller et al. 2005, Kaczmarek and Michalczyk 2009a, Kaczmarek et al. 2014a), and used to be considered cosmopolitan, but it is most likely a complex of similar (possibly cryptic) species found throughout the world. Due to the limited original description, *H. dujardini* needs a modern redescription. Nevertheless, the examined specimens correspond perfectly with the original description and the *H. dujardini* characteristics reviewed by Miller et al. (2005).

Hypsibius **cf.** ***scabropygus*** **Cuénot, 1929**

Table 1, Figs 1–7

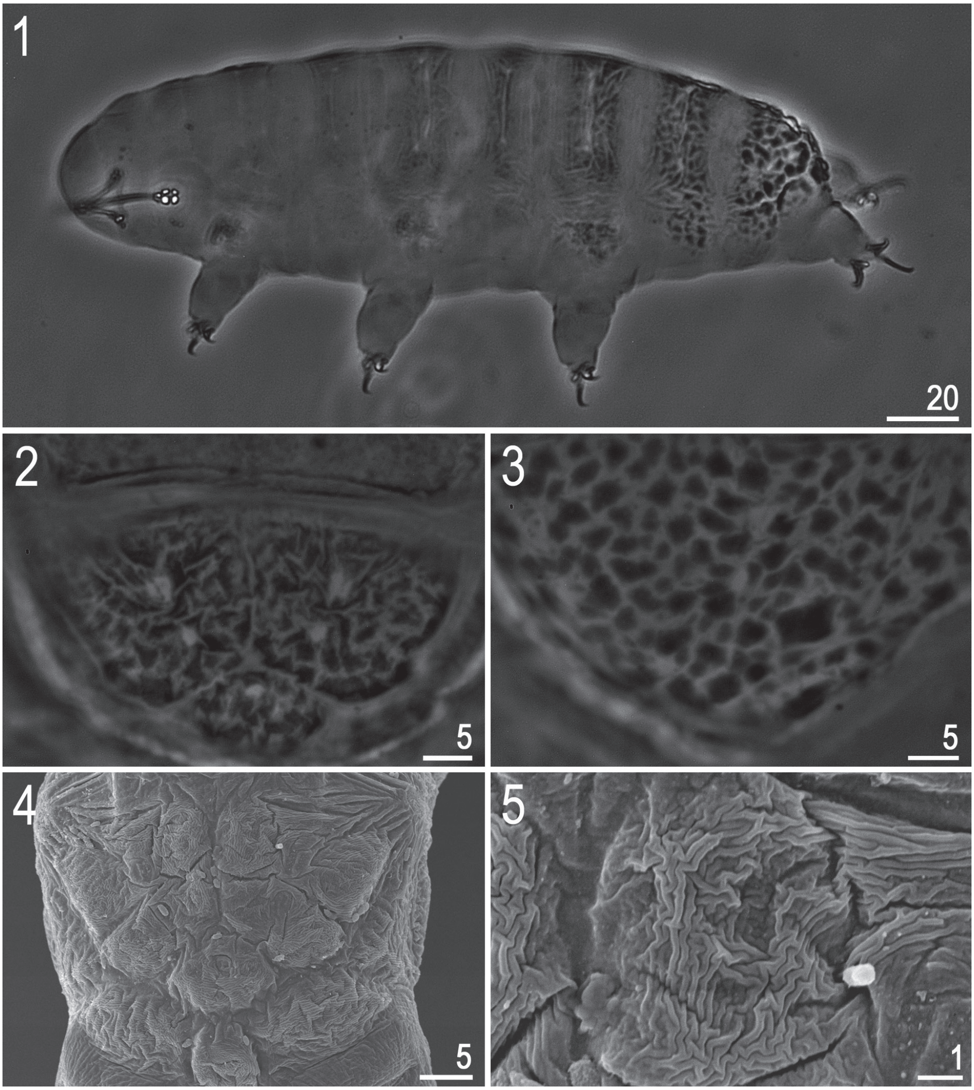
Localities and specimen numbers. XI: 1 simplex, XII: 1 specimen, XIV: 34 specimens (including 4 simplexes), XV: 24 specimens (including 6 simplexes).

Description (measurements in Table 1). Adults. Body transparent/white (after preparation), eyes present in 6 of 15 (40%) specimens mounted in Hoyer's medium (Fig. 1). Dorsal cuticle sculptured: from head to legs II without tubercles but clearly thickened, from legs II to the caudal end of the body (including legs IV) with irregular tubercles and platelets. Tubercles increasing in size from the anterior to the posterior part of the body, reaching maximum dimensions between legs III and IV, where tubercles sometimes merge and form irregular platelets (Figs 2–5). Irregular tubercles 1.0–6.0 µm in diameter. Ventral cuticle smooth (i.e. without sculpturing). Gibbosities and cuticular pores absent.

Bucco-pharyngeal apparatus of the *Hypsibius* type, without the ventral lamina, and with forked apophyses for stylet muscles (Fig. 6). Peribuccal lamellae absent. Teeth in the oral cavity armature absent or not visible under PCM. Pharyngeal bulb with apophyses and with two granular macroplacoids (both, without constrictions). Macroplacoid length sequence 2<1. Microplacoid and septulum absent.

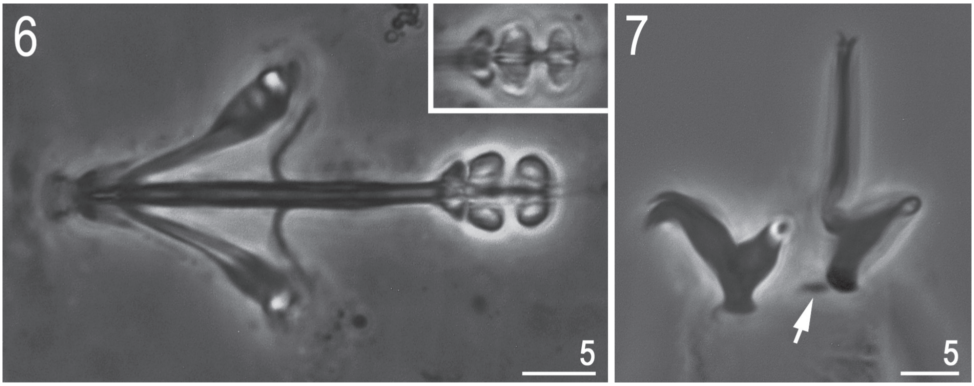
Claws of the *Hypsibius* type, internal claws much smaller and of a different shape than the external claws (Fig. 7). All main branches with large accessory points. Smooth, indistinct areoles under claws usually visible only on posterior claws IV. Cuticular bars under claws I-III absent but a small bar is present near the posterior claw IV (Fig. 7, arrow).

Eggs. Unknown.



Figures 1–5. *Hypsibius* cf. *scabropygus* Cuénot, 1929: **1** habitus (dorso-lateral view) **2–4** caudo-dorsal cuticle with distinct sculpturing – tubercles and tubercles merged into platelets **5** a single caudo-dorsal platelet. (**1–3**: PCM, **4–5**: SEM).

Remarks. *Hypsibius scabropygus* has been recorded from many localities, mostly in the Holarctic (McInnes 1994). In general, our specimens correspond to the original description by Cuénot (1929, 1932) and later descriptions by Marcus (1930) (=*Hypsibius callimerus* spec. nov.), and by Ramazzotti and Maucci (1983). However, importantly, none of the above mentioned descriptions reported a bar between anterior and posterior claws IV, which is present in all our specimens. Given the bar is small, it is possible that it was overlooked by Cuénot and later authors. If, however, *H. scabropygus* does not have the bar, then our specimens should probably be classified as a new species. Thus, until



Figures 6–7. *Hypsibius* cf. *scabropygus* Cuénot, 1929: **6** bucco-pharyngeal apparatus (dorso-ventral projection, ventral placoids in the insert) **7** claws IV (arrow indicates a small cuticular bar near the posterior claw). (Both PCM).

H. scabropygus is redescribed, our Latvian and Estonian records should be regarded as *H.* cf. *scabropygus*. As there is a possibility of our specimens belonging to a new species, we provide standard morphometrics (Table 1) and photographs (Figs 1–7).

Subfamily: Itaquasconinae Rudescu, 1964
Genus: *Astatumen* Pilato, 1997

Astatumen bartosi (Węglarska, 1959)

Localities and specimen numbers. XIV: 1 specimen.

Remarks. Our specimen corresponds perfectly with characters of *A. bartosi* proposed by Dastych (1988) with the main difference between *A. bartosi* and *A. trinacriae* being the absence/presence of cuticular bars on legs II–III. Due to the notorious difficulties in differentiating the two species, the actual distribution of *A. bartosi* cannot currently be described with confidence. McInnes (1994) cited this species from several localities in Europe and from single African, Asian and South American sites.

Superfamily: Isohypsibioidea Marley, McInnes & Sands, 2011
Family: Isohypsibiidae Marley, McInnes & Sands, 2011
Genus: *Isohypsibius* Thulin, 1928

Isohypsibius ronsisvallei Binda & Pilato, 1969

Localities and specimen numbers. III: 1 specimen.

Remarks. The species has previously been reported from several, mostly European, localities in the Holarctic (McInnes 1994).

Table 1. Measurements and *pt* values of selected morphological structures of *Hypsibius* cf. *scabropygus* Cuénot, 1929 mounted in Hoyer's medium (N – number of specimens/structures measured, RANGE refers to the smallest and the largest structure among all measured specimens; SD – standard deviation).

CHARACTER	N	RANGE						MEAN		SD	
		µm			*pt*			µm	*pt*	µm	*pt*
Body length	14	183	–	293	*808*	–	*1132*	235	*949*	33	*97*
Buccopharyngeal tube											
Buccal tube length	15	22.0	–	28.2		–		24.6	–	2.0	–
Stylet support insertion point	15	12.0	–	15.9	*51.3*	–	*57.1*	13.5	*54.9*	1.1	*1.6*
Buccal tube external width	15	1.5	–	2.0	*6.5*	–	*8.0*	1.8	*7.2*	0.2	*0.5*
Buccal tube internal width	15	0.6	–	0.9	*2.1*	–	*3.4*	0.7	*2.7*	0.1	*0.4*
Placoid lengths											
Macroplacoid 1	15	1.8	–	3.2	*7.7*	–	*12.3*	2.4	*9.6*	0.4	*1.3*
Macroplacoid 2	15	1.7	–	2.7	*7.2*	–	*11.3*	2.2	*8.9*	0.3	*1.1*
Macroplacoid row	15	4.7	–	6.3	*19.1*	–	*26.5*	5.3	*21.7*	0.5	*1.8*
Claw 1 lengths											
External base	14	2.2	–	4.5	*9.1*	–	*17.2*	3.5	*14.1*	0.7	*2.1*
External primary branch	14	4.0	–	8.8	*18.2*	–	*36.1*	6.9	*28.1*	1.5	*5.0*
External secondary branch	14	2.3	–	5.9	*10.5*	–	*24.4*	4.4	*17.9*	1.0	*3.9*
Internal base	12	2.1	–	4.1	*9.3*	–	*15.5*	3.3	*13.4*	0.6	*1.8*
Internal primary branch	12	3.8	–	5.9	*16.0*	–	*23.5*	4.8	*19.3*	0.6	*2.0*
Internal secondary branch	12	2.4	–	4.3	*9.9*	–	*16.5*	3.3	*13.3*	0.6	*2.0*
Claw 2 lengths											
External base	11	3.0	–	5.2	*12.4*	–	*19.9*	4.1	*16.7*	0.7	*2.2*
External primary branch	13	6.7	–	10.4	*29.7*	–	*43.7*	8.5	*34.7*	1.3	*4.4*
External secondary branch	13	4.3	–	6.7	*19.0*	–	*27.2*	5.4	*21.9*	0.7	*2.6*
Internal base	10	2.4	–	4.5	*10.9*	–	*18.9*	3.6	*14.6*	0.7	*2.2*
Internal primary branch	12	4.0	–	6.7	*17.7*	–	*27.2*	5.4	*22.0*	0.9	*2.9*
Internal secondary branch	12	2.6	–	5.4	*11.8*	–	*22.0*	4.1	*16.7*	0.9	*3.0*
Claw 3 lengths											
External base	9	2.7	–	6.2	*11.9*	–	*23.8*	4.3	*17.3*	1.0	*3.5*
External primary branch	9	7.2	–	10.4	*29.3*	–	*43.7*	8.8	*35.7*	1.1	*4.4*
External secondary branch	9	3.6	–	6.5	*12.8*	–	*27.3*	5.2	*21.0*	1.0	*4.3*
Internal base	11	2.3	–	4.1	*10.5*	–	*17.2*	3.4	*13.9*	0.6	*1.9*
Internal primary branch	13	3.8	–	6.5	*17.3*	–	*27.3*	5.4	*21.8*	0.9	*3.1*
Internal secondary branch	12	2.7	–	6.1	*12.2*	–	*24.8*	3.9	*16.0*	0.9	*3.5*
Claw 4 lengths											
Anterior base	13	3.3	–	5.6	*12.8*	–	*20.1*	4.1	*16.8*	0.6	*2.2*
Anterior primary branch	13	4.4	–	7.5	*19.5*	–	*31.1*	5.9	*24.2*	1.1	*3.9*
Anterior secondary branch	11	3.1	–	13.2	*13.0*	–	*47.3*	4.8	*18.9*	2.9	*9.7*
Posterior base	12	2.7	–	5.4	*12.3*	–	*21.5*	4.5	*18.2*	0.9	*3.1*
Posterior primary branch	12	4.9	–	14.9	*22.0*	–	*60.6*	10.3	*41.9*	2.9	*11.2*
Posterior secondary branch	12	4.0	–	6.5	*15.4*	–	*25.6*	5.2	*21.2*	0.9	*3.4*

Isohypsibius sattleri (Richters, 1902)

Localities and specimen numbers. IX: 1 specimen, XI: 8 specimens (including 5 simplexes), XIV: 3 specimens, XV: 5 specimens, XVI: 1 specimen.

Remarks. The species has previously been reported from many localities throughout the World, thus it is considered cosmopolitan (McInnes 1994, Kaczmarek et al. 2014a).

Superfamily: Macrobiotoidea Thulin, 1928 in Marley et al. 2011
Family: Macrobiotidae Thulin, 1928
Genus: *Macrobiotus* C.A.S. Schultze, 1834

Macrobiotus harmsworthi harmsworthi Murray, 1907

Localities and specimen numbers. XI: 1 egg, XIV: 8 specimens, 1 egg.

Remarks. The species belongs to the *harmsworthi* group which is widely distributed across a broad range of ecosystems throughout the world (McInnes 1994, Kaczmarek et al. 2014a). In the last decade many new species within this group were described from a variety of localities (Michalczyk and Kaczmarek 2003b, Pilato et al. 2004, Tumanov 2005a, Pilato and Lisi 2006a, b, Pilato et al. 2006a, Kaczmarek et al. 2007, Kaczmarek and Michalczyk 2009b, Pilato and Lisi 2009a, Rossi et al. 2009, see also Kaczmarek et al. 2011 for the diagnostic key to the group). Due to many uncertain reports of *M. harmsworthi harmsworthi*, especially in older literature, the distribution of the species is currently unknown. Specimens found in the present study correspond well to the characters presented in Pilato et al. (2000) and were successfully identified with the key by Kaczmarek et al. (2011).

Macrobiotus hufelandi hufelandi C.A.S. Schultze, 1833

Localities and specimen numbers. XIV: 4 specimens, 1 egg.

Remarks. The species belongs to the *hufelandi* group which is widely distributed across a broad range of ecosystems throughout the world (McInnes 1994, Kaczmarek et al. 2014a). In the last decade new species belonging to this group have been described from various localities (Pilato et al. 2003, Kaczmarek and Michalczyk 2004, Dastych 2002, 2005, Fontoura et al. 2008, Bartels et al. 2009, Kaczmarek and Michalczyk 2009b, Pilato and Lisi 2009b, Bertolani et al. 2011, Biserov et al. 2011, Pilato et al. 2012, Guidetti et al. 2013, see also Bertolani and Rebecchi 1993 for the diagnostic key to the group). Due to many uncertain reports of *M. hufelandi hufelandi*, especially in older literature, the distribution of the species is currently unknown. Specimens found in the present study correspond well with the redescription by Bertolani and Rebecchi (1993).

Genus: *Minibiotus* R.O. Schuster, 1980

Minibiotus formosus sp. n.
http://zoobank.org/BDBE49B7-84CF-4FE2-BE55-A399A537DE77
http://species-id.net/wiki/Minibiotus_formosus
http://www.tardigrada.net/register/0012.htm
Tables 2–3, Figs 8–15

Type material. Holotype and 23 paratypes, 24 specimens (including 2 simplexes) and 3 unembryonated eggs).

Type locality. 57°10'33"N; 24°50'32"E, *ca.* 45 m asl: Latvia, Vidzeme region, Sigulda municipality, Gutmana Cave in the Gauja National Park; moss from rock (1 sample, slide codes: ŁO 2427/*, where the asterisk can be substituted by any of the following numbers: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12).

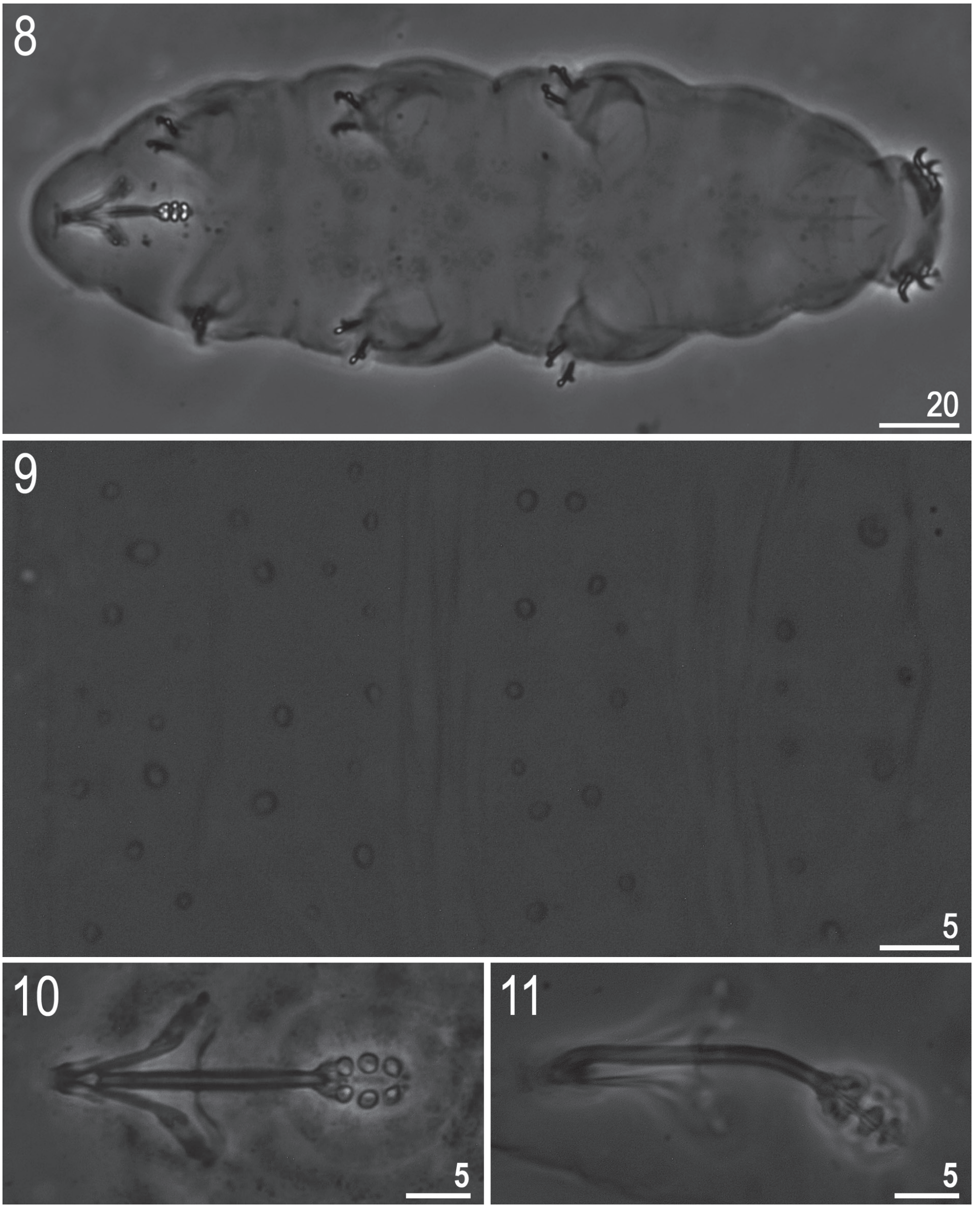
Description (measurements in Table 2). Body white/colourless (Fig. 8). Eyes present in 18 of 24 (75%) specimens mounted in Hoyer's medium. Entire cuticle covered with small (0.4–1.1 µm) and large (1.9–2.5 µm) round or oval pores (Fig. 9). Pores arranged in 9–10 poorly defined transverse bands. Pores on the dorsal cuticle arranged more densely than on the ventral cuticle. A single large pore (diameter: 2.1–2.9 µm) present on external side of legs I–III (Fig. 12, arrow). A ring of pores around the mouth opening absent. Cuticle without granulation, except for legs which are all covered with fine and regular granulation (better developed on legs IV) visible only in larger specimens (Fig 12, arrowhead).

Mouth antero-ventral. Ten peribuccal papulae present. Bucco-pharyngeal apparatus of the *Minibiotus* type (Figs 10–11). Oral cavity armature absent or not visible under PCM. Buccal tube with a poorly visible ventral lamina and with an anterior and a posterior bend (both visible in lateral view only, Fig. 11). Buccal tube walls thickened just below the stylet supports insertion point. Pharyngeal apophyses triangular, very near to the first macroplacoid. Three granular macroplacoids and a minute microplacoid present in the pharyngeal bulb. All macroplacoids of similar but not identical sizes, the macroplacoid length sequence: 2<1<3. Septulum absent.

Claws of the *Macrobiotus* type (Figs 12–13). Primary branches of claws with thin, but obvious accessory points detaching at the apogee of the primary branch curve. Smooth lunules present on all legs, distinctly larger under external and posterior claws. Bars and other cuticular thickenings on legs absent.

Eggs (measurements in Table 3). White/transparent, laid freely (Fig. 14). Spherical, without areolation. Processes in the shape of short, smooth, slightly flexible cones (Fig. 15). Processes are distributed on the surface of the egg close one to another but never in contact. Surface between processes smooth under PCM (Fig. 15).

Remarks. Since ventral lamina is very poorly visible, the measurements of this structure are not included in Table 2. Three unembryonated eggs have been found alongside the described specimens. Given that *M. formosus* sp. n. was the only *Minibiotus* species in the



Figures 8–11. *Minibiotus formosus* sp. n.: **8** habitus (holotype, ventral view) **9** dorsal cuticle with pores (holotype) **10–11** bucco-pharyngeal apparatus (**10** dorso-ventral projection, paratype **11** lateral view, paratype). All PCM.

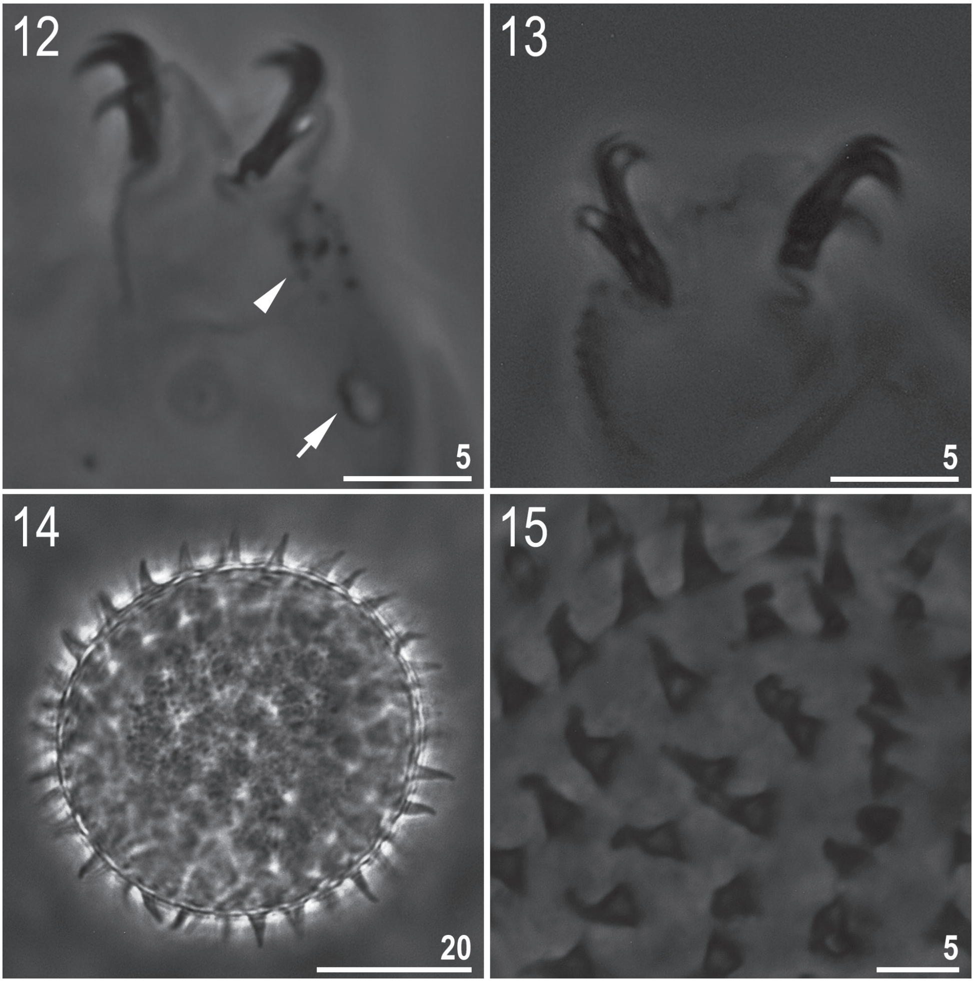
sample and because no *Ramazzottius* Binda & Pilato, 1986 was found in the samples, we assumed that these eggs belong to the new species.

Etymology. Given that we found the composition of small and large pores in the new species beautiful, we decided to name the animal after this impression (in Latin '*formosus*' means 'beautiful').

Table 2. Measurements and *pt* values of selected morphological structures of *Minibiotus formosus* sp. n. mounted in Hoyer's medium (N – number of specimens/structures measured, RANGE refers to the smallest and the largest structure among all measured specimens; SD – standard deviation, ? – trait oriented unsuitably for measurement).

CHARACTER	N	RANGE						MEAN		SD		Holotype	
		µm			*pt*			µm	*pt*	µm	*pt*	µm	*pt*
Body length	7	113	–	236	636	–	1034	184	901	39	139	194	848
Buccal tube													
Length	9	17.7	–	22.9		–		20.3	–	1.7	–	22.9	–
Stylet support insertion point	9	9.5	–	12.2	49.5	–	56.2	10.9	53.8	0.9	2.0	12.2	53.3
External width	9	1.3	–	2.0	7.0	–	9.9	1.6	7.8	0.2	0.8	1.7	7.4
Internal width	9	0.5	–	0.7	2.4	–	3.4	0.6	2.8	0.1	0.3	0.7	3.1
Placoid lengths													
Macroplacoid 1	9	1.3	–	1.9	6.9	–	8.3	1.5	7.6	0.2	0.4	1.8	7.9
Macroplacoid 2	9	1.2	–	1.7	6.8	–	8.3	1.5	7.5	0.2	0.4	1.7	7.4
Macroplacoid 3	9	1.4	–	2.2	7.4	–	9.6	1.7	8.2	0.3	0.6	1.9	8.3
Microplacoid	8	0.5	–	0.9	2.4	–	4.7	0.7	3.3	0.1	0.8	0.8	3.5
Macroplacoid row	9	4.5	–	6.8	24.3	–	33.7	5.5	26.9	0.7	3.0	5.9	25.8
Placoid row	8	5.2	–	7.9	27.1	–	39.1	6.4	31.0	0.9	3.9	6.7	29.3
Claw 1 lengths													
External primary branch	4	4.7	–	6.5	22.8	–	31.6	5.8	27.7	0.8	3.7	6.2	27.1
External secondary branch	3	3.6	–	4.3	17.5	–	20.9	3.9	19.4	0.4	1.7	?	?
Internal primary branch	6	4.7	–	6.6	24.3	–	30.4	5.7	27.4	0.7	2.4	6.3	27.5
Internal secondary branch	5	3.1	–	4.6	15.0	–	20.4	4.0	18.7	0.5	2.3	4.6	20.1
Claw 2 lengths													
External primary branch	5	5.2	–	6.9	25.2	–	34.0	5.9	28.6	0.6	3.5	5.9	25.8
External secondary branch	4	3.3	–	4.7	16.0	–	23.2	3.9	19.4	0.6	2.9	?	?
Internal primary branch	5	5.2	–	6.4	27.1	–	31.9	6.0	29.7	0.5	2.3	6.2	27.1
Internal secondary branch	3	3.5	–	4.1	18.5	–	20.9	3.9	19.9	0.3	1.3	?	?
Claw 3 lengths													
External primary branch	5	5.1	–	6.9	27.0	–	33.2	6.3	30.6	0.7	2.4	6.9	30.1
External secondary branch	6	3.6	–	4.9	19.0	–	24.1	4.6	22.1	0.5	1.8	4.9	21.4
Internal primary branch	7	5.1	–	6.6	25.7	–	32.5	5.9	29.2	0.6	2.5	6.4	27.9
Internal secondary branch	4	4.1	–	4.6	20.9	–	22.8	4.3	21.6	0.2	0.8	?	?
Claw 4 lengths													
Anterior primary branch	5	6.0	–	8.0	31.6	–	39.6	7.0	34.2	0.8	3.5	?	?
Anterior secondary branch	4	4.0	–	6.0	21.2	–	29.7	5.0	24.1	0.9	3.9	?	?
Posterior primary branch	6	6.0	–	7.8	30.7	–	38.4	7.0	33.9	0.7	3.1	?	?
Posterior secondary branch	5	3.9	–	5.5	20.6	–	27.1	4.8	23.8	0.6	2.6	?	?

Type depositories. Holotype 23 paratypes and 3 eggs are deposited in the Department of Animal Taxonomy and Ecology at the Adam Mickiewicz University (Poznań, Poland).



Figures 12–15. *Minibiotus formosus* sp. n.: **12** leg II with claws, granulation (arrowhead) and a single large pore (arrow) (holotype) **13** claws IV (paratype) **14** egg (mid-section) **15** egg surface with processes. All PCM.

Table 3. Measurements of selected morphological structures of *Minibiotus formosus* **sp. n.** eggs mounted in Hoyer's medium.

CHARACTER	**egg 1**	**egg 2**	**egg 3**
Diameter of egg without processes	45.7	44.1	?
Diameter of egg with processes	55.6	55.1	?
Process height	4.5–5.2	4.8–5.2	4.6–5.3
Process base width	2.8–3.4	2.8–3.1	2.4–2.6
Process base/height ratio	57%–69%	54%–65%	47%–57%
Distance between processes	2.0–2.5	1.9–3.9	1.8–2.0
Number of processes on the egg circumference	30	29	30

Differential diagnosis

The new species is most similar to *M. gumersindoi* Guil & Guidetti, 2005, but it differs from it by: the presence of two types of cuticular pores (small and large) in the new species *vs* pores of a uniform size in *M. gumersindoi*, the absence of a triangular or a pentagonal arrangement of pores placed above a single large pore on legs, the presence of granulation on legs, a different macroplacoid length sequence (2<1<3 in the new species *vs* 1=2=3 in *M. gumersindoi*), and by slightly larger macroplacoids (I: 1.3–1.9 µm; II: 1.2–1.7 µm III: 1.4–2.2 µm in the new species *vs* 1.0 µm in *M. gumersindoi*).

Other species to which *M. formosus* sp. n. is similar by some characteristics of adult and/or egg morphology (e.g. pores in transverse bands, eggs with conical processes), include species listed below. The new species differs specifically from:

- ***M. bisoctus*** (Horning et al. 1978) by: the absence of trilobed and star-shaped pores (although their presence was not mentioned in the original description, they are clearly visible in Fig. 114 in Horning et al. (1978), and by stylet supports inserted in a more anterior position (*pt=49.5–56.2* in the new species *vs pt≈60.3* in *M. bisoctus* (according to Claxton 1998)).
- ***M. eichhorni*** Michalczyk & Kaczmarek, 2004 by: a different arrangement of pores on the dorsal cuticle (9–10 transverse bands in the new species *vs* 8 bands in *M. eichhorni*), the absence of star-shaped pores, the absence of four pores around the mouth opening, the presence of a single large pore on lateral sides of legs I-III, slightly shorter buccal tube (17.7–22.9 µm in the new species *vs* 24.7–34.2 µm in *M. eichhorni*), stylet supports inserted in more anterior position (9.5–12.2 µm [*pt=49.5–56.2*] in the new species *vs* 16.2–23.8 µm [*pt=65.4–70.6*] in *M. eichhorni*), a different macroplacoid sequence (2<1<3 in the new species *vs* 2<3<1 µm in *M. eichhorni*), slightly shorter placoids, and by slightly smaller external claws I–IV (compare Table 2 below and Table 1 in Michalczyk and Kaczmarek 2004 for exact differences in dimensions of placoids and claws).
- ***M. furcatus*** (Ehrenberg, 1859) (according to Binda and Pilato 1992) by: the absence of tri- and quadrilobed cuticular pores, the presence of two types of cuticular pores (small and large in the new species *vs* uniformly small pores present in *M. furcatus*), the presence of a single large pore on each of legs I–III, the presence of granulation on legs, the absence of the oral cavity armature, stylet supports inserted in a more anterior position (*pt=49.5–56.2* in the new species *vs pt≈68.4* in *M. furcatus*), a different macroplacoid length sequence (2<1<3 in the new species *vs* 2<3<1 in *M. furcatus*), and by egg processes without an obvious flexible portion (and never bifurcated).
- ***M. harrylewisi*** Meyer & Hinton, 2009 by: the absence of tri- and quadrilobed cuticular pores, the presence of two types of pores (small and large) over the entire cuticle in the new species *vs* small pores present only in the anterior part of the body and large pores present only in the posterior part of the body in *M. harrylewisi*, the presence of a single large pore on each of legs I–III, stylet supports inserted in

a more anterior position (*pt=49.5–56.2* in the new species *vs pt=61.4–67.6* in *M. harrylewisi*), a different macroplacoid length sequence (2<1<3 in the new species *vs* 2≤3<1 µm in *M. harrylewisi*), a different shape of egg processes (short, single-tipped cones in the new species *vs* elongated, tapering cones with bulbous bases in *M. harrylewisi*), a smaller diameter of eggs without and with processes (44.1–45.7 µm and 55.1–55.6 µm in the new species *vs* 66.1–80.0 µm and 78.2–101.9 µm in *M. harrylewisi*), a slightly lower number of processes on egg circumference (29–30 in the new species *vs* 32–41 in *M. harrylewisi*), and by smaller egg processes (4.5–5.3 µm in the new species *vs* 7.6–12.8 µm in *M. harrylewisi*).

- ***M. jonesorum*** Meyer et al., 2011 by: the absence of trilobed and polygonal pores, the presence of two types of cuticular pores (small and large) in the new species *vs* small pores present only in the anterior part of the body, intermediate in size in the middle of the body and large pores in the posterior part of the body in *M. jonesorum*), the presence of a single large pore on each of legs I-III, the presence of granulation on all legs, a slightly shorter buccal tube (17.7–22.9 µm in the new species *vs* 24.4–29.6 µm in *M. jonesorum*), stylet supports inserted in a more anterior position (*pt=49.5–56.2* in the new species *vs pt=63.0–65.6* in *M. jonesorum*), a slightly smaller external diameter of the buccal tube (1.3–2.0 µm [*pt=7.0-9.9*] in the new species *vs* 2.1–2.6 µm [*pt=7.4–10.7*] in *M. jonesorum*), a different macroplacoid length sequence (2<1<3 in the new species *vs* 1<2<3 in *M. jonesorum*), slightly shorter macroplacoids II and III (II: 1.2–1.7 µm [*pt=6.8–8.6*]; III: 1.4–2.2 µm [*pt=7.4–9.6*] in the new species *vs* II: 1.9–2.3 µm [*pt=7.1–8.8*]; III: 2.4–2.6 µm [*pt=8.4–9.9*] in *M. jonesorum*), a slightly shorter macroplacoid row (4.5–6.8 µm [*24.3–33.7*] in the new species *vs* 7.0–8.4 µm [*pt=27.0–34.4*] in *M. jonesorum*), the presence of a microplacoid, and by slightly shorter primary and secondary branches of external claws I–IV (compare Table 2 below and Table 2 in Meyer et al. 2011).
- ***M. keppelensis*** Claxton, 1998 by: the lack of red pigment granules, the presence of two types of cuticular pores (small and large) in the new species *vs* pores uniform in size (*ca.* 1.0 µm) in *M. keppelensis*), the presence of a single large pore on each of legs I-III, a slightly shorter buccal tube (17.7–22.9 µm in the new species *vs* 24.9–28.4 µm in *M. keppelensis*), stylet supports inserted in a more anterior position (*pt=49.5–56.2* in the new species *vs pt≈60.6* in *M. keppelensis*), a different macroplacoid length sequence (2<1<3 in the new species *vs* 2=3<1 in *M. keppelensis*), a slightly shorter macroplacoid row (4.5–6.8 µm in the new species *vs* 7.0–7.6 µm in *M. keppelensis*), the lack of a membrane around egg processes, a smaller diameter of eggs with processes (55.1–55.6 µm in the new species *vs* 65.0–85.0 µm in *M. keppelensis*), a larger number of processes on egg circumference (29–30 in the new species *vs ca.* 11 in *M. keppelensis*), smaller egg processes (4.5–5.3 µm in the new species *vs* 11.0–16.0 µm in *M. keppelensis*), narrower egg processes bases (2.4–3.4 µm in the new species *vs* 9.0–12.0 µm in *M. keppelensis*), and by slightly smaller distances between egg processes (1.8–3.9 µm in the new species *vs* 4.0–6.0 µm in *M. keppelensis*).

- ***M. orthofasciatus*** Fontoura et al., 2009 by: cuticular pores arranged in 9–10 transverse bands (11 transverse bands present in *M. orthofasciatus*), the absence of tri- and quadrilobed cuticular pores, the presence of two types of pores (small and large) in the new species *vs* all pores of similar size in *M. orthofasciatus*, the presence of a single large pore on each of legs I–III, the presence of granulation on all legs, stylet supports inserted in a more anterior position (*pt=49.5–56.2* in the new species *vs pt=66.5–67.8* in *M. orthofasciatus*), a different shape of egg processes (short, single tip cones without a membrane in the new species *vs* screw-like processes with a membrane and six areoles in *M. orthofasciatus*), a slightly larger number of processes on egg circumference (29–30 in the new species *vs ca.* 24 in *M. orthofasciatus*), and by smaller distances between egg processes (1.8–3.9 µm in the new species *vs* 6.4–6.9 µm in *M. orthofasciatus*).
- ***M. poricinctus*** Claxton, 1998 by: cuticular pores arranged in 9–10 transverse bands (8 transverse bands in *M. poricinctus*), the presence of two types of pores (small and large) in the new species *vs* uniform pore size in *M. poricinctus*), the presence of a single large pore on each of legs I–III, stylet supports inserted in a more anterior position (*pt=49.5–56.2* in the new species *vs pt≈59.5* in *M. poricinctus*), a different macroplacoid length sequence (2<1<3 in the new species *vs* 2=3<1 in *M. poricinctus*), a different shape of egg processes (short, single-tipped cones without a membrane in the new species *vs.* screw-like processes within a membrane in *M. poricinctus*), the absence of granulation on egg shell, a larger number of processes on egg circumference (29–30 in the new species *vs* 18–20 in *M. poricinctus*), slightly smaller egg processes (4.5–5.3 µm in the new species *vs* 6.5–7.0 µm in *M. poricinctus*), and by smaller distances between egg processes (1.8–3.9 µm in the new species *vs* 6.0–8.0 µm in *M. poricinctus*).
- ***M. pustulatus*** (Ramazzotti, 1959) by: the absence of triangular and polygonal pores, the presence of two types of cuticular pores (small and large) in the new species *vs* small pores present only in the anterior part of the body, intermediate in size in the middle of the body and the large pores in the posterior part of the body in *M. pustulatus*), the presence of a single large pore on each of legs I–III and, egg processes without a filiform bristle.
- ***M. ramazzottii*** Binda & Pilato, 1992 by: pores arranged in bands, the presence of two types of pores (small and large) in the new species *vs* universal pores size in *M. ramazzottii*), the presence of a single large pore on each of legs I–III, the absence of the oral cavity armature, stylet supports inserted in a more anterior position (*pt=49.5–56.2* in the new species *vs pt=68.2–68.3* in *M. ramazzottii*), a different macroplacoid length sequence (2<1<3 in the new species *vs* 3<2<1 in *M. ramazzottii*), and by a lower number of processes on egg circumference (29–30 in the new species *vs ca.* 34–41 in *M. ramazzottii*).
- ***M. subintermedius*** (Ramazzotti, 1962) by the presence of cuticular pores, the presence of granulation on all legs, and by fully developed lunules (only small open lunules present in *M. subintermedius*).
- ***M. vinciguerrae*** Binda & Pilato, 1992 by: pores arranged in bands, the absence of tri- and quadrilobed pores, the presence of two types of pores (small and large)

in the new species *vs* uniform pore size in *M. vinciguerrae*), the presence of a single large pore on each of legs I–III, the absence of the oral cavity armature, a larger mean body size (184 µm in the new species *vs* 380 µm in *M. vinciguerrae*), stylet supports inserted in a more anterior position (*pt=49.5–56.2* in the new species *vs pt=66.1–68.7* in *M. vinciguerrae*), a different macroplacoid length sequence (2<1<3 in the new species *vs* 2<3<1 µm in *M. vinciguerrae*), a smaller diameter of eggs without and with processes (44.1–45.7 µm and 55.1–55.6 µm in the new species *vs ca.* 76.4 µm and *ca.* 88.0 µm in *M. vinciguerrae*), a slightly larger number of processes on egg circumference (29–30 in the new species *vs ca.* 26 in *M. vinciguerrae*), egg processes without flexible filaments, smaller egg processes (4.5–5.3 µm in the new species *vs ca.* 8.2 µm in *M. vinciguerrae*), and by narrower bases of egg processes (2.4–3.4 µm in the new species *vs ca.* 5.0 µm in *M. vinciguerrae*).

- ***M. weglarskae*** Michalczyk et al., 2005 by: the absence of bi-, trilobed and star-shaped pores, the presence of two types of pores (small and large) in the new species *vs* uniform pore size in *M. weglarskae*), the absence of 3–5 large triangular or irregularly shaped pores on the caudo-dorsal cuticle above hind legs, the presence of a single large pore on each of legs I-III, a different shape of egg processes (short, single tip cones without a membrane in the new species *vs.* screw-like processes within a membrane in *M. weglarskae*), a slightly larger number of processes on egg circumference (29–30 in the new species *vs ca.* 24 in *M. weglarskae*), and by slightly wider bases of egg processes (2.4–3.4 µm in the new species *vs* 1.6–2.0 µm in *M. weglarskae*).
- ***M. xavieri*** Fontoura et al., 2009 by: the absence of trilobed pores, the presence of two types of pores (small and large) in the new species *vs* all pores of similar size in *M. xavieri*), the presence of a single large pore on each of legs I–III, the presence of granulation on all legs, a smaller body size (113–236 µm in the new species *vs* 275–410 µm in *M. xavieri*), stylet supports inserted in a more anterior position (*pt=49.5–56.2* in the new species *vs pt=66.1–67.9* in *M. xavieri*), a different macroplacoid length sequence (2<1<3 in the new species *vs* 2<3<1 in *M. xavieri*). shorter macroplacoids (I: 1.3–1.9 µm [*pt=6.9–8.3*]; II: 1.2–1.7 µm [*pt=6.8–8.6*] III: 1.4–2.2 µm [*pt=7.4–9.6*] in the new species *vs* I: 3.6–4.5 µm [*12.7–13.8*]; II: 2.9–3.6 µm [*10.3–11.1*] III: 3.0–3.9 µm [*pt=10.9–11.9*] in *M. xavieri*), a shorter microplacoid (0.5–0.9 µm [*pt=2.4–4.7*] in the new species *vs* 1.5–2.0 [*5.0–6.2*] in *M. xavieri*), a shorter macroplacoid row (4.5–6.8 µm [*pt=24.3–33.7*] in the new species *vs* 9.8–12.6 µm [*pt=35.6–38.5*] in *M. xavieri*), a shorter placoid row (5.2–7.9 µm [*pt=27.1–39.1*] in the new species *vs* 10.9–13.9 µm [*39.6–43.3*] in *M. xavieri*), a different shape of egg processes (short, single-tipped cones in the new species *vs* long cones with bi- or multi-tipped tips in *M. xavieri*), egg shell and processes without granulation, a smaller diameter of eggs without and with processes (44.1–45.7 µm and 55.1–55.6 µm in the new species *vs* 56.0–79.0 µm and 80.0–99.2 µm in *M. xavieri*), a larger number of processes on egg circumference (29–30 in the new species *vs* 20–23 in *M. xavieri*), smaller egg processes (4.5–5.3 µm in the new species *vs* 10.6–19.0 µm in *M. xavieri*), and by slightly narrower bases of egg processes (2.4–3.4 µm in the new species *vs* 3.7–6.6 µm in *M. xavieri*).

Genus: *Paramacrobiotus* Guidetti, Schill, Bertolani, Dandekar & Wolf, 2009

Paramacrobiotus richtersi (Murray, 1911)

Localities and specimen numbers. XI: 2 specimens (including 1 simplex) and 1 egg.

Remarks. *Paramacrobiotus* species (until recently a collection of species within *Macrobiotus*) can be divided into three groups: *areolatus*, *huziori* and *richtersi*, with respect to the combination of two traits: the presence/absence of the microplacoid in the pharynx and the type of egg areolation. *Paramacrobiotus richtersi*, considered cosmopolitan, is recognised as the nominal species for a group of very similar taxa that require careful taxonomic examination of adults and egg morphology for correct identification. In the last decade many new species of this group have been described from various localities (e.g. Pilato et al. 2004, Kaczmarek et al. 2005, Tumanov 2005b, Michalczyk and Kaczmarek 2006a, b, Michalczyk et al. 2006, Pilato et al. 2006a, b, Degma et al. 2008, Bartels et al. 2009, Pilato et al. 2012), with more recent additions including molecular data (Guidetti et al. 2009, Schill et al. 2010).

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Description of *Medwayella independencia* (Siphonaptera, Stivaliidae), a new species of flea from Mindanao Island, the Philippines and their phoretic mites, and miscellaneous flea records from the Malay Archipelago

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Abstract

Medwayella independencia, a new species of flea, is described from the tupaiid host *Urogale everetti* (Thomas) from Mindanao Island, Philippines. Several other species of fleas are also recorded from the Philippines including a single male of *Lentistivalius philippinensis* Hastriter & Bush, 2013 (previously known only from two males), the bat fleas *Thaumapsylla breviceps orientalis* Smit and *Thaumapsylla longiforceps* Traub, a single unidentified female species of *Macrostylophora* Ewing collected from the murid *Bullimus bagobos* Mearns, and a pair of *Medwayella robinsoni* ssp. from *Sundasciurus hoogstraali* (Sanborn) from Busuanga Island, Philippines. Representatives of *Medwayella* Traub, 1972 and *Macrostylophora* have not previously been recorded from the Philippines. A key to the male sex of *Medwayella* is provided. Phoretic mites of the genus *Psylloglyphus* (family Winterschmidtiidae) were present under the abdominal sclerites of several male and female specimens of *M. independencia*. This is the second report of a phoretic mite on a species of *Medwayella* Traub. The co-evolutionary implications between phoretic mites and fleas are discussed.

Keywords

Bat fleas, key, phoresy, *Psylloglyphus*, *Urogale everetti*, Winterschmidtiidae

Introduction

The genus *Medwayella* Traub, 1972 contains 22 species (including subspecies) distributed as follows: Cambodia (1), Java (2), Peninsular Malaysia (7), Sabah (4), Sarawak (5), Sulawesi (1), Sumatra (3), and Thailand (2) (some species are reported in multiple areas). The first of these species was described by Rothschild (1905), followed by four additional species by Jordan (1926, 1933). Subsequently, Traub (1972a) erected the genus *Medwayella*, placed the previously described taxa by Rothschild and Jordan into *Medwayella*, and described an additional 13 new *Medwayella* species. Traub (1972a) also provided a detailed analysis of host flea relationships, a complex list of morphological characters germane to the genus, and a key to *Medwayella*. *Stivalius cambodius* Klein, 1970 was later included as a member of *Medwayella* by Mardon (1978). Mardon (1981) summarized the species housed in the British Museum while Beaucournu and Wells (2004) added another three species from Sabah and Durden and Beaucournu (2006) described one new taxon from Sulawesi. A small series of fleas from Mindanao, Philippines contained a new species of *Medwayella* that is described herein bringing the total number of species of *Medwayella* to 23. This new species also harbored phoretic mites and these are discussed.

Materials and methods

Mammals and their ectoparasites were surveyed on Mindanao Island, Philippines, during June and July of 2012. Mammals were captured and euthanized according to guidelines of the American Society of Mammalogists (Gannon et al. 2007). Mist nets and harp traps were set in the forest and at, or near cave entrances to capture bats. Bats were processed for ectoparasites in accordance with Hastriter and Bush (2006). Terrestrial mammals were captured with Sherman traps or snap-traps. Each mammal was subjected to a thorough post-mortem visual examination: the face and ears were carefully searched and parasites were removed with forceps. In addition, the fur was systematically searched with the aid of a fine-toothed metal comb (LiceMeister®, National Pediculosis Association, Needham, MA). All ectoparasites recovered were preserved in 95% ethanol for later processing and identification in the laboratory. All associated hosts were prepared as museum specimens and were deposited in the Kansas Museum of Natural History (KUMNH), Lawrence, KS, U.S.A. Terminologies for anatomical terms of flea morphology follow those of Rothschild and Traub (1971) and Traub (1972a). Numbered tergites and sternites are designated with abbreviations as (T) and (S), e.g., T-II–V, and S-II–V. Repositories for fleas are designated as Carnegie Museum Natural History (CMNH), or Brigham Young University flea collection (BYUC). Images were prepared using an Olympus BX61 Compound Microscope, Olympus CC12 digital camera accompanied with an Olympus Microsuite™ B3SV program and Adobe Photoshop, CS4.

Results

Siphonaptera
Ceratophyllidae

Macrostylophora sp.

Material examined. Philippines, Mindanao Island, village: San Antonio (09.0625°N, 125.6726°E), Mt. Hilong, 990 m, *Bullimus bagobos* Mearns ♀ (host # KUMNH-168368, NCA-179), 12 VI 2012, E. DiBlasi, 1♀ (parasite # P-5162) (BYUC).

Remarks. This is the first representative of the genus *Macrostylophora* recorded from the Philippines. This single female likely represents an undescribed species; however, without additional material, especially males, it would be premature to describe the species at this time. Few ceratophyllid genera are found in Southeast Asia and the Philippines is the periphery of the genus *Macrostylophora*. Additional collecting is badly needed to better delineate the geographic parameters of *Macrostylophora* and this potentially new species of interest.

Ischnopsyllidae, Thaumapsyllinae

Thaumapsylla breviceps orientalis Smit, 1954

Material examined. Philippines, Luzon Island, Aurora Province, San Luis, Minoli, 15.680°N, 121.529°E, 520m, *Rousettus amplexicaudatus* (E. Geoffroy) ♂ (host# KUMNH-167960, JAE-3026F), J. Esselstyn, 16 VI 2009, 1♀ (parasite # JAE-3026) (BYUC).

Remarks. The nominate subspecies is commonly found on *Rousettus aegyptiacus* (Geoffroy) in its western ranges from South Africa to Southwest Asia while in more eastern areas, *T. b. orientalis* is found on *R. amplexicaudatus*. Other Philippine records of *T. b. orientalis* were discussed in Hastriter and Bush (2013).

Thaumapsylla longiforceps Traub, 1951
http://species-id.net/wiki/Thaumapsylla_longiforceps\according to Hastriter et al 2014

Material examined. Philippines, Mindanao Island, village: San Antonio (09.064°N, 125.642°E), Mt. Hilong, 110 m, *R. amplexicaudatus* ♀ (host # KUMNH-168427, NCA-264), 20 VI 2012, E. DiBlasi, 1♀ (parasite #: P-5383) (BYUC).

Remarks. This species commonly occurs on pteropodid bats (fruit bats) but has also been documented on vespertilionid and rhinolophid bats in Asia. See additional discussion of *T. longiforceps* in the Philippines by Hastriter and Bush (2013).

Stivaliidae, Stivaliinae

Lentistivalius philippinensis Hastriter & Bush, 2013

http://species-id.net/wiki/Lentistivalius_philippinensis\according to Hastriter et al 2014

Material examined. Sumatra, 6 km from Sidikalang, North Sumatra Province, Indonesia, "scrub and lalang grass near stream"; *Rattus rattus diardii* ♀, 8 IV 1973, M. Nadchatram, R. Traub, and D. Roberts, (B-87343, Sub. 231, 1♂) (CMNH).

Remarks. Hastriter and Bush (2013) described this species from Luzon Island, Philippines, from *Crocidura grayi* Dobson. A single male was thereafter discovered in the Traub flea collection from the Greater Sunda Island of Sumatra, approximately 1700 km from the type locality. This is the third specimen known for *L. philippinensis* and the female sex remains undescribed. Such a disjunct distribution is indicative of the dearth of ectoparasite collections throughout the Malay Archipelago. A host voucher specimen of "*Rattus rattus diardii*" is not available to verify the recorded field identification. Wilson and Reeder (2005) included "diardii" as a synonym of *Rattus tanezumi* Temminck, a species widely introduced throughout insular Southeast Asia, including the Greater and Lesser Sunda Islands and the Molucca Islands (Flannery 1995). *Rattus tanezumi* might be considered relevant in the apparent dissemination of *L. philippinensis* to Sumatra or from Sumatra to the Philippines. In addition, although *C. grayi* is restricted to the island of Luzon, the importance of other species of *Crocidura* across the region may also account for the broader distribution on islands outside of the Philippines, such as Sumatra. Traub (1972a) noted, "… the remarkable facility of this genus [*Lentistivalius*] to adapt to a broad variety of hosts, in widely separated areas", a statement supported by the various species of *Lentistivalius* that are found on birds, shrews, and murid rodents. Flea collections throughout the Malay Archipelago are drastically lacking. Future collections and studies of fleas and other ectoparasites are badly needed in Southeast Asia and the insular regions of the Malay Archipelago, especially with the alarmingly rapid destruction of habitat and loss of mammalian host species.

Medwayella independencia Hastriter & Bush, sp. n.

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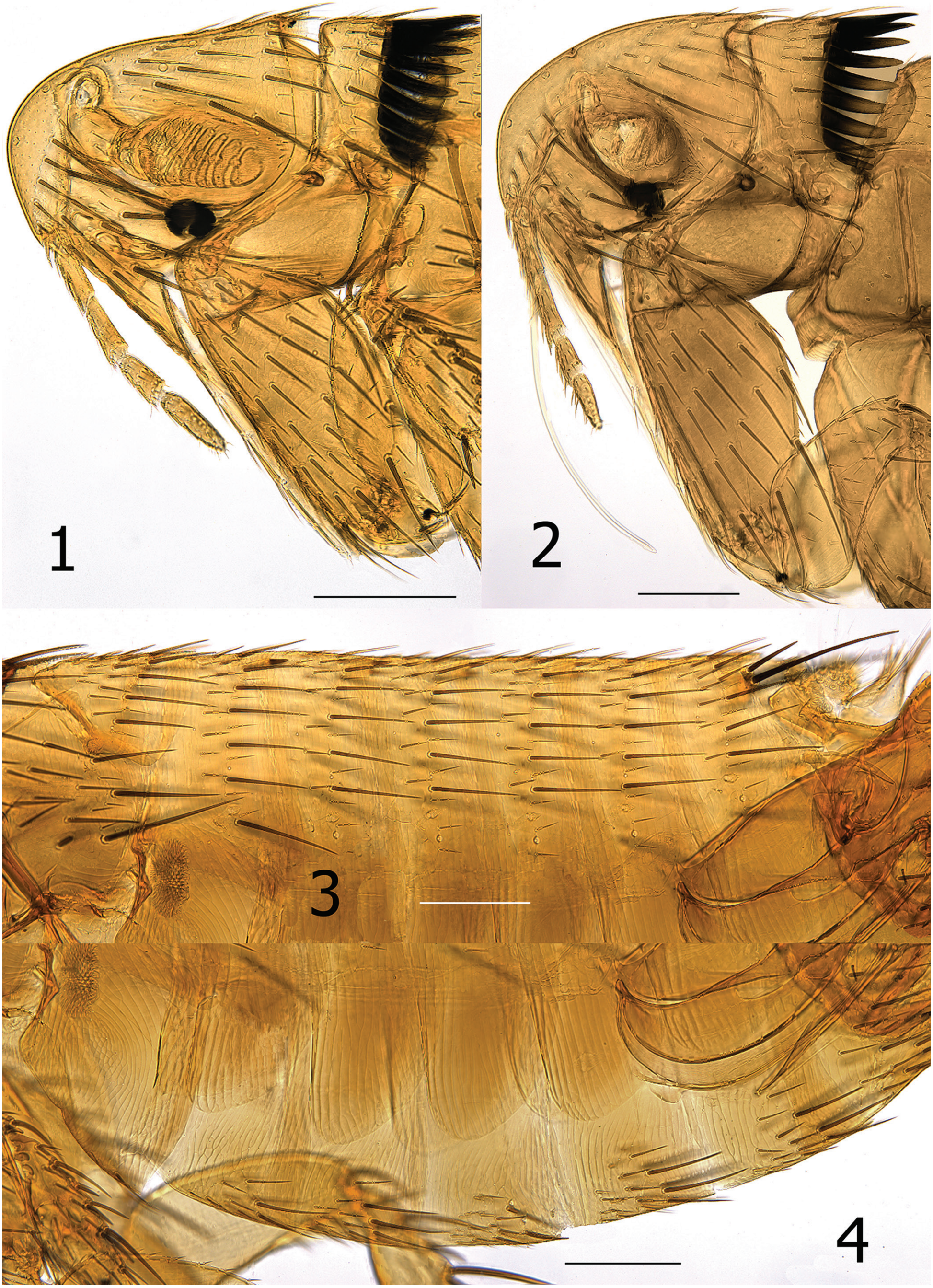
http://species-id.net/wiki/Medwayella_independencia

Type material. Philippines, Mindanao Island, village Lunutan (08.6959°N, 125.0259°E), Mt. Lumont, 1236 m, *Urogale everetti* (Thomas) ♂ (host # KUMNH-168413, NCA-307), 4 VII 2012, E. DiBlasi, holotype ♂, allotype ♀ (parasite # P-5525) (CMNH), 1♂ paratype (dissection), (BYUC); same data as holotype except *U. everetti* ♂ (host # KUMNH-168696, NCA-382), 10 VII 2012, 1♂ paratype (parasite # P-5657) (CMNH), 1♀ paratype (BYUC), *U. everetti* ♂ (host # KUMNH-168719, NCA-383), 10 VII 2012, 2♂ paratypes (DNA F-345) (parasite # P-5658) (BYUC),

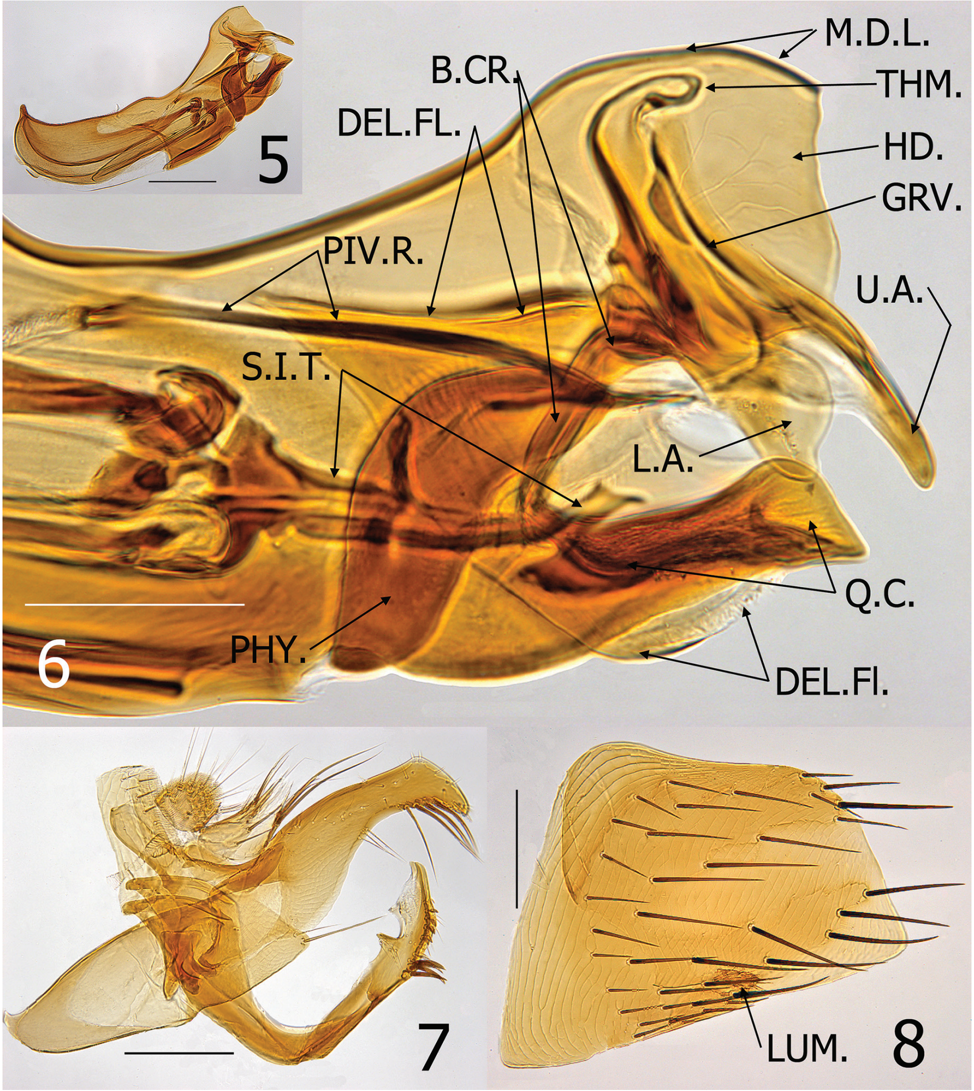


Figures 1–4. *Medwayella independencia* sp. n. **1** Head and pronotum, male holotype (P-5525) **2** Head and pronotum, female paratype (P-5657) **3** Abdominal tergites, male holotype (P-5525) **4** Abdominal sterna, male holotype (P-5525). (Scale: **1–4** = 200 µm).

and *U. everetti* ♂ (host # KUMNH-168372, NCA-351), 6 VII 2012, 1♂ paratype (parasite # P-5585) (CMNH).

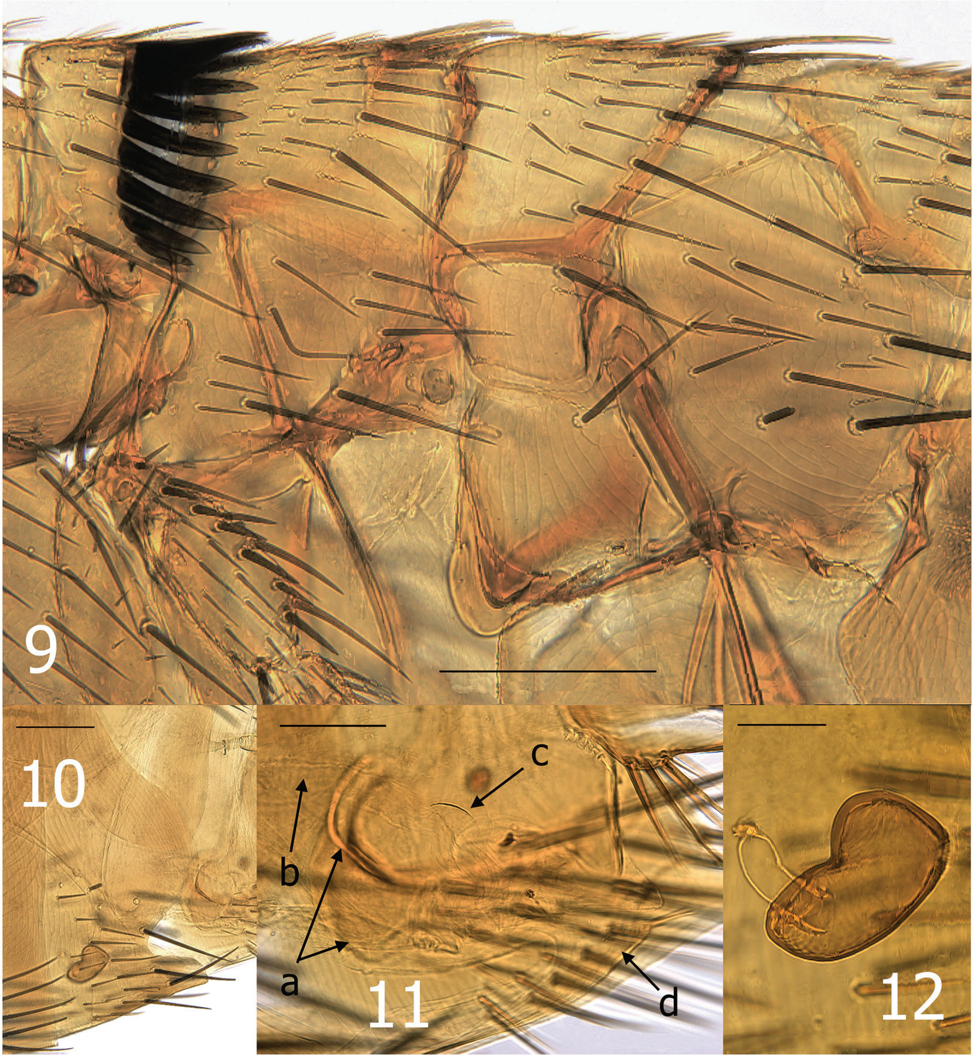
Diagnosis. Males are distinguished from all other species of *Medwayella* by 1) the deep sinus (as deep as width) below the subapical lobe on the dorsal surface of the distal arm of the S-IX, 2) the very long upper arm of the securifer of Ford's sclerite, 3) the lower arm of the securifer of Ford's sclerite is lobular, 4) the quasi crochet is distinctly squared at its apex, and 5) the presence of a long, slender recurved spur on the dorsal surface at the basal third of the sclerotized inner tube (Figs 6–7). Females are not separable from those of other species of *Medwayella*.

Description. Numbers of setae represent one side of the flea unless otherwise stated. Head (Figs 1–2). Frons evenly rounded from antennal falx to oral angle; falx slightly indicated in male, more so and longer in female. Two placoid discs in pre-antennal area and three in occipital area. Pre-antennal area with four vertical rows of long setae (6, 3, 4, and 3); second row in female with upper setae long and lower three much weaker. A small patch of 4–5 setae between second and third rows of setae. Area anterior to first (front) row of setae delineated by minute punctuations (differing from smooth area behind anterior row of setae). Maxillary palpus 4 segmented; penultimate segment shortest. Maxillae long and acutely sharp at apex. Labial palpus of 5 segments extended to middle of trochanter: apical segment longest. Antennal scape with oblique row of 5–6 short setae, pedicel fringed with 5 short setae, none extending onto clavus. Clavus of male symmetrical, extended to margin of head. Clavus of female short and asymmetrical, only 6 visible segments with basal 4 apparently fused. Numerous setulae along dorsal margin of antennal fossa; group of multiple setulae at each end of marginal row of setulae. Eye large, darkly pigmented, sinuate, fused to gena, and dorsum bulging into antennal fossa. Occipital area with four rows of setae (male: 5, 7, 1 and 7 with intercalaries; female: 6, 7, 1 and 6 with intercalaries). Intercalaries are extended posteriad to that of posterior row in lower setae. Thorax (Fig. 9). Pronotal ctenidia longer than pronotum in male, sub-equal in female; both sexes with total of 18 regular ctenidia plus the last spine about ¼ the length of more dorsal spines. Lateral pronotal ctenidia slightly curved (concave upper, convex lower margins). Pronotum with two rows of setae; main row complete, anterior row incomplete. Lowest seta of main row twice length of other setae. Prosternosome without notch for cervical link plate. First thoracic link plate robust and housing spiracle; second thoracic link plate with ventral sclerite protruding down from anterior apex (fused with wall of mesepimeron). Meso- and metanota each with three rows of setae; main row with intercalaries. Metanotum with single pseudoseta under metanotal collar; unusual among other taxa in that the seta is stout and spine-like. Mesepisternum with three closely spaced short setae and one long seta. Mesepimeron with 7 setae in male, 5 in female; each sex with alveoli of one seta situated directly over spiracle (spiracle opens beneath pleuron of mesepimeron. Pleural rod bifurcate. Lateral metanotal area separated from metepimeron by suture; metepimeron with single long seta. Pleural arch and pleural ridge robust. Squamulum present; long. Metasternum rounded. Setae on metepimeron variable in number and arrangement: 10–16 long setae and 1–7 small setae in male; 11–12 long setae



Figures 5–8. *Medwayella independencia* sp. n. male paratype (P-5525). **5** Aedeagus **6** Enlargement of apex of aedeagus (B.CR. = body of crochet, DEL.FL = deltoid flap of hood of aedeagus, GRV. = groove-like structure of Ford's sclerite, HD. = hood of aedeagus, L.A. = lower arm of securifer, M.D.L. = median dorsal lobe of aedeagus, PHY. = phylax, PIV.R. = pivotal ridge of phylax, Q.C. = quasi-crochet, S.I.T. = sclerotized inner tube, THM. = thumb-like apex of alpha-portion of Ford's sclerite, U.A. = upper arm of securifer **7** Basimere, telomere, and S-IX **8** Eighth sternum, LUM. = lumacaudate process. (Scale: **5, 7–8** = 200 µm; **6** = 100 µm).

and 4–8 small setae in female. Differs from side to side in same specimen. All setae below level of spiracle on metepimeron. Legs. Fore coxa with numerous scattered setae on upper ⅓; setae on lower ⅔ arranged in two rows more or less with 6–7 setae in each row. Suture of mesocoxa complete. Setae confined to anterior margin and apical ½ of meso- and meta-coxae. Ten to 12 small lateral setae on fore femur. Single long stout seta at femoral-tibial joint of fore tibia; short lateral spiniform seta and long stout mesal seta at femoral-tibial joints of meso- and metatibiae. All tibiae with seven dorsal notches: setae per notch of fore tibia (2, 2, 2, 2, 2, 2, 2), meso- and metatibiae (2, 2, 2, 2, 2, 2, 3); notch three with one of two setae minute. Lateral surface of all tibiae clad with numerous setae. First tarsal segment of fore leg with fringe of 4 large setae on caudal margin. Setae on basal portion of first tarsi of meso- and metatarsi small and un-pigmented; more distal setae distinctly more spiniform and darkly pigmented. Distotarsomeres with six lateral plantar bristles; basal three stouter than distal three pairs. Fore and meso-distotarsomeres with four spiniform pre-apical plantar bristles and meta-distotarsomere with two stout sharp pre-apical plantar bristles in male; female with two pre-apical plantar bristles on each distotarsomere. Mesal surface of tarsal claws on hind leg serrate; claws of anterior legs not serrate. All claws with stout basal lobe. Unmodified Abdominal Segments, male (Figs 3–4). Tergites I–VII each with three rows setae; T-II–V with single spinelet per side. Single seta of main row of each tergite below level of spiracles II–VII. Two antesensilial bristles; mesal bristle half length of lateral. Tergum VIII reduced with 4 small setae and large eighth abdominal spiracle. Sensilium convexly globular; brush-like setae surrounding 16–18 sensilial pits. Base of sensilium with sclerotized projection bearing several minute setae at apex. Dorsal anal lobe pointed with 5–6 long setae. Ventral anal lobe conical with two long setae near apex. Sternum I with 2 small ventral setae; group of multiple minute leuco discs on lateral surface. Sterna III–VII with main row of three long setae; anterior scattered setae. Modified Abdominal Segments, male (Figs 5–8). Dorsal and ventral margins of manubrium nearly parallel; upturned at apex. Stiva of telomere developed; with marginal group of four stout long setae ventrad to stiva and three smaller setae below main group. Telomere with oblique lateral row of minute setae. Dorso-anterior angle of telomere with two un-pigmented small spiniform setae. Base of telomere twice its narrowest width near group of four setae. Basimere with single triangular lobe bearing one long apical acetabular bristle and a smaller bristle dorsal to apex. Base of telomere extended to condyle hinging at base of fulcral sclerite. Proximal arm of S-IX expanded at apex; connected to and integrally associated with fulcral sclerite and base of telomere. Distal arm of S-IX, hyaline along basal dorsal margin with minute spicules. Similar hyaline spiculated area on dorsal surface pre-apically. Spiculated area subtended by a sinus that is as deep as wide. Subapical lobe below sinus pointed with 3–4 caudally directed setae. Ventro-apical margin with five short spiniform setae; medial to these are 6–7 small setae, subtended by two long, darkly pigmented setae. The lower ventral portion of the distal arm without setae; paired distal arms are fused from base to near apex. Sternum VIII quadrate and oblique at apex; ~40 long lateral setae. Lumacaudate process mesal to S-VIII with numerous short, light spiniform setae and one longer darkly pigmented spiniform seta. Median lamella of aedeagus broader than lateral lamella; proximal laminar margin deeply excised from short crescent sclerite to half the distance to the apex of the aedeagal apodeme. Aedeagal apodeme with slight convexity at mid dorsal area; margin sclerotized to arched median dorsal lobe near apex. Hood extended



Figures 9–12. *Medwayella independencia*, sp. n. **9** Thorax, holotype male (P-5525) **10** Seventh sternum, female paratype (P-5657) **11** Vaginal canal, female allotype, a = mesal tanned ridge of T-VIII, b = dilated portion of duct of spermatheca, c = sclerotized ventral wall of perula, d = eighth sternum **12** Spermatheca, female allotype. (Scale: **9–10** = 200 µm, **11** = 100 µm, **12** = 50 µm).

laterally to envelop Ford's sclerite. Fords sclerite well developed with a caudally directed thumb-like process, with elongate thin upper arm of securifer and lobular lower arm of securifer. Deltoid flap covers sclerotized inner tube, large phylax, and quasi crochet. Sclerotized inner tube long, narrow, straight ribbed at apical ¼ with minute backward pointing spines. A long spur is present on the dorsal surface on the basal ⅓ of the sclerotized inner tube. Pivotal ridge appears fused with dorsal margin of phylax; body of quasi crochet fused with ventral margin of Ford's sclerite. Quasi crochet blunt at apex; dorso-apical angle rounded, ventro-apical angle moderately acutely angled. Penis rods barely reaching apex of aedeagal apodeme. Ventral wall of aedeagal pouch heavily sclerotized. Unmodified Abdominal Segments, female. Tergites I–VI indistinguishable from male, except T-II with one seta below level of spiracle, T-III–V with two or three, and T-VI with one. Mesal antesensilial bristle half length of lateral bristle (opposite of male). Triangular lobe on margin of T-VII immediately below antesensilial setae; bearing single long seta almost contiguous with lateral antesensilial seta. Lobe extends between pairs of antesensilial bristles; with two stout setae between lobe and mesal antesensilial bristle. Lateral surface S-II with group of four to eight short setae; ventral margin with single setae. Sterna III–V with four setae in main rows, S-VI with five setae in main row and numerous scattered setae anterior to main rows. Modified Abdominal Segments, female (Figs 10–12). Tergum VIII with six to eight setae anterior to "L" shaped eighth spiracle. Tergum VIII large, laterally expanded with caudal triangular process; four marginal long setae dorsal to process and main row of eight long setae sub-marginally with scattered anterior smaller setae. Internal incrassation present on T-VIII. Sternum VII with broad lobe on caudal margin subtended by deep sinus and ventral truncate lobe. Three long setae below sinus on ventral lobe (one out of line) and two similar sized setae above sinus; row of seven or eight medium setae anterior to main row with additional scattered smaller setae anterior to these. Convex sensilium with ventral margin nearly contiguous with dorsal anal lobe; with 16 sensilial pits. Dorsal anal lobe with two very long setae on each side of anal stylet; several smaller setae anterior to base of anal stylet. Anal stylet with single robust seta; two minute setae at base of seta. Ventral anal lobe with basal lobe bearing about six long setae and apical pair of long setae; these interrupted by space without setae. Sternum VIII reduced; narrowing from base to pointed apex that bears several un-pigmented stout setae. Hilla of spermatheca inserted into bulga and perpendicular to linear axis of bulga. Proximal end of bulga wider than distal portion. Perula with expanded hood; ventral portion slightly sclerotized. Duct of spermatheca dilated from perula of bursa for distance about equal to length of bulga. Bursa copulatrix and *glandula vaginalis* expanded, *duplacatura vaginalis* distinctly recurved.

Dimensions. Male holotype: 3.0 mm, male average: 3.3 mm (n = 3); range: 3.0–3.5 mm. Female average: 3.7 mm (n = 2); range: 3.3–4.6 mm).

Etymology. The date on which the holotype was collected was the fourth of July, a national holiday in the United States commemorating the independence of the United States from Great Britain in 1776, thus the specific epithet *independencia*.

Remarks. This new species was collected from the Mindanao Tree-Shrew, *U. everetti*. *Urogale everetti* is restricted to the most southerly Philippine islands of Minadanao, Dinagat, and Siargao (Wilson and Reeder 2005). This tupaiid is diurnal with arboreal and terrestrial habits much like North American sciurids. Like most species of *Medwayella*, *M. independencia* occurs on a member of the family Tupaiidae. This is the first published record of *Medwayella* in the Philippines, although Traub (1972a, 1972b) alluded to two new species of *Medwayella* on Mindanao Island and a third on Palawan Island. Those were never published and the repositories of specimens from Mindanao are unknown, however, a pair of *Medwayella robinsoni* from Palawan are reported herein (see below). It is unlikely that any of the specimens to which Traub alluded were *M. independencia* because he stated that he knew of no unique fleas on *Urogale* (Traub, 1972b). The discovery of *M. independencia* on four different males of *U. everetti* in the same locality, while absent on other mammalian hosts, would indicate a significant association. Additional collecting is required to substantiate this relationship.

An additional single male and female *Medwayella* was discovered among unidentified material loaned to the author (MWH) by the National Museum of Natural History, Washington, DC. Label data on this single slide included: "Chicago Nat. Hist. Museum, RT 6492, CNHM 2612-2625, ex *Sciurus* [*Sundasciurus hoogstraali* (Sanborn), the Busuanga Squirrel, FMNH Mammal catalog numbers 63077-63095, Pers. Comm. with Lawrence R. Heaney, FMNH], locality: Dimaniang, Busuanga Island, Palawan Province [Philippines, part of the Calamian group], 17 III 47, leg. H. Hoogstraal, Philippines Expedition". The identification label indicated: "*Stivalius robinsoni*" det. R. Traub, 1949" and inscribed in pencil was "sp. n. – Traub in ms". To date, there are four published subspecific populations of *Medwayella robinsoni* but none occur as far northeast as the Philippine islands. These two specimens represent a subspecific population of *Medwayella robinsoni*. There are few morphological differences in the current published subspecific populations of *M. robinsoni*. Therefore, adding an additional subspecies is of little taxonomic value, but is reported here to further expand the range of the genus as a supplement to the new *Medwayella* taxon described herein.

Phoretic astigmatid mites were noted on three of the five whole mounted specimens of *M. independencia*. Phoresy among mites is a well-known behavior (Houck and OConnor 1991, Bajerlein et al. 2013) and involves numerous accounts of the deutonymphs infesting fleas (Fain and Beaucournu 1993). The bionomics of the twelve genera representing three families (Acaridae, Histiostomatidae and Winterschmidtiidae) that infest fleas (Fain and Beaucournu 1993) are poorly understood. All mites infesting *M. independencia* appear to represent the same species. These mites are tentatively identified as the genus *Psylloglyphus* (family Winterschmidtiidae) (Personal Comm. Dr. Barry M. OConnor, University of Michigan, Ann Arbor, MI, based on his observation of image, Fig. 13). Fain and Beaucournu (1976) described *Psylloglyphus maculatus* from *Medwayella robinsoni* ssp. collected from *Tupaia glis* Diard and Duvaucel from Selangor, Malaysia. Our record is the second documentation of a phoretic mite found on the genus *Medwayella*.

The senior author (MWH) has observed phoretic hypopial mites over 40 years on many different flea species; however, it is unusual for them to situate themselves under the terminal tergite (T-VIII) of male fleas as are the four mites seen in the male holotype (Fig. 13). An additional mite (not shown in Fig. 13) was present under T-VI of the same specimen. The mites usually attach themselves under more anterior sclerites. Mites were also present under T-VIII of a second male, and one female had one mite each under T-VI and S-VII, and two mites under S-V. The usual absence of mites under the T-VIII of males may be a reflection of the lack of protection afforded in this anatomical position. Deutonymphal hypopi possess

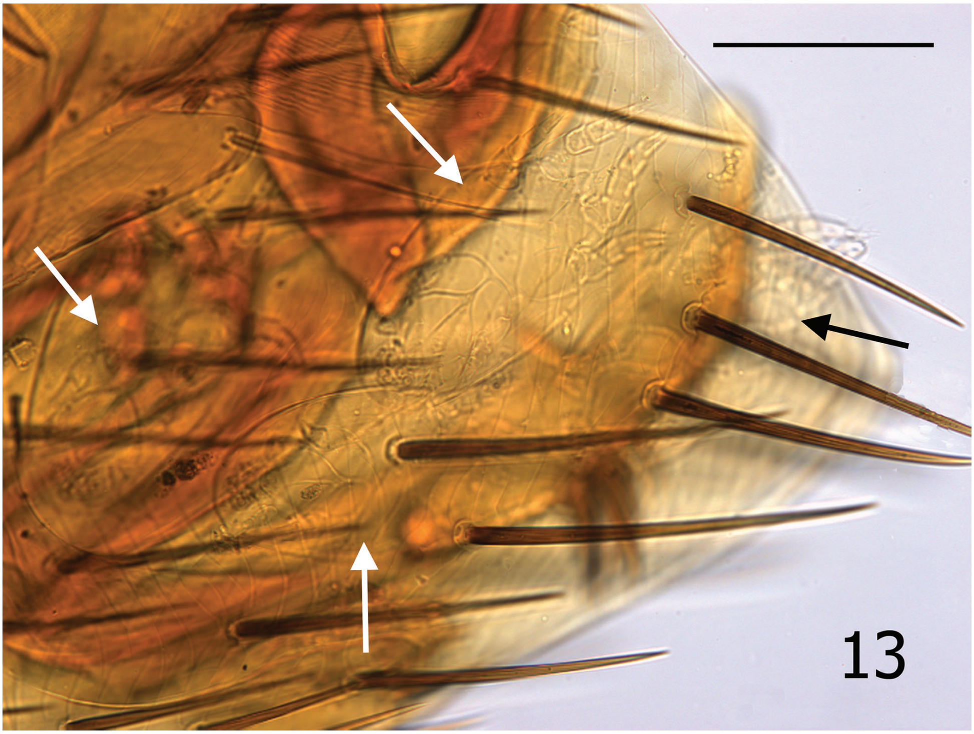


Figure 13. *Medwayella independencia*, sp. n., holotype male (P-5525) terminal segments illustrating four mites beneath T-VIII (see arrows). (Scale: 400 µm).

sucker-like organelles on their venter that aid in affixing them to the underside of the overlapping abdominal sclerites of fleas. The T-VIII of species of *Medwayella* is large and expands broadly, enveloping the aedeagus. During flea copulation, the extreme movement of the aedeagus would potentially produce an unstable environment for the attached mites by mechanically dislodging them. Phoretic mites locate beneath the abdominal sclerites of fleas as an adaptive strategy to avoid being dislodged during host grooming and flea locomotion. Phoretic mites of fleas have not been reported to attach to any other anatomical sites on the fleas other than under the abdominal segments, nor do they ever appear to feed, or attach with their mouthparts. The mobility of these minute phoretic mites is unmistakably very limited; therefore, attaching to a flea is a means to increase their distribution and survival.

OConnor and Pfaffenberger (1987) concluded that some phoretic mite species were highly specific for certain flea species, while others appeared less selective in their choice of flea host species. Subsequently, Schwan (1993) demonstrated a high level of specificity of *Psylloglyphus uilenbergi* Fain occurring on two species of fleas, and of *Paraceroglyphus xenopsylla* Fain and Schwan on a single flea species. The specificity of hypopial mites to a particular flea species may facilitate their attainment of an optimal environment (in a different nest of the flea's preferred host species and/or assuring the post-deutonymphal stages an optimal nest in which to develop) than otherwise might be possible. Fain and Beaucournu (1993) listed 83 flea species (excluding subspecies) that harbored astigmatid phoretic mites. Noteworthy are the distributions of the three mite families and the associations with their fleas: 1) the single genus (*Psylloglyphus*) in the family Winterschmidtiidae is found only in the southern hemisphere, and their flea host families are also exclusive to these areas; 2) of the two genera in the family Histiostomatidae, one genus is limited to continental Africa, and the second genus is limited to Europe, while one host flea genus (*Ctenophthalmus*) occurs in both Europe and Africa; and 3) the distributions of all genera of the family Acaridae are restricted to the northern hemisphere, and their flea host families are also limited to the northern hemisphere, with the exception of two species. One of these [*Notiopsylla kerguelensis kerguelensis* (Taschenberg)] is found on sea birds with extensive flight ranges, and the other is a cosmopolitan flea species [*Xenopsylla cheopis* (Rothschild)] found commonly on commensal rodents. *Psylloglyphus* mite species in our report appear to be specific to *Medwayella* (a southern hemisphere flea), a trend that coincides with the observations reported by Fain and Beaucournu (1993) for numerous cases of mite phoresy on fleas. It is not known whether fleas have physiological or behavioral defenses against these phoretic mites; however, this is a rich system of potentially co-evolving relationships between mites and fleas that warrants further study. OConnor (1982) provided a more thorough discussion of the evolutionary ecology of astigmatid mites. Although OConnor and Pfaffenberger (1987) and Fain and Beaucournu (1993) provided numerous bibliographic references regarding the studies of phoretic and hypopial astigmatid mites, there remains a large gap in our knowledge of the bionomics and degrees of specificity of phoretic mites that occur on many more species of fleas than are indicated in the literature. Fleas harboring phoretic mites observed in future studies should be placed in ethanol, and provided to a mite specialist for study. Such studies would enhance our understanding of the potential co-evolutionary trends of phoretic mites and their host fleas relative to the biology of each association that occurs in the nests of various mammalian or avian host species.

The following key is inclusive of all known male *Medwayella* taxa. For female specimens, readers are referred to the key (with supporting illustrations) by Traub (1972a:265–269). Taxa described subsequent to Traub (1972a) included *M. independencia*, *M. rubrisciurae* Durden and Beaucournu, *M. pheifferi* Beaucournu and Wells, *M. sabahae* Beaucournu and Wells, and *M. traubiana* Beaucournu and Wells. In addition, *Medwayella cambodia* (Klein) was transferred to *Medwayella* by Mardon (1981). Of these six additional species, the female sex is described only for *M. independencia*. The female sex of *M. independencia* keys out to couplet 20 (Traub 1972a) (*M. dryadosa* Traub and *M. veruta* Traub) but cannot be distinguished from either of these species.

Key to males of *Medwayella*

1 Labial palpus extends to apex of trochanter .... ***M. calcarata***

1’ Labial palpus extends at most to apex of fore coxa **2**

2(1’) Stiva short, hidden by distal fringe of stout setae on ventro-apical margin .... ***M. rubrisciurae***

2’ Stiva of various lengths but not hidden by distal fringe of setae.................. **3**

3(2’) Ventro-apical margin of distal arm of ninth sternum without marked sclerotization or sub-marginal delineation **4**

3’ Ventro-apical margin with distinct sclerotized margin, or sub-marginal delineation **13**

4(3) Sub-apical dorsal notch or sinus present on distal arm of ninth sternum..... **5**

4’ Sub-apical dorsal notch or sinus absent... **8**

5(4) Dorsal portion of Ford’s sclerite with distinct thumb-like process.............. **6**

5’ Ford’s sclerite lacking a thumb-like process... **7**

6(5) Sub-apical lobe of distal arm of ninth sternum sharply pointed; sub-apical sinus shallow.. ***M. sabahae***

6’ Sub-apical lobe triangular but not sharply tapered to a point; with deep sub-apical sinus between sup-apical lobe and apical lobe ....***M. robinsoni* ssp.**

7(5’) Apex of distal arm of ninth sternum tapering to rounded point; subtending sinus distinctly wider than deep ....***M. traubiana***

7’ Apex of distal arm bluntly rounded or truncate; subtending sinus hardly wider than deep ....***M. angustata***

8(4’) Distal fringe of long setae on ventro-apical margin of telomere shifted towards apex and arising from near apex of stiva; this group of setae subtended by deep sinus between distal fringe of setae and more proximal group of ventral setae (depth of sinus greater than width of telomere at deepest point of sinus)..***M. rhaeba***

8’ Distal fringe of long setae some distance from apex of stiva; if placement is close to stiva, then sinus is more shallow than width of telomere **9**

9(8’) Thumb-like process present on dorsal portion of Ford’s sclerite **10**

9’ Ford’s sclerite lacking thumb-like process **12**

10(9) Sub-apical lobe of distal arm of ninth sternum sharply pointed and directed downward; apical lobe broadly rounded ....***M. arcuata***

10’ Sub-apical lobe rounded, not sharp; apical lobe round at apex but sides more parallel and more slender **11**

11(10’) Apical lobe of distal arm of ninth sternum extended well over sub-apical lobe (beyond, appearing to arch over); telomere narrower at base than other more distal portions of process...***M. javana***

11’ Apical lobe shorter; not arching over and beyond sub-apical lobe; telomere much broader basally than more distal portions......................***M. cambodia***

12(9’) Sub-apical lobe of distal arm of ninth sternum reduced to flattened bulge; distance from apex of sub-apical lobe to closest point on ventral margin less than distance to apex of apical lobe..***M. pfeifferi***

12’ Sub-apical lobe triangular (as tall as wide); distance from apex of sup-apical lobe to ventral margin about equal distance to apical lobe..... ***M. phangi* ssp.**
13(3’) Margin between sub-apical lobe and apical lobe of ninth sternum with sinus as deep as wide...***M. dryadosa***
13’ Margin without sinus, or sinus much broader than deep...........................**14**
14(13’) Groove formed by sclerotized margins of upper and lower arms of securifers of Ford’s sclerite present ....***M. independencia* sp. n.**
14’ Groove of Ford’s sclerite absent or unapparent 15
15(14’) Sub-apical lobe of ninth sternum hardly visible (indicated by shallow bulge); thumb-like process present on dorsal portion of Ford’s sclerite ....***M. thurmani***
15’ Sub-apical lobe well developed; thumb-like process absent **16**
16(15) Sub-apical lobe of ninth sternum narrow and sharply pointed **17**
16’ Sub-apical lobe well developed, but broadly triangular and rounded at apex ....***M. limi***
17(16) Telomere short and broad, hardly more than 3 times as long (above apex of basimere) as broad at narrowest level (immediately below distal fringe of setae on ventral margin) ....***M. loncha***
17’ Telomere at least 3.75 times as long as broad (at narrowest level) **18**
18(17’) Lower arm of securifer as broad as long; distal arm of ninth sternum much broader below sub-apical lobe than above it.................................***M. veruta***
18’ Lower arm of securifer not broad but vermiform; width of distal arm about same above as below sub-apical lobe ....***M. batibacula***

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