ZooKeys 323: 1–33 (2013)
doi: 10.3897/zookeys.323.5195
www.zookeys.org

RESEARCH ARTICLE

A peer-reviewed open-access journal
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Revision of the genus *Dercetina* from Taiwan and their similar species, with description of a new species from Myanmar (Insecta, Chrysomelidae, Galerucinae)

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Academic editor: *A. Konstantinov* | Received 23 March 2013 | Accepted 6 August 2013 | Published 13 August 2013

http://zoobank.org/EE619CDD-5399-4349-B79D-47EC4EA4C3CA

Citation: Lee C-F, Bezděk J (2013) Revision of the genus *Dercetina* from Taiwan and their similar species, with description of a new species from Myanmar (Insecta, Chrysomelidae, Galerucinae). ZooKeys 323: 1–33. doi: 10.3897/zookeys.323.5195

Abstract

Species of the genus *Dercetina* Gressitt & Kimoto, 1963 in Taiwan are revised. *Dercetina azumai* Gressitt and Kimoto, 1966, *D. itoi* Kimoto, 1969, and *D. shirozui* Kimoto, 1969 are redescribed. *Dercetina chinensis* (Weise, 1889), *D. taiwana* (Chûjô, 1938), and *D. unifasciata* (Allard, 1889) are removed from synonymy with *D. flavocincta* (Hope, 1831). *Dercetina flavocincta* and *D. nakanei* Kimoto, 1969 are transferred to the genus *Arthrotus* Motschulsky, 1858. Lectotypes are designated for *Dercetis taiwana* Chûjô, 1938, and *Antipha varipennis* Jacoby, 1890. The synonymies of *Antipha flavofasciata* Baly, 1879 and *Dercetes femoralis* Weise, 1922 with *Arthrotus flavocincta* (Hope, 1831), *Antipha varipennis* Jacoby, 1890 with *Dercetina chinensis* (Weise, 1889) are supported. A new species, *D. barclayi* **sp. n.** which was confused with *D. flavocincta*, is described from Myanmar.

Keywords

Dercetina, *Arthrotus*, Taiwan, taxonomic revision

Introduction

Dercetina Gressitt & Kimoto, 1963 is very similar to the genus *Arthrotus* Motschulsky, 1858. These genera differ from each other only by the structure of male antenna: the antennomere III is about twice longer than antennomere II in *Dercetina*, while antennomeres II and III are subequal in length in *Arthrotus*. Thus females are impossible to assign to either genus if they are not associated with males. Moreover, most members of *Dercetina* have similar shapes of male aedeagi and some species have great color variation. These factors have caused taxonomic confusion in *Dercetina* and *Arthrotus*. To solve this problem, examination of extensive collections and evaluation of characters other than the external morphology of the male aedeagi are necessary. The examination of endophallic sclerites, which we studied here for the first time in *Dercetina* and *Arthrotus*, seems to be very helpful for resolving many taxonomical problems in both genera.

Dercetina is an Asian genus and comprises 88 species (Wilcox 1971, 1975, Bezděk, unpublished data), of which 23 species are distributed in the Palearctic region (Beenen 2010). Five species were recorded from Taiwan (Kimoto and Takizawa 1997). *Dercetes flaviventris* (Jacoby, 1890) was the first species to be recorded from Taiwan by Weise (1922). Later Chûjô (1938) described the new species *Dercetis taiwana*. Kimoto (1969) indicated that the record of *Dercetes flaviventris* was a misidentification and described a new species as *Dercetina itoi*. In addition to *Dercetina itoi*, two more new species were described (*D. shirozui* Kimoto, 1969 and *D. nakanei* Kimoto, 1969) and one new country record for Taiwan (*D. azumai* Kimoto & Gressitt, 1966).

Dercetina taiwana (Chûjô, 1938) has a complicated nomenclatural history. It was synonymized with *D. chinensis* (Weise, 1889) by Gressitt and Kimoto (1963). *Antipha varipennis* Jacoby, 1890 was also regarded as a junior synonym in the same paper. Later, *D. chinensis* was synonymized with *D. flavocincta* (Hope, 1831) by Kimoto (1989b). *Antipha unifasciata* Allard, 1889 and *Dercetes femoralis* Weise, 1922 were also regarded as junior synonyms of *Dercetina flavocincta* in the same paper. *Antipha flavofasciata* Baly, 1879 was synonymized with *D. flavocincta* by Maulik (1936). To clarify the status of all available names, the types of them were re-examined and diagnostic characters examined.

Material and methods

To study specimens and prepare drawings of the adult reproductive systems, the abdomens of adults were separated and boiled in a 10% KOH solution, cleared in distilled water, and then mounted on slides with glycerin. Slides were examined using a Leica M165 stereomicroscope, and figures were drawn using a Nikon ECLIPSE 50i microscope.

Studied specimens have been deposited at the following institutes and museums and

BMNH The Natural History Museum, London, UK [Maxwell V. L. Barclay]
BPBM Bernice P. Bishop Museum, Honolulu, USA [Shepherd Myers]

ISNB Institut royal des Sciences Naturelles de Belgique, Bruxelles, Belgium [Pol Limbourg]
KMNH Kitakyushu Museum of Natural History and Human History, Kitakyushu, Japan [Kyoichiro Ueda]
KUEC Faculty of Agriculture, Kyushu University, Fukuoka, Japan [Osamu Tadauchi]
MCZC Museum of Comparative Zoology, Harvard University, Massachusetts, USA [Philip D. Perkins]
MNHUB Museum für Naturkunde, Leibniz-Institut für Evolutions- und Biodiversitätsforschung an der Humboldt-Universität zu Berlin, Berlin, Germany [Joachim Willer, Johannes Frisch]
NHRS Naturhistoriska Riksmusset, Stockholm, Sweden [Johannes Bergsten]
SDEI Senckenberg Deutsches Entomologisches Institut, Müncheberg, Germany [Stephan Blank]
TARI Taiwan Agricultural Research Institute, Taichung, Taiwan.
USNM National Museum of Natural History, Smithsonian Institution, Washington DC, USA [Alexander Konstantinov]

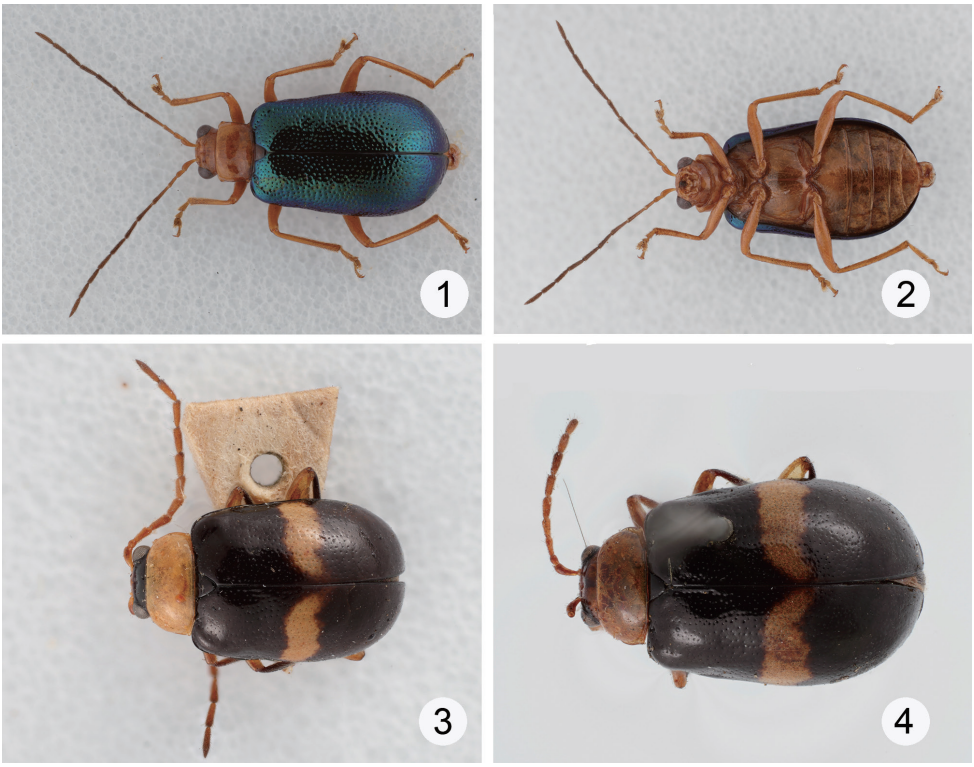
Results

***Dercetina azumai* Kimoto & Gressitt, 1966**
http://species-id.net/wiki/Dercetina_azumai

Dercetina azumai Kimoto & Gressitt, 1966: 534 (Japan: Iriomote island); Kimoto 1969: 66 (Taiwan); Kimoto 1989a; 260 (Taiwan).

Type series. *Dercetina azumai*: Holotype ♀ (KUEC): "RYUKYU IS. Iriomote I. Ushiku-mori 11.III.1964 / S. Kimoto Collector / Japan-U. S. Co-op. Sci. Programme (yellow label) / HOLOTYPE DERCETINA AZUMAI J. L. GRESSITT (red label)".

Material examined. TAIWAN: 1♂, Kaoshiung, Chuyunshan trail, 1.III.2009, leg. U. Ong (TARI); 1♀, Kaoshiung, Taoyuan, 3.VII.2009, leg. S.-F. Yu (TARI); 5♂♂, 12♀♀, Kaoshiung, Tengchih (= Shihshan trail), 2-5.VI.2008, leg. C.-F. Lee (TARI); 3♂♂, 16♀♀, same locality, 2.X.2008, leg. M.-H. Tsou (TARI); 6♀♀, same locality, 1–3.X.2008, leg. M.-H. Tsou (TARI); 1♂, 1♀, same locality, 5.II.2009, leg. M.-H. Tsou (TARI); 1♂, 1♀, same locality, 26.V.2009, leg. C.-F. Lee (TARI); 1♂, same locality, 4.VII.2011, leg. M.-H. Tsou (TARI); 1♀, Pingtung, Jinshuiying, 12.IV.2012, leg. C.-F. Lee (TARI); 2♀♀, Pingtung, Tahanshan, 22.I.2009, leg. S.-F. Yu (TARI); 1♀, same locality, 24.I.2009, leg. M.-H. Tsou (TARI); 1♀, same locality, 8.V.2009, leg. U. Ong (TARI); 1♂, same locality, 21.VII.2009, leg. J.-C. Chen (TARI); 6♂♂, 14.VIII.2011, leg. Y.-T. Wang (TARI); 1♀, same locality, 6.VI.2012, leg. C.-F. Lee (TARI); 1♂, same locality, 19.VII.2012, leg. C.-F. Lee (TARI); 2♂♂, Taitung, Motien, 23.VI.2010, leg. S.-F. Yu (TARI); 1♂, same locality, 19.VI.2011, leg. C.-F. Lee (TARI).

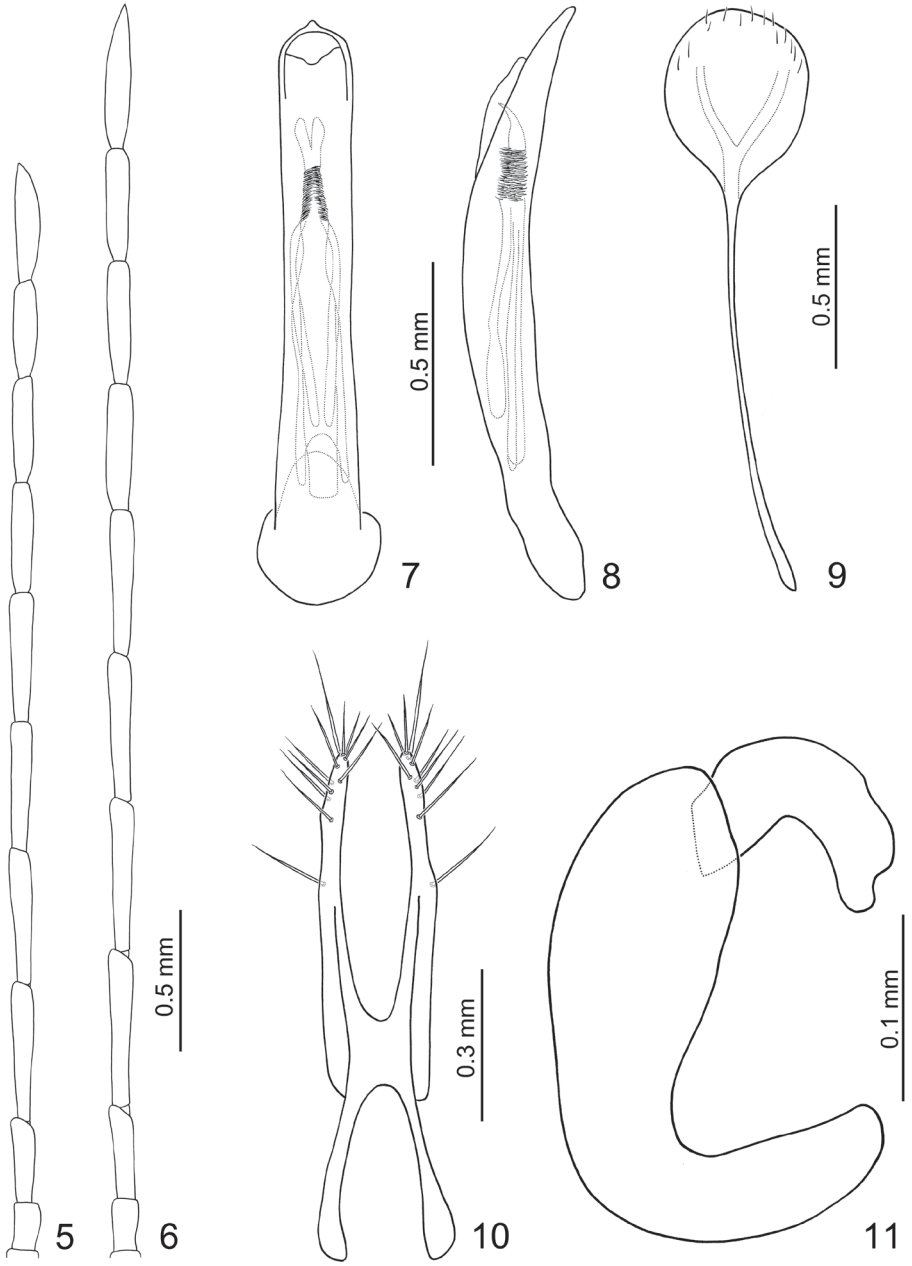


Figures 1–4. Habitus of *Dercetina* species. **1** *D. azumai*, dorsal view **2** *D. azumai*, ventral view **3** *D. barclayi* sp. n., dorsal view **4** *D. barclayi* sp. n., ventral view.

Diagnosis. *Dercetina azumai* is similar to *D. shirozui* with metallic green elytra but differs by the yellowish brown head, prothorax, meso- and metathoracic ventrites (in contrast with metallic green head, prothorax, meso- and metathoracic ventrites in *D. shirozui*).

Redescription. Color (Figs 1–2) yellowish brown except eye black; antennomeres III-XI dark brown; elytron metallic green or blue. Head shagreened and impunctate. Pronotum transverse, 1.4–1.5 times wider than long, disc with a pair of deep fovea, and scattered prominent and fine punctures; lateral margin sinuate, narrowed posterior, anterior margin slightly concave, posterior margin slightly rounded. Elytra more or less widened posterior, apex convergent rounded, 1.6–1.7 times longer than wide, disc with densely prominent punctures; epipleurae with scattered prominent prunctures.

Male. Length 4.9–5.6 mm, width 2.1–2.4 mm. Antenna filiform (Fig. 5), ratio of length of antennomeres III to XI about 1.0 : 1.6 : 1.6 : 1.6 : 1.6 : 1.3 : 1.2 : 1.1 : 1.4; ratio of length to width of antennomeres III to XI about 3.9: 6.4 : 6.1 : 6.0 : 6.2 : 5.1 : 4.8 : 4.1 : 5.1. Penis (Fig. 7) extremely slender, about 8.9 times longer than wide, parallel-sided, basally widened, apex pointed; tectum membranous, with scattered stout



Figures 5–11. *Dercetina azumai*. **5** Antenna, male **6** Antenna, female **7** Aedeagus, dorsal view **8** Aedeagus, lateral view **9** Sternite VIII **10** Gonocoxae **11** Spermatheca.

membranous setae; weakly curved in lateral view (Fig. 8); endophallic sclerite elongate, about 0.7 times as long as penis, apex curved in lateral view, bifurcate, with a cluster of dense setae near apex; a pair of hooked dorsal slclerite connected at apical 1/5, an

elongate sclerite between dorsal sclerite and ventral sclerite, connected at apical 1/3; ventral sclerite with base deeply bifurcate.

Female. Length 5.5–6.8 mm, width 2.6–3.3 mm. Ratio of length of antennomeres III to XI about 1.0 : 1.7 : 1.6 : 1.6 : 1.5 : 1.4 : 1.3 : 1.3 : 1.5; ratio of length to width of antennomeres III to XI about 3.8: 6.3 : 6.1 : 5.9 : 5.6 : 5.1 : 4.9 : 4.9 : 5.7 (Fig. 6). Sternite VIII (Fig. 9) weakly sclerotized laterally and apically, with scattered setae along lateral and apical margin, spiculum extremely slender. Spermathecal receptaculum (Fig. 11) weakly swollen; pump narrow and moderately curved, apex broadly rounded; spermathecal duct long, strongly curved, deeply projecting into receptaculum. Gonocoxae (Fig. 10) widely connected at middle, about 4.4 times longer than wide, curved inwards at apical 1/3, with one long seta at apical 1/3, eleven setae at apex.

Host plants. Myrsinaceae: *Embelia lenticellata* Hayata; Saxifragaceae: *Hydrangea angustipetala* Hayata.

Distribution. Japan (Iriomote island) and Taiwan. This species occurs in mountains (1000–2000 m) of southern Taiwan (Fig. 12) but locally abundant.

Dercetina barclayi sp. n.

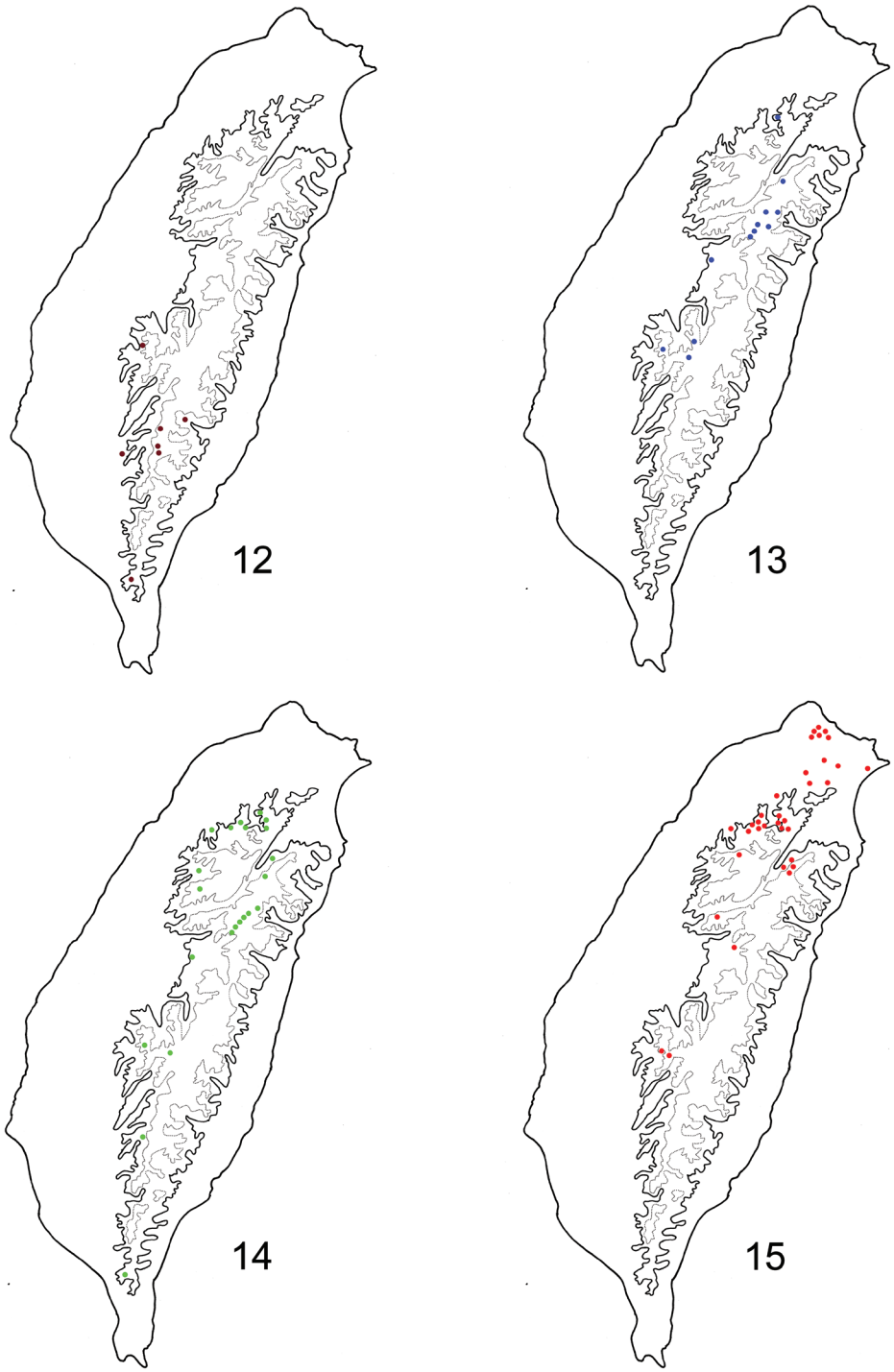
http://zoobank.org/AD8891A6-94FF-483F-B6D8-70378076A04E
http://species-id.net/wiki/Dercetina_barclayi

Type series. Holotype ♂ (BMNH): "Doherty / Birmah RubyMes / Fry Coll. 1905. 100.". Paratypes: 1♂, same as holotype (BMNH); 1♂, 2♀♀: "Ruby Mines. Burma. 5.500 to 7.500 ft. 1904-150." (BMNH); 4♂♂, 1♀: "Ruby Mines U. M. / Gift of F. G. Bowditch" (USNM).

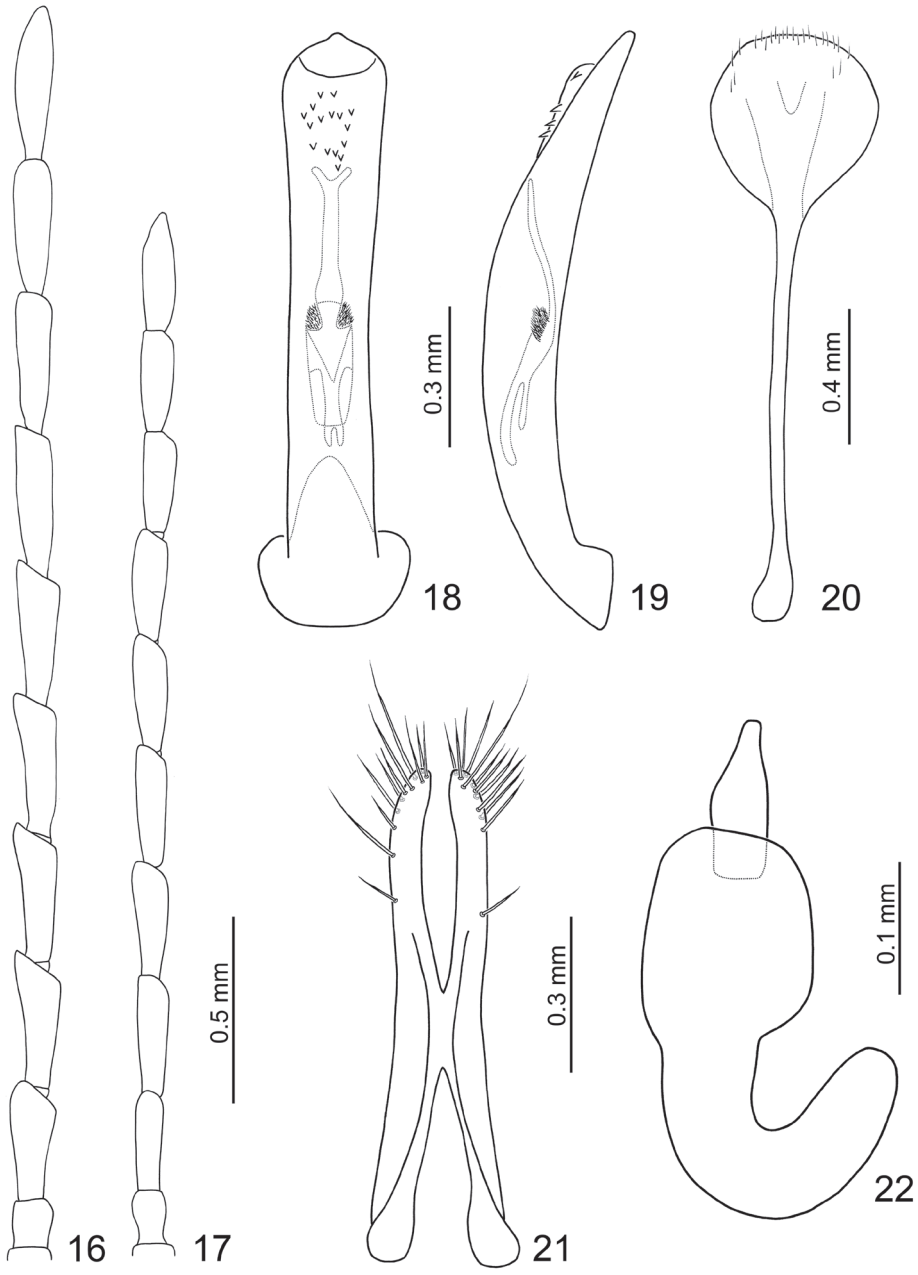
Diagnosis. This new species is similar to *D. taiwana* but differs by yellowish brown antennae, no color variation, wider penis, and with longer endophallic sclerites.

Description. Color (Figs 3–4) bluish black, prothorax, coxae, and tibiae yellowish brown; elytron with one trasverse white stripe at basal 1/3; head brown, vertex and labium black. Head smooth and impunctate. Pronotum transverse, 2.2 times wider than long, evenly convex on disc and lacking fovea or punctured depression, disc with scattered fine punctures; lateral margin rounded, anterior margin slightly concave, posterior margin straight. Elytra more or less widened posteriorly, apex convergently rounded, 1.4-1.5 times longer than wide, disc with punctures in part arranged in longitudinal rows, epipleurae smooth and impunctate.

Male. Length 3.9–4.3 mm, width 2.1–2.4 mm. Antennomeres III-X weakly serrate (Fig. 16), ratio of length of antennomeres III to XI about 1.0 : 1.2 : 1.2 : 1.2 : 1.2 : 1.2 : 1.1 : 1.1 : 1.3; ratio of length to width of antennomeres III to XI about 2.6: 3.0 : 3.3 : 3.4 : 3.4 : 3.9 : 3.8 : 3.7 : 4.8. Penis (Fig. 18) extremely slender, about 7.3 times longer than wide, parallel-sided, basally and apically widened, apex narrowly rounded; tectum membranous, with scatted stout setae; weakly curved in lateral view (Fig. 19); endophallic sclerites elongate, about 0.5 times as long as penis, dorsal scler-



Figures 12–15. Distribution map of *Dercetina* species, solid line: 1000 m, broken line: 2000 m. **12** *D. azumai* **13** *D. itoi* **14** *D. shirozui* **15** *D. taiwana*.



Figures 16–22. *Dercetina barclayi* sp. n. **16** Antenna, male **17** Antenna, female **18** Aedeagus, dorsal view **19** Aedeagus, lateral view **20** Sternite VIII **21** Gonocoxae **22** Spermatheca.

ite with base bifurcate, apex truncate; ventral sclerite much longer than dorsal sclerite, apex bifurcate, base rounded, with a cluster of short setae at middle; in lateral view moderately curved.

Female. Length 4.7–5.3 mm, width 2.8–3.1 mm. Antenna 11-segmented, antennomeres III-X weakly serrate (Fig. 17), comparatively narrower than male, ratio of length of antennomeres III to XI about 1.0 : 1.2 : 1.2 : 1.2 : 1.2 : 1.2 : 1.0 : 1.0 : 1.2; ratio of length to width of antennomeres III to XI about 3.2: 3.6 : 3.4 : 3.6 : 3.5 : 3.3 : 3.0 : 3.2 : 3.8. Sternite VIII (Fig. 20) weakly sclerotized subapically, apex rounded, with dense short setae along lateral and apical margin, spiculum long. Spermathecal receptaculum (Fig. 22) strongly swollen; pump narrow and strongly curved, apex widely rounded; spermathecal duct short, deeply projecting into receptaculum. Gonocoxae (Fig. 21) narrowly connected in middle, about 5.5 times longer than wide, slightly curved inwards near apex, apex rounded, with one short setae at apical 1/3, ten to eleven setae at apex.

Etymology. This new species is named for Maxwell V. L. Barclay who is one of Britain's leading entomologists and curator of Coleoptera at the Natural History Museum in London.

Distribution. Only known from the type locality.

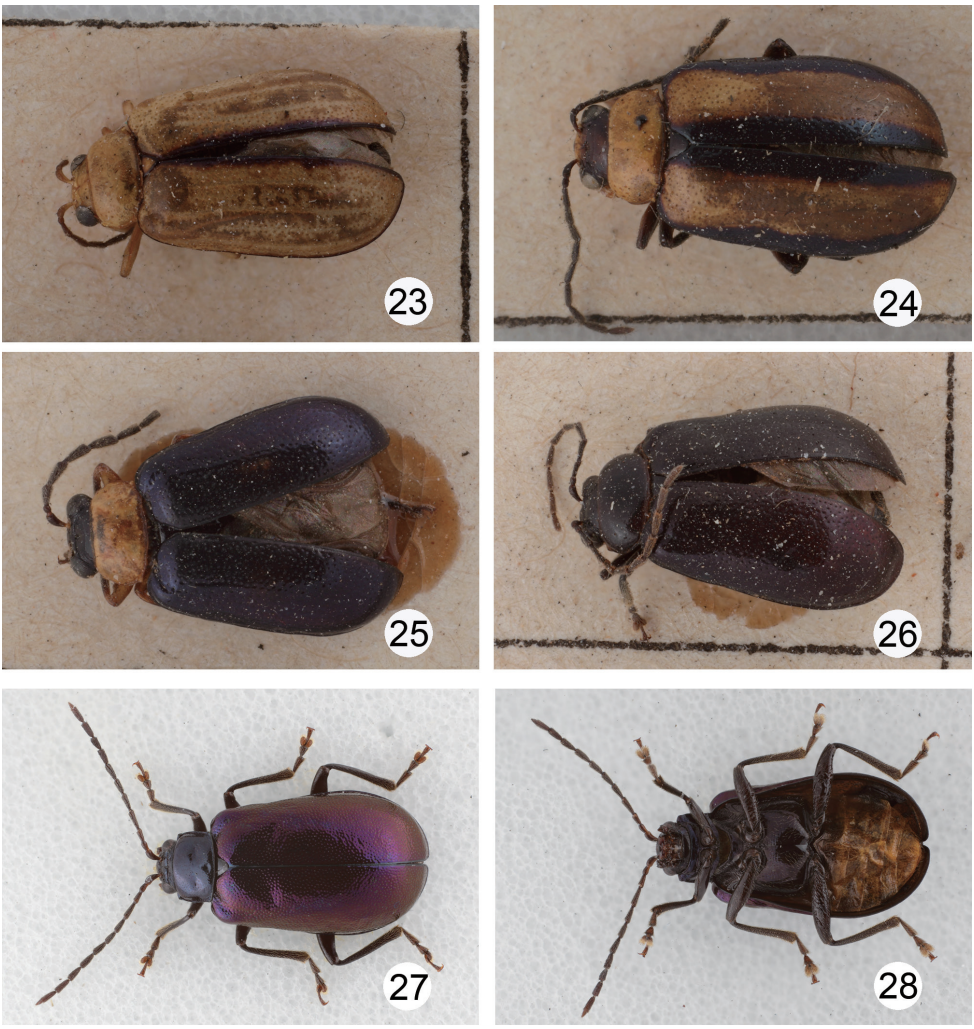
***Dercetina chinensis* (Weise, 1889), stat. r.**
http://species-id.net/wiki/Dercetina_chinensis

Arthrotus chinensis Weise, 1889: 626; Ogloblin 1936: 330 (Jiangsu); Kimoto 1989b: 229 (as synonym of *Dercetina flavocincta* Hope, 1831)
Dercetina chinensis: Gressitt and Kimoto 1965: 802.
Antipha varipennis Jacoby, 1890: 214. synonymy confirmed
Dercetina varipennis: Gressitt and Kimoto 1963: 710 (as synonym of senior *D. chinensis*); Kimoto 1965: 489; Gressitt and Kimoto 1965: 802 (corrected as junior synonym of *D. chinensis*).

Type series. *Arthrotus chinensis*: Holotype ♀ (MNHUB): "Yunnan Fischer / Yünnan Fischer / Arthrotus chinensis 89., m. / Typus (red label) / *Arthrotus chinensis* Wse L. N. Medvedev det. 1987". Although locality labels of the holotype didn't fit the original description, where Peking is clearly indicated, we prefer to treat it as true holotype because the specimen perfectly fit the original description and bears also original Weise´s handwritten identification label.

Antipha varipennis: Lecotype ♂ (BMNH), here designated, labeled: "Chang Yang A. E. Pratt Coll. July 1888. / Jacoby Coll. 1909-28a / *varipennis* Jac". Paralectotypes: 1♂ (BMNH), same with lecotype but without determination label; 2♂♂ with black elytra and same labels are not designated as paralectotypes since Jacoby (1890) himself explicitely excluded dark specimens from the type series. Three more paralectotypes are deposited at the MCZC: 2♂♂, labeled "Chang Yang A. E. Pratt Coll. July 1888. / 1st Jacoby Coll."; 1♂, same but with additional labels: "Type 18269 (red label) / *A. varipennis* Jac. / Jan.-Jul. 2004 MCZ Image Database".

Diagnosis. *Dercetina chinensis* is similar to *D. taiwana* by the absence of lateral fovea on the pronotum and by the antennomere IV being slightly longer than III. It



Figures 23–28. Habitus of *Dercetina* species. **23** *D. chinensis*, pale individual **24** *D. chinensis*, pale individual **25** *D. chinensis*, dark individual **26** *D. chinensis*, dark individual **27** *D. itoi*, dorsal view **28** *D. itoi*, ventral view.

can be distinguished by its characteristic color patterns (yellowish brown elytra with black longitudinal bands along suture and lateral margins) and oblong elytra (1.6 times longer than wide in contrast to 1.4 times longer than wide in *D. taiwana*).

Redescription. Color very variable, in pale individuals generally yellowish brown, antennae, apical 2/3 of tibiae, and tarsi dark brown, meso- and metathoracic and abdominal ventrites blackish brown, margin of scutellum, and suture and lateral margins of elytra darkened (Fig. 23); in darker individuals black areas on elytra expanding inside, scutellum blackish brown, and head sometimes darkened (Fig. 24); in some individuals entire elytra black (Fig. 25); in darkest individuals entire body black (Fig.

26). Head smooth and impunctate. Pronotum transverse, 1.8 times wider than long, evenly convex on disc and lacking fovea or punctured depression, disc with scattered fine punctures; lateral margin rounded, anterior margin slightly concave, posterior margin slightly rounded. Elytra parallel-sided, apex convergently rounded, 1.6 times longer than wide, disc with random punctures, epipleurae smooth and impunctate.

Male. Length 4.7–5.2 mm, width 2.4–2.8 mm. Atennomere II as long as antennomere III, ratio of length of antennomeres III to VIII (IX–XI lost) about 1.0 : 1.3 : 1.3 : 1.3 : 1.5 : 1.5; ratio of length to width of antennomeres III to VIII about 2.3: 2.7 : 2.9 : 3.3 : 3.5 (Fig. 29). Penis (Fig. 31) extremely slender, about 10.6 times longer than wide, parallel-sided, basally and apically widened; apex narrowly rounded, with small process in middle; tectum membranous, with dense stout setae; moderately curved in lateral view (Fig. 32); endophallic sclerites elongate, about 0.5 times as long as penis, apex concave and membranous, with a dorsal sclerite connected at middle, almost reaching base, with a row of short setae along lateral margin at apical 1/3; in lateral view almost straight.

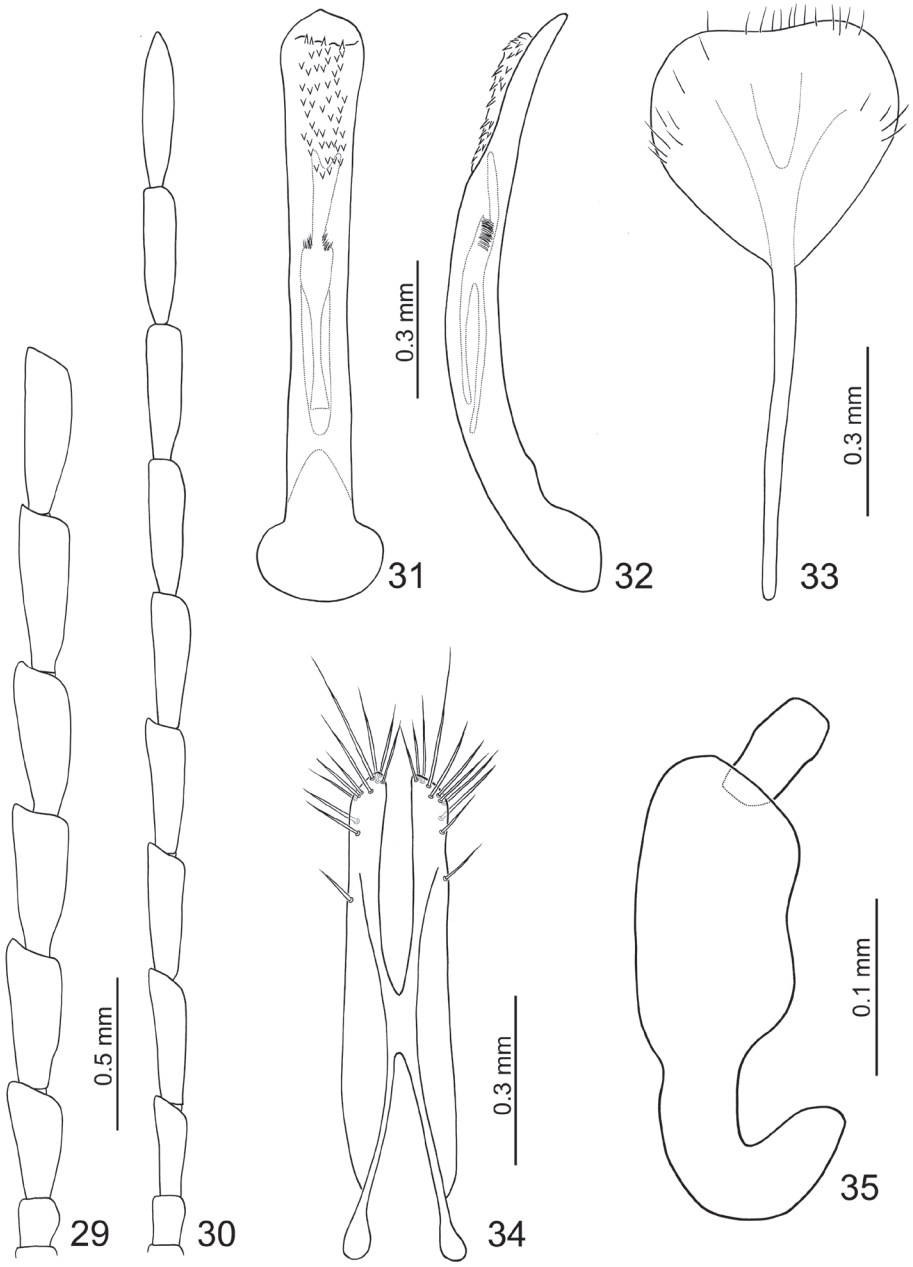
Female. Length 4.5 mm, width 2.5 mm. Antenna comparatively narrower than male (Fig. 30), ratio of length of antennomeres III to XI about 1.0 : 1.3 : 1.3 : 1.3 : 1.3 : 1.3 : 1.3 : 1.3 : 1.6; ratio of length to width of antennomeres III to XI about 2.9: 3.4 : 3.5 : 3.5 : 3.5 : 4.0 : 4.0 : 4.0 : 4.9. Sternite VIII (Fig. 33) very small, weakly sclerotized subapically, setae along lateral and apical margins, spiculum short. Spermathecal receptaculum (Fig. 35) strongly swollen; pump narrow and strongly curved, apex narrowly rounded; spermathecal duct short and stout, shallowly projecting into receptaculum. Gonocoxae (Fig. 34) narrowly connected in middle, elongate, about 4.7 times longer than wide, slightly curved inwards at apical 1/4, with one short setae at apical 1/3, ten short and long setae located apically or subapically.

Distribution. China (Yunnan).

***Dercetina itoi* Kimoto, 1969**
http://species-id.net/wiki/Dercetina_itoi

Dercetes flaviventris: Weise 1922: 94 (Taiwan; misidentification); Chûjô 1962: 143 (redescription).
Dercetina itoi Kimoto, 1969: 64 (Taiwan); Kimoto 1987: 190 (Taiwan).

Type series. Holotype ♀ (KUEC): "(Taiwan) Alishan, 2300m Chiayi Hsien / 6.vii.1965 S. Ito / Japan-U. S. Co-op. Sci. Programme (yellow label) / HOLOTYPE (red label) / *Dercetina itoi* Kimoto, n. sp.". Paratypes: 1 ex. (KMNH): "(Taiwan) Sungkang Nantou Hsien / 31.v.1965 T. Shirôzu / PARATYPE (blue label) / *Dercetina itoi* Kimoto, n. sp."; 1 ex. (KMNH): "(Taiwan) Sungkang, 2000m – Tsuifeng, 2300m Nantou Hsien / 29.vi.1965 S. Kimoto / Japan-U. S. Co-op. Sci. Programme (yellow label) / PARATYPE (blue label) / *Dercetina itoi* Kimoto, n. sp."; 1 ex. (KMNH): "[Formosa] Oiwake (Tsuifeng in Nantou county) 2,300 m 4.V.1965 T. Shirôzu / PARATYPE (blue label) / *Dercetina itoi* Kimoto, n. sp.".



Figures 29–35. *Dercetina chinensis*. **29** Antenna, male **30** Antenna, female **31** Aedeagus, dorsal view **32** Aedeagus, lateral view **33** Sternite VIII **34** Gonocoxae **35** Spermatheca.

Material examined. TAIWAN: 6♂♂, 4♀♀, Ilan, Ssuyuan, 25.IV.2009, leg. C.-F. Lee (TARI); 6♂♂, 12♀♀, same locality, 25.IV.2009, leg. M.-H. Tsou (TARI); 1♀, same locality, 9.VI.2009, leg. S.-F. Yu (TARI); 1♀, same locality, 6.V.2011, leg.

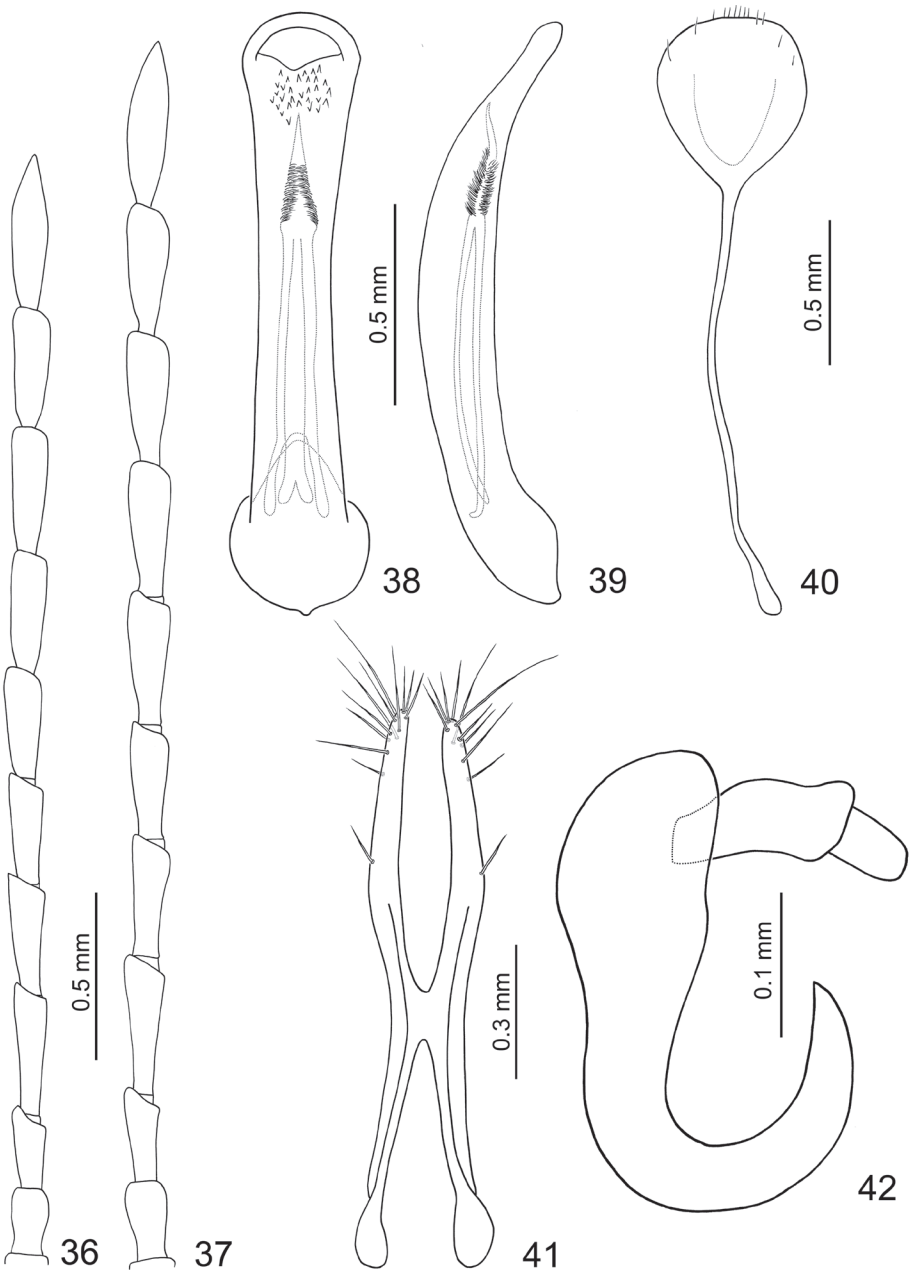
S.-F. Yu (TARI); 1♀, Hohuanshan, 17.V.2009, leg. C.-F. Lee (TARI); 1♀, Nantou, Meifeng, 7–9.V.1981, leg. K. S. Lin & S. C. Lin (TARI); 1♀, same locality, 24–26. VI.1981, leg. K. S. Lin & W. S. Tang (TARI); 1♀, same locality, 22.V.1982, leg. L. Y. Chou (TARI); 1♀, same locality, 3.VII.2008, leg. M.-H. Tsou (TARI); 1♂, same locality, 20.IV.2011, leg. C.-F. Lee (TARI); 2♂♂, 2♀♀, same locality, 30.V.2011, leg. M.-H. Tsou (TARI); 1♀, Nantou, Tatachia, 9.VI.2009, leg. C.-F. Lee (TARI); 1♂, same locality, 20.VII.2009, leg. S.-F. Yu (TARI); 1♂, same locality, 21.IX.2009, leg. C.-F. Lee (TARI); 1♂, 4♀♀, same locality, 17.V.2010, leg. C.-F. Lee (TARI); 1♂, Nantou, Tsuifeng, 3.VI.1980, leg. L. Y. Chou & C. C. Chen (TARI); 2♂♂, 6♀♀, same locality, 8.V.1981, leg. K. S. Lin & S. C. Lin (TARI); 2♀♀, same locality, 25–27.VI.1981, leg. K. S. Lin & W. S. Tang (TARI); 1♂, 4♀♀, same locality, IV.1984, leg. K. S. Lin & K. C. Chou (TARI); 1♀, same locality, 23.VII.1984, leg. K. S. Lin (TARI); 2♂♂, 3♀♀, Nantou, Tungfu, 8.V.2011, leg. C.-F. Lee (TARI); 2♂♂, Nantou, Musha (= Wushe), 18.V.-15.VI.1919, leg. T. Okuni (TARI); 2♀♀, same locality, 6–11.V.1981, leg. K. S. Lin & S. C. Lin (TARI); 4♂♂, 3♀♀, Taichung, Pilu, 17.V.2009, leg. C.-F. Lee (TARI); 6♂♂, same locality, 17.V.2009, leg. M.-H. Tsou (TARI); 2♂♂, 1♀, Taoyuan, Lalashan, 1–2.IV.2009, leg. C.-F. Lee (TARI); 2♀♀, same locality, 14.V.2009, leg. C.-F. Lee (TARI).

Diagnosis. *Dercetina itoi* is characterized by its metallic purple color. Some individuals of *D. shirozui* with blackish brown legs are similar to *D. itoi* in color pattern. *Dercetina itoi* can be separated from *D. shirozui* by the tiny punctures on the pronotum (in contrast with the prominent puncures on the pronotum in *D. shirozui*).

Redescription. Color (Figs 3–4) dark metallic purple, antennae and legs blackish brown, abdomen yellowish brown. Antennal calli separated by deep furrow; vertex with distinct punctures, disc shagreened. Pronotum 1.6–1.7 times wider than long, disc evenly convex, with scattered fine punctures, and a pair of deep round fovea at sides; lateral margin straight, narrowed posteriorly, anterior margin straight, posterior margin slightly rounded. Elytra more or less widened posteriorly, apex convergently rounded, 1.6–1.7 times longer than wide, disc with densely prominent punctures; epipleurae impunctate, somewhat rugose.

Male. Length 5.1–5.3 mm, width 2.4–2.6 mm., Antennomeres VIII-XI filiform, ratio of length of antennomeres III to XI about 1.0 : 1.5 : 1.4 : 1.3 : 1.4 : 1.5 : 1.6 : 1.5 : 1.9; ratio of length to width of antennomeres III to XI about 2.4: 3.6 : 3.0 : 2.7 : 2.9 : 3.5 : 3.7 : 3.5 : 4.0 (Fig. 36). Penis (Fig. 38) slender, about 7.7 times longer than wide, parallel-sided, apically and basally widened, apex broadly rounded; tectum membranous, with scattered stout setae; weakly curved in lateral view (Fig. 39); endophallic sclerite elongate, about 0.7 times as long as penis, apex pointed, and recurved in lateral view, with a cluster of setae near apex; dorsal sclerite with base deeply bifurcate, narrower than ventral sclerite, base bifurcate, in lateral view weakly curved.

Female. Length 5.9–6.6 mm, width 3.0–3.3 mm. Ratio of length of antennomeres III to XI about 1.0 : 1.4 : 1.3 : 1.3 : 1.4 : 1.4 : 1.4 : 1.3 : 1.8; ratio of length to width of antennomeres III to XI about 2.7: 3.3 : 3.2 : 3.0 : 3.2 : 3.1 : 3.2 : 3.1 : 4.1 (Fig. 37). Sternite VIII (Fig. 40) weakly sclerotized subapically, apex truncate, with few setae



Figures 36–42. *Dercetina itoi*. **36** Antenna, male **37** Antenna, female **38** Aedeagus, dorsal view **39** Aedeagus, lateral view **40** Sternite VIII **41** Gonocoxae **42** Spermatheca.

along apical margin, spiculum extremely long. Spermathecal receptaculum (Fig. 42) weakly swollen; pump narrow and strongly curved, apex pointed; spermathecal duct long, deeply projecting into receptaculum. Gonocoxae (Fig. 41) narrowly connected at

middle, about 4.8 times longer than wide, curved inwards at apical 1/3, with one short setae at apical 1/3, ten or eleven setae at apex.

Host plants. Sabiaceae: *Sabia transarisanensis* Hayata; Stachyuraceae: *Stachyurus himalaicus* Hook. f. & Thomson ex Benth.

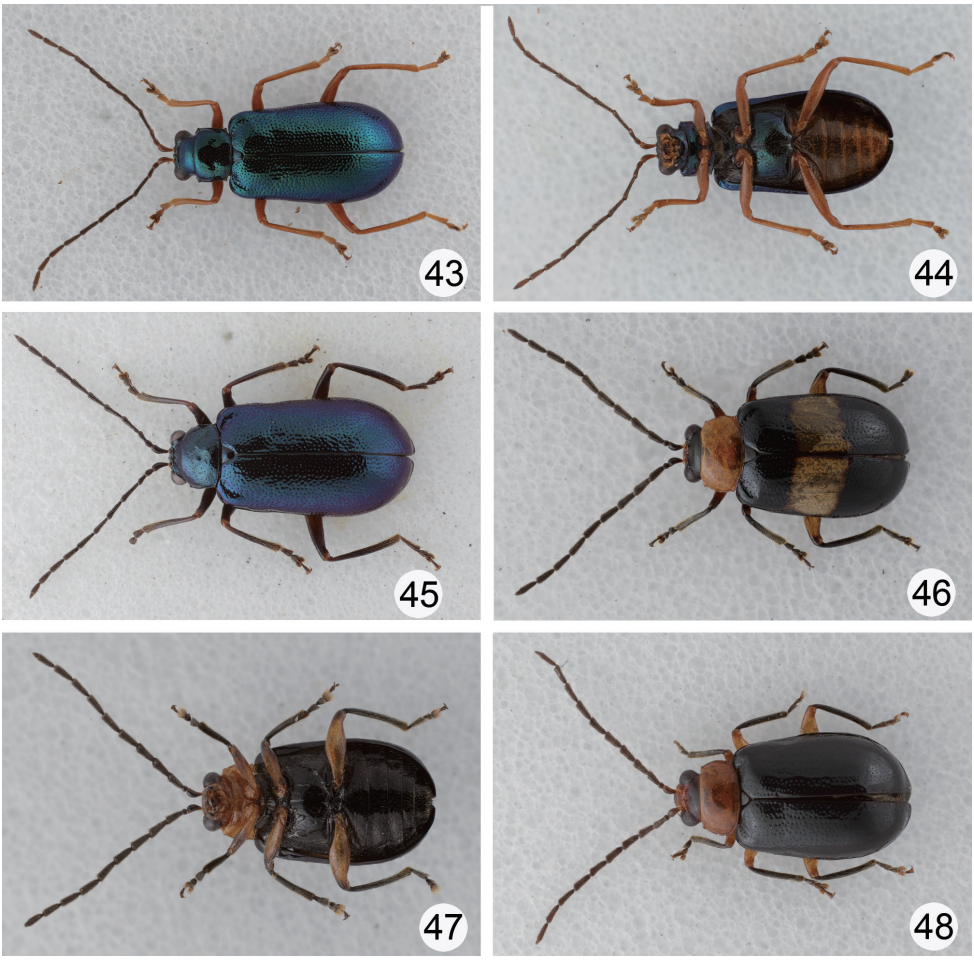
Distribution. Taiwan. It is widespread in high mountains (above 2000 m) (Fig. 13).

***Dercetina shirozui* Kimoto, 1969**
http://species-id.net/wiki/Dercetina_shirozui

Dercetina shirozui Kimoto, 1969: 63; Kimoto 1989b: 260 (Taiwan); Kimoto 1991: 17 (Taiwan).

Type series. Holotype ♀ (KUEC): "(Taiwan) Sungkang Nantou Hsien / 5.V.1965 T. Shirôzu / HOLOTYPE (red label) / *Dercetina shirozui* Kimoto, n. sp.". Paratypes: 1 ex., same as holotype (KMNH); 1 ex.: "(Taiwan) Sungkang Nantou Hsien / 1.VI.1965 T. Shirôzu / PARATYPE (blue label) / *Dercetina shirozui* Kimoto, n. sp." (KMNH); 1 ex.: "(Taiwan) Sungkang Nantou Hsien / 18.V.1965 T. Shirôzu / PARATYPE (blue label) / *Dercetina shirozui* Kimoto, n. sp." (KMNH); 1 ex.: "(Taiwan) Taiko (= Tahu) – Nihonmatsu (= Sungen) Byoritsu-ken (= Miaoli county) 9.iv.1967 T. Shirozu / PARATYPE (blue label) / *Dercetina shirozui* Kimoto, n. sp." (KMNH); 1 ex.: "(Taiwan) Alishan, 2300m Chiayi Hsien / 6.vii.1965 S. Kimoto / Japan-U. S. Co-op. Sci. Programme (yellow label) / PARATYPE (blue label) / *Dercetina shirozui* Kimoto, n. sp." (KMNH); 1 ex.: "(Taiwan) Hokuko (= Peikeng) – Kaminoshima-onsen (= Hushan) Byoritsu-ken (= Miaoli county) 11.iv.1967 T. Shirozu / PARATYPE (blue label) / *Dercetina shirozui* Kimoto, n. sp." (KMNH).

Material examined. TAIWAN: 1♂, Hsinchu, Litungshan, 23.III.2007, leg. M.-H. Tsou (TARI); 3♂♂, same locality, 15.III.2009, leg. M.-H. Tsou (TARI); 1♂, Hsinchu, Mamei, 13.III.2011, leg. M.-H. Tsou (TARI); 2♀♀, Hsinchu, Tahunshan, 24.II.2009, leg. S.-F. Yu (TARI); 1♂, 2♀♀, same locality, 1.III.2009, leg. M.-H. Tsou (TARI); 1♂, Hsinchu, Wufeng, 17.II.2009, leg. S.-F. Yu (TARI); 1♂, Hualien, Pilu, 17.V.2009, leg. C.-F. Lee (TARI); 8♂♂, Ilan, Chiuchihtse, 7.XII.2008, leg. M.-H. Tsou (TARI); 1♂, 1♀, Ilan, Suyuan, 28.IV.2009, leg. M.-H. Tsou (TARI); 1♀, Kaoshiung, Tengchih (= Shihshan trail), 2–5.VI.2008, leg. C.-F. Lee (TARI); 22♂♂, same locality, 6.II.2009, leg. M.-H. Tsou (TARI); 1♀, Nantou, Hohuanshan, 18.V.2009, leg. C.-F. Lee (TARI); 1♀, Nantou, Meifeng, 5–8.VI.1980, leg. C. C. Chen (TARI); 1♀, same locality, 7–9.V.1981, leg. K. S. Lin & S. C. Lin (TARI); 1♀, same locality, 24–26.VI.1981, leg. K. S. Lin & W. S. Tang (TARI); 1♂, 1♀, same locality, 22.V.1982, leg. L. Y. Chou (TARI); 1♀, Nantou, Tattaka (= Sungkang), VI.1925, leg. J. Sonan (TARI); 1♂, 1♀, same locality, 4.IV.2010, leg. Y.-T. Wang (TARI); 2♂♂, Nantou, Tatachia, 9.VI.2009, leg. C.-F. Lee (TARI); 3♀♀, same locality, 27.IV.2010, leg. C.-F. Lee (TARI); 2♀♀, Nantou, Tayuling, 9-16. VI.1981, leg. K. S. Lin & B. H. Chen (TARI); 1♀, Nantou, Tsuifeng, 3.VI.1980,



Figures 43–48. Habitus of *Dercetina* species. **43** *D. shirozui*, dorsal view **44** *D. shirozui*, ventral view **45** *D. shirozui*, color variation **46** *D. taiwana*, dorsal view **47** *D. taiwana*, ventral view **48** *D. taiwana*, color variation.

leg. L. Y. Chou & C. C. Chen (TARI); 3♀♀, same locality, 8.V.1981, leg. K. S. Lin & S. C. Lin (TARI); 1♀, same locality, 25–27.VI.1981, leg. K. S. Lin & W. S. Tang (TARI); 2♀♀, Nantou, Wushe, 6–11.V.1981, leg. K. S. Lin & S. C. Lin (TARI); 1♂, Pingtung, Tahanshan, 2.II.2008, leg. M.-H. Tsou (TARI); 1♀, same locality, 3.III.2008, leg. C.-F. Lee (TARI); 1♂, 1♀, same locality, 21.III.2009, leg. M.-H. Tsou (TARI); 1♂, same locality, 6.III.2010, leg. U. Ong (TARI); 1♂, same locality, 28.IV.2012, leg. M.-H. Tsou (TARI); 2♀♀, same locality, 16.IV.2012, leg. C.-F. Lee (TARI); 1♂, 2♀♀, Taoyuan, Hsitsun, 12.IV.2009, leg. M.-H. Tsou (TARI); 2♂♂, 2♀♀, Taoyuan, Hsuehwunao, 10.IV.2011, leg. M.-H. Tsou (TARI); 1♀, Taoyuan, Lalashan, 2.IV.2009, leg. H.-J. Chen (TARI); 1♀, same locality, 2.IV.2009, leg. C.-

F. Lee (TARI); 1♂, same locality, 4.V.2010, leg. S.-F. Yu (TARI); 1♀, same locality, 14.V.2009, leg. C.-F. Lee (TARI).

Diagnosis. *Dercetina shirozui* is similar to *D. azumai* with metallic green elytra and yellowish brown legs but differs by its metallic green head, prothorax, meso- and metathoracic ventrites (in contrast with yellowish brown ones in *D. azumai*). Some individuals of *D. shirozui* with blackish brown legs may be similar to *D. itoi*. However, *D. shirozui* is distinguished from *D. itoi* by the prominent punctures on the pronotum.

Redescription. Color (Figs 43–44) metallic green or blue, legs and abdomen yellowish brown, antenna dark brown or blackish brown. Antennal calli with deep furrow in middle; vertex with dense distinct punctures, disc shagreened. Pronotum 1.5-1.6 times wider than long, disc evenly flat, with dense prominent punctures, and a pair of deep round fovea at sides; lateral margin straight, narrowed posteriorly, anterior margin slightly concave, posterior margin slightly rounded. Elytra more or less widened posteriorly, apex convergently rounded, 1.7–1.8 times longer than wide, disc with densely prominent punctures; epipleurae with dense prominent punctures.

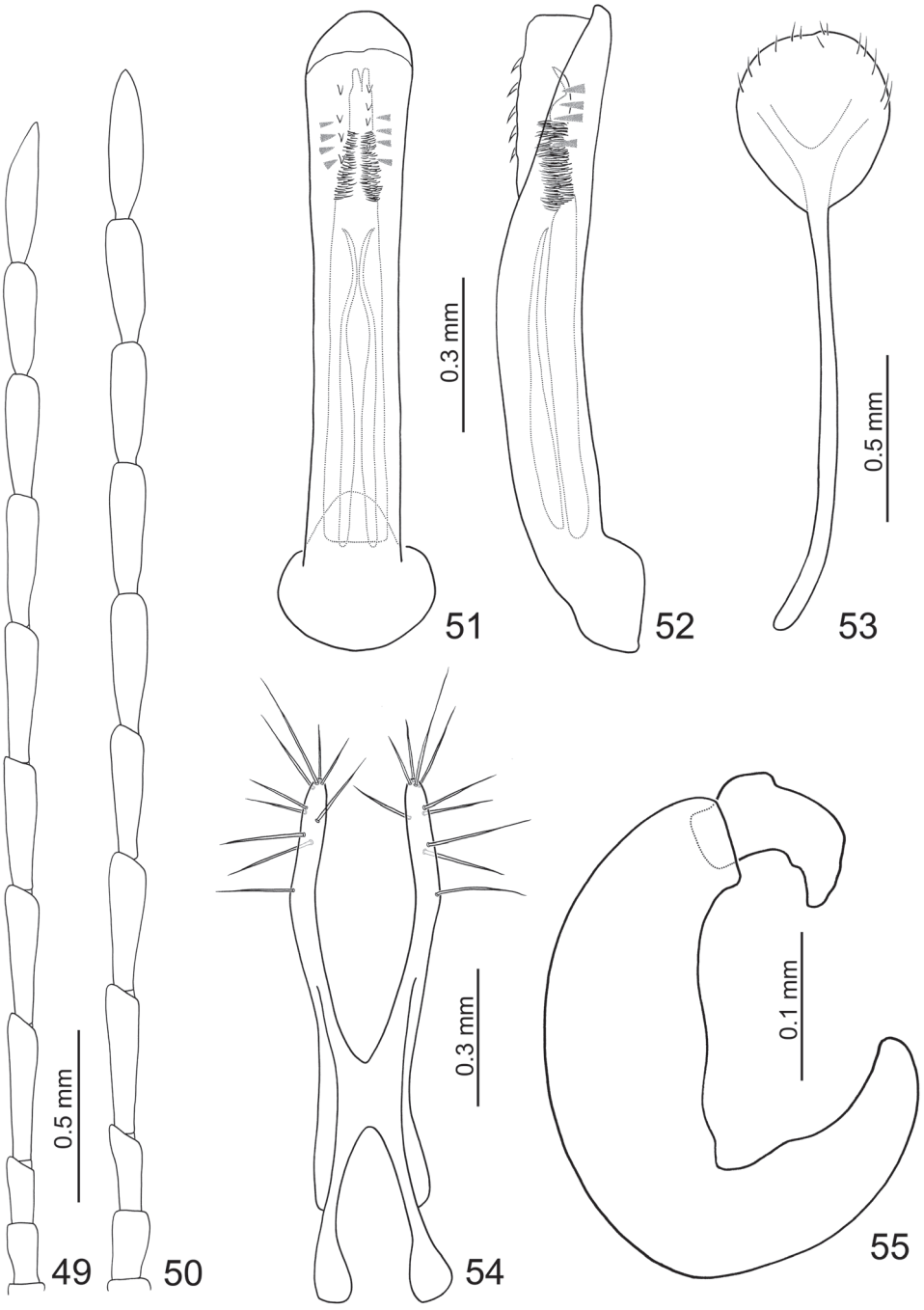
Male. Length 4.8–5.1 mm, width 2.1–2.3 mm. Ratio of length of antennomeres III to XI about 1.0 : 2.2 : 2.0 : 2.0 : 2.1 : 2.0 : 1.9 : 1.7 : 2.2; ratio of length to width of antennomeres III to XI about 2.4: 4.9 : 3.9 : 4.1 : 4.1 : 3.9 : 3.8 : 3.4 : 4.6 (Fig. 49). Penis (Fig. 51) slender, about 7.3 times longer than wide, parallel-sided, basally widened, apex broadly rounded; tectum membranous, with two longitudinal rows of stout setae; weakly curved in lateral view (Fig. 52); endophallus with four pairs of small teeth near apex, ventral sclerite long, about 0.7 times as long as penis, base truncate, apex bifurcate and curved in lateral view; with a cluster of setae near apex; a pair of elongate dorsal sclerites located from base to apical 1/3, apices pointed and recurved subapically.

Female. Length 5.5–6.3 mm, width 2.7–3.0 mm. Antenna 11-segmented, filiform (Fig. 50), ratio of length of antennomeres III to XI about 1.0 : 1.6 : 1.5 : 1.5 : 1.5 : 1.5 : 1.4 : 1.4 : 1.7; ratio of length to width of antennomeres III to XI about 2.6: 4.3 : 3.7 : 3.7 : 3.6 : 3.7 : 3.4 : 3.4 : 4.1. Sternite VIII (Fig. 53) weakly sclerotized laterally and apically, with a few setae along apical margin, spiculum extremely long. Spermathecal receptaculum (Fig. 51) elongate and weakly swollen; pump narrow and strongly curved, apex narrowly rounded; spermathecal duct short, apically narrowed, shallowly projecting into receptaculum. Gonocoxae (Fig. 54) widely connected in middle, about 3.4 times longer than wide, curved inwards in apical 1/3, with ten long setae in apical 1/3.

Color variation. Some populations have blackish brown legs and black antenna (Fig. 45).

Host plants. Aceraceae: *Acer albopurpurascens* Hayata; Actinidiaceae: *Actinidia callosa* Lindl.; Rosaceae: *Prunus phaeosticta* (Hance) Maxim.; Saxifragaceae: *Deutzia pulchra* Vidal and *Schizophragma integrifolium* Oliv. var. *fauriei* (Hayata) Hayata; Stachyuraceae: *Stachyurus himalaicus* Hook. f. & Thomson ex Benth.; Staphyleaceae: *Turpinia formosana* Nakai.

Distribution. Taiwan. It is widespread in mountains above 1000 m (Fig. 14).



Figures 49–55. *Dercetina shirozui*. **49** Antenna, male **50** Antenna, female **51** Aedeagus, dorsal view **52** Aedeagus, lateral view **53** Sternite VIII **54** Gonocoxae **55** Spermatheca.

***Dercetina taiwana* (Chûjô, 1938), stat. r.**
http://species-id.net/wiki/Dercetina_taiwana

Dercetis taiwana Chûjô, 1938: 140; Chûjô 1962: 145 (redescription); Gressitt and Kimoto 1963: 710 (as synonymy of *D. chinensis*).
Dercetis taiwana ab. *melania* Chûjô, 1938: 140; Gressitt and Kimoto 1963: 710 (confirmed as infraspecific variation of *D. chinensis*)
Dercetis taiwana var. *melania*: Chûjô 1962: 146 (redescription).
Dercetis taiwana f. *melania*: Chûjô 1965: 95 (Taiwan).
Dercetina chinensis: Kimoto 1966: 33 (Taiwan); Kimoto 1969: 66 (Taiwan); Takizawa et al. 1995: 63 (Taiwan).
Dercetina flavocincta: Kimoto 1989a: 260 (Taiwan); Kimoto 1991: 17 (Taiwan).

Type series. *Dercetis taiwana*: Lecotype ♂, here designated, labeled: "Formosa Shinchiku (= Hsinchu), -18. VII 1–30. J. Sonan / COType (circular label with yellow letters and border) / *Dercetis taiwana* CHÛJÔ DET. M. CHUJO / 1916" (TARI). Paralectotypes: 3♀♀: "Urai (= Wulai, in Taipei county) FORMOSA 28.III.1932 COL. M. CHUJO / COType (circular label with yellow letters and border) / *Dercetis taiwana* CHÛJÔ DET. M. CHUJO / 2379, 2380, 2384 (respectively)" (TARI); 2♀♀: "Taiheizan (= Taipingshan, in Ilan county) FORMOSA Jul 1930 S. Minowa / COType (circular label with yellow letters and border) / *Dercetis taiwana* CHÛJÔ DET. M. CHUJO / 2162 or 2385" (TARI); 1♀: "Formosa Arisan (= Alisan, in Chiayi county), 1918 X 2-23. J. Sonan COType (circular label with yellow letters and border) / *Dercetis taiwana* CHÛJÔ DET. M. CHUJO / 2159" (TARI); 1♂: "Formosa Y. Miwa / Rimogan (= Fushan, in Taipei county) 22.7.1929 (on the back) / COType (circular label with yellow letters and border) / *Dercetis taiwana* CHÛJÔ DET. M. CHUJO / 2160" (TARI); 1♀: "Formosa Y. Miwa / Kobayashi, 25.7.1929 / Syntypus (red label) / *Dercetis taiwana* CHÛJÔ DET. M. CHUJO / DEI Müncheberg Col - 03095" (SDEI); 1♀: "Paroe (Form.) H. Sauter IX.1912 / Syntypus (red label) / *Dercetis taiwana* CHÛJÔ DET. M. CHUJO / DEI Müncheberg Col - 03096" (SDEI); 1♀: "Taihorin (= Talin, in Chiayi county) Formosa H. Sauter, 1911 / 7.VII. / Syntypus (red label) / *Dercetis taiwana* CHÛJÔ DET. M. CHUJO / DEI Müncheberg Col - 03097" (SDEI); 1♀: "Formosa Y. Miwa / Hsuanyan (in Japanese) 23.7.1929 / COType (circular label with yellow letters and border) / *Dercetis taiwana* CHÛJÔ DET. M. CHUJO / 2161" (TARI).

Dercetis taiwana ab. *melania*: Syntypes: 1♂, 1♀: "Urai (= Wulai, in Taipei county) FORMOSA 28.III.1932 COL. M. CHUJO / COType (circular label with yellow letters and border) / *Dercetis taiwana* ab. *melania* CHÛJÔ DET. M. CHUJO / 2374 or 2375" (TARI); 2♀♀: "Urai (= Wulai, in Taipei county) FORMOSA 28.III.1932 COL. M. CHUJO / Syntypus (red label) / *Dercetis taiwana* ab. *melania* CHÛJÔ DET. M. CHUJO / DEI Müncheberg Col – 03098 and 03099" (SDEI); 1♂, 1♀: "Formosa Shinchiku (= Hsinchu), -18. VII 1-30. J. Sonan / COType (circular la-

bel with yellow letters and border) / *Dercetis taiwana* ab. *melania* CHÛJÔ DET. M. CHUJO / 2163 or 1923" (TARI); 1♀: "Formosa Y. Miwa / Urai (= Wulai in Taipei county) 20.7.1929 (on the back) / COType (circular label with yellow letters and border) / *Dercetis taiwana* ab. *melania* CHÛJÔ DET. M. CHUJO / 1915" (TARI); 1♂: "Formosa Y. Miwa / Hsitsun (in Chinensis) 24.7.1929 (on the back) / COType (circular label with yellow letters and border) / *Dercetis taiwana* ab. *melania* CHÛJÔ DET. M. CHUJO / 2164".

Material examined. CHINA: 1♂, 1♀, Guangdong, Tsha-jiu-san, V.-VI.1912, leg. S. V. Mell (KMNH); 1♂, Hubei, Lichuan, Suisapa, 23.VIII.1948, leg. J. L. Gressitt (KMNH); 1♂, Hubei, Lichuan, Lianghokeu, 1.IX.1948, leg. Gressitt & Djou (KMNH); **TAIWAN**: 1♀, Hsinchu, Chienshih, 26.VII.2008, leg. H.-J. Chen (TARI); 1♂, same locality, 26.IX.2009, leg. H.-J. Chen (TARI); 1♂, 1♀, Hsinchu, Lupi, 24.VI.2008, leg. H. Lee (TARI); 1♀, Hsinchu, Peitelaman, 26.VI.2008, leg. S.-F. Yu (TARI); 3♂♂, 5♀♀, Hsinchu, Talu trail, 22.VIII.2009, leg. Y.-L. Lin (TARI); 1♀, same locality, 19.VI.2010, leg. Y.-L. Lin (TARI); 2♂♂, Hsinchu, Wufeng, 12.VII.2008, leg. H.-J. Chen (TARI); 1♀, same locality, 29.IX.2009, leg. Y.-L. Lin (TARI); 1♂, 2♀♀, Hsinchu, Yulao, 3.IV.2011, leg. M.-H. Tsou (TARI); 2♀♀, Ilan, Fushan Botanical Park, 1.IV.2008, leg. H.-J. Chen (TARI); 4♂♂, 5♀♀, same locality, 1.IV.2008, leg. M.-H. Tsou (TARI); 1♂, same locality, 2.IV.2008, leg. H.-J. Chen (TARI); 2♂♂, same locality, 20.III.2009, leg. C.-F. Lee (TARI); 1♂, 1♀, Ilan, Mingchi, 17.III.2007, leg. M.-H. Tsou (TARI); 2♂♂, 7♀♀, same locality, 29.VII.2007, leg. M.-H. Tsou (TARI); 3♂♂, 2♀♀, same locality, 27.IV.2008, leg. S.-F. Yu (TARI); 2♀♀, same locality, 25.V.2008, leg. M.-H. Tsou (TARI); 1♀, Ilan, Suchi trail, 19.V.1910, leg. H.-J. Chen (TARI); 1♀, Ilan, Taipingshan, 3.VI.2007, leg. S.-F. Yu (TARI); 1♂. 5♀♀, Ilan, Tsuifenghu, 3.VII.2010, leg. M.-H. Tsou (TARI); 1♀, Taichung, Yuantsuishan, 16.VII.2010, leg. J.-C. Chen (TARI); 2♀♀, Taipei, Chutzuhu, 16.IX.2007, leg. S.-F. Yu (TARI); 3♂♂, same locality, 15.VI.2008, leg. M.-H. Tsou (TARI); 1♂, 1♀, Taipei, Erhkoshan, 26.XI.2006, leg. M.-H. Tsou (TARI); 1♂, 1♀, Taipei, Fengkueitsui, 29.VI.2007, leg. S.-F. Yu (TARI); 1♀, Taipei, Fushan, 5.IV.2007, leg. S.-F. Yu (TARI); 1♂, 2♀♀, Taipei, Hsiaoyuken, 29.III.2008, leg. M.-H. Tsou (TARI); 1♂, 2♀♀, Taipei, Lengshuiken, 22.VI.2008, leg. S.-F. Yu (TARI); 3♂♂, 2♀♀, Taipei, Menghu, 27.IX.2007, leg. S.-F. Yu (TARI); 3♂♂, 7♀♀, Taipei, Pinglin, 29.III.2008, leg. M.-H. Tsou (TARI); 1♂, 3♀♀, Taipei, Wulai, 10.VII.2007, leg. H.-T. Cheng (TARI); 4♀♀, same locality, 27.IX.2006, leg. H.-J. Chen (TARI); 2♂♂, 3♀♀, same locality, 22.X.2006, leg. S.-F. Yu (TARI); 1♂, 1♀, same locality, 26.X.2006, leg. S.-F. Yu (TARI); 2♀♀, same locality, 19.VI.2007, leg. M.-H. Tsou (TARI); 2♀♀, 30.IX.2007, leg. M.-H. Tsou (TARI); 1♀, Taipei, Yangmingshan, 3.III.1998, leg. C.-F. Lee (TARI); 1♂, same locality, 15.III.1998, leg. C.-F. Lee (TARI); 1♂, 1♀, same locality, 29.VIII.2006, leg. H.-J. Chen (TARI); 1♀, same locality, 15.IV.2007, leg. M.-H. Tsou (TARI); 1♀, same locality, 19.V.2007, leg. M.-H. Tsou (TARI); 2♀♀, same locality, 1.VI.2007, leg. S.-F. Yu (TARI); 3♂♂, 1♀, same locality, 23.VI.2007, leg. S.-F. Yu (TARI); 1♂, Taipei, Yingtzuling, 24.VII.2010, leg. Y.-L. Lin (TARI); 2♀♀, same locality, 25.IX.2010, leg. Y.-L. Lin (TARI); 1♀, Taoyuan, Hsiaowulai,

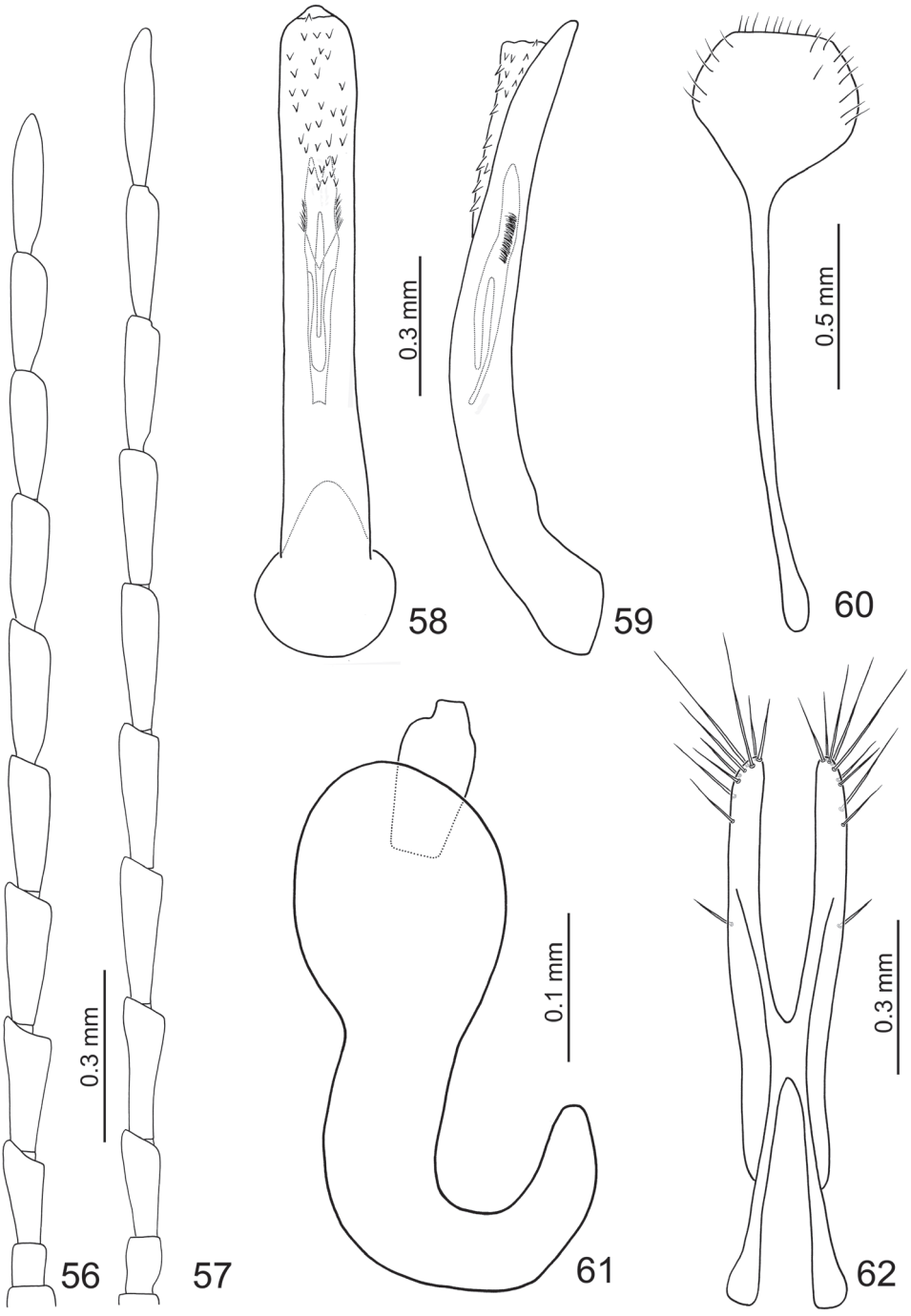
29.IX.2009, leg. M.-H. Tsou (TARI); 1♂, same locality, 1.VI.2010, leg. S.-F. Yu (TARI); 1♂, Taoyuan, Tsuehwunao, 10.IV.2011, leg. M.-H. Tsou (TARI); 2♂♂, Taoyuan, Mamei, 3.IV.2011, leg. M.-H. Tsou (TARI); 6♂♂, 13♀♀, Taoyuan, Paling, 8.XI.2009, leg. M.-H. Tsou (TARI); 1♂, same locality, 11.IV.2010, leg. M.-H. Tsou (TARI); 1♂, 1♀, Taoyuan, Tungyanshan, 14.VII.2008, leg. H. Lee (TARI); 1♀, same locality, 17.IV.2009, leg. H. Lee (TARI); 3♂♂, same locality, 10.V.2009, leg. H. Lee (TARI); 1♀, same locality, 16.VI.2009, S.-F. Yu (TARI);

Diagnosis. *Dercetina taiwana* is similar to *D. chinensis* and *D. barclayi* sp. n. in the absence of lateral fovea on the pronotum and antennomere III slightly longer than IV. *Dercetina taiwana* and *D. chinensis* are separated from *D. barclayi* sp. n. by its sexually dimorphic antennae. Both species have their distinct color patterns in most individuals: the bluish black elytra with white transverse band at middle in *D. taiwana*; the yellowish brown elytra with or without longitudinal black bands long suture and lateral margins in *D. chinensis*. Although some individual specimens of both species share the same color pattern, *D. taiwana* differs from *D. chinensis* by a more oval elytra (1.4 times longer than wide in contrast with 1.6 times longer than wide in *D. chinensis*).

Redescription. Color (Figs 46–47) bluish black, head (except eyes and antennae), prothorax, coxae, and tibiae yellowish brown; elytra with one transverse white stripe at basal 1/3. Head smooth and impunctate. Pronotum transverse, 1.9–2.0 times wider than long, evenly convex on disc and lacking fovea or punctured depression, disc with scattered fine punctures; lateral margin rounded, anterior margin concave, posterior margin slightly rounded. Elytra more or less widened posteriorly, apex convergently rounded, 1.4 times longer than wide, disc with punctures in part arranged in longitudinal rows, epipleurae smooth and impunctate.

Male. Length 4.0–4.5 mm, width 2.2–2.5 mm. Ratio of length of antennomeres III to XI about 1.0 : 1.3 : 1.3 : 1.3 : 1.3 : 1.2 : 1.2 : 1.1 : 1.3; ratio of length to width of antennomeres III to XI about 2.5: 2.9 : 3.0 : 3.2 : 3.3 : 3.3 : 3.6 : 3.6 : 4.5 (Fig. 56). Penis (Fig. 58) extremely slender, about 8.4 times longer than wide, parallel-sided, basally widened, apex narrowly rounded; tectum membranous, with scatted stout setae; weakly curved in lateral view (Fig. 59); endophallic sclerite elongate, about 0.4 times as long as penis, base and apex concave and membranous, with a dorsal sclerite connected at basal 1/4, almost reaching base, with a row of short setae along lateral margin at apical 1/4; in lateral view almost straight.

Female. Length 5.2–5.7 mm, width 3.0–3.3 mm. Antenna 11-segmented, filiform (Fig. 57), comparatively narrower than in male, ratio of length of antennomeres III to XI about 1.0 : 1.3 : 1.3 : 1.3 : 1.3 : 1.3 : 1.3 : 1.2 : 1.5; ratio of length to width of antennomeres III to XI about 2.9: 3.1 : 3.3 : 3.5 : 3.6 : 3.5 : 3.9 : 4.0 : 5.4. Sternite VIII (Fig. 60) weakly sclerotized subapically, apex truncate, setae along lateral and apical margin, spiculum long. Spermathecal receptaculum (Fig. 61) swollen; pump narrow and strongly curved, apex narrowly rounded; spermathecal duct short, deeply projecting into receptaculum. Gonocoxae (Fig. 62) narrowly connected in middle, about 4.6 times longer than wide, straight, with one short setae at apical 1/3 and nine setae at apex.



Figures 56–62. *Dercetina taiwana*. **56** Antenna, male **57** Antenna, female **58** Aedeagus, dorsal view **59** Aedeagus, lateral view **60** Sternite VIII **61** Spermatheca **62** Gonocoxae.

Color variation. A number of individuals have transverse white strip on elytra reduced at various degrees, or even totally absent (Fig. 48); some have the vertex, clypeus, and labrum darkened; a few individuals have pronotum darkened.

Host plants. Betulaceae: *Alnus formosana* (Burkill ex Forbes & Hemsl.) Makin; Compositae: *Eupatorium formosanum* Hayata; Fagaceae: *Quercus variabilis* Bl.; Lauraceae: *Cinnamomum camphora* (L.) Presl. and *Litsea cubeba* (Lour.) Persoon; Lythraceae: *Lagerstroemia subcostata* Koehne; Moraceae: *Humulus scandens* (Lour.) Merr.; Rosaceae: *Prunus campanulata* Maxim.; Rutaceae: *Tetradium glabrifolium* (Champ. ex Benth.) T. Hartley; Stachyuraceae: *Stachyurus himalaicus* Hook. f. & Thomson ex Benth.; Ulmaceae: *Trema orientalis* (L.) Bl.

Distribution. China (Guandung, Hubei) and Taiwan. *Dercetina taiwana* is widespread in northern Taiwan from lowlands to high mountains (above 2000 m) (Fig. 15). This species is rather abundant.

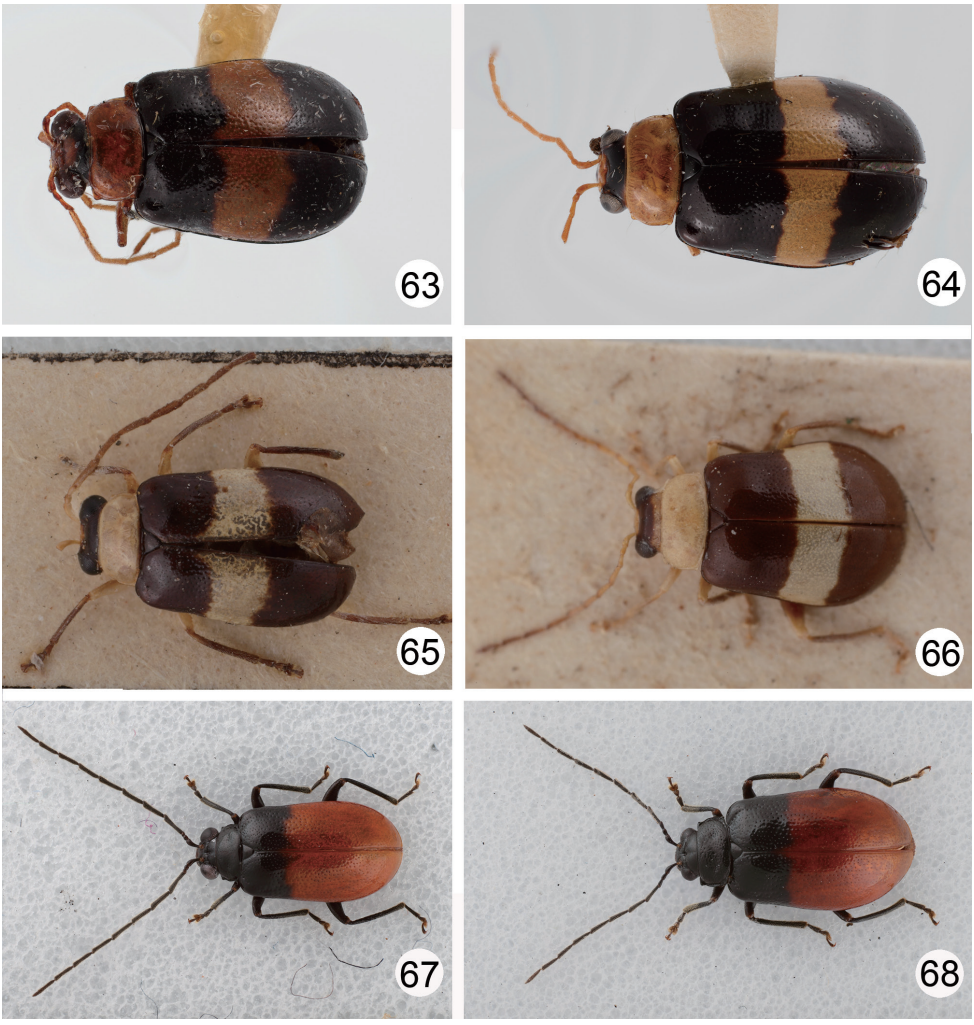
***Dercetina unifasciata* (Allard, 1889), stat. r. and comb. n.**
http://species-id.net/wiki/Dercetina_unifasciata

Antipha unifasciata Allard, 1889: 107; Kimoto 1989b: 229. (as synonymy of *Dercetina flavocincta*)

Type material. *Antipha unifasciata*: Holotype ♀ (head lost; ISNB): "Cambodge / Coll. Chapuis / E. Allard det.: *Antipha unifasciata* All. / *Antipha unifasciata* All. (yellow label) / TYPE (pink label) / cf. Ann. Soc Ent. Belg., XXXIII, 1889, p. 107-108 / sec. Weise, Col. Cat. Junk (78), 1924: p. 145 *Dercetis unifasciata* All.".

Material examined. CAMBODIA: 1♀, Kampot prov., Bokor, 8.V.1961, leg. J. L. Nickel (USNM); **INDIA**: 1♀ (BMNH), Darjeeling, Bengal, Debrepani, 6000', 18.IX.1929, leg. J.C.M. Gardner; **LAOS**: 1♀, Attapeu Prov., Houei Kong, 31.V.1965, leg. Native Collector (BPBM); 1♀, Borikhane Prov., Pakkading, 31.VII.1965, leg. Native Collector (BPBM); 1♀, Sayabouly Prov., Sayaboury, 16.IV.1965, leg. J. L. Gressitt (BPBM); 1♀, Sedone Prov., Paksong, 18.V.1965, leg. P. D. Ashlock (BPBM); 1♂, 1♀, Vientiane Prov., Ban Van Eue, 20km E of Phou-kow-kuei, 1–15.V.1965, leg. J. A. Rondon (BPBM); 1♂, same locality, 11.IV.1965, leg. J. L. Gressitt (KMNH); 1♂, 1♀, same locality, 12.IV.1965, leg. J. L. Gressitt (BPBM); 1♂, 15.VIII.1965, leg. J. L. Gressitt (BPBM); 1♀, same locality, 15.III.1966, leg. Native Collector (BPBM); 1♀, 15.XII.1966, leg. Native Collector (BPBM); 1♀, same locality, 2.II.1968, leg. Native Collector (BPBM); 1♀, same locality, 15.II.1968, leg. Native Collector (BPBM); 1♀, same locality, 15.VIII.1968, leg. Native Collector (BPBM); 1♀, Phou-kow-kuei, 15.IV.1965, leg. J. L. Gressitt (BPBM); 1♀, Vientiane Prov., Vientiane, 30.IV.1967, leg. Native Collector (BPBM); 1♀, Xieng Kyouang Prov., Ban Sam Thang, 5.XI.1965, leg. Native Collector (BPBM).

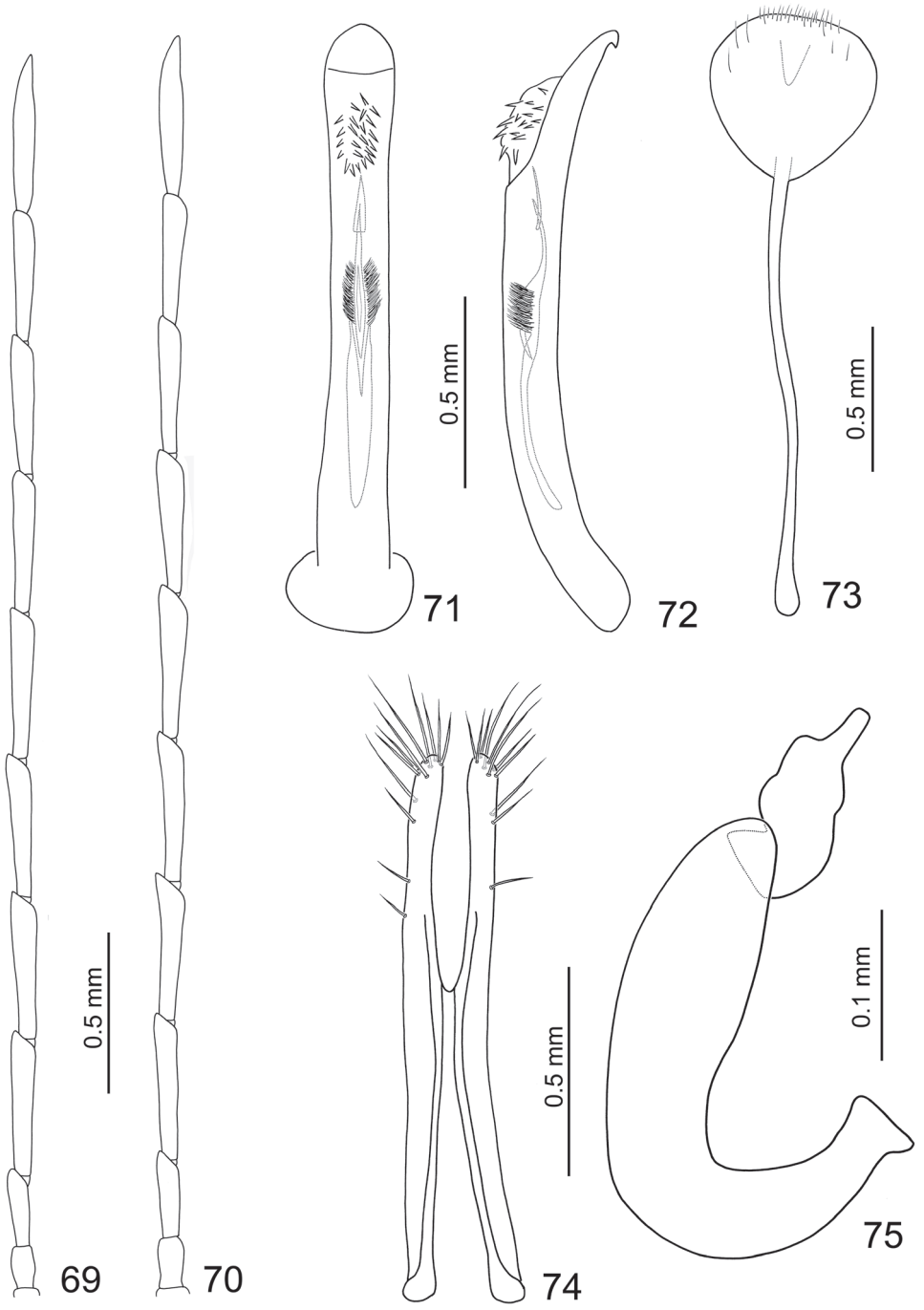
Diagnosis. *Dercetina unifasciata* is similar to *D. taiwana* and *D. barclayi* sp. n. with the evenly convex pronotum and similar color pattern but differing by antenno-



Figures 63–68. Dorsal habitus of *Dercetina* and *Arthrotus* species. **63** *D. unifasciata*, male **64** *D. unifasciata*, female **65** *A. flavocincta*, male **66** *A. flavocincta*, female **67** *A. nakanei*, male; 68. *A. nakanei*, female.

mere IV much longer than III (1.8 times in *D. unifasciata* in contrast with 1.2 or 1.3 times in *D. taiwana* and *D. barclayi* sp. n.).

Redescription. Color (Figs 63–64) bluish black, head, prothorax, coxae, and tibiae yellowish brown; elytra with one transverse white stripe at basal 1/3. Head smooth and impunctate. Pronotum transverse, 2.0 times wider than long, evenly convex on disc and lacking fovea or punctured depression, disc with scattered fine punctures; lateral margin almost straight, anterior margin slightly concave, posterior margin slightly rounded. Elytra more or less widened posteriorly, apex convergently rounded, 1.4 times longer than wide, disc with punctures in part arranged in longitudinal rows, epipleurae smooth and impunctate.



Figures 69–75. *Dercetina unifasciata*. **69** Antenna, male **70** Antenna, female **71** Aedeagus, dorsal view **71** Aedeagus, lateral view **73** Sternite VIII **74** Gonocoxae **75** Spermatheca.

Male. Length 4.7 mm, width 2.5 mm. Ratio of length of antennomeres III to XI about 1.0 : 1.8 : 1.9 : 1.9 : 1.9 : 1.8 : 1.8 : 1.7 : 2.0; ratio of length to width of antennomeres III to XI about 3.8: 6.0 : 6.2 : 6.1 : 6.3 : 5.9 : 6.2 : 6.3 : 7.1 (Fig. 69). Penis (Fig. 71) extremely slender, about 11.0 times longer than wide, parallel-sided, basally and apically widened, apex narrowly rounded; tectum membranous, with scattered long setae; weakly curved in lateral view, apex recurved and pointed (Fig. 72); endophallic sclerites elongate, about 0.6 times as long as penis; apex pointed, ventrally covered with a small apically pointed sclerite; with a cluster of long setae at middle; sinuate in lateral view.

Female. Length 4.7–5.8 mm, width 2.7–3.2 mm. Antenna filiform (Fig. 70), similar to male, ratio of length of antennomeres III to XI about 1.0 : 1.7 : 1.7 : 1.7 : 1.8 : 1.7 : 1.6 : 1.5 : 1.9; ratio of length to width of antennomeres III to XI about 3.9 : 6.6 : 6.2 : 6.3 : 6.3 : 5.7 : 5.7 : 5.4 : 6.7. Sternite VIII (Fig. 73) weakly sclerotized subapically, apex rounded, with dense short setae along apical margin, spiculum extremely long. Spermathecal receptaculum (Fig. 75) slightly swollen; pump narrow and strongly curved, apex widened and truncate; spermathecal duct short, narrowed in middle, shallowly projecting into receptaculum. Gonocoxae (Fig. 74) very close at middle, about 5.9 times longer than wide, slightly curved inwards near apex, apex rounded, with one or two short setae at apical 1/3, two subapically, eight setae at apex.

Distribution. Cambodia, India, Laos.

Key to species of the genus *Dercetina* from Taiwan and their similar species

1	Pronotum with lateral fovea	**2**
–	Pronotum evenly convex and without lateral fovea	**4**
2.	Head, prothorax, meso- and metathoracic ventrites yellowish bown	***D. azumai* Gressitt & Kimoto**
–	Head, prothorax, meso- and metathoracic ventrites metallic green or purple	**3**
3	Metallic green; pronotum with prominent punctures	***D. shirozui* Kimoto**
–	Metallic purple; pronotum with fine punctures	***D. itoi* Kimoto**
4	Antennomere IV much longer than III (1.8 times)	***D. unifasciata*** (Allard)
–	Antennomere IV a little longer than III (1.2–1.3 times)	**5**
5	Elytra oblong (1.6 times longer than wide); elytra yellowish brown with black bands along suture and lateral margins in most individuals	***D. chinensis* (Weise)**
–	Elytra oval (1.4 times longer than wide); elytra bluish black with white transverse band at middle in most individuals	**6**
6	Antenna yellowish brown; endophallic sclerites longer	***D. barclayi* sp. n.**
–	Antenna blackish brown, endophallic sclerites shorter	***D. taiwana* (Chûjô)**

Species excluded from the genus *Dercetina*

***Arthrotus flavocincta* (Hope, 1831), comb. n.**
http://species-id.net/wiki/Arthrotus_flavocincta

Galleruca flavocincta Hope, 1831: 29.
Monolepta flavocincta: Weise 1924: 168.
Dercetis flavocincta: Maulik 1936: 355.
Dercetina flavocincta: Kimoto and Takizawa 1972: 222 (Nepal); Kimoto 1989b: 229 (Thailand, Laos, Vietnam).
Antipha flavofasciata Baly, 1879: 456; Maulik 1936: 355. (as synonym of *Dercetina flavocincta*) synonymy confirmed
Dercetes femoralis Weise, 1922: 97; Kimoto 1989: 229 (as synonym of *flavocincta*) synonymy confirmed

Type series. *Galleruca flavocincta*: Holotype ♀ (BMNH), labeled: "Type (circular label with red border) / *Antipha flavocincta* Hope Type (*Galleruca*) / Hardwicke Bequest".

Antipha flavofasciata: Holotype ♀ (BMNH), labeled: "Type (circular label with red border) / Assam / *Antipha flavofasciata* Baly / *Antipha flavofasciata* Baly Cist. Ent. II p. 56 [on the back] / Baly Coll.".

Dercetina femoralis: Holotype ♂ (NHRS): "Tonkin Montes Mauson / April,May 2-3000' H Frustorfer / femoralis m. / Typus (red label) / NHRS-JLKB 000020341".

Material examined. INDIA: 2♀♀, Assam, 15.VIII.1918 (BMNH); 1♀, Assam, Jorhat, 3721, coll. H. E. Andrewes (BMNH); 1♀, Darjeeling, Bengal, Debrepani, 6000', 18.IX.1929, leg. J.C.M. Gardner (BMNH); 2♂♂, 1♀, Darjeeling, Bengal, Lopchu, 5000', 21.IX.1929, leg. J.C.M. Gardner (BMNH); 1♀, Mongpoh, Khasi Hills, 2178, coll. H. E. Andrewes (BMNH); 2♀♀, Sikkim (MUHUB); 2♀♀, Simla (MNHUB); **LAOS**: 1♀, Vientiane Prov., Ban Van Eue, 15.III.1966, leg. Native Collector (BPBM); 1♀, Xiengkhoang Prov., Ban Theuong, 1035 m, 10-17.VIII.1960, leg. R. E. Leech (BPBM); 1♀, Blao (Balao), 500 m, 14–21.X.1960, leg. C. M. Yoshimoto (BPBM); 1♀, Muong Sing, NW of Luang Prabang, 650 m, 6–10.VI.1960, leg. S. Quate & L. Quate (BPBM); **THAILAND**: 1♀, Chiengmai, 3.XII.1962 (KMNH); 2♀♀, Khao Yai Natioal Park, 800–1000m, 18.VIII.1992, leg. D. Furth (USNM); **VIETNAM**: 2♀♀, Dalat, 1500 m, 29.IV.–4.V.1960, leg. C. M. Yoshimoto (BPBM); 1♀, Fyan, 1200 m, 11.VII. –9.VIII.1961, leg. N. R. Spencer (BPBM); 1♀, M'Drak, E of BanMeThuot, 400-600 m, 8–19.1960, leg. C. M. Yoshimoto (BPBM);

Diagnosis. Females of *Arthrotus flavocincta* are similar to *Dercinta unifasciata* with antennomere IV much long than III, but differs by more slender antenomeres IV-VII (4.5–5.7 times longer than wide in *Arthrotus flavocincta* in contrast with 6.0-6.6 times longer than in wide in *Dercetina unifasciata*). Males of *Arthrotus flavocincta* are easily recognized by the similar length of antnnomeres III and IV.

Redescription. Color (Figs 65–66) bluish black, head, prothorax, coxae, and tibiae yellowish brown; elytra with one transverse white stripe in middle; vertex darkened. Head smooth and impunctate. Pronotum transverse, 2.1 times wider than long, evenly convex on disc and lacking fovea or punctured depression, disc with scattered fine punctures; lateral margin straight, anterior margin slightly concave, posterior margin slightly rounded. Elytra parallel-sided, apex convergently rounded, 1.6 times longer than wide, disc with random punctures, epipleurae smooth and impunctate.

Male. Length 4.3 mm, width 2.0 mm. Antenna filiform (Fig. 76), antennomere II as long as antennomer III, ratio of length of antennomeres III to XI about 1.0 : 3.5 : 3.4 : 3.3 : 3.4 : 3.3 : 3.0 : 2.8 : 3.4; ratio of length to width of antennomeres III to XI about 2.1: 5.9 : 5.7 : 5.7 : 5.4 : 5.2 : 4.5 : 4.2 : 5.4. Penis (Fig. 78) extremely slender, about 9.4 times longer than wide, parallel-sided, basally widened but apically narrowed; apex narrowly rounded; tectum membranous, with dense long setae; weakly curved in lateral view, apex hooked (Fig. 79); endophallic sclerites elongate, about 0.6 times as long as penis, with a cluster of long setae near apex; in lateral view apex curved; from basal 1/3 to apical 1/3 dorsally covered with a pair of longitudinal areas covered by dense setae.

Female. Length 4.4–6.6 mm, width 2.4–3.3 mm. Antenna much shorter than male, comparatively narrower than male (Fig. 77), ratio of length of antennomeres III to XI about 1.0 : 1.8 : 1.8 : 1.8 : 1.8 : 2.0 : 1.8 : 1.8 : 2.3; ratio of length to width of antennomeres III to XI about 3.1: 5.7 : 4.5 : 4.6 : 4.5 : 5.2 : 4.9 : 5.1 : 5.2. Sternite VIII (Fig. 80) weakly sclerotized subapically, apex rounded, setae along lateral and apical margins, spiculum long. Spermathecal receptaculum (Fig. 82) slightly swollen; pump narrow and strongly curved, apex narrowly rounded; spermathecal duct short and wide, shallowly projecting into receptaculum. Gonocoxae (Fig. 81) narrowly connected in middle, extremely elongate, about 6.6 times longer than wide, slightly curved inwards at apical 1/4, with one short setae at apical 1/3, another short setae near apex, six to eight setae at apex.

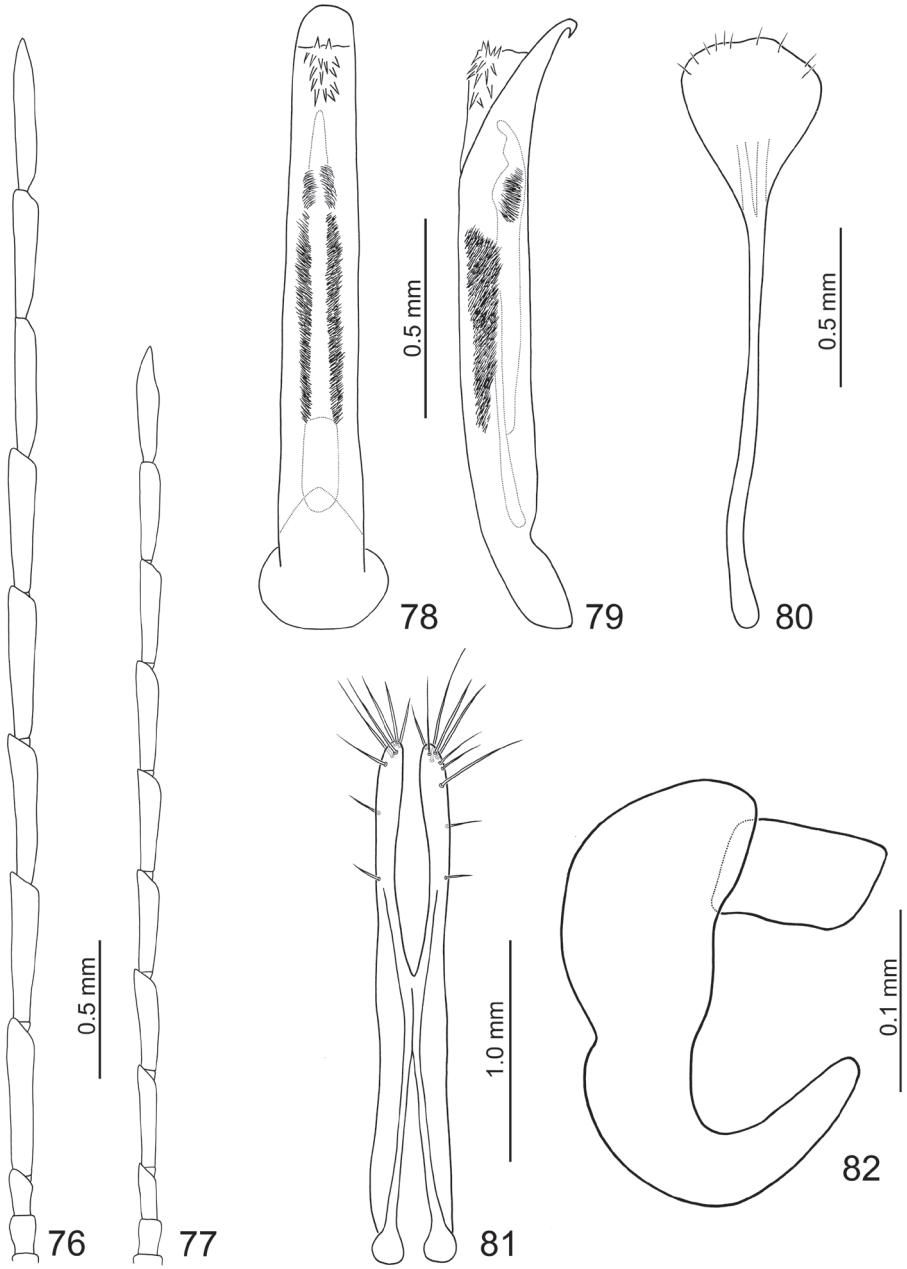
Color variation. Some specimens have blackish brown meso- and metacoxae, femora, and vertex, or yellowish brown abdomen.

Distribution. India, Laos, Nepal, Thailand, Vietnam.

***Arthrotus nakanei* (Kimoto, 1969) comb. n.**
http://species-id.net/wiki/Arthrotus_nakanei

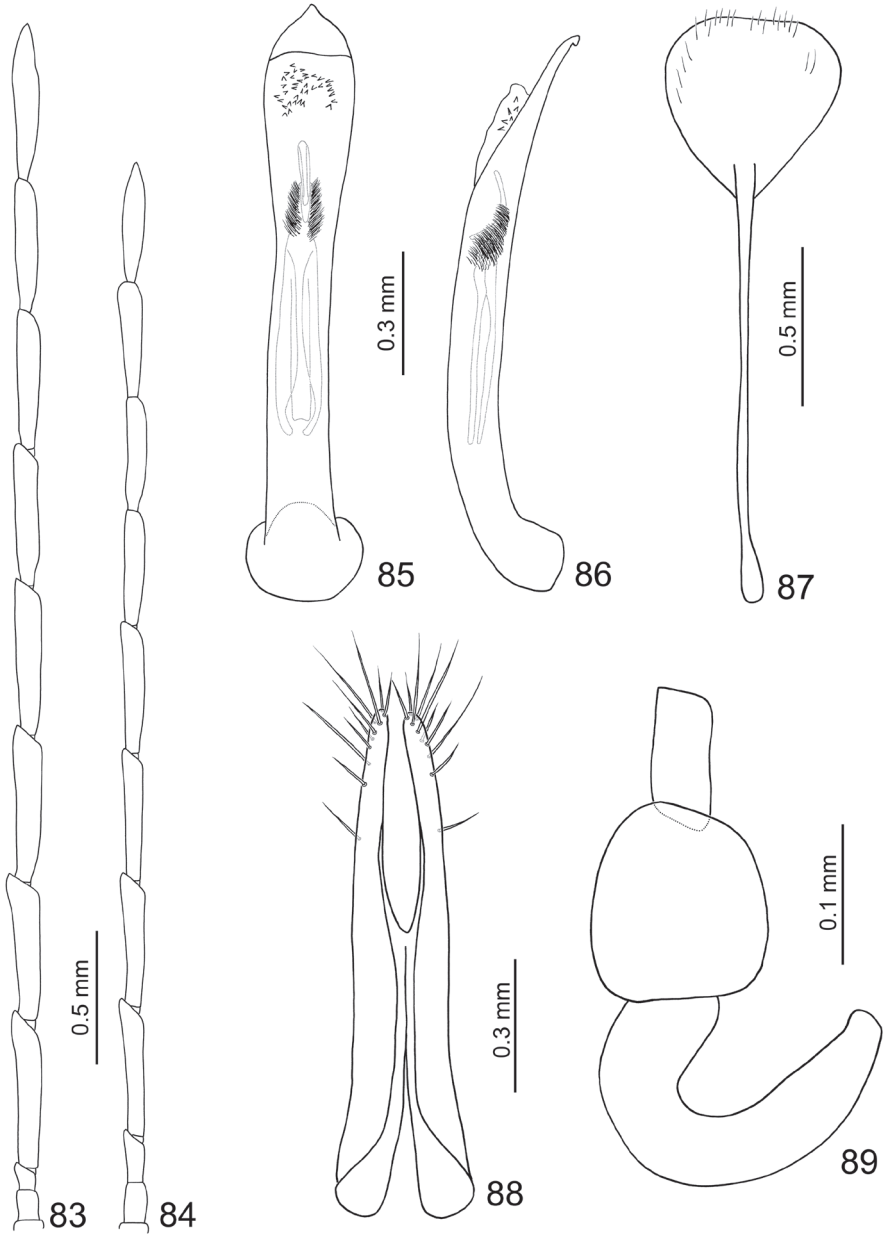
Dercetina nakanei Kimoto, 1969: 65.

Type series. Holotype ♀ (KUEC): "(Taiwan) Sungkan, 2000m – Tsifeng, 2300m Nantou Hsien / 29.vi.1965 T. Nakane / Japan-U.S. Co-op. Sci. Programme (yellow label) / *Dercetina nakanei* Kimoto, n. sp. / HOLOTYPE (red label)". Paratypes: 1♀ (KMNH): "(Taiwan) Sungkang Nantou Hsien / 19.v.1965 T. Shirôzu / *Dercetina nakanei* Kimoto, n. sp. / PARATYPE (blue label)"; 1♀ (KMNH): "(Taiwan) Meifeng Nantou Hsien / 18.v.1965 B.C. Chang / *Dercetina nakanei* Kimoto, n. sp. / PARATYPE (blue label)".



Figures 76–82. *Arthrotus flavocincta*. **76** Antenna, male **77** Antenna, female **78** Aedeagus, dorsal view **79** Aedeagus, lateral view **80** Sternite VIII **81** Gonocoxae **82** Spermatheca.

Material examined. TAIWAN: 1♀, Hsinchu, Kuanwu, 6.IV.2010, leg. L.-H. Sun (TARI); 5♂♂, 8♀♀, same locality, 30.IV.–1.V.2010, leg. M.-H. Tsou (TARI); 1♂, 1♀, same locality, 30.IV.2010, leg. C.-F. Lee (TARI); 1♀, same locality,



Figures 83–89. *Arthrotus nakanei*. **83** Antenna, male **84** Antenna, female **85** Aedeagus, dorsal view **86** Aedeagus, lateral view **87** Sternite VIII **88** Gonocoxae **89** Spermatheca.

7.VI.2010, leg. L.-H. Sun (TARI); 5♂♂, Nantou, Chingching, 4.IV.2010, leg. Y.-T. Wang (TARI); 6♂♂, 7♀♀, Nantou, Meifeng, 15.IX.2009, leg. H. Lee (TARI); 1♂, same locality, 20.IV.2011, leg. C.-F. Lee (TARI); 2♀♀, Nantou, Sungkang,

4.IV.2010, leg. Y.-T. Wang (TARI); 1♂, 1♀, Nantou, Tsuifeng, 5.IV.2010, leg. Y.-T. Wang (TARI); 1♂, Taichung, Anmashan (= Tashueshan), 15.X.2009, leg. J.-C. Chen (TARI); 1♀, same locality 19.X.2011, leg. C.-F. Lee (TARI); 1♀, same locality, 24.IV.2012, leg. C.-F. Lee; 1♂, Taichung, Henglingshan, 5.VI.2012, J.-C. Chen (TARI);

Diagnosis. *Arthrotus nakanei* is easily recognized by its color pattern.

Redescription. Color (Figs 67–68) black, abdomen and apical 2/3 of elytra reddish brown. Head smooth and impunctate. Pronotum transverse, 1.9–2.0 times wider than long, disc with scattered prominent punctures, and a pair of round fovea at sides; lateral and posterior margins slightly rounded, anterior margin slightly concave. Elytra more or less widened posteriorly, apex convergently rounded, 1.6–1.7 times longer than wide, disc with punctures in part arranged in longitudinal rows, epipleurae smooth and impunctate.

Male. Length 5.2–5.7 mm, width 2.4–2.7 mm. Antenna filiform (Fig. 83), antennomere II a little smaller than III, ratio of length of antennomeres III to XI about 1.0 : 5.7 : 5.3 : 5.6 : 5.6 : 5.1 : 5.1 : 5.1 : 5.6; ratio of length to width of antennomeres III to XI about 1.2: 5.1 : 4.8 : 5.3 : 5.6 : 5.4 : 5.7 : 5.7 : 5.6. Penis (Fig. 85) extremely slender, about 8.9 times longer than wide, lateral margin medially narrowed, apex narrowly rounded, with a short process at top; tectum membranous, with scattered short setae; weakly curved in lateral view, apex recurved and hooklike (Fig. 86); endophallic sclerites elongate, about 0.5 times as long as penis; apically narrowed, apex ventrally covered with a small curved sclerite; with a cluster of long setae from middle to apex; straight in lateral view.

Female. Length 6.0–6.2 mm, width 2.9–3.2 mm. Antenna filiform (Fig. 84), shorter than male, ratio of length of antennomeres III to XI about 1.0 : 2.5 : 2.4 : 2.4 : 2.4 : 2.1 : 2.1 : 2.1 : 2.2; ratio of length to width of antennomeres III to XI about 2.3 : 5.9 : 5.7 : 5.7 : 5.7 : 5.3 : 5.2 : 5.2 : 5.5. Sternite VIII (Fig. 87) weakly sclerotized subapically, apex truncate, with dense long setae along apical margin, spiculum extremely long. Spermathecal receptaculum (Fig. 89) strongly swollen; pump narrow and strongly curved, apically narrowed; spermathecal duct short, shallowly projecting into receptaculum. Gonocoxae (Fig. 88) very close at middle, about 5.0 times longer than wide, slightly curved inwards near apex, apex rounded, with one or two short setae at apical 1/3, two subapically, nine setae at apex.

Distribution. Taiwan.

Discussion

Endophallic sclerites is useful for species identities but not for generic diagnosis for *Dercetina* and *Arthrotus*. The extreme narrow connection between gonocoxae seems to characterize the genus *Arthrotus* based on the studies on two member of the genus, although this character should be evaluated after more species are studied.

Acknowledgements

We would like to thank all curators listed above for giving us the opportunity to study the material from their collections. We thank the Taiwan Chrysomelid Research Team for assistance in collecting material, including S.-F. Yu, M.-H. Tsou, H.-J. Chen, J.-C. Chen, and H. Lee; and C. Staines for critically reading manuscript. We especially thank T.-H. Lee for photos of dorsal and ventral habitus of each species

This study was also supported by the National Science Council of Taiwan NSC 100-2313-B-055-001 and the Research plan No. MSM6215648905 'Biological and technological aspects of sustainability of controlled ecosystems and their adaptability to climate change', financed by the Ministry of Education, Youth and Sports of the Czech Republic.

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ZooKeys 323: 35–74 (2013)
doi: 10.3897/zookeys.323.4950
www.zookeys.org

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The dorsal chaetotaxy of *Trogolaphysa* (Collembola, Paronellidae), with descriptions of two new species from caves in Belize

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Academic editor: *Louis Deharveng* | Received 3 March 2013 | Accepted 1 August 2013 | Published 13 August 2013

http://zoobank.org/7EB6DCE7-D909-49FE-930F-6A746BE7FF0D

Citation: Soto-Adames FN, Taylor SJ (2013) The dorsal chaetotaxy of *Trogolaphysa* (Collembola, Paronellidae), with descriptions of two new species from caves in Belize. ZooKeys 323: 35–74. doi: 10.3897/zookeys.323.4950

Abstract

Species diagnosis in *Trogolaphysa* has been based, until now, almost exclusively on number of eyes and shape of claws and mucro. Chaetotaxy, a character system important to diagnose species in other genera of scaled Entomobryoidea, has been described only for a few *Trogolaphysa* species. Here the complete dorsal chaetotaxy of six species of *Trogolaphysa* is described using the AMS and Szeptycki's systems for head and body, respectively. A morphology-based parsimony analysis was performed to evaluate whether chaetotaxic characters overcome the influence of putatively cave adaptive convergent characters to resolve species level relationships, and to evaluate the evolution of the dorsal macrochaetae of the head. Phylogenetic analysis using only putative cave-adaptive characters support clades of unrelated taxa, but the addition of chaetotaxy overcomes the influence of convergent characters. A phylogeny based on all characters supports a trend towards reduced head macrochaetae number. Head macrochaetae are lost beginning with A3 and followed, in order, by S5, S3 and M3. In addition, a checklist of New World *Trogolaphysa* is provided and two new species, *Trogolaphysa giordanoae* **sp. n.** and *Trogolaphysa jacobyi* **sp. n.**, are described on the basis of material collected in six caves in southern Belize.

Keywords

Puerto Rico, *Dicranocentruga*, phylogeny, cave-adaptive characters

Introduction

The collembolan fauna of Belize is among the least known of any Central American country. The Catalogue of Neotropical Collembola (Mari Mutt and Bellinger 1990) and subsequent updates (Mari Mutt and Bellinger 1996, Mari Mutt et al. 2009) list one species, the troglomorphic *Trogolaphysa belizeana* Palacios-Vargas & Thibaud, 1997, for Belize. A recent biospeleological expedition to the Toledo District of Belize yielded several new springtail species, including two new species in the genus *Trogolaphysa*.

What is understood about the evolution of morphological adaptations to cave habitats in entomobryoid springtails is derived from northern temperate members of the genera *Pseudosinella* and *Sinella* (Christiansen 1961, Gama 1984). The evolution of troglobiont species in tropical *Trogolaphysa* (Palacios Vargas et al. 1985[1986]) and *Troglopedetes* (Deharveng 1987, Deharveng and Gers 1993), could provide important independent information to test hypotheses about the direction of character evolution in Entomobryoidea. The characters utilized in the descriptions of most of the 33 species of *Trogolaphysa* reported from the New World (Mari Mutt and Bellinger 1990, Mari Mutt et al. 2009; Table 1) are limited to claw complex and mucronal shape (e.g., Palacios-Vargas et al. 1985[1986]), two character systems prone to convergent evolution in cave habitats (Christiansen 1961, Christiansen and Culver 1987). Chaetotaxy is known for few species (Gruia 1987, Mari Mutt 1987[1988], Thibaud and Najt 1988[1989]), and is limited to the number of macrochaetae. While convergence itself is of interest in understanding evolution in caves (Derkarabetian et al. 2010, Hedin and Thomas 2010), distinguishing convergent characters adaptive for subterranean life from characters that better reflect phylogenetic history has proven to be important in a variety of groups of animals (e.g., Wiens et al. 2003).

The relationships between the genera *Paronella*, *Troglopedetes*, *Trogolaphysa*, and *Dicranocentruga* has been a source of confusion. Thibaud and Najt (1988[1989]) evaluated morphological characters of these genera and provided clear diagnoses for all of them: *Paronella* was retained for species with 1+1 rows of external spines on the manubrium; *Troglopedetes* was restricted to species with a single subdivision of the fourth antennal segment; *Trogolaphysa* was circumscribed to include *Paronella*-like species with Ant. 4 not subdivided, manubrium without spines and a short mucro (in relation to dens) with 3-5 teeth; whereas *Dicranocentruga* was placed as a junior synonym of *Trogolaphysa*. Thibaud and Najt (1988 [1989]) did not consider the presence of EOS (extra ocular structure) as a diagnostic character. Mitra (1992, 1993, 2002) argued that species without manubrial spines but sharing the presence of an EOS and 8+8 (or apparently 6+6) eyes should be placed in the genus *Dicranocentruga*, whereas species with fewer than 6+6 eyes and without EOS should be allocated to *Trogolaphysa* or *Troglopedetes*. Mitra (1993) suggested that further observations of the chaetotaxy would furnish characters to support this separation, but until now, the complete dorsal chaetotaxy of these taxa remained undescribed.

Here we present complete descriptions of the dorsal chaetotaxy of the head and trunk for the two new species of *Trogolaphysa* and for *T. belizeana,* and compare their

Table 1. Check-list of the species of *Trogolaphysa sensu* Thibaud and Najt (1988[1989]) of the New World, with distribution by country (given as ISO 3166–1 alpha-3 code).

Species	Distribution
Trogolaphysa aelleni Yoshii, 1988	BRA
Trogolaphysa belizeana Palacios-Vargas and Thibaud, 1997	BLZ
Trogolaphysa berlandi (Denis, 1925)	ARG, GUF
Trogolaphysa bessoni Thibaud & Najt, 1989	ECU
Trogolaphysa caripensis (Gruia, 1987)	VEN
Trogolaphysa carpenteri (Denis, 1925)	CRI, GUF, MEX, VEN
Trogolaphysa cotopaxiana Thibaud & Najt, 1989	ECU
Trogolaphysa distinguenda (Denis, 1931)	CRI
Trogolaphysa ecuatorica (Palacios-Vargas, Ojeda & Christiansen, 1986)	ECU
Trogolaphysa geminata (Mari Mutt, 1988)	PRI
Trogolaphysa giordanoae Soto-Adames & Taylor sp. n.	BLZ
Trogolaphysa guacharo Yoshii, 1988	CRI, VEN
Trogolaphysa haitica (Palacios-Vargas, Ojeda & Christiansen, 1986)	HTI
Trogolaphysa hauseri Yoshii, 1988	BRA
Trogolaphysa hirtipes (Handschin, 1924)	ARG, BRA, VEN
Trogolaphysa hondurasensis (Palacios-Vargas, Ojeda & Christiansen, 1986)	HND
Trogolaphysa jamaicana (Palacios-Vargas, Ojeda & Christiansen, 1986)	JAM
Trogolaphysa jataca (Wray, 1953)	JAM, PRI
Trogolaphysa jacobyi Soto-Adames & Taylor sp. n.	BLZ
Trogolaphysa luquillensis (Mari Mutt, 1988)	PRI
Trogolaphysa marimutti (Palacios-Vargas, Ojeda & Christiansen, 1986)	MEX
Trogolaphysa maya Mills, 1938	CUB, DOM, MEX
Trogolaphysa millsi Arlé, 1939	BRA
Trogolaphysa nacionalica (Palacios-Vargas, Ojeda & Christiansen, 1986)	MEX
Trogolaphysa oztotlica (Ojeda & Palacios-Vargas, 1984)	MEX
Trogolaphysa relicta (Palacios-Vargas, Ojeda & Christiansen, 1986)	MEX
Trogolaphysa riopedrensis (Mari Mutt, 1988)	PRI
Trogolaphysa separata (Denis, 1933)	CRI
Trogolaphysa strinatii Yoshii, 1988	MEX
Trogolaphysa subterranea (Mari Mutt, 1988)	PRI
Trogolaphysa tijucana (Arlé & Guimarães, 1979)	BRA
Trogolaphysa toroi (Palacios-Vargas, Ojeda & Christiansen, 1986)	MEX
Trogolaphysa variabilis (Palacios-Vargas, Ojeda & Christiansen, 1986)	MEX
Trogolaphysa xtolokensis (Palacios-Vargas, Ojeda & Christiansen, 1986)	MEX
Trogolaphysa yoshiia (Palacios-Vargas, Ojeda & Christiansen, 1986)	MEX

chaetotaxy to that of *T. jataca* (Wray, 1953), *T. geminata* (Mari Mutt, 1987[1988]) and *T. riopedrensis* (Mari Mutt, 1987[1988]), three surface species from Puerto Rico. Finally, we present a morphology-based phylogenetic analysis to assess the value of chaetotaxy in elucidating species relationships in this genus, and to evaluate the evolution of some elements of the dorsal chaetotaxy of the head.

Materials and methods

Springtails were collected with aspirators and preserved in 70% ethanol. Samples were associated with substrate characterizations and field-collected measurements of temperature, light intensity and humidity.

Selected specimens were cleared in Nesbitt's solution, mounted in Mark André II (Mari Mutt 1979) on glass slides, and examined under a compound microscope with phase contrast. The extra-ocular structure (EOS) was examined under polarized light. Drawings were made using a drawing tube, with final illustrations completed using Adobe Illustrator CS5, version 15.0.2.

Abbreviations used for structures are: antennae (Ant.), thorax (Th.) abdomen (Abd.), extra ocular structure (EOS). Abbreviations used for names are: Avelardo Canti (AC), Gabriel Chaco (GaC), Germano Coe (GeC), William R. Elliott (WRE), Geoff B. Hoese (GBH), JoAnn Jacoby (JJ), Jean K. Krejca (JKK), Bruno K. Kuppinger (BKK), C. Marcela Ospina (CMO), Rosalio Sho (RS), Christy M. Slay (CMS), Michael E. Slay (MES), Felipe N. Soto-Adames (FSA), and Steven J. Taylor (SJT).

To protect vulnerable sites, latitude and longitude are not provided for the Belize material. These locations are controlled by, and may be requested from, the Institute of Archaeology, Belmopan, Belize (see Acknowledgements). Holotypes and paratypes of the new species are deposited in the Illinois Natural History Survey Insect Collection (INHS).

Here we describe only elements of the chaetotaxy that are modified into microchaetae, macrochaetae or sensilla (i.e., idiochaetotaxy, Szeptycki 1979). We follow the nomenclature of Szeptycki (1979) for the body and the AMS system (Jordana and Baquero 2005, Soto-Adames 2008, 2010) for the head. Mitra (1993) proposed a system for the chaetotaxy of the head in Paronellidae, but it has not been widely embraced, whereas the AMS system has been applied to entomobryoids since the 1970's (Szeptycki 1973, Mari Mutt 1979) and allows evaluation of homologies between families of Entomobryoidea.

The idiochaetotaxy of *Trogolaphysa* is reduced, and in naming body setae we assume it represents the remnant of primary chaetotaxy. The setae closest to the mesothoraxic pseudopore (Figs 12, 32, 53) are identified as m1 and m2, even though they occupy positions that in entomobryoids with more abundant idiochaetotaxy might be assigned to setae m2i and m2e, respectively. The nomenclature of setae on the fourth abdominal segment follows Szeptycki's system (Soto-Adames 2010): setae in columns A and B are named sequentially from posterior to anterior, irrespective of their relative insertion. Columns A and B have a maximum of four setae, and when all are present they are always setae 3-6 (e.g., A3, A4, A5 and A6). In the species described below, setae A3, A6, B3 and B6 are always present, and it is assumed that setae A4 and B4 are always suppressed before A5 and B5.

For the labial chaetotaxy, upper case letters represent macro- or mesosetae and lower case represent microsetae, an underscore in the formula identifies ciliate setae.

The eye patch of a generalized springtail comprises a group of 5 anterior and 3 posterior simple eyes, we refer to the space between these two groups of eyes as the 'eye patch well' to distinguish it from the inter-ocular space, which is the gap between the eye patches on either side of the head.

The formula of the dorsal macrochaetae of head and trunk is based on Gisin's (1967) model, but we consider all macrochaetae associated with the bothriotricha on abdominal segments 2-4, instead of only those found between the bothriotrichal complexes. The number of macrochaetae on the head is presented as two digits; the first digit refers to macrochaetae anterior to the head sulcus (series A, M and S), the second to the posterior macrochaetae (series Ps, Pa and Pm). The macrochaetae on abdominal segment 4 are represented by three digits separated by plus (+) symbol, where the first, second and third numbers refer to the inner (series A and B), medial (assumed, in Szeptycki's system, to be series C) and outer macrochaetae (series T, D, E, F and Fe). The last number in the macrochaeta formula may be represented by a range because the number of outer macrochaetae may be variable, as some macrochaetae external to series F appear to be added as individuals grow older. The formula is based on the relative size of the sockets and includes all macrochaetae, irrespective of whether they are large (i.e., short, thick and blunt) or small (long, slender and acuminate).

Phylogenetic trees were estimated using parsimony as implemented in PAUP 4.0* (Swofford 2002).

The habitat parameters substrate temperature, air temperature, light, and relative humidity were measured with hand held meters. Differences in abiotic parameters between habitats occupied by the two new species were tested using a Wilcoxon rank sum test in R 2.15.2 (R Developmental Core Team 2012), with continuity correction.

Results

Genus *Trogolaphysa* Mills, 1938 *sensu* Thibaud and Najt (1988[1989])

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

Diagnosis. Paronellidae with finely denticulate scales covering dorsum of head and body, and ventral face of furcula; Ant. 4 sometimes annulated, never subdivided in two; labial seta L2 normal, not reduced; eyes 0-8; EOS present; Abd. 2-4 with 2, 3, 3 bothriothricha; manubrium without spines, dens with 1-2 rows of spines; mucro short, with 3-5 more or less evenly spaced teeth.

Remarks. As currently circumscribed (Thibaud and Najt 1988 [1989]), the absence of a subdivision on Ant. 4 in *Trogolpahysa* is the only character that distinguishes this genus from *Troglopedetes*.

It is not known if the type species of the genus, *T. maya* Mills, 1938, has EOS, but the presence of this structure in all species discussed below, including the two troglomorphic forms, suggests it is likely also present in that species.

Trogolaphysa giordanoae **Soto-Adames & Taylor, sp. n.**
http://zoobank.org/3C37791A-056D-496F-87E2-58D72A355B4B
http://species-id.net/wiki/Trogolaphysa_giordanoae
Figs 1–21; Figs 22–23 (habitat)

Type locality. BELIZE: Toledo District: 29 km WNW of Punta Gorda, Blue Creek Cave, Hokeb Ha entrance, 11.IV.2011, SJT, MES, JJ, CMS, GBH & RS, coll.

Type material: Holotype, female on microscope slide preparation, INHS Collection Number 579,406; Paratypes: BELIZE: Toledo District: 29 km WNW of Punta Gorda, Blue Creek Cave, Hokeb Ha entrance, 11.IV.2011, (3 in alcohol), SJT, MES, JJ, CMS, GBH & RS, coll.; 37 km WNW of Punta Gorda, cave near Pueblo Creek Cave, 16.IV.2011, (4 in alcohol-one headless), MES, JKK, CMS, GBH & GeC, coll.; 28 km NNW of Punta Gorda, Tiger Cave, 9.IV.2012, (1 on slide, 33 in alcohol), SJT, MES, JJ, CMS, GBH, BKK & GaC, coll.; 28 km NNW of Punta Gorda, Bat Cave, 10.IV.2011, (2 on slides, 29 in alcohol—some in poor condition, one headless), SJT, MES, JJ, CMS & GBH, coll.; 31 km WNW of Punta Gorda, Okebal Ha, 14.IV.2011, (3 on slides, 16 in alcohol), SJT, MES, JJ, CMS, GBH, BKK & RS, coll.

Diagnosis. *Trogolaphysa giordanoae* sp. n. is unique among species with 6–8 eyes in having 5 dorsal head macrochaetae, 3 metathoracic macrochaetae and 4 inner macrochaetae on Abd. 4. Among species with known dorsal chaetotaxy, the new species is most similar to *T. riopedrensis*, but the two species are easily distinguished by the combination of characters given above and by the presence of a relatively shorter mucro in the new species (Table 2). Additional diagnostic characters distinguishing the new species from all other New World *Trogolaphysa* with 6–8 eyes and capitate/spatulate tenent hair are presented in Table 2. Among the species described before the introduc-

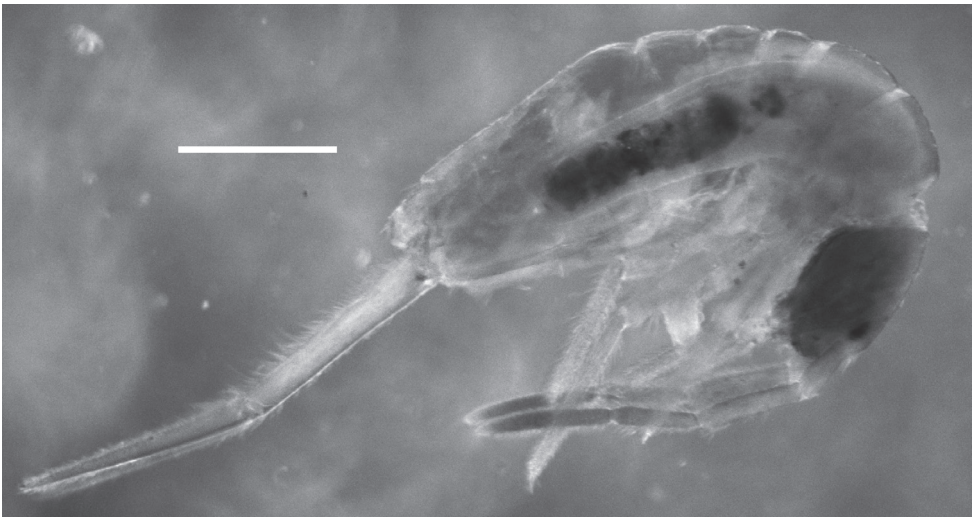
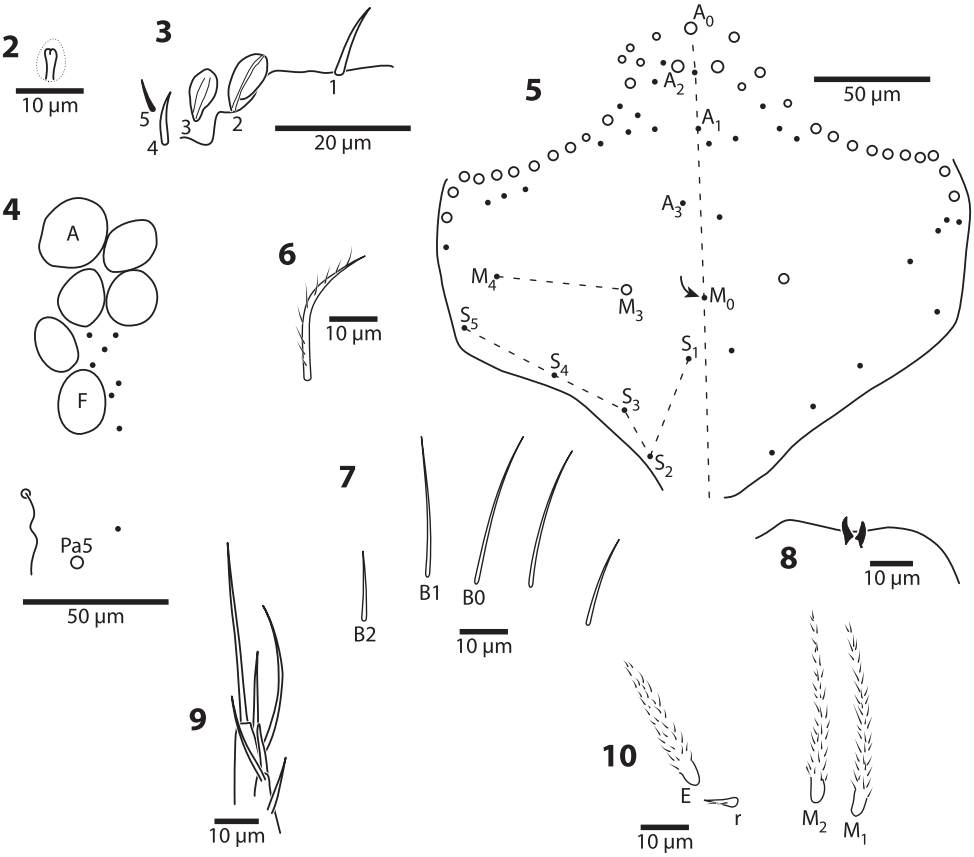


Figure 1. *Trogolaphysa giordanoae* sp. n. habitus, scale=0.5 mm.

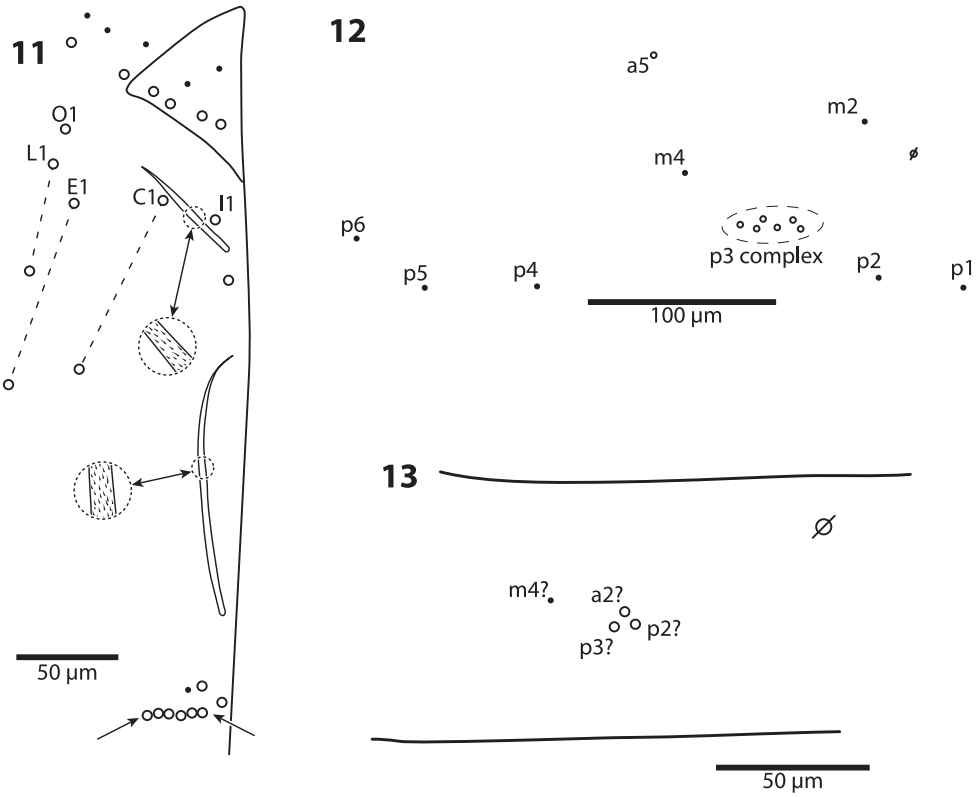
Table 2. Diagnostic table for species of *Trogolaphysa* with 6–8 eyes and capitate or spatulate tenent hair.

Species	Mucronal teeth	Mucro length/ Width dens apex	Inner ungual teeth	Dorsal head macro-chaetae	Th. 2 Macro-chaetae	Th. 3 Macrochaetae	Abd. 4 Inner large macrochaetae
T. giordanoae sp. n.	4	1.8	4	5	7	3	4
T. riopedrensis	4	2.9	4	7	7	0	4
T. geminata	4	2.2	4	6	7	0	3
T. jataca	4	2.9	4	7	7	0	3
T. carpenteri †	4	3.5	3	2	0	0	0
T. relicta	4	2.7	3	0	0	0	0
T. subterranea	4	2.7	3	3	7	0	3
T. cotopaxiana	5	3.6	4	2	3	0	3
T. distinguenda	5	3.3	4	?	?	?	?

† Most characters based on Yoshii (1988).



Figures 2–10. *Trogolaphysa giordanoae* sp. n., circles are macrochaetae, filled circles are ciliate microchaetae **2** Antennal segment 4, subapical sensillum **3** Antennal segment 3, sense organ **4** Eyepatch and associated setae, **5** Head dorsal chaetotaxy, line represents dorsal sulcus **6** Prelabral seta **7** Labral row B setae **8** Distal margin of labrum **9** Labial papilla E **10** Posterior setae of labial triangle.



Figures 11–13. *Trogolaphysa giordanoae* sp. n. **11** Postlabium, circles are ciliate setae, filled circles are smooth setae, arrows point at ventral cervical setae **12** Mesothorax, dorsal chaetotaxy, circles are macrochaetae, filled circles are microchaetae **13** Metathorax, dorsal chaetotaxy, circles are macrochaetae, filled circles are microchaetae, seta a6 present but not shown.

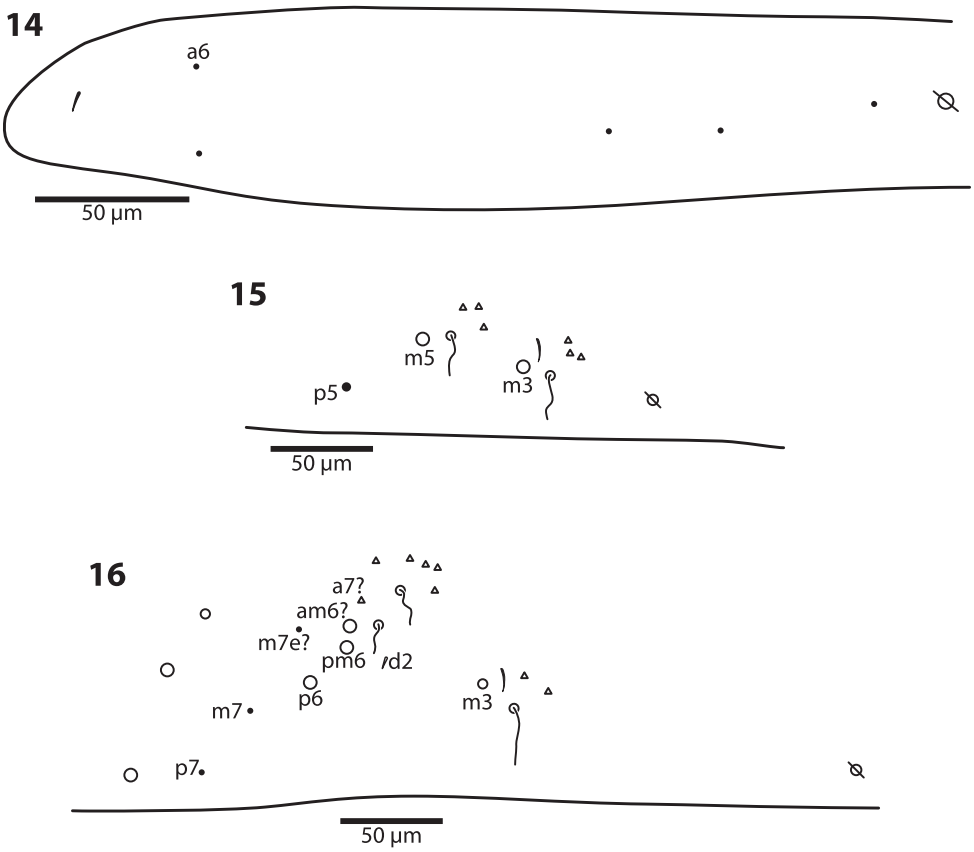
tion of chaetotaxy, the new species is most similar to *T. distinguenda* (Denis, 1931), but the two species can be separated by the presence of a relatively long mucro with 5 teeth in *distinguenda*, and a 4-toothed short mucro in *T. giordanoae* sp. n. *Trogolaphysa belizeana* is the only other New World *Trogolaphysa* with 3 metathoracic macrochaetae. However, *T. belizeana* is a troglobiont (*sensu* Sket 2008, Culver and Pipan 2009)—blind, with long antennae and modified ungues.

Description. Size. Body length up to 2.1 mm.

Color. Pattern, if any, obscured by green dye present in the alcohol in which specimens were preserved (Fig. 1).

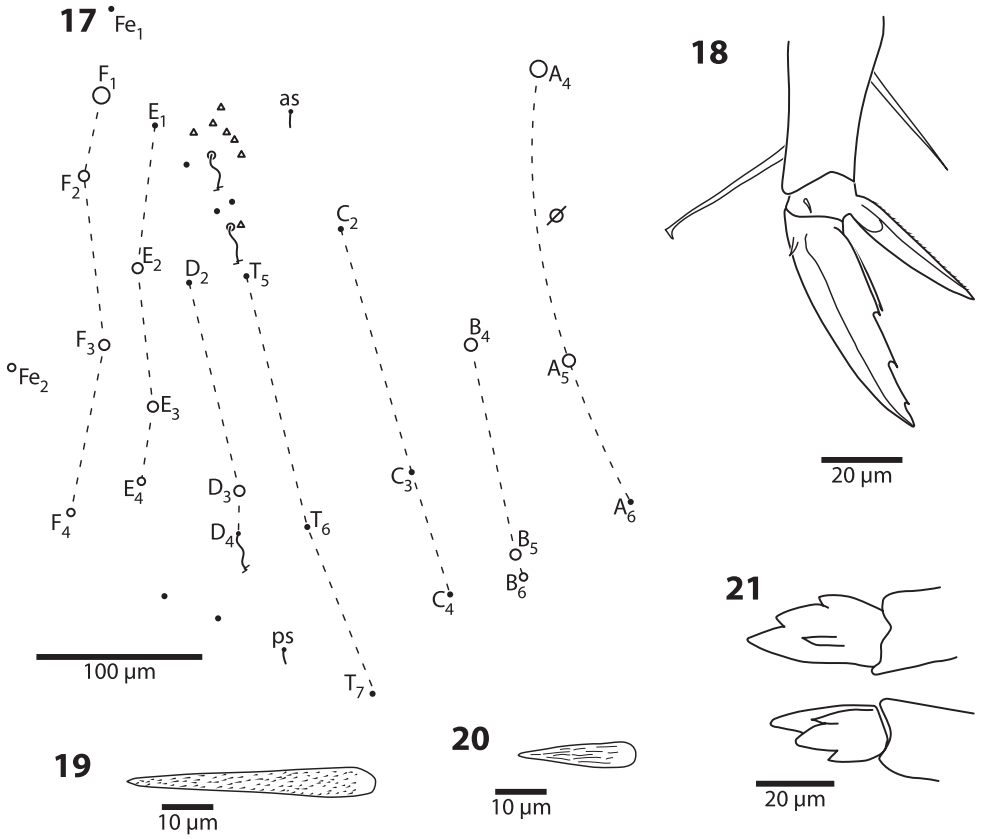
Scale distribution. Scales dark brown, present on Ant. 1-2 and base of Ant. 3, more abundant on dorsal face than on ventral face of segment. Scales absent from ventral tube, legs and dorsal face of manubrium.

Head. Antenna/cephalic diagonal ratio 2.0–2.5 (Fig. 1). Apical bulb of Ant. 4 absent; subapical sensillum capitate (Fig. 2), fully contained in circular depression; guard sensillum absent. Sense organ of Ant. 3 (Fig. 3) with sensilla 1 and 4 acumi-



Figures 14–16. *Trogolaphysa giordanoae* sp. n. Dorsal chaetotaxy of abdominal segments 1–3, triangles are fan-shaped setae, circles are macrochaetae, filled are circles ciliate microchaeta **14** First abdominal segment **15** Second abdominal segment **16** Third abdominal segment.

nate, thin-walled and translucent; sensillum 5 acuminate, dark (light dense), shorter than 1 and 4; sensilla 2–3 wide, leaf-like, resting in shallow grooves. Eyes 6+6 (Fig. 4), chaetotaxy of eyepatch well with 4, sometimes 6 ciliate setae, and 1 seta posterior to eye F. Head dorsally with 5 macrochaetae (A0, A2, M3, Pa5 and Pm3— Figs 4–5). Series M with 2 setae (M3–4); series S with 5 setae (S1–5); seta M0 seen only in one individual; S0 absent. Prelabral setae serrate (Fig. 6). Labral setae smooth: setae in rows A and C subequal; seta B2 distinctly shorter than setae B0 and B1 (Fig. 7). Distal margin of labrum with 1+1 medial hooks, papillae absent (Fig. 8). Apical and subapical setae of maxillary palp smooth; sublobular plate with 2 seta-like appendages. Lateral process of labial papilla E weakly bent dorsally, barely reaching apex of papilla (Fig. 9). Labial triangle setae as M1M2rEL1–2A1–5 (Fig. 10); r short, stout and sparsely ciliate; L1 inserted close to E and distant from L2 when compared to other entomobryoids (Fig. 11). Postlabium covered by setae and scales, all postlabial setae ciliate, modified setae absent. Columns ICELO with 42221 setae (Fig. 11): col-



Figures 17–21. *Trogolaphysa giordanoae* sp. n. **17** Fourth abdominal segment dorsal chaetotaxy, diameter of circle is approximately proportional to size of macrochaeta **18** Metathoracic claw complex **19** Dens basal spine, outer row **20** Dens basal spine, inner row **21** Mucro.

umn I with posterior seta detached from main group and much longer than anterior setae. Ventral cervical setae usually 8+8.

Body. Mesothoracic hood not developed. Complete dorsal macrochaetae as 32/73/0245+0+9. Mesothorax with 1 anterior (a5) and 6 posterior (p3 complex) macrochaetae arranged as is typical for genus (Fig. 12); microchaetae m2, m4, p1, p2, p4, p5 and p6 present. Inner chaetotaxy of metathorax with 3 macro- and 1 microchaetae (Fig. 13). First abdominal segment with 1 anterior (a6) and 4 posterior setae arranged in a single row (Fig. 14). Second abdominal segment (Fig. 15) inner bothriotrix with 3 fan-shaped setae, one microsensillum and macrochaeta m3; outer bothriotrix with 3 fan-shaped setae and macrochaeta m5; setae a6, m6 and p5 present. Third abdominal segment (Fig. 16) inner bothriotrix complex with 2 fan-shaped setae, 1 sensillum, and macrochaeta m3; external bothriotricha with 7 fan-shaped setae, and macrochaetae am6, pm6 and p6; sensillum d2 present, inserted near pm6. Fourth abdominal segment with 5 inner and 9 outer macrochaetae (Fig. 17): large inner macrochaetae A4, A5, B4, and B5 present; B6 a small macrochaeta;

Figure 22. *Trogolaphysa giordanoae* sp. n. paratype habitat Okebal Ha entrance/twilight zone. Specimens were collected from a small pile of fruit bat guano near the researchers in the foreground, below a bat roost site. Sample site was much darker than it appears in this enhanced image. Photo courtesy of MES.

large outer macrochaetae D3, E2, E3, F1, F2, and F3 present; macrochaetae E4, F4 and one other seta probably homologous to Fe4, small. Anterior and medial bothriotricha with 7 and 3 fan-shaped supplementary setae, respectively. Posterior bothriotrix, corresponding to D4, without associated supplementary setae. Posterior setae 19–21+19–21. Intersegmental membrane between Abd. 4–5 with 4–10 lenticular organs (as in *T. riopedrensis*, Fig. 60).

Legs. Trochanteral organ with up to 36 setae. Metathoracic claw complex as in Fig. 18. Tenent hair weakly spatulate. Smooth posterior setae on metathoracic legs 0.76× as long as unguiculus. Unguis with 4 inner teeth: 1 basal tooth sometimes ap-

Figure 23. *Trogolaphysa giordanoae* sp. n. on old feces in Tiger Cave. Photo courtesy of GBH.

pearing slightly larger than other, both paired teeth ending near middle of inner edge; proximal unpaired tooth as large as basal paired teeth, ending on distal half of inner edge; distal unpaired tooth smallest of all inner teeth and ending on distal fourth of inner edge. Outer tooth ending on basal quarter of outer ungual edge. Unguiculus lanceolate, with outer margin serrate.

Ventral tube. Anterior face with 3+3 or 4+4 distal macrochaetae; lateral and posterior setae not seen clearly.

Furcula. Dens with 2 rows of ciliate spines: inner row with 35–42 spines; outer row with 25–28 spines. Basal outer spines longest (Figs 19–20). Mucro with 4 short, stout teeth (Fig. 21), ratio mucro length/width of dens tip 1.2–1.8×; basal outer tooth reaches to at least half length of basal inner tooth.

Etymology. This species is dedicated to Rosanna Giordano, the senior author's wife, for her years of support and contributions to science.

Distribution. The species is known only from Belize

Habitat. *Trogolaphysa giordanoae* sp. n. is a guanophile, recorded from entrance, twilight (Fig. 22) and dark zones of caves (6.7, 53.3 & 40.0 % of 15 collections, respectively), often in association with fruit bat or other guano (Fig. 23) (noted for 40% of 15 collections). It was commonly found on the floor of caves (76.9% of 13 collections where position was noted), but also on cave walls (23.1% of 13 collections where position was noted).

***Trogolaphysa jacobyi* Soto-Adames & Taylor, sp. n.**
http://zoobank.org/5F865EE9-B5E0-4844-8482-902F8E9EA2B2
http://species-id.net/wiki/Trogolaphysa_jacobyi
Figs 24–43; Fig. 44 (habitat)

Type locality. BELIZE: Toledo District: 32 km WNW of Punta Gorda, Yok Balum Cave, 13.IV.2012, SJT, MES, JJ, CMS, GBH & AC, coll.

Type material. Holotype, female on microscope slide preparation, INHS collection number 579,407; BELIZE: Toledo District: 32 km WNW of Punta Gorda, Yok Balum Cave, 13.IV.2012, SJT, MES, JJ, CMS, GBH & AC, coll.; Paratypes: BELZE: Toledo District: 32 km WNW of Punta Gorda, Yok Balum Cave, 13.IV.2012, (2 adults & 1 juvenile on slides, 3 adults or subadults & 3 juveniles in alcohol), SJT, MES, JJ, CMS, GBH & AC, coll.; 37 km WNW of Punta Gorda, cave near Pueblo Creek Cave, 16.IV.2011, (1 adult on slide—without legs), MES, JKK, CMS, GBH & GeC, coll.

Diagnosis. *Trogolaphysa jacobyi* sp. n. is the only member of the genus that is blind, has 3-toothed mucro and unguis, and has a single macrochaeta on the metathorax. *Trogolaphysa belizeana* is the only other New World *Trogolaphysa* lacking eyes and having a 3-toothed mucro, but it differs from *T. jacobyi* sp. n. in having 3 metathoracic macrochaetae (1 in *T. jacobyi* sp. n.), in the arrangement and identity of inner macrochaetae on Abd. 4 (cf. Figs 38, 49 see discussion below), in having few postlabial scales (absent in *T. jacobyi* sp. n.) and setae (many in *T. jacobyi* sp. n., cf. Figs 30, 46), in the presence of sensillum d2 on Abd. 3 (absent in *T. jacobyi* sp. n.), in the absence of unpaired ungual teeth (1 tooth in *T. jacobyi* sp. n.) and in having a typical lanceolate unguiculus (basally swollen in *T. jacobyi* sp. n.). Table 3 provides a list of characters that distinguish *T. jacobyi* sp. n. from all other New World *Trogolaphysa* lacking eyes and having paired basal ungual teeth inserted near the basal fourth of the inner edge.

Description. Size. Body length up to 2.0 mm.

Color. Living specimens yellowish, with pigment only on a small eyepatch and mesothorax (Fig. 24). Specimens in alcohol white, without trace of pigment.

Table 3. Diagnostic table for blind species of *Trogolaphysa* with basal paired ungual teeth originating on basal fourth of inner edge of claw.

Species	Mucronal teeth	Inner ungual teeth	Unguiculus shape	Mesothorax macrochaetae	Metathorax macrochaetae	4th Abdominal segment large inner macrochaetae
T. jacobyi sp. n.	3	3	basally swollen	4	1	A5, B4, B5
T. belizeana	3	2	lanceolate	4	3	A4, A5, B5
T. haitica	4	2	lanceolate	0	0	0
T. ecuatoriana	5	2	basally swollen	0	0	0
T. bessoni	5	2	basally swollen	3	0	apparently A5, B4, B5

Figure 24. *Trogolaphysa jacobyi* sp. n. habitus, photographed in Yok Balum Cave.

Scale distribution. Scales transparent, present on Ant. 1–2. Scales absent from postlabial region of head, ventral tube, legs and dorsal face of manubrium.

Head. Antenna/cephalic diagonal ratio up to 5.8 (Fig. 24). Fourth antennomere with incomplete but clear constriction near middle, with many shallow whorls of setae (Fig. 25); apical bulb absent; subapical sensillum not seen. Sense organ of Ant. 3 with sensilla 1 and 4 short, acuminate, thin-walled and translucent; sensillum 5 acuminate, dark and shorter than 1 and 4; sensilla 2–3 broad, leaf-like, resting in shallow grooves. Eyes not seen on slide-mounted specimens, but 1–2 pigment patches visible in life (Fig. 24). Head dorsally with 8 macrochaetae (A0, A2, A3, M3, S3, S5, Pa5 and Pm3—Fig. 26). Seta M4 displaced laterally towards cephalic sulcus. Series S with setae S1–5; S0 absent, macrochaeta S3 displaced anteriorly, away from cephalic sulcus (cf. Figs 5, 26). Prelabral and all labral setae smooth: setae within row A and C subequal; seta B2 shorter than B0 and B1 (Fig. 27). Distal margin of labrum smooth, papillae absent. Apical and subapical setae of maxillary palp smooth; sublobular plate without seta-like appendages. Lateral process of labial papilla E weakly bent dorsally and not nearly reaching apex of papilla (Fig. 28). Labial triangle setae as M1M2rEL1–2A1–5 (Fig. 29), seta M1 ciliate, all others smooth; r short; A2 close to r, L1 close to E and distant

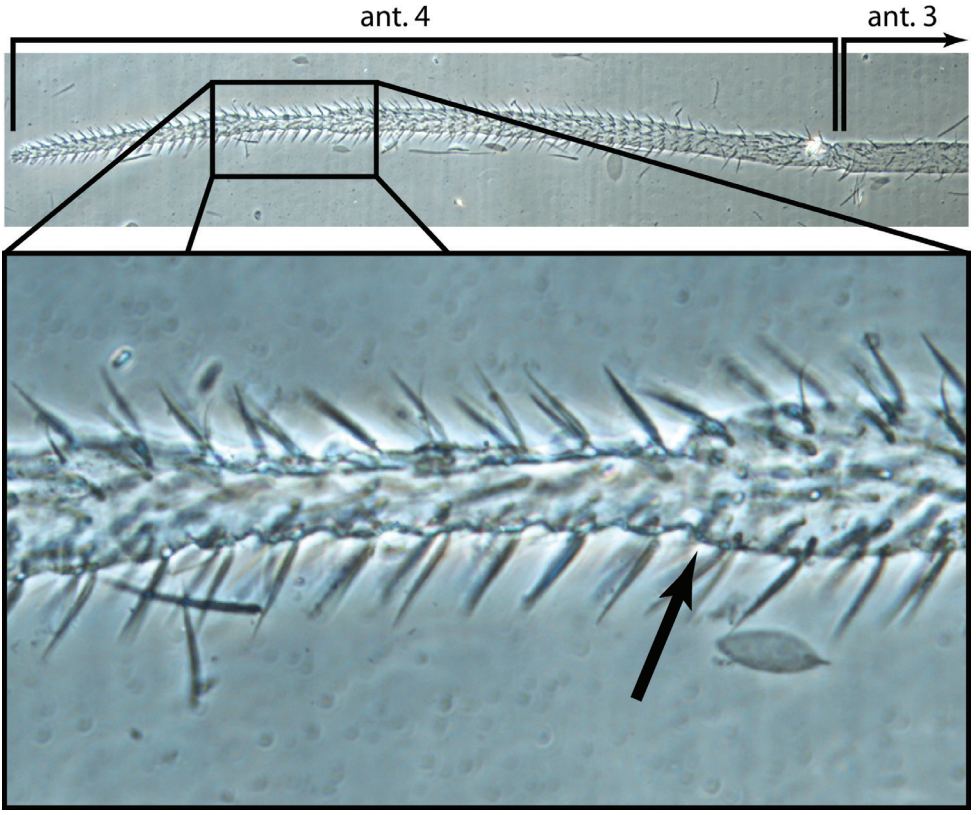
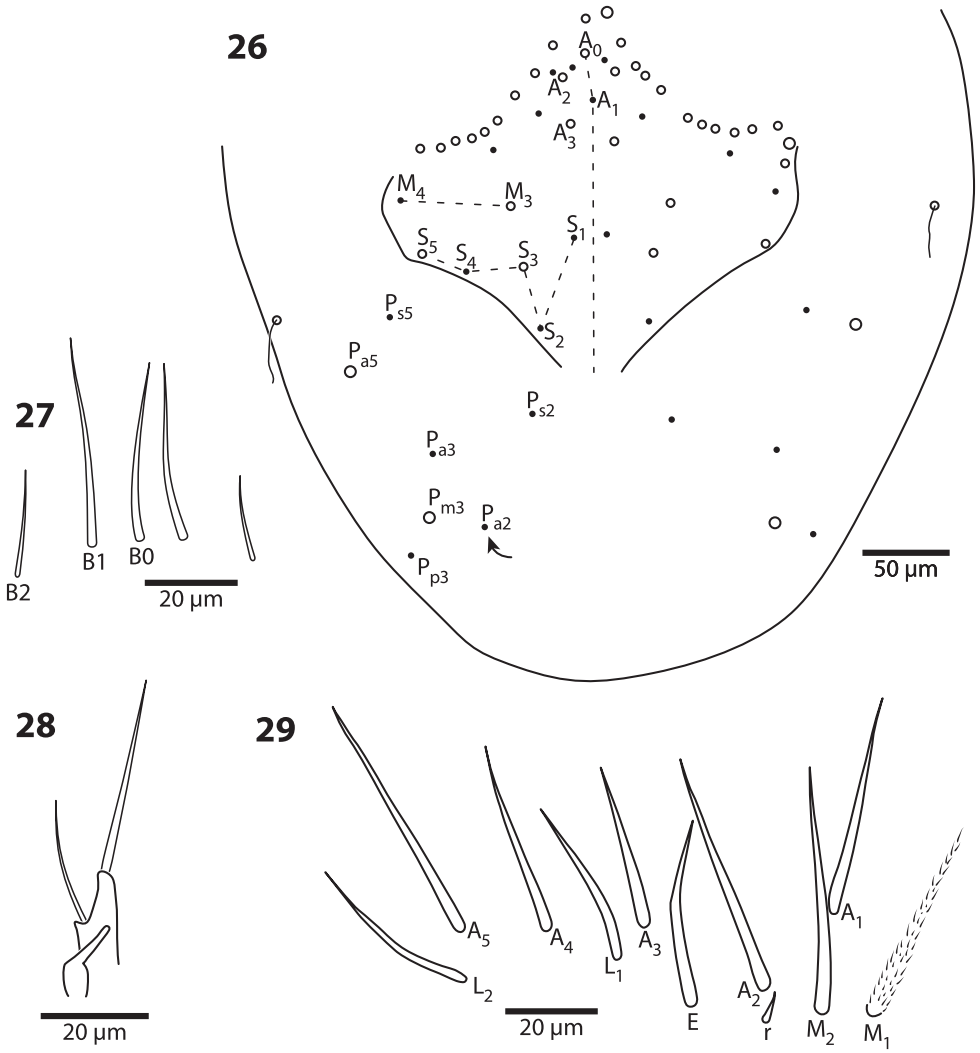


Figure 25. *Trogolaphysa jacobyi* sp. n. Fourth antennal segment showing constriction and incomplete suture (arrow).

from L2. Postlabium without scales, polychaetotic, uniformly covered with many large and small, weakly ciliate or smooth setae (Fig. 30); modified setae absent. Columns ICELO ill defined due to polychaetosis. Ventral cervical setae usually 6+6.

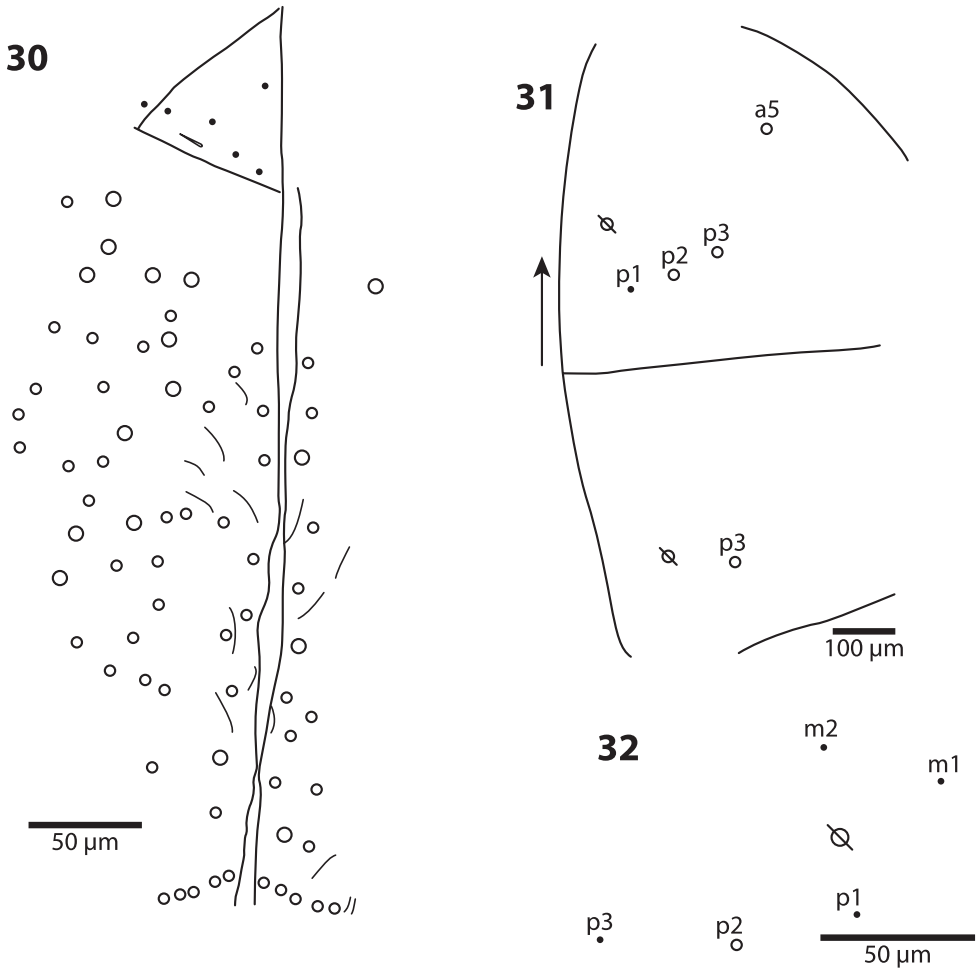
Body. Mesothoracic hood not developed. Complete dorsal macrochaetae as 62/41/0244+0+9-11. Mesothorax with 1 anterior (a5) and usually 3 posterior (p1–3) macrochaetae forming an arch (Fig. 31); some individuals with only mesothoraxic macrochaeta p2 (Fig. 32); microchaetae m1, m2, m4, p4 and p5 present. Metathorax with 1 macro- and 5 microchaetae (Fig. 33). First abdominal segment seta a6 absent; 4 posterior setae arranged in a single row (Fig. 34–36). Inner bothriotrix complex of Abd. 2 with 3 fan-shaped setae, one microsensillum and macrochaeta m3; outer bothriotrix with 3 fan-shaped setae and macrochaeta m5; setae a6, m6 and p5 present. Inner bothriotrix complex of Abd. 3 with 3 fan-shaped setae, one sensillum and macrochaetae m3; external bothriotrichal complex (Fig. 37) with 6–7 fan-shaped setae, macrochaetae am6, pm6 and p6; sensillum d2 absent. Fourth abdominal segment with 4 inner (Fig. 38) and 9–11 outer (Fig. 39) macrochaetae: inner macrochaetae A5, B4, and B5 large, B6 small; B5 displaced towards A6 instead of B6; (Fig. 38). Outer



Figures 26–29. *Trogolaphysa jacobyi* sp. n. **26** Head dorsal chaetotaxy **27** Labral setae on row B **28** Lateral process of labial papilla E **29** Labial triangle.

macrochaetae D3, E2, E3, F1, and F2 large; small outer macrochaetae E4, F3, F4 and 3 others probably belonging to series Fe present. Abd. 4 anterior and medial bothriotricha with 4 and 2 fan-shaped supplementary setae, respectively (Fig. 39). Posterior bothriotrix corresponds to D4, without associated supplementary setae. Posterior setae 6–7+6–7. Intersegmental membrane between Abd. 4–5 with 4–7 lenticular organs.

Legs. Trochanteral organ with up to 25 setae. Claw complex as in Figs 41–42. Tenent hair acuminate, longer on L1 than L3. Smooth posterior setae on metathoraxic legs as long as unguiculus. Unguis with 3 inner teeth: basal teeth small, subequal and ending on basal fourth of inner edge; unpaired tooth distinctly larger than basal

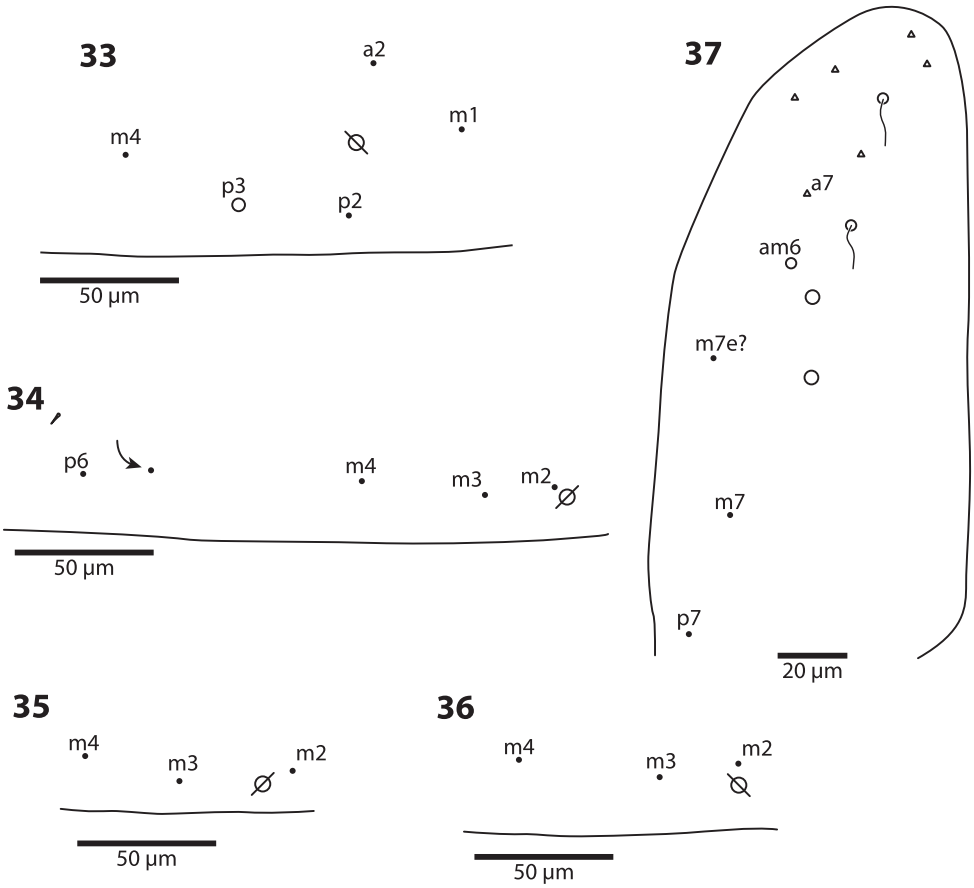


Figures 30–32. *Trogolaphysa jacobyi* sp. n. **30** Labial triangle and postlabium, open and filled circles represent ciliate and smooth setae, respectively **31** Thorax macrochaetae **32** Mesothorax, detail of inner chaetotaxy on a different individual.

teeth, ending near middle of inner ungual edge. Outer tooth absent on all claws; lateral teeth present only on pro- and mesothoracic legs, and ending on basal quarter of outer edge of unguis (Fig. 41). Unguiculus basally swollen, with basal fifth of outer margin weakly serrate.

Ventral tube. Anterior face with 2+2 distal macrochaetae; lateral and posterior setae not seen.

Furcula. Dens with 2 rows of finely ciliate spines, number of spines per row unclear on all specimens examined, but inner row with at least 36 spines. Mucro elongate and slender, with 3 teeth, basal inner tooth absent (Fig. 43): ratio mucro length/width of dens tip 2.3–2.8 (mode=2.4).

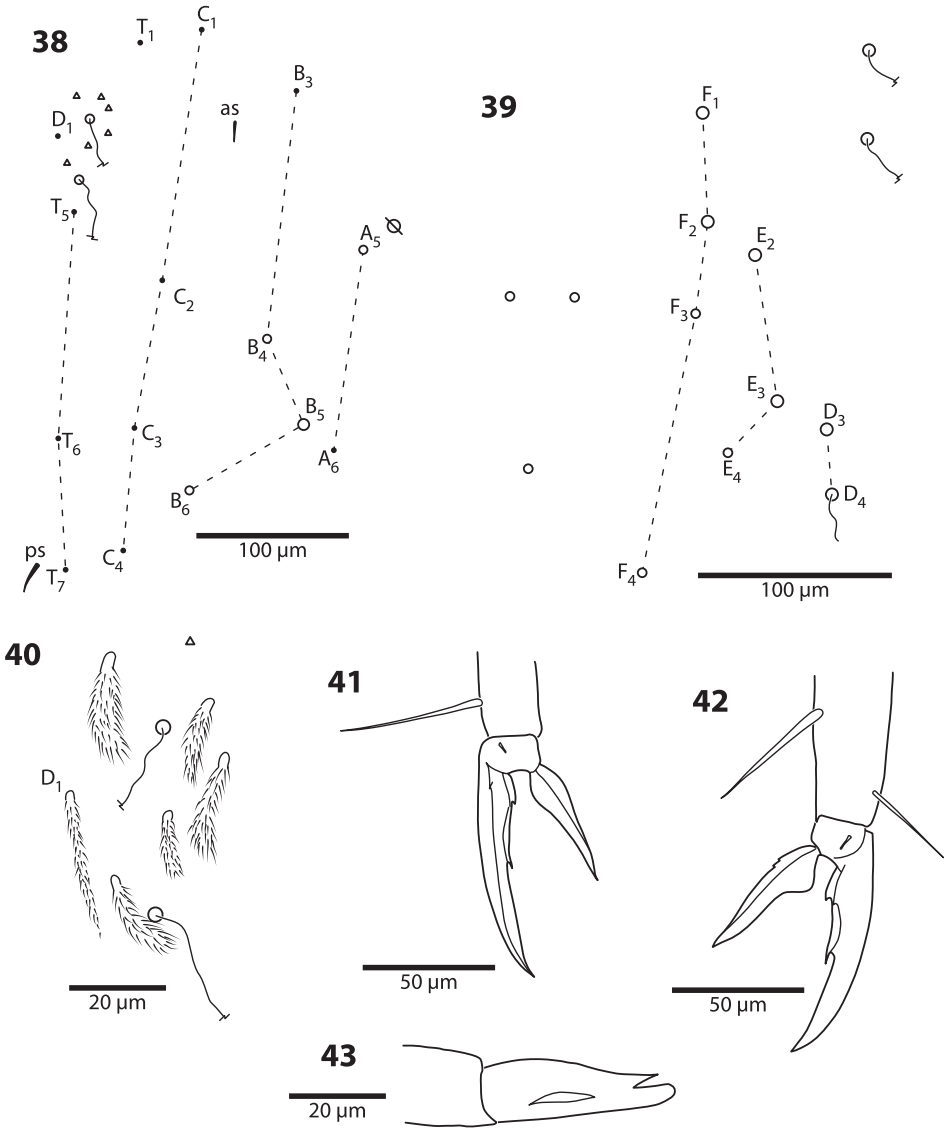


Figures 33–37. *Trogolaphysa jacobyi* sp. n., open and filled circles represent macro- and microchaetae, respectively, triangles represent fan-shaped microchaetae. **33** Metathorax, detail of inner chaetotaxy, seta a6 present but not shown **34** First abdominal segment, chaetotaxy, arrow points at seta seen in a single individual **35–36** First abdominal segment, alternative insertions of seta m2 **37** Third abdominal segment, setae associate with lateral bothriotricha.

Distribution. The species is known only from caves in southern Belize

Remarks. *Trogolaphysa jacobyi* sp. n. is a troglobiont (*sensu* Sket 2008, Culver and Pipan 2009). Living specimens seem to have eye pigment (Fig. 24), but we were unable to identify corneas on specimens examined. The only structure resembling a cornea corresponds to the EOS.

It could be argued that the constriction of the fourth antennomere places this species in *Troglopedetes*. However, the presence of a well-developed ciliate labial seta L2, the incomplete nature of the constriction on Ant. 4, and the similarity with *T. belizeana* (presumably with complete, unconstricted Ant. 4, and therefore an uncontested *Trogolaphysa*) suggest that *T. jacobyi* sp. n. should be retained in *Trogolaphysa*.



Figures 38–43. *Trogolaphysa jacobyi* sp. n., symbols as in previous plate. **38** Fourth abdominal segment, inner chaetotaxy **39** Fourth abdominal segment, outer macrochaetae **40** Fourth abdominal segment anterior bothriotrichal complex **41** Prothoracic claw complex **42** Metathoracic claw complex **43** Mucro.

Additionally, the fact that all other *Troglopedetes* species are restricted to the Old World have prompted us to retain the new species in *Trogolaphysa*.

Etymology. This species is dedicated to JoAnn Jacoby, the junior author's wife, in gratitude for her enthusiasm and assistance in the planning and execution of field-work in the caves of Belize and in many earlier excursions.

Figure 44. Type locality for *Trogolaphysa jacobyi* sp. n. in the dark zone of Yok Balum. Photo courtesy of MES.

Habitat. This species is a troglobiont, and all 5 collections (11 individuals) were taken in the dark zone (0 lux) on the floor (Fig. 44), often (80% of collections) in wet conditions associated with flowstone or calcite and drip pools, sometimes with scattered cricket droppings.

Trogolaphysa belizeana Palacios-Vargas & Thibaud, 1997

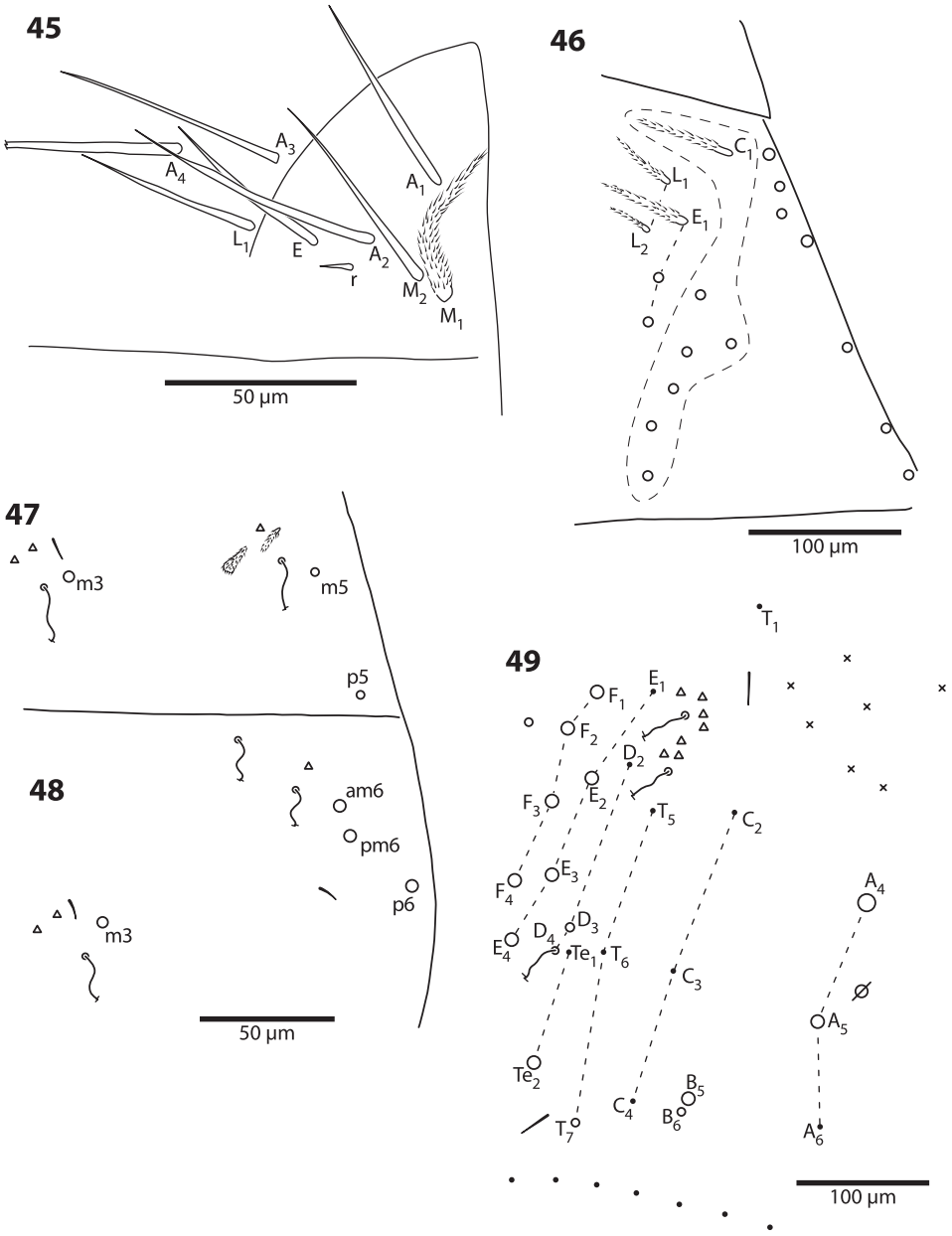
http://species-id.net/wiki/Trogolaphysa_belizeana
Figs 45–52

Material examined. Two paratypes; Belize: Cayo District, Actun Chapal cave, 7 km SE of Benque Viejo del Carmen, 10.XII.1992, W.R. Elliott.

Additions to the original description.

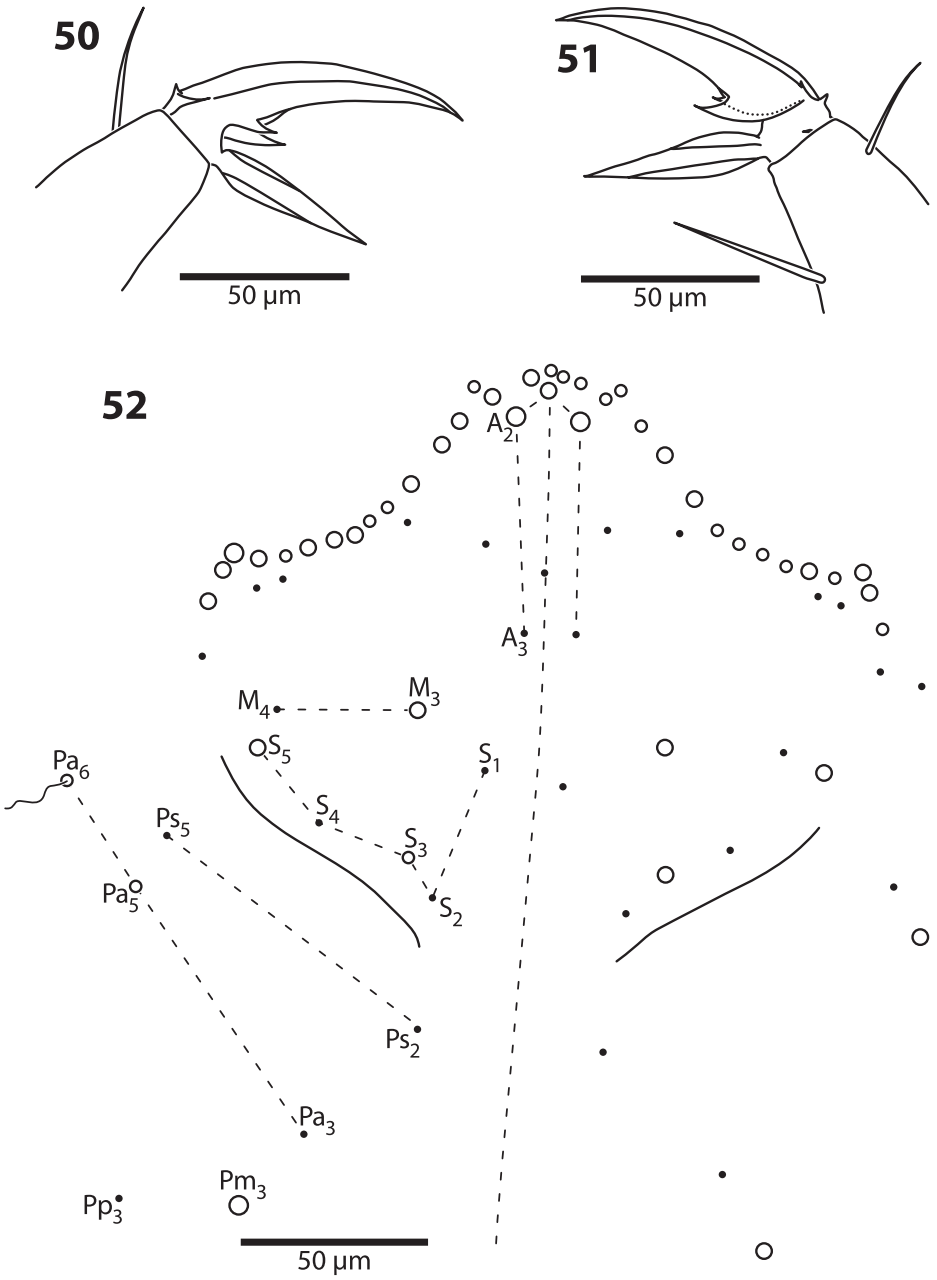
Head. Dorsal chaetotaxy of the head identical to that of *T. jacobyi* sp. n., with macrochaetae A0, A2, A3, M3, S3, S5, Pa5 and Pm3. Labral margin smooth. Sublobular plate of outer maxillary lobe without setae-like appendages. Labial papilla E with lateral appendage reaching tip of papilla; 5 proximal smooth labial setae present, seta z (Soto-Adames 2010) longest. Labial triangle formula as M1M2rEL1L2A1-5 (Fig. 45): M1 ciliate, shorter but thicker than M2; r short, stout, apically acuminate; A2 close to r. Postlabium with few scales; columns ICEL with 7732 setae (Fig. 46); seta L2 shortest; ventral cervical setae 6+6.

Body. Dorsal macrochaeta formula as 62/3–43/0343+0+11. Mesothorax with macrochaetae p2, p3 and a5, and microchaetae m4 and p5 clearly visible; setae p1,



Figures 45–49. *Trogolaphysa belizeana* **45** Labial triangle **46** Postlabial chaetotaxy **47** Chaetotaxy of second abdominal segment **48** Chaetotaxy of third abdominal segment **49** Complete chaetotaxy of fourth abdominal segment, x represent sensilla-like setae.

m2 and p6 obscured. Metathorax with 3 macro- and 1 microchaetae arranged as in *T. giordanoae* sp. n. (Fig. 13). Abd. 1 with at least three inner microchaetae, apparently without a6, but lateral field of segment not clearly visible. Abd. 2 chaetotaxy normal



Figures 50–52. *Trogolaphysa belizeana* (**50**, **51**) and *Trogolaphysa jataca* (**52**) **50** Prothoracic claw **51** Metathoracic claw **52** Dorsal chaetotaxy of head.

(Fig. 47): with bothriotricha m2 and a5, sensillum as, macrochaetae m3 and m5, setae a6, m6 and p5, and fan-shaped supplementary setae around bothriotrichal complexes. Abd. 3 (Fig. 48) with insertion of bothriotricha m2, a5 and m5, macrochaetae m3,

a7, pm6 and p6, and sensillum d2 normally placed. Chaetotaxy of Abd. 4 as in Fig. 49: inner macrochaetae A4, A5, B5 and B6 present, B6 smallest; outer macrochaetae T7, D3, E2, E3, E4, F1, F2, F3, F4, one member of series Fe and one posterior setae of unclear homology present; relative position of bothriotricha normal; microchaeta B4 absent, microchaeta Te1 present. Posterior setae 7+7. Intersegmental membrane between Abd. 4–5 with at least 4 lenticular organs, actual number of organs unclear due to folding of membrane.

Legs. Claw complex of pro- and metathoracic legs as in Figs 50–51. Tenent hair acuminate. Outer and lateral unguis teeth small, inconspicuous; inner paired teeth with one tooth slightly, but clearly larger, unpaired teeth absent. Unguiculus lanceolate.

Ventral tube. With 2+2 distal macrochaetae on anterior face.

Remarks. The paratypes examined differ from the original description of the species in having labial seta L2 smooth instead of ciliate, in having only 2 posterior mesothoraxic macrochaetae, in the claws having lateral teeth and in the number of bothriotricha on Abd. 2 and Abd. 4.

Variation in the number of mesothoraxic macrochaetae is also seen in *T. jacobyi* sp. n and may be related to post-embryonic development. The chaetotaxy of Abd. 2 in fig. 12 of Palacios-Vargas and Thibaud (1997) suggests a composite of the chaetotaxy of Abd. 2 and 3, whereas the bothriotrichal complex of Abd. 4 shown in Palacios-Vargas and Thibaud (1997, fig. 13) seems based on an aberrant specimen.

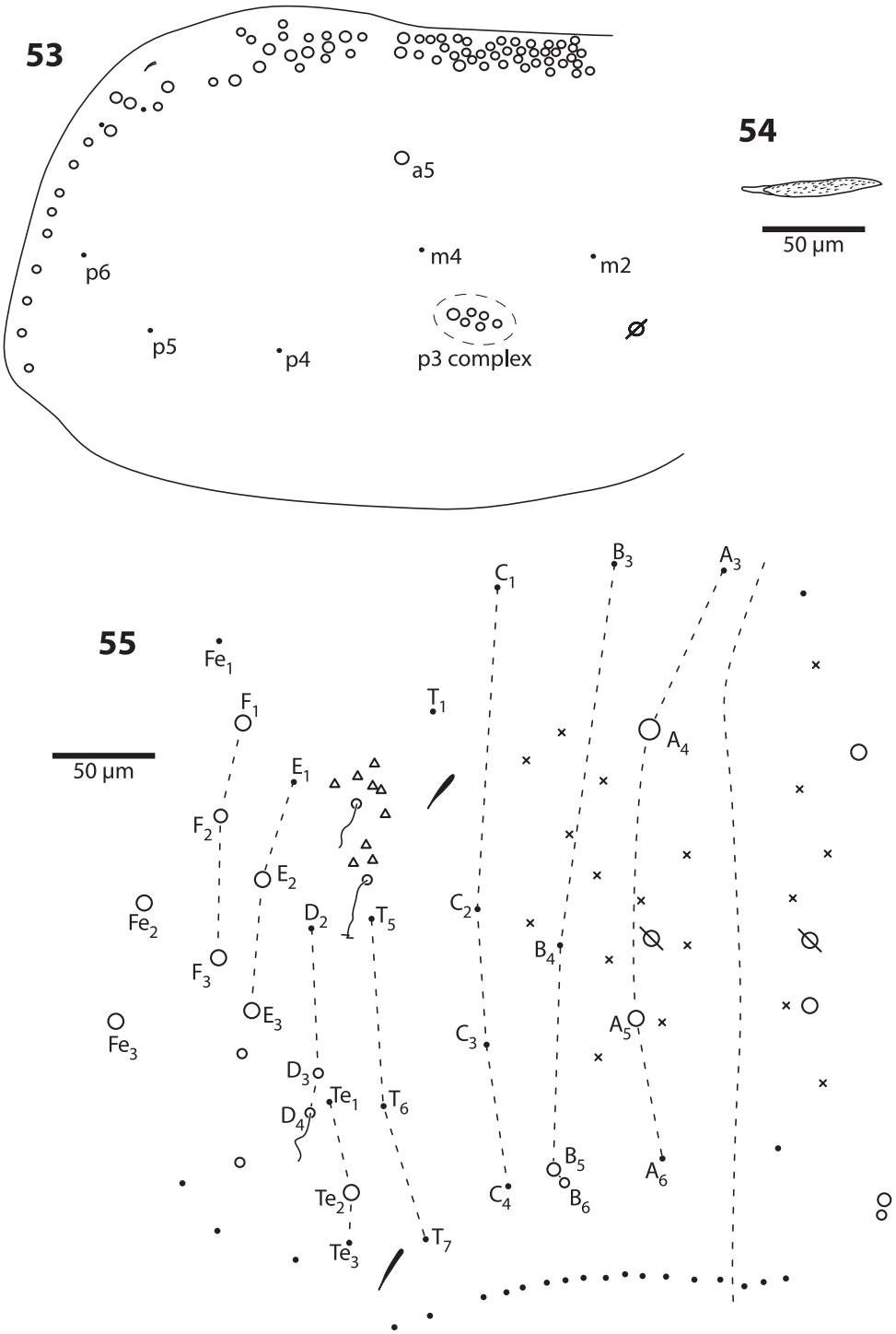
***Trogolaphysa jataca* (Wray, 1953)**
http://species-id.net/wiki/Trogolaphysa_jataca
Fig. 53–55

Material examined. Puerto Rico: Isabela, Guajataca Commonwealth Forest, Rd. 446, 18.41263°N, 66.96887°W, top of mogote at crossroad between trails 6, 25 & 26, leaf litter, 15.V.2009, F. Soto (2 specimens); Cayey, Rd. 4471, Km 4.1, leaf litter, 18.VI.1998, F. Soto (1 specimen); Mayagüez, University of Puerto Rico, secondary forest east of Biology Building, 18.21350°N, 67.13774°W, royal palm (*Roystonea borinquena* O.F. Cook) leaf litter, III.2009, M. Ospina (3 specimens).

Additions to the original description.

Head. Dorsal chaetotaxy as in Fig. 52: macrochaetae A0, A2, M3, S3, S5, Pa5 and Pm3 present; 1+1 microchaetae inserted near A1. Postlabium with all setae ciliate; columns ICELO with 41232; posterior setae on column I detached from anterior group.

Body. Mesothorax (Fig. 53) with one anterior (a5) and six posterior macrochaeta; microchaetae m2, m4, p5 and p6 present; microchaetae p1 and p2 absent. Metathorax with 4 inner microchaetae, as in *T. riopedrensis* (Fig. 58). Abd. 1 with 4 posterior setae; seta a6 absent. Abd. 2 and 3 as in *T. giordanoae* sp. n. (Figs 15, 16); Abd. 2 seta p5 fusiform, with enlarged socket (Fig. 54). Abd. 4 as in Fig. 55: inner macrochaetae A4, A5, B5 and B6 present; macrochaetae Te2, D3, E2, E3, F1–3 present; 4 other lateral



Figures 53–55. *Trogolaphysa jataca* **53** Mesothorax chaetotaxy **54** Second abdominal segment seta p5 **55** Complete chaetotaxy of fourth abdominal segment.

and posterior small macrochaetae present. Posterior setae 13–14+13–14. Intersegmental membrane between Abd. 4–5 with 4 lenticular organs.

Ventral tube. Anterior face with 3+3 distal macrochaetae; smaller individuals with 2+2 macrochaetae.

***Trogolaphysa geminata* (Mari Mutt, 1988)**
http://species-id.net/wiki/Trogolaphysa_geminata
Fig. 56

Material examined. Puerto Rico: Maricao, Maricao Commonwealth Forest, near observation tower on Rd. 120, 18.14444°N, 66.97962°W, leaf litter, 8.VI.1998, F. Soto (1 specimen); Mayagüez, University of Puerto Rico, secondary forest east of Biology Building, 18.21350°N, 67.13774°W, royal palm (*R. borinquena*) leaf litter, III.2009, M. Ospina (3 specimens).

Additions to the original description.

Head. Dorsal chaetotaxy as in Fig. 56: macrochaetae A0, A2, M3, S3, Pa5 and Pm3 present. Postlabium with all setae ciliate; columns ICELO with 41232; posterior setae on column I detached from anterior group.

Body. Mesothorax as in *T. jataca* (Fig. 53). Metathorax as in *T. riopedrensis* (Fig. 58). Abd. 1 as in *T. riopedrensis* (Fig. 59) with one anterior (a6) and 4 posterior setae. Abd. 2 and 3 as in *T. giordanoae* sp. n. (Figs 15, 16); Abd. 2 seta p5 fusiform as in *T. jataca*. Abd. 4 as in *T. jataca* (Fig. 55): inner macrochaetae A4, A5, B5 and B6 present; macrochaetae Te2, D3, E2, E3, F1, F2, F3 present; 4 other lateral and posterior small macrochaetae present. Posterior setae 13–14+13–14. Intersegmental membrane between Abd. 4–5 with 4–6 lenticular organs.

Ventral tube. Anterior face with 3+3 distal macrochaetae.

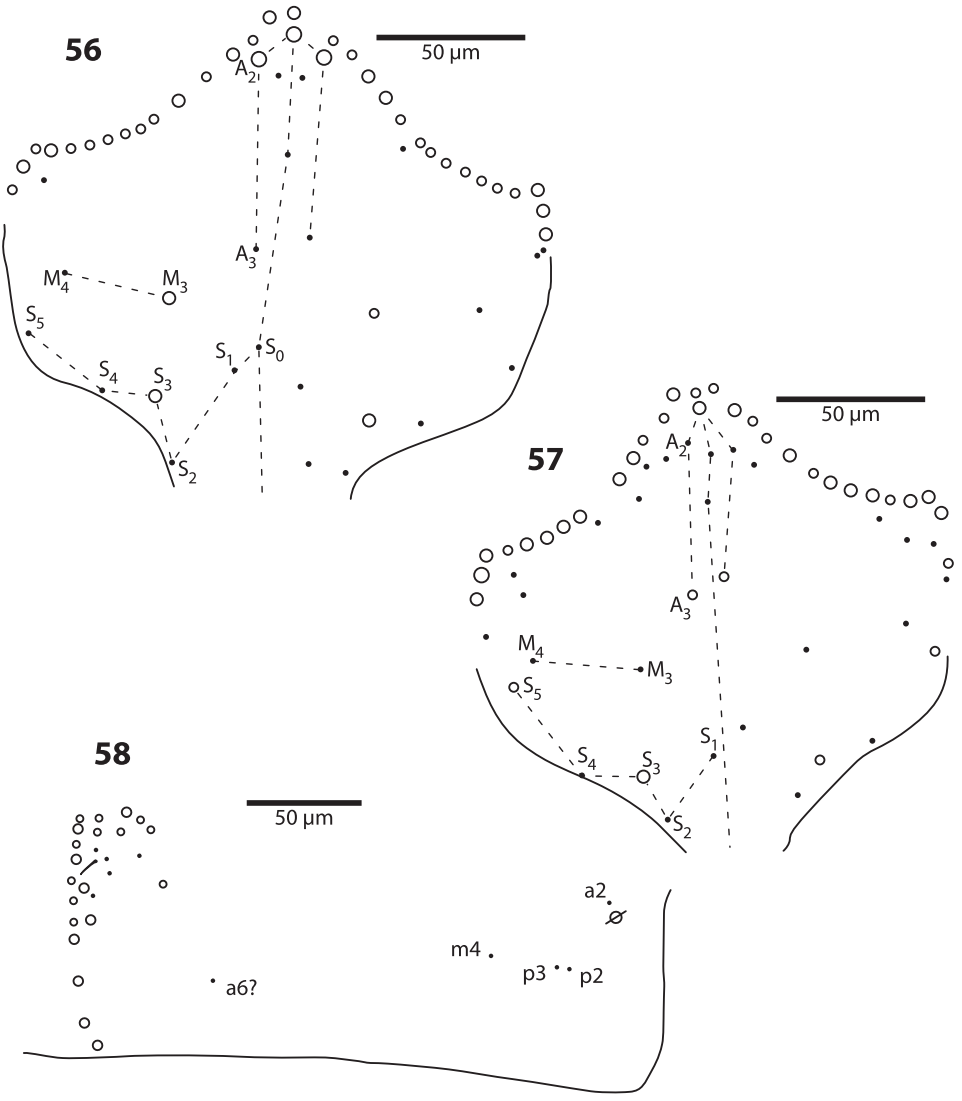
***Trogolaphysa riopedrensis* (Mari Mutt, 1988)**
http://species-id.net/wiki/Trogolaphysa_riopedrensis
Fig. 57–60

Material examined. Puerto Rico, Aguadilla, Caimital Alto, Villa Grajales, 18.44058°N, 67.11840°W, moist mown lawn, 9.VII.1999, F. Soto (1 specimen); USA Virgin Islands, St. Thomas, 18.35348°N, 64.93520°W, wet leaf litter, patch of forest along Rd. 33 near intersection with Rd. 40, 28.VI.2000, F. Soto (1 specimen).

Additions to the original description.

Head. Dorsal chaetotaxy as in Fig. 57: macrochaetae A0, (A2), A3, S3, S5, Pa5 and Pm3 present. Postlabium with all setae ciliate; columns ICELO with 41232; posterior setae on column C detached from anterior group.

Body. Mesothorax as in *T. jataca* (Fig. 53). Metathorax as in (Fig. 58). Abd. 1 with 1 anterior (a6) and 4 posterior setae (Fig. 59). Abd. 2 and 3 as in *T. giordanoae*

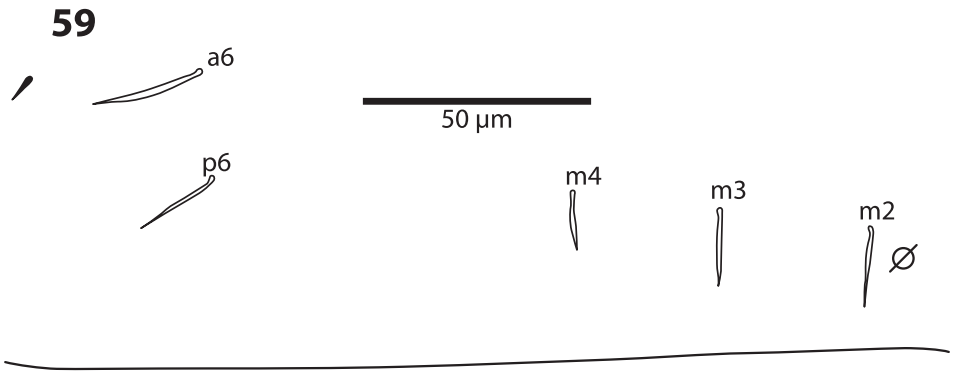


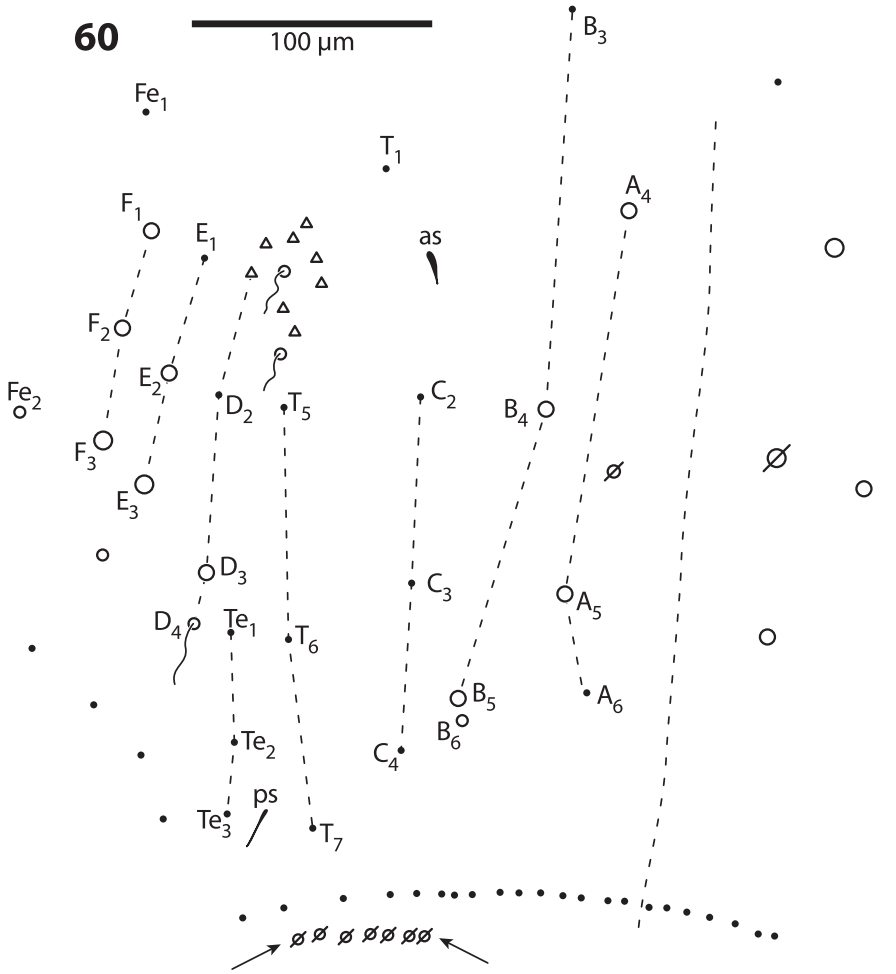
Figures 56–58. *Trogolaphysa geminata* (**56**) and *Trogolaphysa riopedrensis* (**57, 58**) **56** Head dorsal chaetotaxy **57** Head dorsal chaetotaxy **58** Metathorax chaetotaxy.

sp. n. (Figs 15, 16). Abd. 4 as in Fig. 60: inner macrochaetae A4, A5, B4, B5 and B6 present; outer macrochaetae D3, E2, E3, F1, F2, F3, Fe3 present; at least one other outer macrochaeta present. Posterior setae 17+17. Intersegmental membrane between Abd. 4–5 with 4–6 lenticular organs (Fig. 60).

Ventral tube. Anterior face with 4+4 distal macrochaetae.

Remarks: The individual from St. Thomas lacks head macrochaetae A2. In the individual from Aguadilla the dorsal and outer teeth of the unguis end on the basal fourth of the claw instead of the distal half.





Figures 59, 60. *Trogolaphysa riopedrensis* **59** Chaetotaxy of first abdominal segment **60** Complete chaetotaxy of fourth abdominal segment, arrows identify the lenticular organs.

Discussion

Dorsal chaetotaxy

The dorsal chaetotaxy of *Trogolaphysa* has not been fully described in the context of the AMS (Soto-Adames 2010) and Szeptycki (1979) systems of nomenclature. The notes presented below are based on the study of *T. jataca*, *T. geminata* and *T. riopedrensis*, three surface species from Puerto Rico, in addition to the three species of cave *Trogolaphysa* from Belize.

Head. The dorsal chaetotaxy of the head is reduced when compared to other genera of scaled Entomobryidae (e.g., *Seira, Pseudosinella*; cf. Fig. 26 here to fig. 1 in Soto-Adames [2008] and fig. 4 in Soto-Adames [2010]). In the species studied, series A includes setae A0-3. Some species have additional microchaetae that can be construed as belonging to this series (e.g., *T. jataca*, Fig. 52) but only A0–3 are present in all species examined. Seta A1 is always a normal, coarsely ciliate microchaeta, all other members of the series can develop into macrochaetae.

Series M includes 2 setae, probably homologous to M3–M4. In most species the lateral seta in series M is internal to S5, but in troglomorphs *T. jacobyi* sp. n. and *T. belizeana* the seta is inserted external to S5 and just internal to the dorsal cephalic suture. M0 is absent (seen only in one individual of *T. giordanoae* sp. n.), whereas M3 is often developed into a macrochaetae. Series S includes setae S1–5, S0 is absent (seen only in one individual of *T. geminata*). Among the species examined only setae S3 and S5 are modified into macrochaetae. Most setae in series S are inserted along the dorsal cephalic sulcus; the exceptions are S1, which is anterior to all others, and seta S3 when it is modified into a macrochaeta (cf., *T. giordanoae* sp. n. [Fig. 5] versus *T. jacobyi* sp. n. [Fig. 26]).

There is a pattern in the addition of macrochaetae on the interocular region of the head for species with 3–4 macrochaetae, but the pattern in not retained for species with five macrochaetae: whenever three macrochaetae are present they are always A0, A2 and M3; the species with four macrochaetae carries A0, A2 and M3 plus S3; the species with five macrochaetae have A0, A2, S3, S5, and either A3 or M3.

Series Ps includes only two setae (Ps2 and Ps5) whereas series Pa has four setae (Pa2, 3, 5 and bothriotrix Pa6), and series Pm and Pp has one seta each (Pm3 and Pp3). Posterior setae Pa5 and Pm3 are often modified into macrochaetae.

*Mesothorax***.** The chaetotaxy of the mesothorax is reduced, as in scaled Entomobryidae (e.g., *Seira, Pseudosinella* [Soto-Adames 2008, 2010]), the closest group of Entomobryoidea for which detailed information about chaetotaxy is available. All *Trogolaphysa* species share the presence of macrochaetae a5 and p3, and microchaetae m2, m4, p4, p5, and what we provisionally call p6. Setae p1 and p2 are present in the three species from Belize but either absent or integrated in the p3 macrochaetae complex in the three surface species from Puerto Rico (Fig. 53)

The homologies of the posterior macrochaetae across the species examined are unclear. The presence of setae p1 and p2 in *T. giordanoae* sp. n. suggests that the cluster of six posterior macrochaetae represent a multiplication of seta p3; whereas the transfor-

mation of p1 and p2 into macrochaetae in *T. jacobyi* sp. n. and *T. belizeana*, and their absence in the surface species *T. jataca*, *T. geminata* and *T. riopedrensis* suggest that the three setae have been integrated (and duplicated) into the macrochaetal complex. We propose three hypotheses to explain the evolution of posterior macrochaeta: the macrochaetae evolved independently more than once in the genus, either as 1) a duplication of p1–3 or as 2) multiplication of p3 alone; 3) the cluster evolved only once, a duplication of p1–3, and the setae we have identified as p1 and p2 in *T. giordanoae* sp. n. are secondary and not homologous to those present in *T. jacobyi* sp. n. and *T. belizeana*. A study of the postembryonic development of these setae or molecular phylogenetic analysis may provide evidence in support one of the hypotheses proposed above.

Metathorax. The chaetotaxy of this segment is reduced to five setae (e.g., *T. geminata*, Fig. 58). The homologies of these setae are uncertain, and names provided in Fig. 58 are based on comparison with the general organization of the chaetotaxy in first instar *Seira dowlingi* (Wray, 1953), *Heteromurus nitidus* (Templeton, 1835) and *Willowsia buskii* (Lubbock, 1870) (Soto-Adames 2008, Szeptycki 1979). The single macrochaeta present in *T. jacobyi* sp. n. appears to be homologous to p3, whereas the three macrochaetae present in *T. giordanoae* sp. n. and *T. belizeana* appear to be homologous to a displaced a2, p2 and p3.

Abdomen 1. This segment also has a reduced chaetotaxy, carrying not more than six setae (Figs 14, 59). The homologies proposed are based on comparisons with first instar *S. dowlingi, H. nitidus* and *W. buskii* (Soto-Adames 2008, Szeptycki 1979). Seta a6 is present in *T. giordanoae* sp. n., *T. geminata* and *T. riopedrensis* and absent in *T. jacobyi* sp. n. and *T. jataca.*

Abdomen 2–3. The chaetotaxy of these segments was previously described by Mari Mutt (1987[1988]) and the species examined here, including *T. belizeana,* conform to that description. These two segments do not carry inner microchaetae beyond those associated with the bothriotichal complexes. The macrochaetae on Abd. 2 are homologous to m3 and m5. Lateral setae a6, m6 and p5 appear to be present in all species, although a6 and m6 are often difficult to see. The socket of p5 is enlarged, macrochaeta-like, but this seta falls off in most slide-mounted individuals, it was observed in *T. jacobyi* sp. n, where it is a ciliate mesochaeta and in *T. jataca*, where it is enlarged and fusiform (Fig. 54).

The macrochaetae on Abd. 3 appear to be homologous to m3, am6, pm6 and p6 (Fig. 16). Sensillum d2 is absent in *T. jacobyi* sp. n. (Fig. 37), in *T. belizeana* it is inserted posterior to macrochaeta pm6 (Fig. 48), whereas in *T. giordanoae* sp. n., *T. jataca*, *T. geminata* and *T. riopedrensis* it is inserted anterior to or forming a row with pm6 (Fig. 16).

Abdomen 4. The chaetotaxy of Abd. 4 is similar to that in scaled Entomobryidae and setae modified in, for example, *Seira* or *Lepidocyrtus*, can also be modified in *Trogolaphysa*. The chaetotaxy displays some unique peculiarities. For example, what appears to be seta B6 is, in most species, a meso- or small macrochaeta inserted just posterior to B5 (Fig. 17). In addition, the posterior bothriotrix corresponds to D4 (D3 in *Seira,* Soto-Adames 2008). The number, identity and relative insertion of inner

macrochaetae varies between *Trogolaphysa* species. *Trogolaphysa giordanoae* sp. n. and *T. riopedrensis* share the same inner macrochaetae (A4, A5, B4, B5), but the insertion of B4 in relation to the pseudopore and seta C2 differ between these two species (cf., Figs 17, 60). *Trogolaphysa geminata*, *T. jataca* and *T. belizeana* have three inner macrochaetae and share macrochaetae A5 and B5, but whereas in *T. jacobyi* sp. n. the third macrochaetae is B4, in the other two species it is A4. *Trogolaphysa jacobyi* sp. n. is also unusual in having macrochaeta B5 displaced towards A6 instead of C4 (Fig. 38).

The external macrochaetae in the first three rows of columns D, E and F are stable in the species of examined. All species have macrochaetae D3, E2, E3, F1 and F2. Macrochaeta F3 is present in all species except *T. jacobyi* sp. n. The number of macrochaetae external to column F and posterior to row 3 varies intra- and interspecifically. However, the lateral and posterior fields are often difficult to see in regular preparations and it is possible that some of the apparent differences are simply incomplete observations.

The number of posterior setae (per side) on Abd. 4 also varies between species: 6–7 in *T. belizeana* and *T. jacobyi* sp. n., 13–14 in *T. jataca* and *T. geminata*, 17 in *T. riopedrensis* and 19–21 in *T. giordanoae* sp. n.

Chaetotaxy and phylogenetic analysis of cave-adapted species

The morphological information for surface species *T. luquillensis* (Mari Mutt 1987[1988]), cave species *T. subterranea* (Mari Mutt 1987[1988]) and the six species treated here was coded into 69 characters (Appendix 1). The data matrix (Appendix 2) includes character systems identified (Christiansen 1961, 1965; Gama 1984) as most responsive to adaptation to cave habitats (i.e., eye number, claw complex morphology), but most characters (60) refer to chaetotaxy. *Campylothorax sabanus* (Wray, 1953) was designated as outgroup.

Phylogenetic analysis based on all characters supports two equally parsimonious trees (Figs 61–64) in which the two troglobiontic species from Belize form a monophyletic group and *T. giordanoae* sp. n. is placed at the base of the species from Puerto Rico. The parsimony trees support the sister species relationship between *T. subterranea* and *T. luquillensis*, but relationships between the other three species from Puerto Rico are unresolved, as *T. riopedrensis* is placed as sister to either *T. jataca* or to a clade that includes all other island species.

The apparently rare occurrence of metathoracic macrochaetae in the three Belizean species suggests a close relationship between them, but the parsimony trees show the troglobiontic species diverging before the separation of *T. giordanoae* sp. n. from the ancestor of the island species. The lack of support for the monophyly of Belizean species may be an artifact of a disproportionate contribution of characters under strong cave habitat selection to the final topology of the tree. However, parsimony analysis based only on chatotactic characters results in a single shortest tree (Fig. 63), which also supports the monophyly of troglobiontic species while retaining *T. giordanoae* sp. n. at the base of the island species clade.

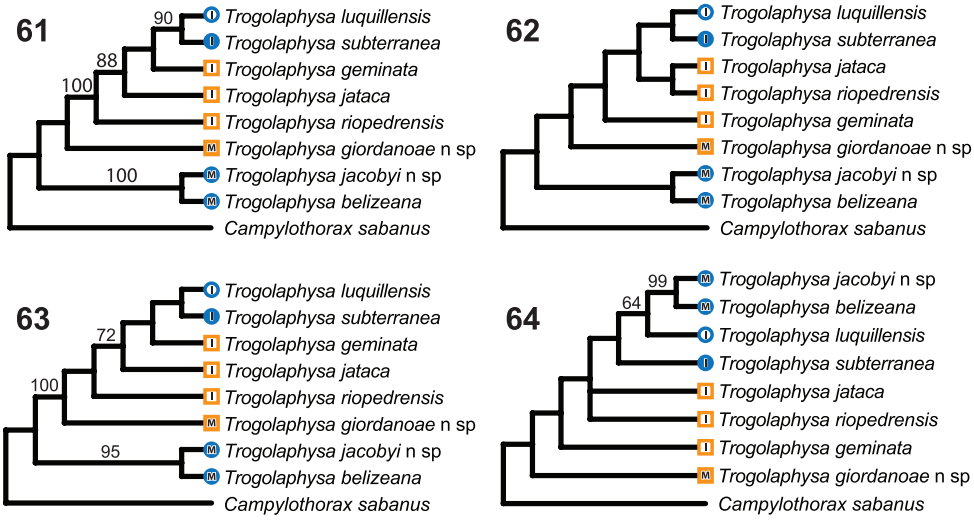


Figure 61–64. Cladograms. Branch lengths are arbitrary. All searches performed using branch and bound, including the bootstrap analyses. Numbers above branches are bootstrap values based on 5000 pseudoreplicates. Circles: taxa with troglomorphies, squares-not troglomorphic. Solid symbols recorded only from caves, open symbols recorded from surface. M, mainland species: I, island species **61**–**62** The two shortest trees found when all characters are included in the analysis **63** Shortest tree found when only chaetotactic characters are analyzed **64** Shortest tree found when only eye number, characters related to claw complex morphology and mucro are analyzed.

To assess whether putative adaptive characters provide support for alternative relationships, we conducted a phylogenetic analysis using only eye number, ornamentation of labral papilla, and claw and mucro morphology. These characters support a single tree (Fig. 64) that places most surface forms at the base of the tree while supporting a clade comprising the cave species (*T. jacobyi* sp. n., *T. belizeana*, *T. subterranea*) and *T. luquillensis*. *Trogolaphysa luquillensis* is endemic to the tropical rainforest and is unique among surface species examined here in having an acuminate tenent hair and three inner ungual teeth close to each other and inserted in the basal half of the claw. These characters of the claw have been identified as adaptations to walking on water surface or other, permanently wet, surfaces such as those found in rainforest leaf litter and caves (Christiansen 1961, 1965).

Evaluation of the direction of evolution of head chaetotaxy using trees in Fig. 61 and Fig. 62 supports a trend towards a reduction in number of macrochaetae. However, the pattern is equivocal because some macrochaetae may be lost independently through out the tree, depending on tree topology. For example, S5 might have been lost once and regained or it might have been lost twice independently. What is clear from this analysis is that A3 is the first macrochaetae to be lost, followed by S5, S3 and M3 (Table 4). *Trogolaphysa riopedrensis* is the only species in which this pattern seems to be disrupted: under either tree this species is hypothesized to have lost M3 and gain A3 independently.

Table 4. Distribution of head macrochaetae in eight species of New World *Trogolaphsya.*

Species	Macrochaetae number	Macrochaeta identity					
T. jacobyi sp. n.	6	A0	A2	A3	M3	S3	S5
T. belizeana	6	A0	A2	A3	M3	S3	S5
T. riopedrensis	5	A0	A2	A3	—	S3	S5
T. jataca	5	A0	A2	—	M3	S3	S5
T. geminata	4	A0	A2	—	M3	S3	—
T. luquillensis,	3	A0	A2	—	M3	—	—
T. giordanoae sp. n.	3	A0	A2	—	M3	—	—
T. subterranea	2	A0	A2	—	—	—	—

Taxonomic status of *Dicranocentruga* and *Trogolaphysa*

The character used by Mitra (1993, 2002) to diagnose genera *Trogolaphysa* and *Dicranocentruga* can be difficult to apply. The presence of EOS is difficult to ascertain using phase contrast or DIC light microscopy. The retention of *Dicranocentruga* as a valid genus hinges on whether *Trogolaphysa maya*, the type species of *Trogolaphysa*, carries the EOS. As pointed out above, the presence of EOS in the two troglomorphic species considered here suggests that this structure is also present in *T. maya*. We examined the single alcohol preserved syntype of *T. maya* deposited at the Illinois Natural History, but the condition of the specimen is such that confirmation of the presence of the EOS is impractical.

It is possible, as proposed by Mitra (1993), that a more extensive analysis of idiochaetotaxy may provide diagnostic characters for these two genera that are easier to see and interpret. The present study does not support this idea. The organization of the idiochaetotaxy is the same in all the species studied. Changes in the distribution of setae, as in the case of the metathorax, are related to the morphology of the elements (whether macro- or microsetae), and not to the presence of EOS, number of eyes, or other cave adaptive characters. Until such time as the presence of EOS can be reliably determined, or other diagnostic characters are found, we retain all New World *Dicranocentruga* in the genus *Trogolaphysa*, as proposed by Thibaud and Najt (1988[1989]).

Morphological characters and phylogeny

The genus *Trogolaphysa* has diversified in the New World from where now 35 species have been named (Table 1, Fig. 65), many of which are troglobionts or at least eutroglophiles (*sensu* Sket 2008, Culver and Pipan 2009). Phylogenetic studies of species-level relationships have not been published for this genus, perhaps as a result of the scarcity and quality of the characters available for analysis. Most described species, es-

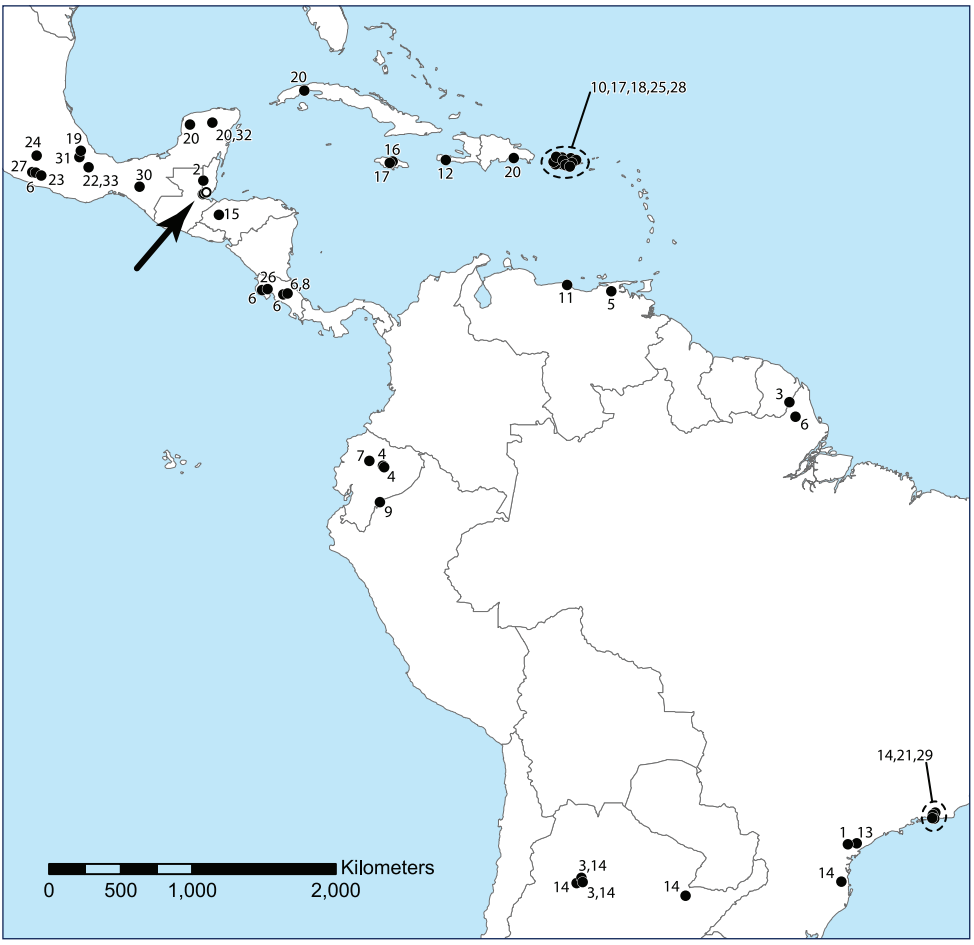


Figure 65. Central and South America and the Caribbean Islands, showing the published distributions of described New World species of the genus *Trogolaphysa*. Open circles (arrow): *Trogolaphysa jacobyi* sp. n., *Trogolaphysa giordanoae* sp. n. Closed circles: **1** *T. aelleni* Yoshii, 1988 **2** *T. belizeana* **3** *T. berlandi* (Denis, 1925) **4** *T. bessoni* Thibaud & Najt, 1989 **5** *T. caripensis* (Gruia, 1987) **6** *T. carpenteri* (Denis, 1925) **7** *T. cotopaxiana* Thibaud & Najt, 1989 **8** *T. distinguenda* (Denis, 1931) **9** *T. ecuatorica* (Palacios-Vargas, Ojeda & Christiansen, 1986) **10** *T. geminata* **11** *T. guacharo* Yoshii, 1988 **12** *T. haitica* (Palacios-Vargas, Ojeda & Christiansen, 1986) **13** *T. hauseri* Yoshii, 1988 **14** *T. hirtipes* (Handschin, 1924) **15** *T. hondurasensis* (Palacios-Vargas, Ojeda & Christiansen, 1986) **16** *T. jamaicana* (Palacios-Vargas, Ojeda & Christiansen, 1986) **17** *T. jataca* **18** *T. luquillensis* **19** *T. marimutti* (Palacios-Vargas, Ojeda & Christiansen, 1986) **20** *T. maya* **21** *T. millsi* Arlé, 1939 **22** *T. nacionalica* (Palacios-Vargas, Ojeda & Christiansen, 1986) **23** *T. oztotlica* (Ojeda & Palacios-Vargas, 1984) **24** *T. relicta* (Palacios-Vargas, Ojeda & Christiansen, 1986) **25** *T. riopedrensis* **26** *T. separata* (Denis, 1933) **27** *T. strinatii* Yoshii, 1988 **28** *T. subterranea* **29** *T. tijucana* (Arlé & Guimarães, 1979) **30** *T. toroi* (Palacios-Vargas, Ojeda & Christiansen, 1986) **31** *T. variabilis* (Palacios-Vargas, Ojeda & Christiansen, 1986) **32** *T. xtolokensis* (Palacios-Vargas, Ojeda & Christiansen, 1986) **33** *T. yoshiia* (Palacios-Vargas, Ojeda & Christiansen, 1986).

pecially cave forms, have been diagnosed almost exclusively based on characters of the claw complex, mucronal shape and development of the antennae, characters identified as malleable under selective pressures (Christiansen 1961). A new set of characters or character systems, would be needed to perform more reliable phylogenetic analyses. Most other studies addressing the evolution of morphological convergence in cave-adapted arthropods have used molecular data (e.g., Trontelj et al. 2012) to generate phylogenies for hypothesis testing. However, many troglobiontic springtail species are known only from a few individuals from few, seldom visited localities (as is evident from the small number of records reported in Mari Mutt and Bellinger 1990, 1996, and Mari Mutt et al. 2009), which are not suitable or available for molecular analysis. For these species only morphological information can be used to evaluate the evolution of other morphological characters.

Ever since the publication of Gisin's (1967) "systématique ideal," collembolan systematists have assumed that ideochaetotaxic characters are non-adaptive characters that evolve neutrally, are less prone to convergence and, therefore, more valuable for phylogenetic analysis. However, this assumption has never been tested in a phylogenetic context. The simple test performed here supports the traditional view of chaetotaxy as less vulnerable to directional convergence than characters related to claw structure. Analysis based exclusively on putative cave-adaptive characters support a clade comprising cave species from Puerto Rico and Belize, whereas analysis of chaetotaxy alone supports the placement of cave species from Puerto Rico and Belize in independent clades. Despite the clear difference in signal in the character partitions it should be noted that analysis of the complete character set results in higher bootstrap values for what is basically the chaetotaxy-only tree, than when only chaetotactic characters are analyzed. It is clear that some putative adaptive characters retain phylogenetic information concordant with chaetotaxy characters, an observation which argues in favor of the retention of all characters in the analysis. The simple test preformed here has to be expanded to include many more species, to determine if the result obtained are consistent or just an artifact of the sparse taxon sampling. It is unclear if chaetotaxy will provide sufficient characters to resolve relationships in an analysis that includes all species. In any case, there are problems related to the evolution and homology of some chaetotactic characters (e.g., posterior macrochaetae on the meso- and metathorax, and the inner macrochaetae on the fourth abdominal segment) that may be intractable on morphology-based datasets, and will require the use of putatively independent molecular characters.

Habitats

The two new species were found in conditions of similar substrate (*T. jacobyi* sp. n. mean=23.0 °C; *T. giordanoae* sp. n. mean=23.1 °C; W=11, p=0.7200) (Fig. 66) and air temperatures (*T. jacobyi* sp. n. mean=23.7 °C; *T. giordanoae* sp. n. mean=24.3 °C; W=23.5, p=0.3947) (Fig. 67), but *T. jacobyi* sp. n. was found only in complete

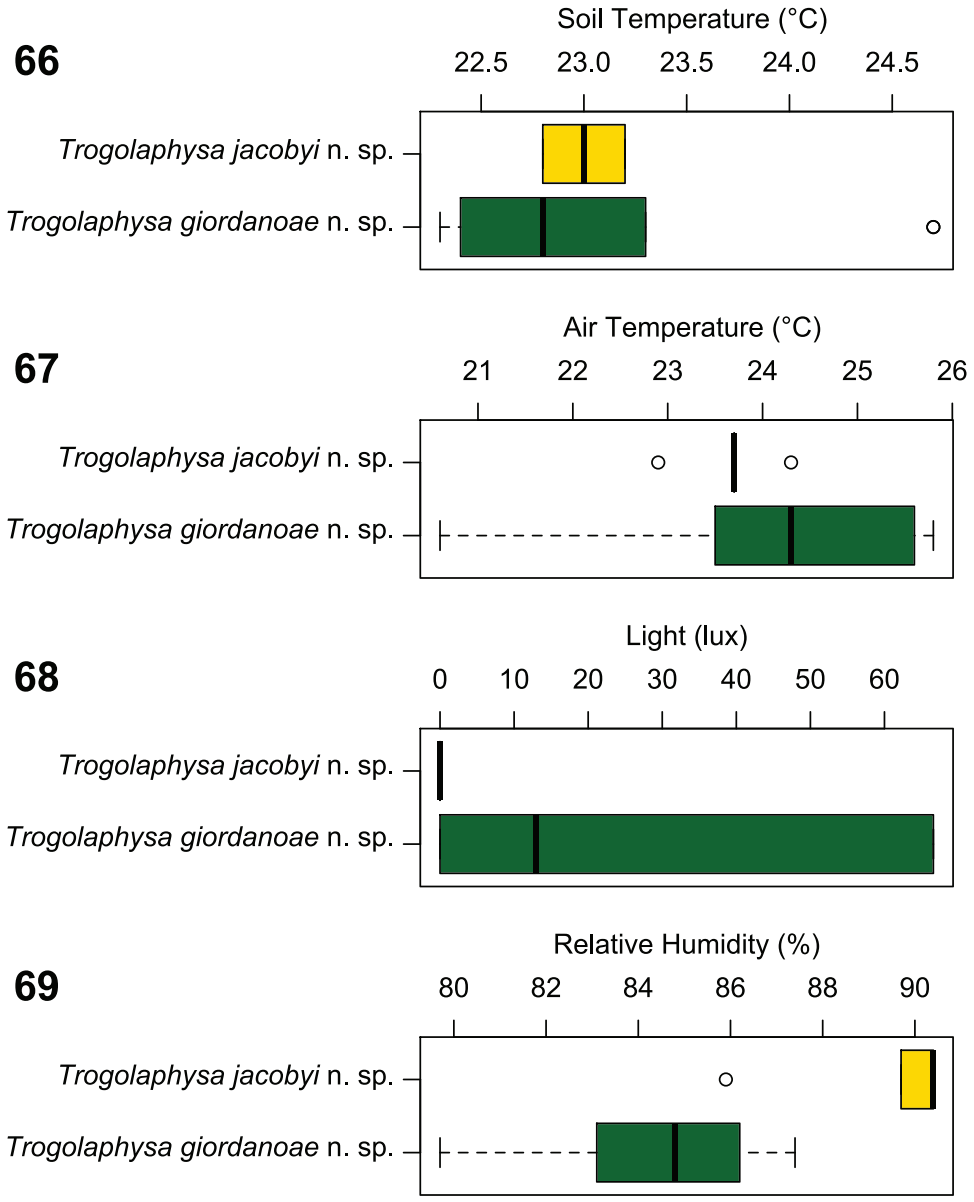


Figure 66–69. Boxplot comparisons of environmental parameters for collections of *Trogolaphysa jacobyi* sp. n. and *Trogolaphysa giordanoae* sp. n. **66** Soil temperature **67** Air temperature **68** Light **69** Relative humidity.

darkness (Fig. 68), whereas *T. giordanoae* sp. n. was found at significantly brighter and varying light conditions, typically in twilight (*T. jacobyi* sp. n. mean=0.0 lux; *T. giordanoae* sp. n. mean=29.5 lux; W=12.5, p=0.0260). *T. jacobyi* sp. n. also was found primarily under conditions of significantly elevated humidity, whereas *T. giordanoae* sp. n. was more varied in the humidity levels at which it was found (*T. jacobyi* sp. n.

mean=89.36 %; *T. giordanoae* sp. n. mean=84.56 %; W=65, p=0.0056) (Fig. 69). In addition, *T. giordanoae* sp. n. was frequently associated with fruit bat guano or other scat (Fig. 23). These observations support our classification of *T. jacobyi* sp. n. as a troglobiont and *T. giordanoae* sp. n. as a guanophile.

Acknowledgements

We thank members of the 2011 Belize biospelology expedition, Michael E. Slay, JoAnn Jacoby, Geoffrey B. Hoese, Jean K. Krejca and Christy M. Slay, who, along with the junior author, collected the species described in this paper. We thank local guides Avelardo Canti, Gabriel Chaco, Germano Coe and Rosalio Sho for taking the field crew to the caves in southern Belize. Bruno Kuppinger facilitated various logistical aspects of the Belize fieldwork. We thank the Belize Institute of Archeology, especially Dr. John Morris, Dr. Jaime J. Awe and George Thompson, and the Belize Forest Department, especially Rasheda M. Garcia and Hector Mai, for their support, advice, permissions and cooperation in undertaking research in the caves of Belize. Phil Walker, Alan Braybrooke and Keith Prufer provided valuable information about study sites. The Subterranean Ecology Institute, Inc. and the National Speleological Foundation provided financial support for fieldwork, and in-kind support was provided by the Illinois Natural History Survey, the University of Illinois, The Nature Conservancy and Zara Environmental, LLC. We thank Jim Nardi for graciously providing access to a polarized light-equipped microscope used to visualize the EOS.

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Appendix I

Character and character states as circumscribed for phylogenetic analysis. (doi: 10.3897/zookeys.323.4950.app1) File format: Microsoft Word document (doc).

Citation: Soto-Adames FN, Taylor SJ (2013) The dorsal chaetotaxy of *Trogolaphysa* (Collembola, Paronellidae), with descriptions of two new species from caves in Belize. ZooKeys 323: 35–74. doi: 10.3897/zookeys.323.4950 Character and character states as circumscribed for phylogenetic analysis. doi: 10.3897/zookeys.323.4950.app1

Appendix II

Data matrix of morphological characters used in the phylogenetic analysis. (doi: 10.3897/zookeys.323.4950.app2) File format: Microsoft Word document (doc).

Citation: Soto-Adames FN, Taylor SJ (2013) The dorsal chaetotaxy of *Trogolaphysa* (Collembola, Paronellidae), with descriptions of two new species from caves in Belize. ZooKeys 323: 35–74. doi: 10.3897/zookeys.323.4950 Data matrix of morphological characters used in the phylogenetic analysis. doi: 10.3897/zookeys.323.4950.app2

ZooKeys 323: 75–89 (2013)
doi: 10.3897/zookeys.323.5684
www.zookeys.org

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Annotated checklist of Albanian butterflies (Lepidoptera, Papilionoidea and Hesperioidea)

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Academic editor: *Carlos Peña* | Received 25 May 2013 | Accepted 6 August 2013 | Published 13 August 2013

Citation: Verovnik R, Popović M (2013) Annotated checklist of Albanian butterflies (Lepidoptera, Papilionoidea and Hesperioidea). ZooKeys 323: 75–89. doi: 10.3897/zookeys.323.5684

Abstract

The Republic of Albania has a rich diversity of flora and fauna. However, due to its political isolation, it has never been studied in great depth, and consequently, the existing list of butterfly species is outdated and in need of radical amendment. In addition to our personal data, we have studied the available literature, and can report a total of 196 butterfly species recorded from the country. For some of the species in the list we have given explanations for their inclusion and made other annotations. Doubtful records have been removed from the list, and changes in taxonomy have been updated and discussed separately. The purpose of our paper is to remove confusion and conflict regarding published records. However, the revised checklist should not be considered complete: it represents a starting point for further research.

Keywords

Balkan Peninsula, review, biodiversity, taxonomy, conservation

Introduction

The Republic of Albania is situated in the Balkan Peninsula, in south-eastern Europe. It is predominantly a mountainous country with a Mediterranean climate, lying entirely within the Mediterranean 'hotspot' zone of biodiversity (Cuttelod et al. 2008). Its fauna and flora is exceptionally rich (MMPAU 2007, Radford et al. 2011, Marka et al. 2012), undoubtedly due to its geographic position, the diversity of its landscape, its complex geology and altitudinal range (from sea level up to 2753 m on Korab peak), but the country

has unquestionably been understudied. This may, in part, be attributed to its political isolation from the rest of Europe during the communist regime. In recent years, however, the situation has changed dramatically, and Albania has become more accessible to outsiders.

As in other European countries, the butterflies of Albania have been studied in more detail than other insect groups. However, there is a considerable disparity between the number of species that have been recorded. Many of these differences can be attributed to doubtful and undocumented records, along with changes in taxonomy and nomenclature. The number of species recorded from Albania varies from 167 (Rebel and Zerny 1931) to 180 (Misja and Kurrizi 1984). These differences are also demonstrated in the most recent lists of species compiled by Fauna Europaea (2012) and the Red Data book of European butterflies (Van Swaay and Warren 1999).

As a result of this confusion, and with the prospect of new surveys, we present a revised checklist of butterflies for Albania, compiled from available literature and personal records. An updated list is essential for further faunistic studies, and provides a foundation for butterfly conservation in Albania. We discuss the species we have excluded but mentioned in previous lists and provide, where necessary, annotations for some species we have included.

A review of the published records

The first comprehensive overview of the butterfly fauna for Albania was compiled by Rebel and Zerny (1931), who listed 167 butterfly species for the country, providing personal records for most of the species. In some instances, most notably *Pontia chloridice* (Hübner, 1813), the list is based on material collected by other researchers or on previously published records. After World War II, research continued, including a German expedition in the 1960s. However, the published results from this survey included only butterflies from the family Hesperiidae (Alberti 1965) and the genus *Erebia* (Popescu-Gorj 1971), and added no new species to the list compiled by Rebel and Zerny (1931). Moucha (1963a, 1963b), who visited the country in 1959, also provided no new additions to the list.

The first local entomologist to publish a list of butterfly fauna was Murraj (1972), and he also compiled an identification key for the 93 listed species. Among these *Carterocephalus palaemon* (Pallas, 1771), *Heteropterus morpheus* (Pallas, 1771), *Muschampia tessellum* (Hübner, 1803), *Coenonympha glycerion* (Borkhausen, 1788), *Melanargia lachesis* (Hübner, 1790) and *Melitaea aurelia* Nickerl, 1850 were the first records for the country. They were not, however, included in any of the subsequent lists or faunistic reports. An updated list of butterfly species for Albania was collated by Misja and Kurrizi (1984), listing 180 species. Several new findings for the country were added, including *Danaus chrysippus* (Linnaeus, 1758) (published also as new for Albania by Luquet and Misja (1989)), *Euphydryas maturna* (Linnaeus, 1758), *Satyrus actaea* (Esper, 1781) and *Pseudochazara mamurra* (Herrich-Schäffer, 1852).

In recent years, further new species have been added by Beshkov (1995) and Abadijev and Beshkov (1996): *Muschampia proto* (Ochsenheimer, 1808), *Hipparchia sen-*

thes (Fruhstorfer, 1908) and *Hipparchia volgensis* (Mazochin-Porshnjakov, 1952). During the authors' survey in south-eastern Albania in July 2012, three more species were discovered: *Colias aurorina* Herrich-Schäffer, 1850, *Pieris balcana* Lorković, 1970 and *Apatura iris* (Linnaeus, 1758) (Verovnik and Popović 2013).

The butterfly fauna of Albania was summarized in the Red data book of European butterflies (Van Swaay and Warren 1999). Kastriot Misja from the Museum of Natural Sciences in Tirana provided the data for Albania. In the overview of distribution there were 173 butterfly species recorded in Albania. Among these, *Euchloe penia* (Freyer, 1852), *Nymphalis vaualbum* ([Denis & Schiffermüller], 1775), *Hipparchia hermione* (Linnaeus, 1764) and *Pseudochazara cingovskii* (Gross, 1973) were important new additions. However, as none of these records was published separately, their inclusion should be regarded as questionable. The credibility of the list is further questioned by several omissions of common species, the absence of *Vanessa cardui* (Linnaeus, 1758) and *Coenonympha pamphilus* (Linnaeus, 1758) being the most obvious examples. The Fauna Europaea (2012) list, which indicates 170 species as present in Albania, has several similar omissions, and a single, more plausible, addition of *Aricia artaxerxes* (Fabricius, 1793).

If we include all published and unconfirmed records, the total number of butterfly species for Albania amounts to 208. This provides a starting point for revision.

The revised checklist of the butterflies of Albania

After a systematic revision of the butterflies recorded for Albania, and having included all recent taxonomic changes, the checklist contains a total of 196 butterflies. The nomenclature follows Van Swaay et al. (2010) and Fauna Europaea (2012). Species marked with an asterisk are discussed in annotations which follow the list.

Family Hesperiidae

1. *Pyrgus malvae* (Linnaeus, 1758)
2. *Pyrgus alveus* (Hübner, [1803])*
3. *Pyrgus armoricanus* (Oberthür, 1910)
4. *Pyrgus serratulae* (Rambur, 1839)
5. *Pyrgus cinarae* (Rambur, 1839)
6. *Pyrgus sidae* (Esper, 1784)
7. *Pyrgus carthami* (Hübner, [1813])
8. *Spialia orbifer* (Hübner, [1823])*
9. *Spialia phlomidis* (Herrich-Schäffer, [1845])
10. *Muschampia proto* (Ochsenheimer, 1808)
11. *Muschampia tessellum* (Hübner, [1803])*
12. *Carcharodus alceae* (Esper, [1780])
13. *Carcharodus lavatherae* (Esper, [1783])

14. *Carcharodus floccifera* (Zeller, 1847)
15. *Carcharodus orientalis* Reverdin, 1913
16. *Erynnis tages* (Linnaeus, 1758)
17. *Erynnis marloyi* (Boisduval, [1834])
18. *Carterocephalus palaemon* (Pallas, 1771)*
19. *Heteropterus morpheus* (Pallas, 1771)*
20. *Thymelicus acteon* (Rottemburg, 1775)
21. *Thymelicus lineola* (Ochsenheimer, 1808)
22. *Thymelicus sylvestris* (Poda, 1761)
23. *Hesperia comma* (Linnaeus, 1758)
24. *Ochlodes sylvanus* (Esper, 1777)
25. *Gegenes nostrodamus* (Fabricius, 1793)
26. *Gegenes pumilio* (Hoffmannsegg, 1804)

Family Papilionidae

27. *Papilio machaon* Linnaeus, 1758
28. *Papilio alexanor* Esper, 1800
29. *Iphiclides podalirius* (Linnaeus, 1758)
30. *Zerynthia cerisy* (Godart, 1824)
31. *Zerynthia polyxena* ([Denis & Schiffermüller], 1775)
32. *Parnassius apollo* (Linnaeus, 1758)
33. *Parnassius mnemosyne* (Linnaeus, 1758)

Family Pieridae

34. *Aporia crataegi* (Linnaeus, 1758)
35. *Pieris brassicae* (Linnaeus, 1758)
36. *Pieris rapae* (Linnaeus, 1758)
37. *Pieris mannii* (Mayer, 1851)
38. *Pieris ergane* (Geyer, [1828])
39. *Pieris balcana* Lorković, 1970
40. *Pieris napi* (Linnaeus, 1758)
41. *Pieris krueperi* Staudinger, 1860
42. *Pontia edusa* (Fabricius, 1777)*
43. *Pontia chloridice* (Hübner, [1813])
44. *Euchloe ausonia* (Hübner, [1804])
45. *Anthocharis cardamines* (Linnaeus, 1758)
46. *Anthocharis gruneri* Herrich-Schäffer, [1851]
47. *Colias aurorina* Herrich-Schäffer, 1850
48. *Colias hyale* (Linnaeus, 1758)*

49. *Colias alfacariensis* Ribbe, 1905
50. *Colias croceus* (Fourcroy, 1785)
51. *Gonepteryx rhamni* (Linnaeus, 1758)
52. *Gonepteryx cleopatra* (Linnaeus, 1767)
53. *Gonepteryx farinosa* (Zeller, 1847)
54. *Leptidea sinapis* (Linnaeus, 1758)
55. *Leptidea duponcheli* (Staudinger, 1871)

Family Riodinidae

56. *Hamearis lucina* (Linnaeus, 1758)

Family Lycaenidae

57. *Thecla betulae* (Linnaeus, 1758)
58. *Favonius quercus* (Linnaeus, 1758)
59. *Satyrium acaciae* (Fabricius, 1787)
60. *Satyrium ilicis* (Esper, 1779)
61. *Satyrium spini* ([Denis & Schiffermüller], 1775)
62. *Satyrium w-album* (Knoch, 1782)
63. *Satyrium pruni* (Linnaeus, 1758)
64. *Callophrys rubi* (Linnaeus, 1758)
65. *Lycaena phlaeas* (Linnaeus, 1761)
66. *Lycaena dispar* (Haworth, 1802)
67. *Lycaena virgaureae* (Linnaeus, 1758)
68. *Lycaena ottomanus* (Lefèbvre, 1830)
69. *Lycaena tityrus* (Poda, 1761)
70. *Lycaena alciphron* (Rottemburg, 1775)
71. *Lycaena thersamon* (Esper, 1784)
72. *Lycaena candens* (Herrich-Schäffer, 1844)*
73. *Lampides boeticus* (Linnaeus, 1767)
74. *Leptotes pirithous* (Linnaeus, 1767)
75. *Tarucus balkanica* (Freyer, 1844)
76. *Cupido argiades* (Pallas, 1771)
77. *Cupido decolorata* (Staudinger, 1886)
78. *Cupido minimus* (Fuessly, 1775)
79. *Cupido osiris* (Meigen, 1829)
80. *Celastrina argiolus* (Linnaeus, 1758)
81. *Glaucopsyche alexis* (Poda, 1761)
82. *Phengaris alcon* ([Denis & Schiffermüller], 1775)
83. *Phengaris arion* (Linnaeus, 1758)

84. *Iolana iolas* (Ochsenheimer, 1816)
85. *Scolitantides orion* (Pallas, 1771)
86. *Pseudophilotes vicrama* (Moore, 1865)
87. *Plebejus sephirus* (Frivaldzky, 1835)
88. *Plebejus argyrognomon* (Bergsträsser, 1779)
89. *Plebejus argus* (Linnaeus, 1758)
90. *Plebejus idas* (Linnaeus, 1761)
91. *Aricia eumedon* (Esper, [1780])
92. *Aricia agestis* ([Denis & Schiffermüller], 1775)
93. *Aricia artaxerxes* (Fabricius, 1793)*
94. *Aricia anteros* (Freyer, 1838)
95. *Cyaniris semiargus* (Rottemburg, 1775)
96. *Polyommatus damon* ([Denis & Schiffermüller], 1775)
97. *Polyommatus ripartii* (Freyer, 1830)
98. *Polyommatus admetus* (Esper, [1783])
99. *Polyommatus escheri* (Hübner, [1823])
100. *Polyommatus amandus* (Schneider, 1792)
101. *Polyommatus thersites* (Cantener, 1835)
102. *Polyommatus dorylas* ([Denis & Schiffermüller], 1775)
103. *Polyommatus daphnis* ([Denis & Schiffermüller], 1775)
104. *Polyommatus coridon* (Poda, 1761)
105. *Polyommatus bellargus* (Rottemburg, 1775)
106. *Polyommatus icarus* (Rottemburg, 1775)
107. *Polyommatus eros* (Ochsenheimer, 1808)*

Family Nymphalidae

108. *Libythea celtis* (Laicharting, 1782)
109. *Danaus chrysippus* (Linnaeus, 1758)
110. *Charaxes jasius* (Linnaeus, 1767)
111. *Apatura iris* (Linnaeus, 1758)
112. *Apatura ilia* ([Denis & Schiffermüller], 1775)
113. *Limenitis reducta* Staudinger, 1901
114. *Neptis rivularis* (Scopoli, 1763)
115. *Nymphalis antiopa* (Linnaeus, 1758)
116. *Nymphalis polychloros* (Linnaeus, 1758)
117. *Nymphalis xanthomelas* (Esper, 1781)
118. *Aglais io* (Linnaeus, 1758)
119. *Aglais urticae* (Linnaeus, 1758)
120. *Vanessa atalanta* (Linnaeus, 1758)
121. *Vanessa cardui* (Linnaeus, 1758)
122. *Issoria lathonia* (Linnaeus, 1758)

123. *Polygonia c-album* (Linnaeus, 1758)
124. *Polygonia egea* (Cramer, 1775)
125. *Argynnis pandora* ([Denis & Schiffermüller], 1775)
126. *Argynnis paphia* (Linnaeus, 1758)
127. *Argynnis aglaja* (Linnaeus, 1758)
128. *Argynnis adippe* ([Denis & Schiffermüller], 1775)
129. *Argynnis niobe* (Linnaeus, 1758)
130. *Brenthis hecate* ([Denis & Schiffermüller], 1775)
131. *Brenthis daphne* (Bergsträsser, 1780)
132. *Brenthis ino* (Rottemburg, 1775)
133. *Boloria pales* ([Denis & Schiffermüller], 1775)
134. *Boloria graeca* (Staudinger, 1870)
135. *Boloria titania* (Esper, [1793])
136. *Boloria euphrosyne* (Linnaeus, 1758)
137. *Boloria dia* (Linnaeus, 1767)
138. *Melitaea cinxia* (Linnaeus, 1758)
139. *Melitaea phoebe* ([Denis & Schiffermüller], 1775)
140. *Melitaea didyma* (Esper, 1779)
141. *Melitaea trivia* ([Denis & Schiffermüller], 1775)
142. *Melitaea athalia* (Rottemburg, 1775)
143. *Melitaea aurelia* Nickerl, 1850*
144. *Euphydryas maturna* (Linnaeus, 1758)
145. *Euphydryas aurinia* (Rottemburg, 1775)
146. *Melanargia galathea* (Linnaeus, 1758)
147. *Melanargia russiae* (Esper, [1783])
148. *Melanargia larissa* (Geyer, [1828])
149. *Hipparchia syriaca* (Staudinger, 1871)*
150. *Hipparchia fagi* (Scopoli, 1763)
151. *Hipparchia volgensis* (Mazochin-Porshnjakov, 1952)
152. *Hipparchia semele* (Linnaeus, 1758)*
153. *Hipparchia senthes* (Fruhstorfer, 1908)
154. *Hipparchia fatua* Freyer, 1844
155. *Hipparchia statilinus* (Hufnagel, 1766)
156. *Chazara briseis* (Linnaeus, 1764)
157. *Pseudochazara geyeri* (Herrich-Schäffer, [1846])
158. *Pseudochazara anthelea* (Hübner, [1824])
159. *Pseudochazara mniszechii* (Herrich-Schäffer, [1851])*
160. *Pseudochazara amymone* Brown, 1976*
161. *Satyrus ferula* (Fabricius, 1793)
162. *Minois dryas* (Scopoli, 1763)
163. *Brintesia circe* (Fabricius, 1775)
164. *Arethusana arethusa* ([Denis & Schiffermüller], 1775)
165. *Erebia ligea* (Linnaeus, 1758)

166. *Erebia euryale* (Esper, [1805])
167. *Erebia epiphron* (Knoch, 1783)
168. *Erebia aethiops* (Esper, 1777)
169. *Erebia triarius* (de Prunner, 1798)
170. *Erebia medusa* ([Denis & Schiffermüller], 1775)
171. *Erebia gorge* (Hübner, [1804])
172. *Erebia rhodopensis* Nicholl, 1900
173. *Erebia cassioides* (Reiner & Hochenwarth, 1792)*
174. *Erebia ottomana* Herrich-Schäffer, [1847]
175. *Erebia pronoe* (Esper, [1780])
176. *Erebia melas* (Herbst, 1796)
177. *Erebia oeme* (Hübner, [1804])
178. *Erebia pandrose* (Borkhausen, 1788)
179. *Maniola jurtina* (Linnaeus, 1758)
180. *Hyponephele lycaon* (Rottemburg, 1775)
181. *Hyponephele lupinus* (Costa, 1836)
182. *Aphantopus hyperantus* (Linnaeus, 1758)
183. *Pyronia tithonus* (Linnaeus, 1767)
184. *Pyronia cecilia* (Vallantin, 1894)
185. *Coenonympha rhodopensis* Elwes, 1900*
186. *Coenonympha pamphilus* (Linnaeus, 1758)
187. *Coenonympha arcania* (Linnaeus, 1761)
188. *Coenonympha orientalis* Rebel, 1910
189. *Coenonympha leander* (Esper, 1784)
190. *Coenonympha glycerion* (Borkhausen, 1788)
191. *Pararge aegeria* (Linnaeus, 1758)
192. *Lasiommata megera* (Linnaeus, 1767)
193. *Lasiommata petropolitana* (Fabricius, 1787)
194. *Lasiommata maera* (Linnaeus, 1758)
195. *Kirinia roxelana* (Cramer, 1777)
196. *Kirinia climene* (Esper, [1783])

Annotations to the list

The status of the following species is clarified. They are numbered according to their order in the checklist:

2. *Pyrgus alveus*
Rebel and Zerny (1931) listed *Pyrgus bellieri* Oberthür, 1910 for Albania. This is a western Mediterranean species whose presence in the Balkan Peninsula is highly doubtful. Alberti (1965) noted that the record is confirmed by dissection of the genitalia, thus it would be important to check its presence at Mt. Beshtriq (Mt. Pashtrik). At present most of the Pasthrik mountain is situated in Kosovo, not in Albania.

8. *Spialia orbifer*
Spialia sertorius (Hoffmannsegg, 1804) was listed for Albania by Misja and Kurrizi (1984). The Red Data book of European butterflies (Van Swaay and Warren 1999) lists both *S. sertorius* and *S. orbifer* for Albania. The south-eastern limit of *S. sertorius* in Europe is the northern Adriatic coast and Krk island in Croatia (Jakšić 1988, Habeler 2003), thus its presence in Albania is highly unlikely.

11. *Muschampia tessellum*
The species is listed for Albania only by Murraj (1972), and confirmation of this record is needed. It is known to occur in neighbouring northern Greece (Pamperis 2009) and from the Republic of Macedonia (Schaider and Jakšić 1989); therefore, its presence in the south-eastern part of Albania is possible.

18. *Carterocephalus palaemon*
The species is listed for Albania only by Murraj (1972) and requires confirmation. It is known from southern Serbia (Popović and Đurić 2011) and was recently discovered in Macedonia (Verovnik and Micevski 2008), thus its presence in the mountains of northern Albania is plausible.

19. *Heteropterus morpheus*
The species is listed for Albania only by Murraj (1972), and confirmation of the record is required. It is known to occur in the northern part of Montenegro (Sijarić et al. 1984) and in all probability is present in the mountainous parts of north-west Albania.

42. *Pontia edusa*
Its sister species *Pontia daplidice* (Linnaeus, 1758) is mentioned in several recent and historical lists (Rebel and Zerny 1931, Murraj 1972, Misja and Kurrizi 1984). The separate species status of *P. edusa*, which occurs in Eastern Europe, was not widely accepted until recently. *P. daplidice* is now credited as only flying in western part of Europe, not reaching the Balkan Peninsula. However, recent records from Cyprus indicate the possibility of a much wider distribution of *P. daplidice* in Europe (John et al. 2013).

48. *Colias hyale*
Records from this far South in the Balkan Peninsula are doubtful, and possibly refer to *C. alfacariensis*. Nevertheless, the species does occur in central Serbia (Popović and Đurić 2011), and due to its migratory habit could potentially reach the northern part of Albania.

72. *Lycaena candens*
This species is listed for Albania only in Fauna Europaea (2012). However, the historical records for *L. hippothoe* made by earlier authors (Rebel and Zerny 1931, Murraj 1972, Misja and Kurrizi 1984) should, in all probability, be referred to as *L. candens*. It

is highly unlikely that *L. hippothoe* is found in Albania, as the closest confirmed records are from northern Bosnia (Lorković and Mihljević 1988) and north-western Serbia (Popović and Đurić 2011).

93. *Aricia artaxerxes*
Apart from its inclusion in Fauna Europaea (2012), the presence of this species in Albania has not appeared in any published record. During our surveys, we found the species on the north-western slopes of Mt. Grammos in 2012, confirming its presence in Albania.

107. *Polyommatus eros*
Only the subspecies *P. eros eroides* (Frivaldszky, 1835) is known to occur in Albania. The nominate subspecies could potentially be found in the calcareous high mountains on the border with Montenegro, where it is known from the Durmitor Mts. (Sijarić et al. 1984). Based on molecular studies, *Polyommatus eroides* has recently been downgraded to subspecies rank, due to a lack of genetic differentiation from *P. eros* (Vodolazhsky and Stradomsky 2008, Wiemers et al. 2010).

143. *Melitaea aurelia*
The species is mentioned for Albania only by Murraj (1972), and confirmation of the record is required. It has recently been found in the Republic of Macedonia (Micevski et al. 2009), also near the Albanian border on Mt. Galičica (Krpač et al. 2011). Its presence in Albania is very probable.

149. *Hipparchia syriaca*
Although mentioned as a separate species by Rebel and Zerny (1931), the taxon was incorrectly listed as *H. alcyone* (Murraj 1972, Misja and Kurrizi 1984) or *H. hermione* in subsequent lists (Van Swaay and Warren 1999). Gaskin (1990) and Beshkov (1995) correctly identified *Hipparchia syriaca* (Staudinger, 1871) as the species from this taxon group present in Albania.

152. *Hipparchia semele*
The exact distribution of this species in the southern and eastern part of the Balkan Peninsula is unknown, and the presence of two additional morphologically, almost indistinguishable, species, *H. volgensis* and *H. senthes*, makes identification difficult. Both these species have been recorded for Albania (Beshkov 1995, Abadijev and Beshkov 1996). The presence of *H. semele* in the mountains of the north-western part of the country is likely, and needs to be checked by future surveys.

159. *Pseudochazara amymone*
Although its status as a species is questionable, we follow the decision taken by Van Swaay et al. (2010), to treat it as a separate species. Its presence in southern Albania was recently reported by Eckweiler (2012). However, it was first reported from Albania as *P. mamurra* by Misja and Kurrizi (1984).

160. *Pseudochazara mniszechii*
Based on external morphology and genitalia, the taxon *Pseudochazara tisiphone* (Brown, 1980) from northern Greece and Albania is considered to be conspecific with *P. mniszechii* (Hesselbarth et al. 1995). It was originally described by Brown (1980) as a subspecies of *P. cingovskii* (Gross, 1973) from Greece, and is listed as such for Albania by Van Swaay and Warren (1999). The first detailed records for Albania are mentioned in Tshikolovets (2011) from the environs of Korçë and Kolonjë.

173. *Erebia cassioides*
Erebia cassioides is included for Albania only in the list of Red Data book of European butterflies (Van Swaay and Warren 1999). However, some of the records for *Erebia tyndarus* (Esper, 1781) – in particular those of the f. *macedonica*, recorded by Rebel and Zerny (1931) – are actually records of *Erebia cassioides*. Two subspecies of *Erebia cassioides* are listed for Albania in the literature: *illyrica* Lorković, 1953 and *illyromacedonica* Lorković, 1953. *Erebia cassioides illyrica* is known from Bosnia and Hercegovina, Montenegro and the northern Albanian Alps, while *Erebia cassioides illyromacedonica* is mentioned for Macedonia, from the mountains on the border with Albania: Shar, Korab and Jakupica Mts. (Sijarić et al. 1984).

185. *Coenonympha rhodopensis*
Coenonympha tullia (Muller, 1764) is listed for Albania by early authors (Rebel and Zerny 1931, Murraj 1972, Misja and Kurrizi 1984), who did not consider *C. rhodopensis* as a separate species. *C. rhodopensis* was also observed during our survey on Mt. Grammos in 2012.

Discussion

In comparison with countries in other parts of Europe, the butterfly fauna of Albania is very rich. Greece, which has been more intensively studied over the years, hosts 235 species of butterflies (Pamperis 2009) and has the most diverse butterfly fauna in the Balkan Peninsula. After recent surveys, however, the Republic of Macedonia, with 203 species (Verovnik and Micevski 2008, Micevski et al. 2009, Verovnik et al. 2010) and Serbia, with 198 species (Dinca et al. 2010, Popović and Đurić 2010, Popović and Milenković 2012, Popović et al. in press, Popović unpublished data), are not far behind. Montenegro, which in terms of landmass is much smaller, is the least studied of Albania's neighbouring countries, with around 160 recorded species (Sijarić 1984).

There are several additional species listed for Albania in the available literature that have not been included in the current checklist: *Melanargia lachesis* (Hübner, 1790), listed by Murraj (1972), and *Satyrus actaea* (Esper, 1781), recorded by Misja and Kurrizi (1984), are both exclusively western European species; therefore, their presence in Albania is highly unlikely. Two species, *Euchloe penia* (Freyer, 1852) and *Nymphalis vaualbum* ([Denis & Schiffermüller], 1775), are listed only in the Red

Data book of European butterflies (Van Swaay and Warren 1999). Both of them are remarkable species, and their occurrence in Albania, in all probability, would have been published separately. However, we can find no reference to them in the available literature. Therefore, they are currently not listed for Albania, but their presence cannot be entirely ruled out.

Certainly, the list of Albanian butterflies is far from complete. There are several species that are known to be present just across the border in neighbouring countries, and are likely to occur in Albania. *Apatura metis* Freyer, 1829 is one obvious example. It is known from north-western Greece (Mairiaux and Hutsebaut 1997) and Skadar Lake in Montenegro (Jakšić 1988) near the border with Albania. Another interesting species that is expected to be found in Albania is *Cacyreus marshalli* (Butler, 1898), which has been recently been reported from the Croatian coast (Kosmač and Verovnik 2009) and Greece (Anastassiu et al. 2010). We hope that our contribution will initiate more interest in the diverse butterfly fauna of Albania and trigger further butterfly studies in this country.

Acknowledgements

The authors are deeply thankful to Stoyan Beshkov for providing valuable missing literature. We wish to express our thanks to Milan Đurić, Dirk Maes, Bosse van Swaay, Chris van Swaay, Irma Wynhoff, Arthur van Dijk, and Martina Šašić for their companionship during our surveys in Albania. We thank Martin Gascoigne-Pees and David Withrington for improving the English of the final version of the text.

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ZooKeys 323: 91–97 (2013)
doi: 10.3897/zookeys.323.5440
www.zookeys.org

RESEARCH ARTICLE

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First record of the twostripe goby, *Valenciennea helsdingenii* (Gobiidae, Gobiiformes) from the southeast coast of India

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Academic editor: *Nina Bogutskaya* | Received 30 April 2013 | Accepted 18 June 2013 | Published 14 August 2013

Citation: Kannan K, Sureshkumar K, Ranjith L, Joshi KK, Madan MS, John S (2013) First record of the twostripe goby, *Valenciennea helsdingenii* (Gobiidae, Gobiiformes) from the southeast coast of Indiae. ZooKeys 323: 91–97. doi: 10.3897/zookeys.323.5440

Abstract

Two specimens of *Valenciennea helsdingenii* (Bleeker, 1858) were collected off Punnakayal coast, from Gulf of Mannar, southeast coast of India in November 2012. The morphometric and meristic characters of the recorded specimens are described and discussed. This is the first record of the species from the Indian waters that is a range extension of its known range within the Indian Ocean.

Keywords

Gobiidae, Bay of Bengal, Tuticorin, geographical range, Gulf of Mannar

Introduction

The Gobiidae constitute one of the largest families of percomorph fishes. The family has a total of over 1,640 species belonging to six subfamilies (Pezold 1993, Hoese and Larson 1994, Nelson 2006).These subfamilies are distributed in reef environments of the Indian and Pacific oceans, which are home to the greatest diversity of gobiid fishes. Recent re-evalutaion of gobioid systematic using molecular methods resulted in six

family clade-based classification for the family Gobiidae that includes all the genera of the former subfamilies (Thacker 2003, 2009, 2011, Ruber and Agorreta 2011). The gobiine genus *Valenciennea* has 15 recognised species, including *V. helsdingenii* that is one of larger sized species with the documented maximal total length of 25 cm (Kuiter 1993). Prior to the discovery of the material reported on in this paper, the known range of *V. helsdingenii* included the Marquesas Islands, Japan, the Philippines, Indonesia, New Britain, the Solomon Islands, the Great Barrier Reef and New South Wales, Australia, Saudi Arabia, Maldives, Seychelles, and southern Africa (Hoese and Larson 1994, Lieske and Myers 1994, Clark et al. 2000, Randall et al. 1990, Randall et al. 1997). In India, about 150 species of gobiids have been reported (Day 1876, Jones and Kumaran 1980, Murty 2002) but the finding of *V. helsdingenii* represents the first occurrence of the species from the southeast coast of India and an extension of its range within the Indian Ocean.

Material and methods

Two specimens of *V. helsdingenii* (Bleeker, 1858) (Fig. 1) were collected from the Punnakayal fish landing centre located about 15 km south of major port town of Tuticorin on 16 November 2012. The capture location was in the Gulf of Mannar (8°38'127"N, 78°12'612"E), 20 km southeast of Tuticorin (Fig. 2) at a depth of 30 to 50 m by a drift gill net operated from traditional fishing craft. The specimens were preserved in 5% formalin and brought to the laboratory for a detailed examination. Morphometric measurements were taken to the nearest millimeter using digital calipers according to Hubbs and Lagler (1958). The specimens are deposited in the National Marine Biodiversity Referral Museum at the Central Marine Fisheries Research Institute, Cochin.

Results

***Valenciennea helsdingenii* (Bleeker, 1858)**
http://species-id.net/wiki/Valenciennea_helsdingenii

Material examined. Two specimens of *V. helsdingenii* (Bleeker, 1858) of SL 97 mm (GB.31.66.230.1) and 145 mm (GB.31.66.230.1.1) were deposited in the Designated National Repository, Central Marine Fisheries Research Institute, Cochin, India.

Description. The body is elongate and compressed, the tongue adnate, the head is slightly compressed. The pelvic fins are completely separated, no membrane is present between the first and the second dorsal fins. The first dorsal fin is shallow and its margin rounded, the fourth spine is slightly longer than the other spines, and the caudal fin is deeply emarginate. The specimens have a pair of elongated caudal fin filaments that makes the caudal fin a peculiar shape as typical for the species. Specimens above 70 mm SL show the presence of the elongated caudal fin filaments (Hoese and Larson

Figure 1. *Valenciennea helsdingenii*, 145 mm SL from the Gulf of Mannar, southeast coast of India.

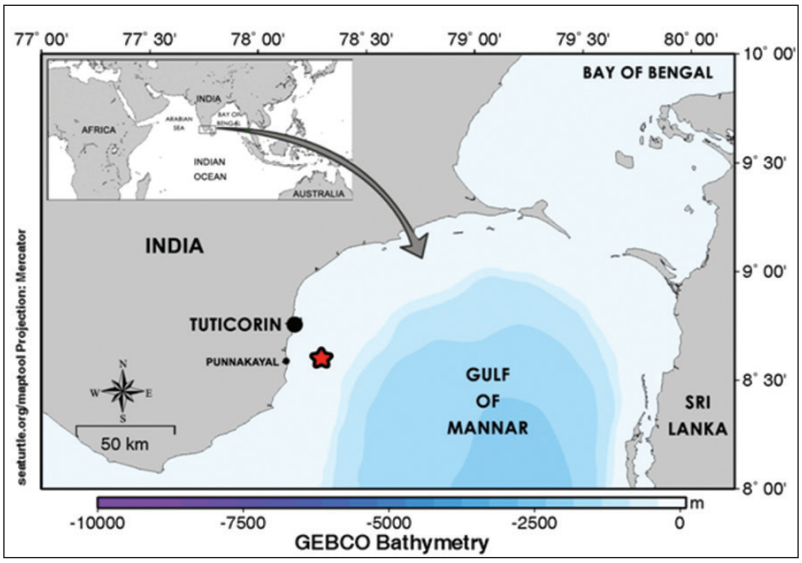

Figure 2. Capture location of *Valenciennea helsdingenii* (red star) in the Gulf of Mannar, southeast coast of India.

1994). Body is covered with ctenoid scales while anteriorly under the middle of the first dorsal fin and on the belly th scale are cycloid; sides of the nape and the pectoral base are scaled; the prepelvic area are naked; the longitudinal-scale count is 142; the transverse-scale count is 40.

Colour. Overall colouration is similar to that described by Hoese and Larson (1994). The top of the head and the dorsal surface of the body are brownish gray; the rest of the head and the body is white to pale gray.

The body has two dark red stripes, the dorsal stripe extending from the front of the snout through the eye and just above the pectoral base and along the upper body to the tip of the upper caudal filament; the ventral stripe runs parallel to the first stripe, beginning at the side of the upper lip, extending across the upper part of the preoperculum and middle of the operculum, over middle of the pectoral base, continuing on the body behind the pectoral base, and reaching the tip of the lower caudal filament. The colour of

Table 1. Morphometric and meristic characters of *Valenciennea helsdingenii* from the Gulf of Mannar, southeast coast of India.

Morphometric measurements	GB.31.66.230.1		GB.31.66.230.1.1	
	mm	% SL	mm	% SL
Standard length (SL)	97	–	145	–
Head length (HL)	23	23.7	37	25.5
Eye diameter	4	4.1	5	3.4
Postorbital length	12	12.4	19	13.1
Upper jaw length	10	10.3	16	11.0
Lower jaw length	9	9.3	15	10.3
Preorbital length	9	9.3	14	9.7
Predorsal length	32	33.0	48	33.1
Prepectoral length	27	27.8	45	31.0
Prepelvic length	27	27.8	42	29.0
Preanal length	56	57.7	86	59.3
Body depth (max.)	17	17.5	26	17.9
Caudal peduncle length	16	16.5	25	17.2
Caudal peduncle width	11	11.3	15	10.3
Distance between anal fin and anus	2	2.1	4	2.8
Distance between pelvic fin and anal fin	29	29.9	45	31.0
Fin-ray counts				
First dorsal	VI		VI	
Second dorsal	I11		I12	
Pectoral	22		22	
Pelvic	6		6	
Anal	I11		I12	
Segmented caudal	17		17	
Branched caudal	13		13	

the stripes is dark red to reddish brown, darkest anteriorly, and the stripes on the caudal filaments are outlined in white. The eye is yellowish white dorsally and ventrally with a reddish brown stripe through the middle, and the lower lip is white. The first dorsal fin possesses a large oval black spot extending between the third and the fifth dorsal spines.

Remarks. *Valenciennea helsdingenii* is easily distinguished from other species of the genus in having two dark red stripes from the snout to the tip of the caudal fin, stripes on the caudal-fin filaments outlined in white and the presence of filamentous caudal rays in adults. The species was first described as *Eleotriodes helsdingenii* by Bleeker (1858), based on specimens collected from Pulau-Pulaus Gorong, Indonesia.

Discussion

Hoese and Larson (1994) revised Indo-Pacific gobiid fishes and described seven new species from this area. Among these species,*V. helsdingenii* shows wide distribution from

Southern Red sea, east Africa to Indonesia and Japan to the Great Barrier Reef (Clark et al. 2000, Lieske and Myers 1994, Randall et al. 1990). *Valenciennea sexguttata* (Valenciennes, 1837) was distributed along the Red sea, Persian Gulf, East Africa and Australia (Hoese and Larson 1994). The species like *Valenciennea longipinnis* (Lay & Bennett, 1839) and *Valenciennea muralis* (Valenciennes, 1837) were widely distributed in the eastern Indian Ocean. *Valenciennea parva* (Hoese & Larson, 1994), *Valenciennea strigata* (Broussonet, 1782) and *Valenciennea puellaris* (Tomiyama, 1956) were distributed in the Indo-Pacific from Red Sea to the Great Barrier Reef. The species *Valenciennea wardii* (Playfair, 1867) is rare and distributed in widely scattered localities in the Indian Ocean (Hoese and Larson 1994). Other species of this genus show narrow ranges. Distribution of *Valenciennea alleni* (Hoese & Larson, 1994) is restricted to the Australian coast whereas *Valenciennea bella* (Hoese & Larson, 1994) occurs along the coast of Japan and Philippines (Hoese and Larson 1994). *Valenciennea immaculata* (Ni, 1981) is distributed along the coast of Taiwan, Hongkong, the Philippines and Australia (Randall et al. 2004) and *V. limicola* (Hoese & Larson, 1994) occurs along the coast of Thailand and Fiji (Allen and Adrim 2003).

The nearest known record of *V. helsdingenii* is from the Maldives. The present report adds to our knowledge of species diversity of Gobiidae from the Bay of Bengal, and it assumes that the Bay of Bengal contains as many species as the entire western Indian Ocean. The long stretch of coral islands along the Gulf of Mannar and Andaman Nicobar Islands increases the chance of species abundance and richness in the Bay of Bengal. During recent years, great numbers of new fish species have been described and recorded from the east coast of India (Kannan et al. 2012, Joshi et al. 2012, Zacharia and Kannan 2012).

Acknowledgements

The authors are grateful to Dr G. Syda Rao, Director, Central Marine Fisheries Research Institute (CMFRI) Cochin, to colleagues from Tuticorin Research Centre of CMFRI, and fisherfolk of Punnakayal fishing village. Online GIS program MAPTOOL, provided by SEATURTLE. ORG is also acknowledged.

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