RESEARCH ARTICLE



# A new species of Ceratoteleas Kozlov (Hymenoptera, Scelionidae) from Japan, with a description of the male of Ceratoteleas

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# Abstract

Ceratoteleas cornus sp. n. is described from Japan. The male of the genus is described for the first time.

#### Keywords

Taxonomy, Teleasinae, East Asia

# Introduction

*Ceratoteleas* Kozlov, 1965 is a monotypic genus belonging to Teleasinae (Scelionidae) (Johnson 1992). The genus is closely related to *Teleas* Latreille (Kozlov 1965), but differs in the presence of the bidentate metanotal spine (sometimes even tridentate in *Teleas*) and the presence of horn on T1 (not always present in *Teleas*). *Ceratoteleas bidentatus* Kozlov 1965, the type species of *Ceratoteleas*, was described from Russian Far East based on 8 females (Kozlov 1965; Kononova and Kozlov 2001). Hereby we represent a new *Ceratoteleas* species based on 42 specimens collected from Honshu Is. and Kyushu Is., Japan.

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#### Materials and methods

Specimens examined are deposited in the Entomological Laboratory, Kyushu University, Fukuoka. The following abbreviations were used for collecting methods: MT – Malaise trap; YPT – yellow pan trap.

Morphological terminology and measurements mainly follow Mikó et al. (2007, 2010). Postacetabulum is defined as the area on the mesopectus that is delimited anteriorly by the acetabular carina, dorsally by the anterior margin of mesopectus and the mesopleural carina, posteriorly by the ventral mesopleural carina. The description of surface sculpture follows Eady (1968) and Harris (1979), and terms of wing venation follow Masner (1980). Abbreviations used for additional measurements are as follows: A2-6 – length of female antennomere 2–6; A5L – length of male antennomere 5; A5W – apical width of male antennomere 5; ty – length of tyloid in antenomere 5.

#### Taxonomy

#### Key to species (female)

1	Gena striate; A3 as long as A2; mesoscutellum with transverse	se carina; T3
	longitudinally striate	Kozlov, 1965
-	Gena areolate; A3 longer than A2; mesoscutellum without tran	sverse carina;
	T3 areolate <i>C</i> .	<i>cornus</i> sp. n.

#### Ceratoteleas cornus sp. n.

http://zoobank.org/5F194C56-510A-44F8-BD8D-54BB4F495A98

**Description.** *Female* (*n* = 5): Length = 2.00–2.50 mm (*m* = 2.28, SD = 0.20).

*Color* (Figs. 1A, C). Body dark brown; interantennal process, A1–2, meso- and metapleura (Fig. 1C) brown; radicle, mandible and legs yellow.

*Head.* FCI = 1.27–1.38 (m = 1.33, SD = 0.04); LCI = 1.55–1.78 (m = 1.61, SD = 0.10); DCI = 2.09–2.30 (m = 2.14, SD = 0.09); HW/IOS = 1.50–1.68 (m = 1.62, SD = 0.07); head about 1.2 times as wide as mesosoma (HW/TSL = 1.17–1.24, m = 1.21, SD = 0.03). Frons (Fig. 2A) dorsoventrally costate with dense long setae; orbital band absent; frontal patch absent; central keel present dorsally; antennal scrobe smooth, without setae; torular triangle smooth; POL as long as OOL (POL/OOL = 0.89–1.00, m = 1.00, SD = 0.06); OOL about 2 times as long as LOL (OOL/LOL = 1.80–2.25, m = 2.00, SD = 0.18); interantennal process (Fig. 1C) angular, forming right angle ventrally. Vertex costate with dense long setae; interocellar space rugose; hyperoccipital carina absent; vertex patch absent; Eyes with sparse setae. Malar region costate with dense setae; facial striae extending to top of eye; orbital carina present. Gena areolate with dense setae; genal patch absent. A1 (Fig. 2B) about 8 times as long as radicle (A1/r = 7.75–8.75, m = 8.25, SD = 0.45), 1.4 times as long as clava (A1/cl = 1.35–1.38, m =

1.35, SD = 0.01), about 16 times as long as A6 (A1/A6 = 15.50–17.50, m = 16.50, SD = 0.89); A2 3.5 times as long as A6 (A2/A6 = 3.50); A3 longest among A2–6, about 4.5 times as long as A6 (A3/A6 = 4.50–5.00, m = 4.50, SD = 0.27); A4 about 3.5 times as long as A6 (A4/A6 = 3.50–4.00, m = 3.50, SD = 0.27); A5 as long as A6 (A5/A6 = 1.00). Mandible tridentate; median tooth small, posterior tooth largest.

Mesosoma. Pronotal suprahumeral sulcus foveolate with long setae; epomial carina present; cervical pronotal area areolate with dense setae, sculpture finer laterally; lateral pronotal area smooth dorsally, weakly rugulose ventrally. Mesoscutum (Fig. 2C) about 1.4 times as wide as long (TSL/ML = 1.37-1.52, m = 1.43, SD= 0.06), areolate with dense long setae; mesoscutal suprahumeral sulcus finely sulcate; mesoscutal humeral sulcus finely sulcate; antero-admedian line absent; notaulus absent. Mesoscutellum (SW/SL = 2.20-2.64, m = 2.55, SD = 0.18), areolate with dense long setae; scutoscutellar sulcus present; axillular carina extending posteriorly as a spine; median mesoscutellum without spine; posterior scutellar sulcus present. Femoral depression (Fig. 2D) transversally costate-areolate; mesopleural carina present; postacetabular sulcus present; postacetabulum areolate with dense setae; postacetabular patch absent; sternaulus absent; mesepimeral sulcus weakly foveolate; speculum smooth dorsally, costate ventrally; prespecular sulcus absent. Metanotal trough foveolate; metascutellum areolate, with bidentate spines; metascutellar carina present. Metapleural sulcus deeply impressed; dorsal metapleural area areolate; ventral metapleural area smooth dorsally, areolate laterally and ventrally; paracoxal sulcus absent; metapleural epicoxal sulcus absent; metapleural epicoxal carina absent; metapleural triangle areolate; prespiracular propodeal area modified to tooth; lateral propodeal carina present; lateral propodeal area areolate-rugose; metasomal depression foveolate; plica poorly defined; posterior propodeal projection present; plical area areolate-rugose, with dense setae. Legs (Fig. 1C) robust. Protibia with dense setae; anterior part of protibia with dense spines. Mesotibia with dense setae; anterior part of mesotibia with dense spines. Metafemur swollen; metatibia with dense setae; anteroapical part of metatibia with dense spines. Fore wing (Fig. 1A) extending to apical metasoma, about as wide as mesoscutum (TSL/WW = 1.02-1.30, m = 1.18, SD = 0.10); marginal vein about 2.3 times as long as stigmal vein (m/st = 2.17-2.67, m = 2.33, SD = 0.19). Hind wing extending to posterior margin of metasoma, about 5.5 times as wide as length of marginal cilia at widest point (HWW/HWS = 5.40-6.25, m = 5.50, SD = 0.34).

*Metasoma.* T1 about 0.7 times as wide as T1+T2 length (T1W/T1+T2L = 0.71– 0.81, m = 0.74, SD = 0.04), areolate, convex anterodorsally, as short horn. T2 areolate; basal depressions on T2 unclear; lateral patch of T2 present, with dense setae. T3 (Fig. 2E) about 1.4 times as wide as long (T3W/T3L = 1.41–1.49, m = 1.45, SD = 0.03), about 1.3 times as wide as mesoscutum (T3W/TSL = 1.18–1.29, m = 1.28, SD = 0.04), areolate, with dense setae laterally, smooth medially; basal depressions on T3 absent; lateral patch of T3 absent; posterodorsal patch of T3 absent; apical setae on T3 absent. S3 (Fig. 2F) deeply punctate with dense setae; basal depressions on S3 absent. T4 areolate with dense long setae; median patch on T4 absent; lateral patch of T4 absent. T5 areolate with dense long setae; lateral patch of T5 absent. T6 puncutulate with dense long setae; lateral patch of T6 absent.



**Figure 1.** *Ceratoteleas cornus* sp. n. **A** female, dorsal view **B** male, dorsal view **C** female, lateral view **D** male, lateral view. Scale bars = 1 mm.

*Male* (n = 5): Length = 1.88–2.25 mm (m = 2.13, SD = 0.15)*Color* (Fig. 1B, D) similar to female, but lighter.

*Head.* FCI = 1.37-1.47 (m = 1.43, SD = 0.04); LCI = 1.40-1.67 (m = 1.50, SD = 0.10); DCI = 2.00 - 2.29 (m = 2.15, SD = 0.10); HW/IOS = 1.43-1.47 (m = 1.45, SD = 0.02); head about 1.3 times as wide as mesosoma; (HW/TSL = 1.20-1.30, m = 1.25, SD = 0.04). Antennal scrobe (Fig. 3A) absent; POL shorter than OOL (POL/OOL = 0.67-0.75, m = 0.69, SD = 0.03); OOL about 4 times as long as LOL (OOL/LOL = 3.25-4.00, m = 4.00, SD = 0.41); interantennal process (Fig. 1D) circular, forming right angle ventrally. Vertex costate–smooth, with dense setae. Clypeus smooth. Gena



**Figure 2.** *Ceratoteleas cornus* sp. n., female. **A** head, anterior view **B** antennae **C** mesosoma, dorsal view **D** mesosoma, lateral view **E** metasoma, dorsal view **F** metasoma, ventral view.

areolate–costate with dense setae; genal patch absent. A1 about 5.3 times as long as radicle (A1/r = 5.00-5.50, m = 5.25, SD = 0.25); A5 (Fig. 3B) about 6.7 times as long as wide (A5L/A5W = 6.33-7.33, m = 6.67, SD = 0.38), 3.8 times as long as tyloid (A5L/ty = 3.50-4.00, m = 3.80, SD = 0.22).

*Mesosoma*. Cervical pronotal area areolate with dense setae; lateral pronotal area smooth dorsally, areolate ventrally. Mesoscutum (Fig. 3C) about 1.3 times as wide as long (TSL/ML = 1.32-1.43, m = 1.33, SD= 0.04), with sparse setae; notaulus weakly



**Figure 3.** *Ceratoteleas cornus* sp. n., male. **A** head, anterior view **B** antennae **C** mesosoma, dorsal view **D** mesosoma, lateral view **E** metasoma, dorsal view **F** metasoma, ventral view.

present; inter notaular area areolate with sparse setae; lateral notaular area smooth– sparsely punctate. Mesoscutellum about 2.3 times as wide as long (SW/SL = 2.14-2.38, m = 2.25, SD= 0.10), areolate with dense setae laterally, smooth dorsally; scutoscutellar sulcus foveolate–sulcate; posterior mesoscutellar sulcus foveolate. Metascutellum shorter than female, with weak bump medially. Metanotal trough (Fig. 3D) foveolate– sulcate. Metasomal depression rugose. Legs (Fig. 1D) slightly robust. Setae and spines of tibiae shorter than female. Fore wing (Fig. 1D) long, exceeding to apical mesosoma, wider than mesoscutellum (TSL/WW = 0.67-0.69, m = 0.69, SD = 0.01); marginal vein about 2.8 times as long as stigmal vein (m/st = 2.44-3.00, m = 2.78, SD = 0.27). Hind wing long, exceeding to apical mesosoma, about 6 times as wide as length of marginal cilia at widest point (HWW/HWS = 5.60-6.50, m = 6.00, SD = 0.32).

*Metasoma.* T1 about 0.4 times as wide as T1+T2 length (T1W/T1+T2L = 0.38– 0.54, m = 0.41, SD = 0.06), longitudinally costate–areolate. T2 costate; basal depressions on T2 unclear. T3 (Fig. 3E) about 1.5 times as wide as long (T3W/T3L = 1.41–1.59, m = 1.50, SD = 0.07), about 1.2 times as wide as mesoscutum (T3W/ TSL = 1.13–1.23, m = 1.20, SD = 0.04), costate–finely areolate, with sparsely deeply punctate sculpture and setae; lateral patch of T3 present, with dense setae. S3 (Fig. 3F) sparsely deeply punctate with dense setae. T4 costate–finely areolate, with sparsely deeply punctate sculpture and setae; lateral patch of T4 present, with dense setae. T5 areolate, with sparsely deeply punctate sculpture and setae; lateral patch of T5 absent. T6 punculate with dense long setae; lateral patch of T6 absent.

**Material examined** (See also Suppl. material 2: Specimens data in DarwinCore format.). **Holotype female:** Fukuoka Pref.: Fukuoka city, Mt. Tachibana-yama (prim. evergr. for.), 20. V. – 9. VI. 1979, K. Yamagishi leg. (YPT). **Paratypes:** Hiroshima Pref.: Hatsukaichi city, Yoshiwa vill., Kanmuri Highlands (weed lands), 21. VI. 2015, Y. Komeda leg.,  $2\overline{\bigcirc}$  (YPT); Fukuoka Pref.: Fukuoka city, Mt. Tachibana-yama (Pond), 11. IX. 1993, H. Honda leg.,  $2\overline{\bigcirc}$  (YPT); 18. IX. 1993,  $1\overline{\bigcirc}12$  (YPT); 7. V. 1994,  $1\overline{\bigcirc}$  (YPT); 12. VI. 1994,  $1\overline{\bigcirc}$  (YPT); 18. VI. 1994,  $7\overline{\bigcirc}32$  (YPT); 25. VI. 1994,  $1\overline{\bigcirc}$  (YPT); 2. VII. 1994,  $6\overline{\bigcirc}$  (YPT); Soeda town, Mt. Hiko-san, 13. V. 1955, T. Esaki, K. Yasumatsu & Y. Hirashima leg.  $1\overline{\bigcirc}$  (with white determination label; "*Trisacantha* Det. L. Masner, 1974"); 14. VI. 1969, K. Kanmiya leg.  $1\overline{\bigcirc}$ ; 31. V. 1971, K. Takeno leg.,  $1\overline{\bigcirc}$ ; 26. VI – 4. VII. 2008, T. Mita & S. Sato leg.,  $1\overline{\bigcirc}$  (MT); 2–9, VII, 2008, T. Mita & S. Sato leg.,  $1\overline{\bigcirc}$  (MT); 2–9, VII, 2008, T. Mita & S. Sato leg.,  $1\overline{\bigcirc}$  (YPT).

**Distribution.** Japan (Honshu: Hiroshima; Kyushu: Fukuoka, Ôita). **Etymology.** The species name refers to a horn of T1.

# Discussion

Kozlov (1965) established the monotypic genus *Ceratoteleas*, based on *C. bidentatus* Kozlov, 1965. *Ceratoteleas cornus* is the second species of this genus. These two species are similar in areolate mesoscutum and mesoscutellum, and bidantate metanotal spines. However, they can be devided by the sculpture of gena and T3 (striate in *C. bidentatus*; areolate in *C. cornus*), and the ratio of antenomeres lengths (A3 as long as A2 in *C. bidentatus*; A3 longer than A2 in *C. cornus*).

Masner (1976) has recorded *Trisacantha* Ashmead, 1887 from Japan based on a specimen deposited in Entomological Laboratory of Kyushu University. We examined the voucher specimen, and found that the specimen belongs to *C. cornus*. Also, *Trisacantha* is most likely restricted to the Nearctic: in Masner (1980), the distribution of that is only Nearctic. Therefore, Japan is excluded from the distribution of *Trisacantha*.

Diagnostic futures of Ceratoteleas are the bidentate metanotal spine (female and male) and the presence of T1 horn (female). Komeda et al. (2015) redescript three species of Teleas; T. strigatus Kozlov, 1965, T. sulcatus (Kozlov, 1961) and T. tridentatus (Kozlov, 1961). One of diagnostic futures between male of T. strigatus and T. sulcatus is shape of the metanotal spine: triangular (T. strigatus) or tridentate (T. sulcatus). Also, that between female of T. strigatus and T. tridentatus is absence (T. strigatus) or weakly presence (T. tridentatus) of the T1 horn. In addition, Fabritius (1970) synonymized Proteleas Kozlov, 1961 because diagnostic futures of it (scutellum with lateral tooth; metanotal spine tridentate; marginal vein 2-2.5 times as long as stigmal; T1 with areolate sculpture) are also common to some species of *Teleas*. Therefore, the shape of metanotal spine and the presence of T1 horn should not regarded as generic diagnosis, but specific. Masner (1976) mentioned another two genera, Gryonella Dodd, 1914 and Echinoteleas Risbec, 1954, which also have bidentate (Gryonella) or tridentate (Echinoteleas) metanotal spine. Diagnostic characters of Teleas and Gryonella are common to Ceratoteleas. Echinoteleas differs from Teleas in presence of transverse carina on strongly convex mesoscutellum. But Masner (1976) indicated that Gryonella might be a synonym of Teleas, and *Echinoteleas* might be a synonym of *Teleas* or *Trisacantha* because of molphorogical similarities. Reevaluation of these genera are required to recognize correctly them.

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#### References

- Eady RD (1968) Some illustrations of microsculpture in the Hymenoptera. Proceedings of the Royal Entomological Society of London Series A 43: 66–72. doi: 10.1111/j.1365-3032.1968.tb01029.x
- Fabritius K (1970) Die Gattung *Teleas* Latr. 1805 in Rumaenien (Hymenoptera: Scelionidae). Nachrichtenblatt der Bayerischen Entomologen 19: 17–22.
- Harris RA (1979) A glossary of surface sculpturing. Occasional Papers in Entomology, State of California Department of Food and Agriculture 28: 1–33.
- Johnson NF (1992) Catalog of world Proctotrupoidea excluding Platygastridae. Memoirs of the American Entomological Institute 51: 1–825.

- Komeda Y, Hirowatari T, Yamagishi K (2015) Three Species of the Genus *Teleas* Latreille (Hymenoptera: Platygastridae) Newly Recorded from Japan. Japanese Journal of Systematic Entomology 21(1): 183–190.
- Kononova SV, Kozlov MA (2001) [Scelionidae (Hymenoptera) of Palearctic. Subfamilies Teleasinae, Baeinae.] Akademperiodika, Kiev, 438 pp. [In Russian]
- Kozlov MA (1965) [On the Teleasinae and Telenominae (Hymenoptera, Scelionidae) of the USSR.] Entomologicheskoye Obozreniye 44: 616–621. [In Russian]
- Masner L (1976) Revisionary notes and keys to world genera of Scelionidae (Hymenoptera: Proctotrupoidea). Memoirs of the Entomological Society of Canada 97: 1–97. doi: 10.4039/entm10897fv
- Masner L (1980) Key to genera of Scelionidae of the Holarctic region, with descriptions of new genera and species (Hymenoptera: Proctotrupoidea). Memoirs of the Entomological Society of Canada 113: 1–54. doi: 10.4039/entm112113fv
- Mikó I, Masner L, Deans AR (2010) World revision of Xenomerus Walker (Hymenoptera: Platygastroidea, Platygastridae). Zootaxa 2708: 1–73.
- Mikó I, Vilhelmsen L, Johnson NF, Masner L, Pénzes Z (2007) Skeletomusculature of Scelionidae (Hymenoptera: Platygastroidea): head and mesosoma. Zootaxa 1571: 1–78.

# Supplementary material I

#### URI table of HAO morphological terms

Authors: Yoto Komeda, Toshiharu Mita, Kenzo Yamagishi

Data type: specimens data

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## Supplementary material 2

## Specimens data in DarwinCore format

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Data type: specimens data

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# Calosoma aethiops (Jeannel, 1940) as a new synonym of Calosoma imbricatum hottentotum Chaudoir, 1852, a new status of Calosoma roeschkei Breuning, 1927, and a revision of the Calosoma senegalense group sensu Häckel, 2012 (Coleoptera, Carabidae, Carabini)

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# Abstract

*Calosoma aethiops* (Jeannel, 1940) as a new synonym of *Calosoma imbricatum hottentotum* Chaudoir, 1852, a new status of *Calosoma roeschkei* Breuning, 1927, and a revision of the *Calosoma senegalense* group sensu Häckel, 2012 (Coleoptera: Carabidae: Carabini). Conducted is a taxonomic revision of the *Calosoma senegalense* group sensu Häckel, 2012. Placed in the group sensu stricto are four species: *C. planicolle* Chaudoir, 1869, *C. scabrosum* Chaudoir, 1843, *C. senegalense* Dejean, 1831, and *C. strandi* Breuning, 1934. *Calosoma aethiops* Jeannel, 1940 is synonymized with *C. imbricatum hottentotum* Chaudoir, 1852, and *C. roeschkei* Breuning, 1927 is newly regarded as a subspecies of *C. scabrosum*. The taxonomic conclusions are based on morphometry of the holotypes and 10 male and 10 female specimens of each taxon, and on morphology of the aedeagus including inflated endophalus.

#### Keywords

Carabidae, Carabinae, Calosoma, new synonymy, Africa

# Introduction

*Calosoma* is the second most speciose genus of the subfamily Carabinae, with 168 (Lorenz 2005), 128 (Bruschi 2013) or 129 (Häckel 2013) species described from all zoogeographic regions. Most species are excellent fliers widely distributed on all continents and numerous islands, but some are secondarily brachypterous or apterous with narrow distributions (Bruschi 2013, Häckel 2012). Some species inhabit more zoogeographic regions, and some extend to a neighboring continent that belongs in the same zoogeographic region (Häckel 2012). Examples of such distributions are some species of the *C. maderae* group (*C. imbricatum* subgroup sensu Häckel 2013) and of the *C. senegalense* group (*C. senegalense* subgroup sensu Häckel 2013), which inhabit the area of the Horn of Africa. The distributions are probably to some extent responsible for the unsettled situation in the species-level taxonomy of the group (Bruschi 2013, Häckel 2012, 2013, Häckel & Farkač 2012), a part of which this paper attempts to resolve. At the same time it respects the recent supraspecific classification (Häckel 2013), which in light of the known genetic analyses (Su et al. 2005) does not support the traditional subgeneric divisions.

# Material and methods

The classification of the group is based primarily on external structural details of the adult, with species-level taxonomy relying also on structural details of the expanded endophalus. The aedeagi were dissected, preserved, studied dry and glued on cards appended beneath the dissected specimens. For study of the endophalus, the aedeagus was soaked 48 hours in 1:1 solution of water and 8% acetic acid, and then the endophalus was inflated using a small Heavy Duty (12V) compressor normally used to inflate tires, set at medium pressure. Fixation of the endophalus morphology was secured by slow drying on a portable electric (220V) single-plate heater, and the whole aedeagus-endophalus preparation was then glued on a paper card. The preparations were photographed by Canon G10 Digital Compact in macrophoto regime with flash. Aedeagi were photographed in the right lateral view, with details of their tips also slanted at an angle.

Inspected and evaluated were the following morphometric parameters of the holotypes and 20 samples (10 males and 10 females) of each species:

- a) total length of the adult including mandibles (TL),
- b) maximum head width including eyes to maximum pronotal width ratio (WP/WH),
- c) maximum pronotal length to maximum width ratio (WP/LP),
- d) maximum elytral length to maximum width ratio (LE/WE).

Subjective evaluations included also differences in termination of the aedeagus (apex) and of the inflated endophalus. Measured were morphometric parameters of 10 males and 10 females of the following taxa: *C. planicolle, C. scabrosum scabrosum, C. scabrosum roeschkei, C. senegalense, C. strandi* (all taxa belong to *C. senegalense* group),

and *C. imbricatum imbricatum* from populations inhabiting the Afrotropical region (including Oman and Yemen on the Arab peninsula) and *C. imbricatum hottentotum* (*C. maderae* group, *C. imbricatum* subgroup). Measured holotypes include *C. scabrosum* (Chaudoir), *C. scabrosum roeschkei* (Breuning), *C. imbricatum hottentotum* (Chaudoir) and *C. aethiops* (Jeannel).

The material examined is housed in the collections listed below:

cMNHN	Muséum national d'Histoire naturelle, Paris, France
cNBCL	National Biodiversity Center, Leiden, Netherlands
cNMP	Národní muzeum, Prague, Czech Republic
cFAR	Jan Farkač collection, Prague, Czech Republic
cHAC	Martin Häckel collection, Hostivice, Czech Republic
cSEH	Rostislav Sehnal collection, Unhošť, Czech Republic
cWRA	David W. Wrase collection, Berlin, Germany

# Systematic part

# C. senegalense species group (sensu Häckel 2013):

C. senegalense subgroup (= C. senegalense group s. str.)

# Calosoma (Calosoma) planicolle Chaudoir, 1869

Plate 4: Fig. 4

*Calosoma planicolle* Chaudoir, 1869: 369 (type loc. "près du Zambéze", type in cMNHN). *Calosoma procerum* Harold, 1880: 260 (type loc. "Taita District, Kenya Colony, Ukamba"), syn. sn. Breuning 1927: 188.

- *C.* (*Ctenosta*) *planicolle* Breuning, 1927: 188. Lapouge 1932: 415; Deuve 1978: 250; Culot 1990: 9; Lorenz 2005: 68; Bruschi 2013: 132.
- Ctenosta (s. str.) planicolle Jeannel, 1940: 130. Rougemont 1976: 248; Vigna Taglianti and Bruschi 1986: 22.

Calosoma (s. str.) planicolle Häckel, 2013: 30.

**Material studied. BOTSWANA.** 1♂, 3♀: Ngamiland district, ne. of Maun, Tamalakane (cHAC).

**KENYA.** 1♂, 1♀: Tsavo, Mtitoanday (cSEH); 1♂, 1♀: Eastern 729, Sosoma, 202 km E of Thika (cSEH).

**MOZAMBIQUE.** 1<sup>Q</sup>: Sofala province, 30 km S Caia (cSEH).

**Namibia.** 1♂: Kavango reg., Okavango river, Rundu, 1050 m (cHAC); 1♂, 1♀: Caprivi reg., Bagani- Popa Falls (cHAC).

Zambia. 1 d: Southern Prov., Livingstone env., Victoria Falls (cHAC).

**Zimbabwe.** 1♂, 2♀: Midlands Prov., Kwekwe env. 20 km w. Ngezi Park (cHAC); 1♂, 1♀: Matabeleland Prov., 60 km N of Bulawayo, Marapoosa road (cHAC); 2♂: Masvingo province, 95 km NE Beitbridge, Bubi river (cSEH)

**Distribution.** Angola, Botswana, Democratic Congo, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mozambique, Republic of South Africa, Somalia, Tanzania, Swaziland, Uganda, Zambia, Zimbabwe.

#### Calosoma (Calosoma) scabrosum scabrosum Chaudoir, 1869

Plate 1: Fig. 1. Plate 2: Figs 1–2. Plate 4. Fig. 1.

Calosoma scabrosum Chaudoir, 1843: 745 (type loc. "Kordofan").

Calosoma kordofanum [Kollar in litt.] syn. sn. Chaudoir 1852: 100.

- *Calosoma (Ctenosta) scabrosum* Breuning, 1927: 185. Lapouge 1932: 414; Deuve 1978: 250; Culot 1990: 9; Lorenz 2005: 68; Bruschi 2013: 127.
- Ctenosta (s. str.) scabrosum Jeannel, 1940: 128. Rougemont 1976: 247; Vigna Taglianti and Bruschi 1986: 21.
- Calosoma (Ctenosta) jakli Häckel, Farkač & Sehnal, 2005: 2 (type loc. "Oman: Dho-far"), syn. sn. Häckel et al., 2010: 11.

Calosoma (s. str.) scabrosum Häckel, 2012: 57. Häckel 2013: 31.

Type material. *Calosoma scabrosum* Chaudoir, 1869. 1∂ labelled "HOLOTYPE / Ex Musaeo Chaudoir / Ctenosta scabrosum (Chd.) P. Basilewsky vid. 1992 (cM-NHN); 1∂ labelled "SW Asia, S Oman, Dzhopar Prov., Al Mughsayi vill. env., 0–50 m a.s.l., VIII.1999, lgt. S. Jákl / HOLOTYPE Calosoma jakli det. Häckel, Farkač & Sehnal, 2005 / Calsoma scabrosum det. Häckel, Farkač & Sehnal, 2010" (cHAC).

**Other material studied. Djibouti.** 1*<sup>(2)</sup>*: "Obock" (cNMP).

**Oman.** 5♀: Dzhophar Prov., Takwa env., 50 m a.s.l. (cFAR, cHAC, cSEH); 1♀: rd. Al Mughsayi – Salalah, ca 3 km from Mughsayi, 20 m a.s.l. (cFAR); 1♀: Dhophar Province, Takwa env., 200 m a.s.l. (cKAL); 3♂, 2♀: Dzhofar prov., Wadi Nashib, 24 km E Salalah (cHAC, cSEH); 5♂: Dzhofar prov., Wadi Nashib, 20 km E Salalah (cHAC, cSEH).

**SENEGAL** (Niger or Chad probably). 1<sup>Q</sup>: "Senegal" (cNMP).

Yemen. 1∂: NW Al Mukhallā: N: 14°37';/ E: 49°03' Kawr Saybān Mtn. (cHÄC).

**Distribution.** Chad, Djibouti, Eritrea, Ethiopia, Kenya, Niger, Nigeria, Oman, Somalia, South Sudan, Tanzania, Yemen. Data from Burundi, Rwanda and Uganda need confirmation.

# Calosoma (Calosoma) scabrosum roeschkei Breuning, 1927

Plate 1: Fig. 2. Plate 2: Fig. 3. Plate 3: Fig. 3. Plate 4: Fig. 2.

Calosoma (Ctenosta) scabrosum roeschkei Breuning, 1927: 185 (type loc. "Usambara"). Ctenosta (s. str.) aethiops (partim) Jeannel, 1940: 128 (loc. "Diré-Daoua"); Rougemont 1976: 247. Vigna Taglianti and Bruschi 1986: 21. Ctenosta (s. str.) orientale (partim) Jeannel, 1940: 129 (loc. "Érythrée: Tessenei"). Ctenosta (s. str.) scabrosum var. roeschkei Jeannel, 1940: 128. Calosoma (Ctenosta) aethiops Culot, 1990: 9. Lorenz 2005: 68. Calosoma (s. str.) scabrosum Häckel, 2012: 57. Häckel 2013: 31. Calosoma (Ctenosta) roeschkei Bruschi, 2013: 129.

**Type material**. *Calosoma roeschkei* Breuning, 1927. 1♂ labelled "Usambara"(cNBCL). **Other material studied. Kenya.** 1♂, 1♀: E of Garsen, W of Witu (cSEH); 2♂, 1♀: S of Voi (cHAC); 1♂, 1♀: Taita prov. Sagala Hills, Voi env. (cHAC); 1♂: Tsavo East, Voi Lodge, 3.23S/38.34E (cWRA); 1♀: NE prov. El Wak (cHAC); 1♂, 1♀: Modo Gashi to Wajir (cHAC); 2♂, 2♀: Coast province, Garissa, N of Bura (cHAC, cSEH), 1♂: Amboseli National Park (cSEH); 2♀: Eastern 729, Sosoma, 202 km E of Thika (cSEH). **Sudan.** 1♂, 1♀: Vad Medani (cSEH).

Geographic distribution. Chad, Kenya, Somalia, Sudan, Tanzania.

## Calosoma (Calosoma) senegalense Dejean, 1831

Plate 4: Fig. 5

Calosoma sengalense Dejean, 1831: 562 (type loc. "Sénegal").

Calosoma mossambicense Klug, 1853: 247 (type loc. "Téte"). C. (Ctenosta) senegalense mossambicense Breuning, 1927: 187.

Ctenosta senegalense Motschulsky, 1865: 306.

- Calosoma (Ctenosta) senegalense Breuning, 1927: 187. Lapouge 1932: 415. Deuve 1978: 247; Culot 1990: 9; Lorenz 2005: 68; Bruschi 2013. 131.
- Ctenosta (s. str.) senegalense Jeannel, 1940: 129. Rougemont 1976: 248; Vigna Taglianti and Bruschi 1986: 21.

Calosoma (s. str.) senegalense Häckel, 2012: 58, 64; 2013: 31.

**Material studied. Botswana.**  $1 \Diamond$ ,  $1 \Diamond$ : Ngamiland district, ne. of Maun, Tamalakane (cHAC).

**Ethiopia.**  $1 \diamondsuit, 1 \updownarrow$ : Gambela region, Gambela env., 400 m (cHAC).

**Ghana.**  $1^{\circ}_{\circ}, 1^{\circ}_{\odot}$ : Northern Prov., West Gonja district, Damongo env. (cHAC).

**Kenya.**  $1 \triangleleft$ ,  $1 \triangleleft$ : Coast Prov., Taita-Taveta Co., s. of Voi (cHAC).

**Madagascar.** 1♂, 2♀: Toliara prov., Ampanihy district, Ejeda env. (c FAR, cHAC); 1♂, 1♀: Mahajanga Prov., Ampatika env., Mahajamba river (cHAC).

**Namibia.** 1 $\mathcal{C}$ : Caprivi reg., Bagani- Popa Falls; 1 $\mathcal{P}$ : Khomas region, 40 km e. Windhoek (airport) (cHAC).

**Senegal.**  $1 \diamondsuit, 1 \updownarrow$ : Thiès region, M'bour department, Saly Portudal (cHAC).

**Tanzania.** 1 $\overline{\Diamond}$ : Arusha reg., Mto Wa Mbu env. (cHAC); 1 $\bigcirc$ : Morogoro region, Mikumi (cHAC). **Zimbabwe.** 1 $\overline{\Diamond}$ : 20 km NE Shamva, Nyagui river (cHAC).

**Distribution.** Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cabo Verde Islands, Chad, Congo, Côte d'Ivoire, Democratic Congo, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Guinea Equatorial, Kenya, Lesotho, Li-



Plate I. Type material (habitus in dorsal aspect, male). Scale bar equals 10 mm. I *C. scabrosum scabro*sum (holotype) 2 *C. scabrosum roeschkei* (holotype) 3 *C. imbricatum hottentottum* (holotype of *Ctenosta aethiops* Jeannel, 1940) 4 *C. imbricatum hottentottum* (holotype).



Plate 2. Material studied (habitus in dorsal aspect, male). I C. scabrosum scabrosum (Djibouti: Obock)
2 C. scabrosum scabrosum (Oman: Dhofar, holotype of C. jakli Häckel, Farkač & Sehnal, 2005) 3 C. scabrosum roeschkei (Kenya: Voi env.) 4 C. imbricatum hottentottum (Namibia: Okahandja). Scale bar equals 10 mm.

beria, Madagascar, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Republic of Central Africa, Republic of South Africa, Rwanda, Senegal, Sierra Leone, Somalia, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe.



**Plate 3.** Aedeagi of *C. imbricatum hottentotum* (Namibia) and *C. scabrosum roeschkei* (Kenya) compared with aedeagus of "*C. aethiops*" (holotype). **I** *C. imbricatum hottentottum* (Namibia: Okahandja); a – aedeagus with expanded endophalus in right lateral view, b – the same in left lateral view, c – the same in anterior view **2** *C. imbricatum hottentottum* (holotype of *Ctenosta aethiops* Jeannel, 1940) aedeagus in left lateral view, **3** *C. scabrosum roeschkei* (Kenya: Voi env.), a – aedeagus with expanded endophalus in right lateral view, c – the same in anterior view.

## Calosoma (Calosoma) strandi Breuning, 1934

Plate 4: Fig. 3.

Calosoma (Ctenosta) strandi Breuning, 1934: 38 (type loc. "Masaua"). Culot 1990: 9; Lorenz 2005: 68; Bruschi 2013: 130.

Ctenosta (s. str.) strandi Jeannel, 1940: 130. Rougemont 1976: 244; Vigna Taglianti and Bruschi 1986: 21.

Calosoma (s. str.) strandi Häckel, 2013: 31.

**Material studied. Kenya.** 83, 69: North-Eastern Prov., El Wak. (cFAR, cHAC, cSEH); 23, 49: Eastern Prov. Marsabit to South Horq (cFAR, cHAC, cSEH).

Distribution. Eritrea, Ethiopia, Kenya, Somalia.

#### C. maderae species group (sensu Häckel 2013)

C. imbricatum subgroup

#### Calosoma (Calosoma) imbricatum imbricatum Klug, 1832

- Calosoma imbricatum Klug, 1832: pl. IX. (type loc. "Cap Vert"). Calosoma (Caminara) imbricatum Breuning, 1927: 221. Caminara (Caminara) imbricata Lapouge 1932: 410, Jeannel 1940: 104. Culot 1990: 7; Lorenz 2005: 69; Bruschi 2013: 76, Häckel 2013: 24.
- Caminara arabica Motschulsky, 1865: 304. Caminara imbricata arabica Lapouge 1932: 410.

Calosoma (Caminara) loffleri Mandl, 1953: 57.

Calosoma (Caminara) loffleri m. rufoapendiculata Mandl, 1967: 44.

Calosoma (Caminara) linnavouri Mandl, 1970: 61.

**Material studied. Kenya.**  $1 \Diamond$ ,  $1 \bigcirc$ : Marsabith to South Orr (cHAC).

**Oman.** 8♂, 8♀: Wadi Qitbit, 150m (cFAR, cHAC, cSEH).

**Senegal.** 1♀: Senegal (cHAC).

**Sudan.**  $1 \stackrel{\frown}{\odot}$ : Port Sudan (cHAC).

**Distribution.** Algeria, Cabo Verde Islands, Canarian Islands, Chad, Djibuti, Egypt, Eritrea, Ethiopia, western India, Iran, Iraq, northern Kenya, Kuwait, Libya, Mali, Niger, Oman, Pakistan, Saudi Arabia, Senegal, Somalia, Sudan, United Arab Emirates, Yemen.

#### Calosoma (Calosoma) imbricatum hottentotum Chaudoir, 1852

Plate 1: Figs 3–4. Plate 2: Fig. 4. Plate 3: Figs 1–2. Plate 4. Fig. 6.

*Calosoma hottentotum* Chaudoir, 1852: 99 (type loc. "Cap de bonne-Espérance"). Deuve 1978: 249.

*Calosoma (Caminara) imbricatum hottentotum* Breuning, 1927: 221. Mandl 1970: 61, 62; Culot 1990: 7; Lorenz 2005: 69; Bruschi 2013: 76.

Caminara (Caminara) imbricata hottentota Lapouge, 1932: 410. Jeannel 1940: 105.

*Ctenosta* (s. str.) *aethiops* Jeannel, 1940: 127 (type loc. "Azbin, à 20 km. d'Agadès, dans l'Aïr"), **new synonym.** 

Calosoma (s. str.) imbricatum hottentotum Häckel, 2013: 24.

**Type material.** 1 labelled "LECTOTYPE / Ex Musaeo Chaudoir / Calosoma hottentotum Lectotype Chaud. 1852 Th. Deuve det, 1978" (cMNHN); 1 labelled



Plate 4. Aedeagi of *C. senegalense* species group (sensu Häckel 2012: 30) and *C. imbricatum hottentotum* (Namibia). a – aedeagus with expanded endophalus in right lateral view, b – same in left lateral view, c – same in anterior view 1 *C. scabrosum scabrosum* (Oman: Dhofar) 2 *C. scabrosum roeschkei* (southeastern Kenya: Voi env.) 3 *C. strandi* (northeastern Kenya: El Wak) 4 *C. planicolle* (Namibia: Kavango) 5 *C. senegalense* (Zimbabwe: Shamva) 6 *C. imbricatum hottentottum* (Namibia: Okahandja).

# "MUSEUM PARIS AZBIN (AIR) REG. de TINTABORAC 20 K E d' AGADÈS CAPde POSTH 1908 / HOLOTYPE / aethiops n. sp. Jeannel det." (cMNHN). **Other material studied. Kenya.** 1♂, 1♀: Amboseli National Park (cSEH).

**Namibia.** 2<sup>(3)</sup>, 2<sup>(2)</sup>: Omaruru (cHAC); 5<sup>(3)</sup>, 3<sup>(2)</sup>: Okahandja, Gross Bamen (cHAC, cSEH); 1<sup>(2)</sup>: Otjivarongo (cSEH); Gobabis-Aranos (cSEH); 1<sup>(3)</sup>: Maltahohe (cSEH).

**Republic of South Africa.**  $1^{\circ}, 3^{\circ}$ : Northern Cape Province, SW Kimberley, 13 km SW Ritchie (cHAC).

Distribution. Southern Kenya, Namibia, Tanzania, Republic of South Africa.

# **Comments on classification**

Our study shows the following:

1. Termination (apex) of the aedeagus. We have found no difference in shape of the apex among species or subspecies within the same group, the shape is distinct only among species belonging to different groups. The apex of *C. imbricatum* (narrower

and sharper, Plate 3: Figs 1–2. Plate 4: Fig. 6) differs from those in all species of the *C. senegalense* group (more blunt apex, Plate 3: Fig. 3. Plate 4: Figs 1–5). The apex in Jeannel's holotype of *C. aethiops* corresponds to that in the *C. imbricatum* group (Plate 3), which does not support the opinion of Bruschi (2013) that *C. aethiops* is a synonym of *C. scabrosum roeschkei*.

- 2. Shape of inflated endophalus. We have not found an apparent difference either among species or subspecies belonging to the same group, or among species belonging to different groups (Plate 4: Figs 1–5). This result does not support the opinion that shape of the endophalus can be used to indicate assignments to to species or species groups.
- 3. Morphometric parameters.
  - A. Total length including mandibles (TL). In three measured holotypes (or lectotypes) are the values within the minimum and maximum intervals found in corresponding populations and sexes, whereas in the male holotype of *C. aethiops* the value is outside of the interval. The TL value in the *C. aethiops* holotype is closest to the values found in males of *C. i. hottentotum*, and lies within the interval found in females of that subspecies (all types are males, see Table 1a, Table 2). This fact supports our opinion that the holotype of *C. aethiops* is an extremely large male of *C. i. hottentotum*.
  - B. Maximum pronotal width to maximum head width including eyes ratio (WP/WH). The WP/WH in two measured holotypes (or lectotypes) is within the minimum and maximum intervals found in the pertinent populations and sexes. In the third taxon the WP/WH value of the holotype is outside of the interval in both sexes. In the holotype of *C. aethiops* is the WP/WH value within the interval found in the corresponding sex (males) of *C. s. roeschkei* and also within the interval found in *C. i. hottentotum* females. Overall the WP/WH values found in the measured taxa is very variable in both species and sexes (Table 1b, Table 2), and in our opinion thus cannot be used as a criterion in species-level taxonomy.
  - C. Maximum pronotal width to its maximum length ratio (WP/LP). The WP/ LP value in two measured holotypes (or lectotypes) is with exception of males of *C. s. scabrosum* within the minimum and maximum intervals found in the pertinent populations and sexes. In the holotype of *C. aethiops* is the WP/WH value within the interval found in all compared species of both sexes. Overall the WP/LP values found in the measured taxa are quite non-specific in both species and sexes (Table 1c, Table 2), and in our opinion thus cannot be used as a criterion in species-level taxonomy.
  - D. Maximum elytral length to its maximum width ratio (LE/WE). The WP/LP value in two measured holotypes (or lectotypes) is in both subspecies of *C. scabrosum* within the minimum and maximum intervals found in the pertinent populations and sexes. In both sexes of *C. i. hottentotum* the value is outside the interval. In the holotype of *C. aethiops* the value is within the interval found in both subspecies of *C. scabrosum*. Overall the WP/LP values found in the measured taxa can be regarded as variable, namely in *C. i. hottentotum*. In our opinion they cannot be used as a criterion in species-level taxonomy (Table 1d, Table 2).

Taxon	Total length including mandibles in millimeters (TL). Interval of			
Holotype (HT), lectotype (LT)	minimum and maximum value of TL measured in 10 specimens			
	same sex is in parentheses.			
	Yes $(Y) - TL$ value of type is within interval.			
	No (N) – TL value of type is outside of interval.			
C. scabrosum scabrosum Chaudoir, 1843 (HT $\Im$ )	25.5 (23.1–26.2 ♂♂)	Y		
C. scabrosum roeschkei Breuning, 1927 (HT ♂)	25.0 (22.0–28.5 ♂♂)	Y		
<i>C. imbricatum hottentotum</i> Chaudoir, 1852 (♂ LT Deuve 1978)	21.0 (17.5–21.3 88)	Y		
C. aethiops (Jeannel, 1940) (HT 👌)	21.5 ( <i>C. i. hottentotum</i> ♂♂ 17.5–21.3 ♀♀ 19.2–23.0)	N		

# Table Ia. Total length, intervals.

**Table 1b.** Pronotal width to head width ratio, intervals.

Taxon	Maximum pronotal width to maximum head widt	<b>h</b> inc. eyes		
Holotype (HT), lectotype (LT)	ratio (WP/WH). Interval of minimum and maximum value			
	of WP/WH measured in 10 specimens of the same se	ex is in		
	parentheses.			
	(Y/Y) – value of type is within interval.			
	(N/N) – value of type is outside of interval.			
	(N/Y) – value of type is outside of interval in males b	ut within		
	interval in females.			
C. scabrosum scabrosum Chaudoir, 1843 (HT 👌)	1.50 (1.34–1.44 ♂♂) (1.35–1.48 ♀♀)	N/N		
C. scabrosum roeschkei Breuning, 1927 (HT 🖒)	1.50 (1.29–1.63 ♂♂) (1.41–1.65 ♀♀)	Y/Y		
C. imbricatum hottentotum Chaudoir, 1852 (d	1.45 (1.33–1.50 ♂♂) (1.23–1.54 ♀♀)	Y/Y		
LT Deuve 1978)				
C. aethiops (Jeannel, 1940) (HT 🖒)	1.32 (C. i. hottentotum)	N/Y		
	(C. s. scabrosum)	N/N		
	(C. s. roeschkei)	Y/N		

**Table Ic.** Pronotal width to length ratio, intervals.

Taxon	Maximum pronotal width to maximum pronotal lea	ngth ratio		
Holotype (HT), lectotype (LT)	(WP/LP). Interval of minimum and maximum value of WP/LP			
	measured in 10 specimens of the same sex is in parenth	leses.		
	(Y/Y) – value of type is within interval.			
	(N/N) – value of type is outside of interval.			
	(N/Y) – value of type is outside of interval in males but	within		
	interval in females.			
C. scabrosum scabrosum Chaudoir, 1843 (HT 👌)	1.65 (1.33–1.56 ♂♂) (1.52–1.67 ♀♀)	N/Y		
C. scabrosum roeschkei Breuning, 1927 (HT 🖒)	1.67 (1.38–1.77 ♂♂) (1.47–1.74 ♀♀)	Y/Y		
C. imbricatum hottentotum Chaudoir, 1852 (d	1.74 (1.43–1.74 ♂♂) (1.55–1.84 ♀♀)	Y/Y		
LT Deuve 1978)				
C. aethiops (Jeannel, 1940) (HT 🖒)	1.55 (C. i. hottentotum)	Y/Y Y/Y		
	(C. s. scabrosum)	Y/Y		
	(C. s. roeschkei)			

Taxon	Maximum elytral length to maximum elytral width	ratio		
Holotype (HT), lectotype (LT)	(LE/WE). Interval of minimum and maximum value of LE/			
	WE measured in 10 specimens of the same sex is in par	entheses.		
	(Y/Y) – value of type is within interval.			
	(N/N) – value of type is outside of interval.			
	(N/Y) – value of type is outside of interval in males but	within		
	interval in females.			
C. scabrosum scabrosum Chaudoir, 1843 (HT $\stackrel{\wedge}{\bigcirc}$ )	1.44 (1.44–1.56 ♂♂) (1.38–1.53 ♀♀)	Y/Y		
<i>C. scabrosum roeschkei</i> Breuning, 1927 (HT ♂)	1.52 (1.39–1.57 ♂♂) (1.33–1.59 ♀♀)	Y/Y		
C. imbricatum hottentotum Chaudoir, 1852	1.54 (1.33–1.50 ♂♂) (1.38–1.57 ♀♀)	N/Y		
(Å LT Deuve 1978)				
C. aethiops (Jeannel, 1940) (HT ♂)	1.39 (C. i. hottentotum)	Y/Y		
	(C. s. scabrosum)	N/Y		
	(C. s. roeschkei)	Y/Y		

Table Id. Elytral length to width ratio, intervals.

**Table 2.** Intervals of all measurements in each taxon (intervals), in TL and LE/WE for both sexes separately and total.

C. s. scabrosum	23.1-26.2	23.1-26.2	23.4–25.7	1.35-1.63	1.33–1.67	1.38-1.56	1.44–1.56	1.38-1.53
C. s. roeschkei	22.0-28.5	22.0-28.5	24.1-27.9	1.29-1.65	1.38-1.77	1.33-1.59	1.39–1.57	1.33-1.59
C. senegalense	23.0-30.0	23.0-29.3	24.9-30.0	1.22-1.62	1.30-1.73	1.45-1.56	1.45-1.55	1.45-1.56
C. strandi	25.2-30.3	25.2-29.0	26.4-30.3	1.32-1.44	1.46-1.62	1.44-1.64	1.50-1.64	1.44-1.64
C. i. imbricatum	17.0-22.0	17.0–20.4	18.2–22.0	1.33–1.43	1.41-1.68	1.26–1.57	1.39–1.53	1.26–1.57
C. i. hottentotum	17.5–23.0	17.5–21.3	19.2–23.0	1.33–1.54	1.43–1.84	1.33–1.57	1.33–1.50	1.38–1.57

The above data lead us to conclude that there are no convincing morphological differences between C. scabrosum scabrosum and C. scabrosum roeschkei. The only exception may possibly be the somewhat higher WP/LP ratio (Table 2) and lighter coppery coloration in most specimens of C. s. roeschkei. Since specimens of both taxa have never been found together, we assume that they belong to allopatric populations of one species that have yet to reach the state of full speciation. Therefore, we lower the status of C. roeschkei (sensu Bruchi 2013) to a subspecies of C. scabrosum. Calosoma scabrosum roeschkei occupies mainly the southern part of distribution of the species. The present data show the north – south distribution of both subspecies to have a virtually disjunct character (Map 1). But it is in our opinion important to realize that in no area have the described subspecies been found to occur together. It is therefore likely that the northern Sudan – Ethiopia borderland will continue to produce C. s. roeschkei. The describer (Breuning 1927: 186) of Calosoma scabrosum roeschkei wrote: ["This form (roeschkei) is due to its more robust head, less bulging eyes, wider, toward base more right-angled pronotum with more rounded hind angles, shallower basal pits, somewhat flatter, at shoulders broader and terminally more abruptly slanted elytra and dark to brownish bronze dorsal coloration with light brown, coppery-rimmed margins and foveae in primary intervals so



Map I. Geographic distribution of the *Calosoma scabrosum* and *Calosoma strandi* species subgroups (sensu Häckel 2012). T – the type locality. Dark blue discs – *Calosoma scabrosum* s. str. Chaudoir, 1843. Light blue discs – *Calosoma scabrosum roeschkei* Breuning, 1927. Green discs – *Calosoma strandi* Breuning, 1934.

conspicuous that I originally intended to describe it as a separate species. However, some individuals of this form (*roeschkei*) are clearly transitional to the typical form (*scabrosum*), with coloration remaining as the only constant character. Differences (of separate populations) from the nominotypical form show step-like transitions, for which reason I presently regard *C. roeschkei* as a subspecies of *C. scabrosum*" (original in German)].

Jeannel (1940: 128) did not see Breuning's subspecies but treated it as a variety and remarked: ["Breuning's variety *roeschkei* rather appears to be another (separate) species closely related to *C. scabrosum*]"; he did not further comment on the taxon and placed specimens corresponding to Breuning's description among African populations of "*C. orientale*" (Jeannel 1940: 128). In this connection, Jeannel and subsequent authors such as Rougemont (1976: 247) and Vigna Taglianti and Bruschi (1986: 21) solved taxonomic uncertainties by incorrect determination of specimens from eastern Africa as *C. squamigerum* Chaudoir, 1869 (Häckel 2012: 57.). The holotype of *C. squamigerum* is from Bengal (today either Bangladesh or West Bengal in India) and other specimens of the type series are from Coimbatore in the vicinity of Madras (today Tamilnadu State in southern India). The name *C. squamigerum* was therefore synonymized with *C. orientale* (Jeannel 1940: 128).

Jeannel nevertheless realized that African populations identified as *C. orientale* (*=squamigerum*) most likely belong to another species, coined for them a new taxon, *Ctenosta* (s. str.) *aethiops* Jeannel, 1940, and included in the distribution of this taxon also populations corresponding to Breuning's *C. s. roeschkei* ("Diré Daoua", Jeannel 1940: 128). The only exception was a population from Eritrea ("Tessenei" 1940: 129), which he continued regarding as *C. orientale*. In the description of *C. aethiops* Jeannel (1940: 127–128) wrote: ["if we regard *C. aethiops* with its gular and labial setae as belonging to the genus *Caminara*, we can see that in reality it is a transitional species combining characters of *Caminara* and *Ctenosta*, an important species attesting to its assignment to the genus *Ctenosta*, which differs by reduction of the said setae and the type of sculpture placing it near the *Castrida-Caminara* lineage. The male mesotibiae have the setal brush prolonged as in *Caminara* and similar to that present in *Ctenosta*. The ventral side of the fourth male protarsomere is smooth]".

Evident from Jeannel's text are the difficulties he had in placing the new species in his system and in defining the "genera". More recently some authors (Culot 1990, Bousquet et al. 2003, Bruschi 2013) regarded the genera as subgenera, but in our opinion Jeannel's criteria do not allow to distinguish them. For instance Bruschi in the key does not adhere to Jeannel's criteria (setae, elytral microsculpture) and originally separates Caminara from Ctenosta on the hind pronotal angles. In the key he (2013: 29) states: "13(14) always perceptible hind angles of pronotum - Caminara/ Campalita; 14(13) very small and pointed hind angles of pronotum, in some cases quite obliterated". In our opinion Jeannel's genera are not valid, which is supported also by their discord with results of DNA analyses. With only one exception, all the subgenera were synonymized with the genus Calosoma s. str. (Häckel 2012: 56, 2013: 12). Jeannel's difficulties in separating the "genera" Ctenosta and Caminara (according to us two close species groups of the genus *Calosoma*) reflect the confused composition of the type series of his C. aethiops. Without examination of Jeannel's holotype of C. aethiops, most subsequent authors regarded all African populations similar to C. scabrosum, with golden bronze coloration, as C. (Ctenosta) aethiops (Vigna Taglianti and Bruschi 1986: 21, Culot 1990: 9, Lorenz 2005: 68).

Only Bruschi, first on the internet and later in print (2013: Plate 17: Figs 8, 9), published photos of the holotypes of *C. scabrosum roeschkei* (Tanzania: Usambara) and *C. aethiops* (Niger: Azbin). The holotype of *C. s. roeschkei* (Usambara, see Map 1) clearly is a species belonging to the *C. senegalense* group, and we concur with Bruschi that in compliance with the priority principle the taxon must be ascribed to Breuning (the name *C. s. roeschkei* has priority over *C. aethiops*, if the two are the same species).

However, in our opinion the specimen from Azbin (Jeannel's holotype of *C. aethi*ops) looks different and does not belong to the *C. senegalense* group (=Jeannel's genus *Ctenosta*). Our comparisons of types and their aedeagi show that the holotype of *C. aethiops* corresponds in shape, size and sculpture of the elytra, shape of the legs, and termination of the aedeagus to *C. imbricatum hottentotum* Chaudoir, 1852. It belongs to another group (*C. maderae* group, *C. imbricatum* subgroup sensu Häckel, 2013: =Jeannel's genus *Caminara*), which partially overlaps the distribution of the *C. senegalense* group. Our conclusions are based chiefly on the different aedeagal morphology unequivocally shown by the photos (Plate 3, Figs 1, 2 versus Fig. 3). Futher documentation of morphological characters is not needed.

Calosoma imbricatum sensu lato is by a number of authors understood as a species with an extremely wide distribution reaching from Canary and Cape Verde Islands through the African Sahel belt, subsaharan Africa, Arabia, Iran and Pakistan to India and Bagladesh (Breuning 1927: 221-223, Jeannel 1940: 104-106, Mandl 1970: 61-63, see Map 2). The cited authors identify southern African populations of *C. imbricatum* as the subspecies C. i. hottentotum, whose holotype comes from the Cape province (Chaudoir 1852: 99). Calosoma imbricatum hottentotum is usually regarded as cofined to southern Africa, and Mandl (1970: 61, 63) even named another subspecies, C. i. linnavourii, for populations from eastern Africa (northern Kenya, Somalia), which is a transitional form differing from the northern (Sahel-Arabian) nominotypical form (C. i. imbricatum) by wider pronotum. Populations from southern Kenya and northern Tanzania with more lighter coppery coloration approaching rather the southern African populations (C. i. hottentotum). Jeannel (1940: 105) is the only author who regarded also the Kenya population as C. i. hottentotum. Mandl (1970: 63) commented these occurrences as "Wahrnscheinlich gehören die folgende Orte zu dieser Subspecies [C. i. linnavourii]: Kenya Sultan Hamid zwischen Voi und Nairobi, die Jeannel für hottentottum angibt", and Bruschi (2013) countered: "It seems that, contrary to the opinions of Mandl (1970: 61) that attributed this citation to his Cimbricatum linnavourii, Jeannel is right since in south western Kenya C imbricatum hottentotum is really present". In our opinion it is evident that the northern limit of C. i. hottentotum is vague and hosts a number of forms transitional to the nominotypical C. i. imbricatum. It is therefore possible that Jeannel's type of *C. aethiops* from Azbin (today northern Niger) belongs to one of the transitional populations and the locality is in fact correct (see Map 2). In our opinion Jeannel's type series of C. aethiops contains the holotype that we regard as Calosoma imbricatum (most likely the subspecies *hottentotum*) and specimens from other populations belonging to some of the subspecies of C. scabrosum, mostly to C. s. roeschkei.

Comparison of the types of *C. s. scabrosum* and *C. s. roeschkei* in our opinion also confirms the original Breuning's idea of one species with two terminal forms and a number of transitional forms between them (Plate 1: Figs 1–2). Another taxonomical inaccuracy was caused by Häckel et al. (2005: 2), who believed that populations newly discovered on the Arabian peninsula (Oman, Yemen, see Map 1) represent a different species (*C. jakli*, Plate 2. Fig. 2). Eventually, after comparison with the type of *C. s. scabrosum* it became clear that the Arabian specimens agree with the type (Häckel et al. 2010: 11), and today they are included in the distribution of the nominotypical subspecies *C. scabrosum* s. str. (Müller 1977, Häckel 2012: 57).



Map 2. Geographic distribution of the *Calosoma imbricatum* species subgroup (sensu Häckel 2013) compared to Mandl's data (1970) and *C. imbricatum hottentotum* Chaudoir, 1852. T – the type locality,
(full disc) – recent records, O (empty disc) – Mandl's data 1–4 *Calosoma imbricatum* s. str. Klug, 1832
5–7 *Calosoma imbricatum hottentotum* Chaudoir, 1852 I *C. imbricatum* s. str. (sensu Mandl 1970) 2 *C. imbricatum arabicum* (Motschulsky, 1865) sensu Mandl 1970 3 *C. imbricatum löffleri* Mandl, 1953 sensu
Mandl 1970 4 *C. imbricatum linnavourii* Mandl, 1970 sensu Mandl 1970 5 *C. imbricatum hottentotum* (holotype of *Ctenosta aethiops* Jeannel, 1940) 6 *C. imbricatum hottentotum* (*C. imbricatum linnavourii* sensu Mandl 1970) 7 *C. imbricatum hottentotum*.

Below we present morphometric tables comparing populations of *C. s. roeschkei* (hitherto labeled as *C. aethiops*) with specimens of *C. s. scabrosum* the Horn of Africa (Djibouti) and the Arabian peninsula (Oman, Yemen). The tables also compare the noted populations of *C. scabrosum* with specimens of *C. i. hottentotum* from southern and eastern Africa and *C. i. imbricatum* from Afrotropical Region. In this connection we consider it important that no known locality has produced sympatrically living *C. s. scabrosum* and *C. s. roeschkei* (see Map 1). However, at at least one locality (Kenya: North-Eastern Province, El Wak, see Map 1) has produced *C. scabrosum* (ssp. *roeschkei*) together with *C. imbricatum* (ssp. *hottentotum*) and another species of the *C. senegalense* group (*C. strandi* Breuning).

Our conclusion therefore is that Breuning's (1928: 185) original idea is valid, and consequently we demote *C. roeschkei* sensu Bruschi (2013: 129) to a subspecies of *C. scabrosum*.

The subgeneric placement of *C. imbricatum*, *C.* in the subgenus *Calosoma* follows the recently proposed classification supported by results of DNA analyses (Su et al. 2005, Häckel 2012, 2013).

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# References

- Bousquet Y, Březina B, Davies A, Farkač J, Smetana A (2003) Carabini. In: Löbl I, Smetana A (Eds) The Catalogue of Palaearctic Coleoptera. Vol. 1. Apollo Books, Stenstrup, 118–201.
- Breuning S (1927) Monografie der Gattung *Calosoma* Web. (Carab.). Koleopterologische Rundschau 13: 129–232.
- Breuning S (1934) Ueber Carabini. Folia Zoologica et Hydrobiologica 31(8): 29-40.
- Bruschi S (2013) *Calosoma* of the World (Coleoptera, Carabidae). Bologna, Natura Edizioni Scientifiche di Alfonso Iorio, 314 pp. + 39 pl.
- Chaudoir M de (1843) Carabiques nouveaux. Bulletin de la Société Impériale des Naturalistes de Moscou 16: 671–791.
- Chaudoir M de (1852) Mémoire sur la famille des carabiques. 3e partie. Bulletin de la Société Impériale des Naturalistes de Moscou 25(1): 1–104.
- Chaudoir M de (1869) Descriptions de *Calosoma* nouveaux des collections de M. M. de Chaudoir et Salle. Annales de la Société Entomologique de France 9 (4. série): 367–378.
- Culot J (1990) Catalogue des Calosomes du monde. Bruxelles, privately published, 19 pp.
- Dejean PFMA (1831) Species général des coléoptères, de la collection de M. le Comte Dejean. Tome cinquième. Paris, Méquignon-Marvis, viii + 883 pp.
- Deuve T (1978) Liste des types de calosomes du Muséum National d'Histoire Naturelle de Paris. Nouvelle Révue d'Entomologie 8(3): 245–258.
- Farkač J, Häckel M (2012) Calosoma chlorostictum ivinskisi, a new synonym of Calosoma chlorostictum chlorostictum (Coleoptera: Carabidae: Carabini). Acta Entomologica Musei Nationalis Pragae 52 (suppl. 2): 69–73.
- Häckel M (2012) Three new records of caterpillar hunters of the genus *Calosoma* Weber 1801 (Coleoptera: Carabidae: Carabini) from Afrotropical and Palearctic regions. Folia Heyrovskyana, series A, vol. 20(1–2): 55–65.
- Häckel M (2013) Kritický náhled na současnou infragenerickou systematiku rodu krajník *Calosoma*, Carabini, Carabidae) [A critical overview on the recent infrageneric taxonomy of

the caterpillar hunter (*Calosoma*, Carabini, Carabidae)]. Diploma's Work. Czech University of Life Sciences Prague, Faculty of Environmental Sciences, Department of Ecology. Prague, 86 pp. + 2 appendices. [In Czech with English abstracts]

- Häckel M, Farkač J, Sehnal R (2005) A new species of *Calosoma* (Coleoptera: Carabidae: Carabini) from Oman and a new subspecies of *Calosoma oceanicum* Perroud & Montrouzier 1864 from the Lombok Island (Lesser Sunda, Indonesia). Animma-X 11: 1–7.
- Häckel M, Farkač J, Sehnal R (2010) New status of *Calosoma jakli* Häckel, Farkač & Sehnal, 2005 (Coleoptera: Carabidae: Carabini). Animma-X 31: 11–13.
- Harold E Von (1880) Beschreibungen neuer, auf seiner, von der Akademie unterstützten Reise in Ostafrika, vorzüglich in den Districten von Taita und Ukamba auf einer Tour von Mombassa nach dem Kenia, von Hrn. M. J. Hildebrandt gesammelter Coleopteren. Monatsberichte der Königlich preussischen Akademie der Wissenschaften zu Berlin, 260.
- Jeannel R (1940) Les calosomes (Coleoptera, Carabidae). Mémoires du Muséum National d'Histoire Naturelle (Paris) 13: 1–240.
- Klug JCF (1853) Ubersicht der von Hrn dr Peters wahrend seines Aufenhalts in Mozambik veranstalteten entomologischen Sammlungen. Monatsberichte der Berliner Akademie der Wissenschaften 1853: 244–250.
- Lapouge G Vacher De (1931) Coleoptera Adephaga, Fam. Carabidae. Subfam. Carabinae, pt.
  3. In: Wytsman P (Ed.) Genera Insectorum, fasc. 192B. Desmet-Verteneuil, Bruxelles, 293–580.
- Lorenz W (2005) Systematic List of extant Ground Beetles of the World (Insecta Coleoptera "Geadephaga": Trachypachidae and Carabidae incl. Paussinae, Cicindelinae, Rhysodinae). Second Edition. Wolfgang Lorenz, Tutzing, 530 pp.
- Mandl K (1970) Calosoma chlorostictum Dejean und Calosoma imbricatum Klug. Koleopterologische Rundschau 48: 57–63.
- Motschulsky V de (1865) Enumeration des nouvelles espèces de coléoptères rapportés de ses voyages. 4-ème article (suite). Bulletin de la Société Impériale des Naturalistes de Moscou 38(4): 227–313.
- Müller P (1977) Tiergeographie. Struktur, Funktion, Geschichte und Indikatorbedeutung von Arealen. Stuttgart, Teubner, 268 pp.
- Rougemont GM de (1976) Contributions à la connaissance de la faune de l'Ethiopie. I. Les Calosomes (Coleoptera: Carabidae). Revue de Zoologie africaine 90(2): 241–274.
- Su Z-H, Imura Y, Osawa S (2005) Evolutionary history of Calosomina ground beetles (Coleoptera, Carabidae, Carabinae) of the world as deduced from sequence comparisons of the mitochondrial ND5 gene. Gene 360: 140–150. doi: 10.1016/j.gene.2005.06.028
- Vigna Taglianti A, Bruschi S (1986) Note sui Calosomini dell'Ethiopia. Memoire della Societa Entomologica Italiana 65: 3–28.

RESEARCH ARTICLE



# Three new species of the subgenus Leipopleura Seidlitz from Tibet, China (Coleoptera, Tenebrionidae, Bioramix Bates)

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#### Abstract

Three new species of darkling beetles (Tenebrionidae) belonging to the subgenus *Leipopleura* of the genus *Bioramix* Bates, 1879, *B.* (*L.*) *baqenensis* Li & Egorov, **sp. n.**, *B.* (*L.*) *nyainrongensis* Li & Egorov, **sp. n.**, and *B.* (*L.*) *banbarensis* Li & Egorov, **sp. n.** are described from the Tibet Autonomous Region in China. Additionally, a new identification key is provided to all known Chinese representatives of the subgenus *Leipopleura*.

#### Keywords

Darkling beetles, identification key, Platyscelidini, taxonomy

# Introduction

The genus *Bioramix* Bates, 1879 (Tenebrionidae: Platyscelidini) consists of approximately 115 species and it is subdivided into 13 subgenera. Only four subgenera, *Bioramix* Bates, 1879, *Cardiobioramix* Kaszab, 1940, *Leipopleura* Seidlitz, 1893 and *Tricholeipopleura* Kaszab, 1940 have been reported from China.

The subgenus *Leipopleura* with *B. integra* Reitter, 1887 as the type species, is characterized by the intercoxal process not raised, sharply sloping behind procoxae; male abdomen medial setose patches absent; protibia underside concave at apex and their outer margin sharp, outer apical angles elongate; male pro- and mesotarsi widened, dense plantar pubescence present on proximal four tarsomeres. So far, 15 species have been described (Seidlitz 1893; Kaszab 1940; Egorov 1990, 2004, 2006a, b, 2008, 2009; Meng and Ren 2005; Li et al. 2013). Among these, 13 species were exclusively reported from China: *B. aenescens* (Blair, 1923), *B. politicollis* (Kaszab, 1940), *B. kochi* (Kaszab, 1940), *B. nagquana* (Meng & Ren, 2005) and *B. igori* Li & L. Egorov, 2013 from Tibet; *B. rubripes* (Reitter, 1889), *B. rufipalpis* (Reitter, 1887) from Qinghai and Tibet; *B. hongyuanensis* Li & L. Egorov, 2013 from Sichuan; *B. frivaldszkyi* (Kaszab, 1940) from Gansu and Qinghai; *B. integra* (Reitter, 1887) from Gansu, Qinghai and Sichuan; *B. micans* (Reitter, 1889) from Gansu, Qinghai and Tibet; *B. reinigi* (Kaszab, 1940) from Qinghai, Sichuan and Tibet. Meanwhile, *B. crypticoides* (Reitter, 1887) from Gansu, Qinghai, Sichuan, Xingjiang and Tibet.

During the identification of tenebrionid specimens collected in Tibet in 2010, three new species of the subgenus *Leipopleura* were found and are described below.

# Material and methods

The specimens examined in this study are deposited in the Museum of China West Normal University, Nanchong, China (MCWNU) and Zoological Institute of Russian Academy of Sciences (ZIN) (St.-Petersburg, Russia). The specimens were examined with a Leica M205C stereomicroscope and recorded with a Nikon D3000 digital camera.

In the morphological descriptions the following measurements were taken (by means of binocular micrometre): 1) length of antennomeres (without interantennal membrane) and their maximum width; 2) length of pronotum along midline between anterior and posterior margins; 3) maximum width of pronotum; 4) length of elytra along suture from base to apex; 5) maximum width of elytra; 6) maximum width of tibia at apex; 7) maximum width of male tarsi; 8) maximum width and length of parameres (taken in dorsal view along middle groove); 9) length of phallobase (taken in lateral view) and general length of the aedeagus from apex of parameres to base of phallobase; 10) general length of the body from base of mandibles to apex of elytra (taken in lateral view). Density of punctation is characterized as follows: 1) dense punctation – distance between punctures less than their diameter; 3) sparse punctation – distance between punctures less than or equal to their diameter; 3) sparse punctation – distance between punctures exceeding their diameter.

## Taxonomy

Family Tenebrionidae Latreille, 1802 Subfamily Tenebrioninae Latreille, 1802 Tribe Platyscelidini Lacordaire, 1859 Genus *Bioramix* Bates, 1879

*Bioramix (Leipopleura) baqenensis* Li & Egorov, sp. n. http://zoobank.org/8D6014AE-22A7-4F2D-BDA1-0A2975D15632 Figs 1–10, 31–32

**Type material.** Holotype: male, **CHINA:** Tibet, Baqen, 31°50.421'N, 094°18.016'E, 4575 m, 3 Jul. 2010, Ai-Min Shi and Yong-Sheng Pan leg. (MCWNU). Paratype: 21 males and 20 females, 4 paratypes (2 males, 2 females) in ZIN, same data as the holotype.

**Diagnosis.** This new species can be distinguished based on the following: anterior margin of pronotum straight; protibia outer apical angles strongly elongated, inner surface with an obscure spur and strong setae at apical <sup>1</sup>/<sub>2</sub>; parameres moderately narrowed apically, slightly sinuate near the apex <sup>1</sup>/<sub>5</sub> (in lateral view).

Etymology. Named after the type locality, Baqen.

Description. Body black; antennae, legs and palps brown; surface weakly shiny.

**Male** (Figs 1–8). *Head* broad, anterior margin of clypeus straight, fronto-clypeal suture slightly obscure; most of genae densely punctate, covered with recumbent hairs. Dorsal surface of head slight convex. Punctation of head fine, dense or moderately dense. Eyes transverse, with shallow emargination at anterior margin. Antennae when posteriorly extended, reaching pronotal base. Length (width) ratio of antennomeres from  $2^{nd}$  to  $11^{th}$  as follows: 14.0(11): 25.5(12.5): 14.0(12.5): 13.5(11.5): 15.0(12.0): 14.5(13.0): 17.5(15.0): 15.5(15.0): 15.5(15.5): 20.5(16.0) (n = 5).

*Pronotum* (Fig. 2) transverse, 1.35-1.51 (1.44 on average, n = 5) times as wide as long, widest before the middle, 1.72-1.82 (1.78 on average, n = 5) times as wide as head. Ratio of pronotal width at anterior margin to its maximum width and width at base (n = 5) 0.69: 1.00: 0.95 on average. Outer margin of pronotum shallowly sinuate in basal <sup>1</sup>/<sub>2</sub>, more abruptly converging anteriorly in anterior <sup>1</sup>/<sub>3</sub>, finely bordered along entire length. Anterior margin straight, bordered laterally; base weakly bisinuate, not bordered or bordered laterally. Anterior angles of pronotum widely obtuse; posterior ones nearly rectangular. Pronotal surface between outer margins convex, punctures larger and denser than those on head, finer at disc than laterally, lateral margins of pronotum weakly flattened. Intercoxal process not raised, sharply sloping behind procoxae. Prothoracic hypomeron with longitudinal wrinkles.

*Elytra* elongate-oval, 1.32-1.43 (1.36 on average, n=5) times as long as wide, maximum width before middle, 1.23-1.27 (1.25 on average, n=5) times as wide as pronotum. Outer margin of epipleural reaching sutural angle, visible dorsally only at base. Elytral surface between epipleura and sutural margin convex, with fine dense



Figures 1–10. *Bioramix (Leipopleura) baqenensis* sp. n.: 1 antenna of male 2 pronotum of male 3 protibiae and protarsomeres of male 4 mesotibiae and mesotarsomeres of male 5 metatibiae and metatarsomeres of male 6–7 apical part of aedeagus in dorsal and ventral views 8 apical part of aedeagus in lateral view 9–10 ovipositor in dorsal and ventral views.

punctation and minute rugae, with traces of longitudinal prominences and also traces of smooth rounded prominences better developed in apical half. Epipleural surface with densely covered irregular wrinkles and small granules. Mesoventrite with rather sparse recumbent hairs; surface finely granulate and wrinkles. Abdominal ventrites with yellow hairs. Intercoxal process of abdomen rounded apically. First and second abdominal ventrites with shallow medial impressions, 4<sup>th</sup> ventrite weakly concave at sides. Last abdominal ventrite with shallow depression and impunctate semicircular area at medial base.

*Legs* (Figs 3–5) robust, length (width) ratio of pro-, meso- and metafemora 69.0(25.0): 73.5(22.5): 88.0(24.5) (n = 5); that of corresponding tibiae 67.0(27.0): 63.5(17.5): 88.0(18.0) (n = 5). Protibiae 2.37–2.59 (2.49 on average, n = 5) times as long as wide, gradually widening in basal  $\frac{2}{3}$ . Outer apical angles strongly elongate, underside concave. Inner surface with an obscure spur and strong setae in apical  $\frac{1}{2}$ . Metatibia straight. Plantar surface of proximal pro- and mesotarsomeres 1-4 with setal

brushes. Length (width) ratio of pro-, meso- and metatarsomeres from  $1^{st}$  to  $4^{th}$  as follows: 8.0 (7.0): 11.0 (15.5): 8.5 (14.5): 4.5 (12.5) (n = 5), 10.0 (8.0): 9.5(12.5): 7.0 (11.0): 5.0 (7.5) (n = 5) and 27.5 (6.5): 13.5 (6.0): 11.5 (5.5): 21.0 (5.0) (n = 5).

Aedeagus (Figs 6–8): length 2.9–3.0 mm, width 0.83 mm. Parameres 1.17 mm long and 0.67 mm wide, moderately narrowed apically, apical <sup>1</sup>/<sub>5</sub> slightly sinuate (in lateral view).

**Female** (Figs 9–10). Body wider. Antennae and epipleural carina shorter than in male. Pronotum 1.60–1.72 (1.65 on average, n = 5) times as wide as long, 1.76–1.81 (1.78 on average, n = 5) times as wide as head. Ratio of pronotal width at anterior margin to its maximum width and width at base 0.71: 1.00: 0.95. Elytra 1.27–1.35 (1.32 on average, n = 5) times as long as wide, 1.29–1.40 (1.35 on average, n = 5) times as wide as pronotum. Plantar surface of pro- and mesotarsomeres without setal brush. Ovipositor in dorsal view with golden setae at apical <sup>1</sup>/<sub>3</sub>, tuft of setae (with 3–4 long setae) present near apical margin.

**Measurements.** Male body length 9.3–10.4 mm, width 4.7–5.0 mm; female body length 9.1–9.8 mm, width 4.7–5.2 mm.

Distribution. China: Tibet (Tanggula Shan, Baqen).

**Remarks.** *Bioramix (Leipopleura) baqenensis* Li & Egorov, sp. n. is similar to *Bioramix (Leipopleura) nagquana* (Meng & Ren, 2005) based on the following characters: length of antennae (when posteriorly extended, reaching pronotal base), anterior margin of clypeus straight, pronotum widest near middle, and metatibia straight.

*Bioramix (Leipopleura) nyainrongensis* Li & Egorov, sp. n. http://zoobank.org/36338F33-8DD8-48DF-B594-522B93D95AC1 Figs 11–20, 33–34

**Type material.** Holotype: male, **CHINA:** Tibet, Nyainrong, 32°06.763'N, 92°17.171'E, 4728 m, 6 Aug. 2010, Yun-Chun Li and Yong-Sheng Pan leg. (MCWNU). Paratype: 4 males and 3 females, 3 paratypes (2 males, 1 females) in ZIN, same data as the holotype.

**Diagnosis.** This new species can be distinguished based on the following: shorter antennae (when posteriorly extended, not reaching pronotal base); anterior margin of pronotum emarginated, and metatibia weakly incurved.

**Etymology.** Named after the type locality, Nyainrong.

Description. Body black; antennae, legs and palps brown; surface weakly shiny.

**Male** (Figs 11–18). *Head* broad, anterior margin of clypeus weakly, but noticeably arcuate in the middle; fronto-clypeal suture slightly obscure; most of genae densely punctate, covered with recumbent hairs. Dorsal surface of head slight convex. Punctation of head coarse large, dense or moderately dense. Antennae very shorter, when posteriorly extended, not reaching posterior ½ of pronotum. Length (width) ratio of antennomeres from  $2^{nd}$  to  $11^{th}$  as follows: 11.7(10.3): 20.7(10.0): 12.7(9.3): 12.3(10.0): 13.7(10.3): 13.3(10.3): 14.0(13.3): 12.0(13.0): 13.0(14.0): 17.0(14.7) (n = 3).



Figures 11–20. *Bioramix (Leipopleura) nyainrongensis* sp. n.: 11 antenna of male 12 pronotum of male 13 protibiae and protarsomeres of male 14 mesotibiae and mesotarsomeres of male 15 metatibiae and metatarsomeres of male 16–17 apical part of aedeagus in dorsal and ventral views 18 apical part of aedeagus in lateral view 19–20 ovipositor in dorsal and ventral views.

*Pronotum* (Fig. 12) transverse, 1.49-1.63 (1.55 on average, n = 3) times as wide as long, widest before in the middle, 1.75-1.87 (1.83 on average, n = 3) times as wide as head. Ratio of pronotal width at anterior margin to its maximum width and width at base (n = 3) 0.66: 1.00: 0.96 on average. Outer margins of pronotum acutely convex, bordered along entire length. Anterior margin emarginate, bordered laterally; base weakly bisinuate, not bordered or bordered laterally. Anterior angles weakly obtuse; posterior ones nearly rectangular. Pronotal surface between outer margins convex, punctures smaller and denser than those on head, finer at disc than laterally, lateral margins of pronotum weakly flattened. Intercoxal process not raised, sharply sloping behind procoxae. Prothoracic hypomeron with longitudinal wrinkles.

*Elytra* elongate-oval, 1.27–1.33 (1.30 on average, n = 3) times as long as wide, maximum width before middle, 1.10–1.20 (1.14 on average, n = 3) times as wide as pronotum. Outer margin of epipleural reaching sutural angle, visible dorsally only at base. Elytral surface between epipleura and sutural margin convex, with traces of longitudinal carina, elytra apex sharply declined. Epipleural surface covered with dense irregular wrinkles and sparse shallow punctures. Lateral carina of elytra (outer margin of pseudepipleura) visible in dorsal view only anteriorly, explanate on humeri, merging with epipleura, reaching sutural angle. Mesoventrite with rather sparse recumbent hairs; surface finely granulate and wrinkles. Abdominal ventrites with yellow hairs.

intercoxal process of abdomen rounded apically. First and second abdominal ventrites with shallow medial impressions.

*Legs* (Figs 13–15), length (width) ratio of pro-, meso- and metafemora 53.3(19.7): 59.7(18.7): 70.7(19.3) (n = 3); that of corresponding tibiae 53.3(20.7): 54.3(14.0): 72.7(14.3) (n = 3). Protibiae 2.55–2.60 (2.58 on average, n = 3) times as long as wide, gradually widening towards apex, Outer apical angles weakly elongate, underside concave. pro-, meso- and metatibiae with densely golden hairs at apex of inner surface, protibiae with obviously a spur. metatibia weakly incurved. Plantar surface of proximal pro- and mesotarsomeres 1-4 with setal brushes. Length (width) ratio of pro-, meso- and metatarsomeres from 1<sup>st</sup> to 4<sup>th</sup> as follows: 8.0(6.7): 7.7 (13.3): 6.3 (13.7): 4.7 (10.0) (n = 3), 8.0 (7.0): 8.0 (12.3): 6.3 (10.0): 4.7 (6.3) (n = 3) and 21.7 (6.7): 10.3 (6.0): 8.3 (5.7): 16.0 (6.0) (n = 3).

*Aedeagus* (Figs 16–18): length 2.4–2.5 mm, width 0.67 mm. Parameres 0.95 mm long and 0.57 mm wide. Parameres noticeably narrowed toward apex in dorsal view, but weakly widened in distal <sup>1</sup>/<sub>4</sub>, distinctly sinuate (in lateral view).

**Female** (Figs 19–20). Body longer and wider. Pronotum 1.57–1.59 (1.58 on average, n = 3) times as wide as long, 1.75–1.77 (1.76 on average, n = 3) times as wide as head. Ratio of pronotal width at anterior margin to its maximum width and width at base (n = 3) 0.67: 1.00: 0.98. Elytra 1.30–1.32 (1.31 on average, n = 3) times as long as wide, 1.19–1.21 (1.20 on average, n = 3) times as wide as pronotum. Plantar surface of pro- and mesotarsomeres without setal brush. Ovipositor in dorsal view with golden setae at apical <sup>1</sup>/<sub>4</sub>, and nearly apex shorter setae formation looped pile, within a strong long setae highlight, inner apical surface of with densely setae.

**Measurements.** Male body length 7.9–8.1 mm, width 3.9–4.0 mm; female body length 8.1–8.2 mm, width 4.0–4.1 mm.

Distribution. China: Tibet (Tanggula Shan, Nyainrong).

**Remarks.** Bioramix (Leipopleura) nyainrongensis Li & Egorov, sp. n. is similar to Bioramix (Leipopleura) baqenensis Li & Egorov, sp. n. and Bioramix (Leipopleura) nagquana (Meng & Ren, 2005) based on the following characters: pronotum (widest near middle), posterior margin of pronotum base weakly bisinuate, elytra elongateoval (widest near middle), and outer margin of epipleural visible dorsally only at base.

# Bioramix (Leipopleura) banbarensis Li & Egorov, sp. n.

http://zoobank.org/4CB6BCA8-16DA-4125-99BA-953536EC0519 Figs 21–30, 35–36

**Type material.** Holotype: male, **CHINA:** Tibet, Banbar, 30°55.964'N, 094°42.482'E, 3730 m, 25 Jul. 2010, Ai-Min Shi and Yong-Sheng Pan leg. (MCWNU). Paratype: 59 males and 51 females, 4 paratypes (2 males, 2 females) in ZIN, same data as the holotype.

**Diagnosis.** This new species can be distinguished based on the following: shorter antennae (when posteriorly extended, not reaching pronotal base), anterior margin of pronotum straight, parameres distinctly sinuate near the apex ¼ (in lateral view).



Figures 21–30. *Bioramix (Leipopleura) banbarensis* sp. n.: 21 antenna of male 22 pronotum of male 23 protibiae and protarsomeres of male 24 mesotibiae and mesotarsomeres of male 25 metatibiae and metatarsomeres of male 26–27 apical part of aedeagus in dorsal and ventral views 28 apical part of aedeagus in lateral view 29–30 ovipositor in dorsal and ventral views.

**Etymology.** Named after the type locality, Banbar.

**Description.** Body dark brown; surface weakly shiny.

**Male** (Figs 21–28). *Head* broad, anterior margin of clypeus straight, fronto-clypeal suture slightly obscure; most of genae densely punctate, covered with recumbent hairs. Dorsal surface of head slight convex. Punctation of head fine, dense or moderately dense. Eyes transverse, with shallow emargination at anterior margin. Antennae short, when posteriorly extended, not apices reaching base of pronotum. Length (width) ratio of antennomeres from  $2^{nd}$  to  $11^{th}$  as follows: 15.8(11.6): 27.2(12.2): 18.4(12.0): 17.4(12.0): 17.6(12.0): 16.8(12.2): 18.8(15.6): 15.8(14.8): 15.8(14.6): 22.4(14.0) (n = 5).

*Pronotum* (Fig. 22) transverse, 1.41–1.51 (1.47 on average, n = 5) times as wide as long, widest in the middle, 1.69–1.79 (1.75 on average, n = 5) times as wide as head. Ratio of pronotal width at anterior margin to its maximum width and width at base (n = 5) 0.64: 1.00: 0.88 on average. Outer margins of pronotum acutely convex, bordered along entire length. Anterior margin straight, bordered laterally; base weakly bisinuate,


Figures 31–36. 31–32 *Bioramix (Leipopleura) baqenensis* sp. n.: 31 male, length 9.3–10.4 mm 32 female, length 9.1–9.8 mm 33–34 *B. (L.) nyainrongensis* sp. n.: 33 male, length 7.9–8.1 mm 34 female, length 8.1–8.2 mm 35–36 *B. (L.) banbarensis* sp. n.: 35 male, length 9.9–10.6 mm 36 female, length 10.0–10.5 mm.

not bordered. Anterior angles of pronotum widely obtuse, posterior ones weakly obtuse. Pronotal surface between outer margins convex, with trace of slight depression. Punctuation on disc similar to that on frons, mainly dense, coarser and denser at sides. Prosternum with rather sparse hairs directed backwards and small granules. Intercoxal process not raised, sharply sloping behind procoxae. Prothoracic hypomeron with obvious longitudinal wrinkles and coarse granules.

*Elytra* elongate-oval, 1.28-1.45 (1.35 on average, n = 5) times as long as wide, widest nearly in the middle, 1.21-1.34 (1.28 on average, n = 5) times as wide as pronotum. Outer margin of epipleural not reaching sutural angle, visible dorsally only at base. Elytral surface between epipleura and sutural margin convex, with sparse and shallow punctures, irregular fine wrinkles and traces of longitudinal carina. Elytra margin setae and abdomen setae subequal length, elytra apex sharply declined. Mesosternum with rather sparse recumbent hairs, surface finely granulate and wrinkles. Abdominal ventrites with yellow hairs. First and second abdominal ventrites with shallow medial impressions. Last abdominal ventrite with depression and impunctate semicircular area at medial base, apical margin widely rounded.

*Legs* (Figs 23–25) robust, length (width) ratio of pro-, meso- and metafemora 70.4(25.0): 76.2(23.0): 93.2(24.6) (n = 5); that of corresponding tibiae 68.4(25.6): 68.6(19.4): 98.4(19.2) (n = 5). Protibiae 2.45–2.95 (2.78 on average, n = 5) times as long as wide, gradually widening towards apex, apical margin extended but not forming sharp triangle, underside concave. Pro- and mesotibia subequal length. Protibia with an obscure spur, metatibia nearly straight. Plantar surface of proximal pro- and mesotarsomeres 1-4 with setal brushes. Length (Width) ratio of pro-, meso- and metatarsomeres from 1<sup>st</sup> to 4<sup>th</sup> as follows: 8.6(8.2): 10.4 (17.4): 8.2 (16.0): 5.4 (9.8) (n = 5), 9.2 (8.2): 9.6 (15.4): 8.4 (12.8): 6.0 (7.4) (n = 5) and 28.2 (7.8): 13.4 (6.6): 10.6 (6.0): 21.6 (5.8) (n = 5).

*Aedeagus* (Figs 26–28): length 3.1–3.2 mm, width 0.93 mm. Parameres 1.15 mm long and 0.70 mm wide, moderately narrowed apically, apical <sup>1</sup>/<sub>6</sub> distinctly sinuate (in lateral view).

**Female** (Figs 29–30). Body longer and wider. Pronotum 1.50-1.57 (1.54 on average, n = 5) times as wide as long, 1.79-1.88 (1.82 on average, n = 5) times as wide as head. Ratio of pronotal width at anterior margin to its maximum width and width at base (n = 5) 0.70: 1.00: 0.95. Elytra 1.32-1.39 (1.35 on average, n = 5) times as long as wide, 1.24-1.34 (1.28 on average, n = 5) times as wide as pronotum. Plantar surface of pro- and mesotarsomeres without setal brush. Ovipositor in dorsal view with golden setae at apical  $\frac{2}{5}$ , tuft of setae (with 7–8 long setae) present near apical margin.

**Measurements.** Male body length 9.9–10.6 mm, width 4.9–5.4 mm; female body length 10.0–10.5 mm, width 5.0–5.4 mm.

**Distribution.** China: Tibet (Nyainqentanglha Shan (Nyenchen Tanglha Mountains), Banbar).

**Remarks.** *Bioramix (Leipopleura) banbarensis* Li & Egorov, sp. n. is similar to *Bioramix (Leipopleura) crypticoides* (Reitter, 1887) based on the following characters: pronotum widest near middle, anterior and posterior angles of pronotum obtuse, base

weakly bisinuate, protibia apical margin extended not sharp apices, and metatibia nearly straight.

**Conclusion.** The world fauna of the tribe Platyscelidini comprises 8 genera, 28 subgenera (Egorov 2004, 2009) and found in Palaearctic area. moreover, its southern border coincides with the part of Palaearctic southern border in the Himalayas. The majority of species live in the steppe and mountain habitats, lesser number in semi-deserts. The mountain regions of Asia, such as the Tien Shan, the Pamirs, the Hindu Kush, the Karakorum Range, the unlun Shan, the Himalayas, as well as Northern and Central China mountains are the main centers of species diversity. The classification of the tribe, developed in detail by Kaszab (1940) and Egorov (2004, 2009).

#### Key to the species of the subgenus Leipopleura from China

1	Pronotum widest near or at base2
_	Pronotum widest anterior to or at middle5
2	Only basal part of the outer margin of epipleura visible dorsally
_	Anterior $\frac{1}{3}$ or half of the outer margin of epipleura visible dorsally
3	Elytra widest at base. Metatibia slightly incurved
	Bioramix igori Li & L. Egorov, 2013
_	Elytra widest at middle. Metatibia straight <i>Bioramix aenescens</i> (Blair, 1923)
4	Anterior and basal margin of pronotum straight, anterior angles obtuse, pos-
	terior angles rectangular Bioramix politicollis (Kaszab, 1940)
_	Anterior margin of pronotum weakly sinuate, Pronotal base straight, anterior
	and posterior angles nearly rectangular
	Bioramix frivaldszkyi (Kaszab, 1940)
5	Outer margin of epipleura not reaching sutural angle6
_	Outer margin of epipleura reaching sutural angle9
6	Anterior margin of pronotum sinuate, base weakly bisinuate
	Bioramix nyainrongensis sp. n.
-	Anterior margin and base of pronotum straight7
7	Parameres noticeably narrowed toward apex in dorsal view, but strongly widened
	in distal <sup>1</sup> / <sub>5</sub> , with very flat apicesBioramix rufipalpis (Reitter, 1887)
-	Parameres subparallel, gradually narrowing towards apex, not widened dis-
	tally, with moderately sharp apices8
8	Parameres (in lateral view) strongly curved in distal <sup>1</sup> / <sub>3</sub>
	Bioramix reinigi (Kaszab, 1940)
-	Parameres (in lateral view) weakly curved in distal ¼, nearly straight
	Bioramix crypticoides (Reitter, 1887)
9	Anterior margin of pronotum weakly sinuate10
-	Anterior margin of pronotum straight12
10	Pronotal base emarginate, elytra widest at the base
	Bioramix hongyuanensis Li & L. Egorov, 2013

_	Pronotal base nearly straight, elytra widest at the middle11
11	Anterior and posterior angles of pronotum obtuse, legs red
	<i>Bioramix rubripes</i> (Reitter, 1889)
_	Anterior angles of pronotum obtuse, posterior angles sharp and rectangular,
	legs brown Bioramix nagquana (Meng & Ren, 2005)
12	Anterior margin of clypeus straight13
_	Anterior margin of clypeus weakly, but noticeably, arcuate in the middle 15
13	Anterior angles of pronotum very rounded, elytra base and pronotum almost
	as wide Bioramix kochi (Kaszab, 1940)
_	Anterior angles of pronotum not rounded, elytra base wider than prono-
	tum14
14	Antenna short, when posteriorly extended, not reaching pronotal base. Outer
	apical angles of protibiae weakly elongated Bioramix banbarensis sp. n.
_	Antenna long, when posteriorly extended, reaching pronotal base. Outer api-
	cal angles of protibiae strongly elongated Bioramix baqenensis sp. n.
15	Pronotal punctation coarse, parameres almost straight in lateral view
	Bioramix micans (Reitter, 1889)
_	Pronotal punctation fine, parameres noticeably curved in distal 1/4 in lateral
	viewBioramix integra (Reitter, 1887)

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## References

- Egorov LV (1990) On the systematics of tenebrionid beetles of the tribe Platyscelidini (Coleoptera, Tenebrionidae). Entomological Review 69(6): 137–150.
- Egorov LV (2004) On the classification of the tenebrionid tribe Platyscelidini (Coleoptera, Tenebrionidae) of the world. Entomological Review 84(6): 641–666.
- Egorov LV (2006a) About composition of the genus *Myatis* Bates, 1879 (Coleoptera, Tenebrionidae, Platyscelidini). Caucasian entomological bulletin 2(1): 73–78.
- Egorov LV (2006b) On the distribution of the tenebrionid tribe Platyscelidini (Coleoptera, Tenebrionidae). Cahiers Scientifiques du Muséum de Lyon 10: 139–142.
- Egorov LV (2008) Tribe Platyscelidini Lacordaire, 1859. In: Löbl I, Smetana A (Ed.) Catalogue of Palaearctic Coleoptera. 5. Apollo Books, Stenstrup, 291–297.

- Egorov LV (2009) The tenebrionid of the tribe Platyscelidini (Coleoptera, Tenebrionidae) of the world fauna: morphology, zoogeography, system. Meetings in memory of N.A. Cholodkovsky Iss. 61(1): 1–122.
- Kaszab Z (1940) Revision der Tenebrioniden-Tribus Platyscelini (Coleoptera, Tenebrionidae). Mitteilungen der Münchener Entomologischen Gesellschaft 30(1): 119–235.
- Li YC, Egorov LV, Shi AM (2013) Two new species of the genus *Bioramix* Bates, 1879 (Coleoptera: Tenebrionidae: Platyscelidini), from the Chinese Provinces Sichuan and Tibet. Caucasian Entomological Bulletin 9(1): 89–94.
- Meng L, Ren GD (2005) A systematic study of the genus *Myatis* Bates from China and adjacent areas (Coleoptera, Tenebrionidae). Acta Zootaxonomica Sinica 30(1): 104–110.
- Seidlitz Gvon (1893) Tenebrionidae. In: von Kiesenwetter H, von Seidlitz GCM (Eds) Naturgeschichte der Insecten Deutschlands. Begonnen von Dr. W.F. Erichson, fortgesetzt von Prof. Dr. H. Schaum, Dr. G. Kraatz, H. v. Kiesenwetter, Julius Weise, Edm. Reitter und Dr. G. Seidlitz. Erste Abteilung Coleoptera. Fünfter Band. Erste Hälfte. Nicolaische Verlags-Buchhandlung, Berlin, 201–400. [issued in parts: 201–400 in March 1893, 401–608 in May 1894, 609–800 in September 1896, 801–877 in September 1898].

RESEARCH ARTICLE



# Revision of the genus Ptomaphagus Hellwig (Coleoptera, Leiodidae, Cholevinae) from Taiwan Island

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#### Abstract

*Ptomaphagus* (s. str.) *chenggongi* **sp. n.** and *P*. (s. str.) *tingtingae* **sp. n.** (Coleoptera, Leiodidae, Cholevinae, Ptomaphagini) are described from Taiwan Island. In addition, a new subjective synonym is proposed, *P*. (s. str.) *yasutoshii* Nishikawa, 1993 = *P*. (s. str.) *smetanai* Perreau, 1996, **syn. n.** Relevant morphological characters of the examined *Ptomaphagus* species are illustrated with colour plates, and their known distributions are mapped.

#### **Keywords**

Leiodidae, Cholevinae, Ptomaphagus, taxonomy, new species, new synonym, Taiwan

## Introduction

*Ptomaphagus* Hellwig, 1795 is the most speciose genus (including 136 known species worldwide) in the tribe Ptomaphagini (Coleoptera, Leiodidae, Cholevinae). However, the nominotypical subgenus, which is limited to the Palaearctic and north Oriental regions, has only 28 species (Perreau 2000, Nishikawa 2011, Wang et al. in press).

On the island of Taiwan, only three species in the subgenus *Ptomaphagus* s. str. had been recorded before this study, namely *P*. (s. str.) *kuntzeni* Sokolowski, 1957, *P*. (s. str.) *yasutoshii* Nishikawa, 1993 and *P*. (s. str.) *smetanai* Perreau, 1996.

In this paper, which is a continuation of our revision of *Ptomaphagus* from East Asia, two new species with very similar aedeagi from Taiwan are described and illustrated: *Ptomaphagus* (s. str.) *chenggongi* sp. n. and *P*. (s. str.) *tingtingae* sp. n. In addition, after examination of the holotypes, a new subjective synonym is proposed: *P*. (s. str.) *yasutoshii* Nishikawa, 1993 = *P*. (s. str.) *smetanai* Perreau, 1996, syn. n. The geographic variation on apicoventral piece of aedeagal median lobe between the populations of *P*. (s. str.) *kuntzeni* from Japan and Taiwan is mentioned. Relevant morphological characters of the examined *Ptomaphagus* species are illustrated with colour plates, and their known distributions are mapped.

#### Material and methods

Specimens were relaxed and softened in a hot saturated solution of potassium hydroxide for 4 minutes (for mounted dry specimens) or 8 minutes (for alcohol-preserved specimens), and then transferred to distilled water to rinse the residual potassium hydroxide off and stop any further bleaching. The softened specimens were moved into glycerine and dissected there to observe morphological details. After examination, the body parts were mounted on a glass slip with Euparal Mounting Medium for future studies. Habitus photographs were taken using a Canon macro photo lens MP-E 65mm on a Canon 550D. Observations, photographs and measurements of morphological details were performed using an Axio Zoom.V16 motorized stereo zoom microscope with an AxioCam MRc 5 in Beijing, or an Olympus BX53 microscope with an Olympus DP73 in Prague. The final deep focus images were created with Helicon Focus 5.3 stacking software in Beijing or Zerene Stacker 1.04 in Prague. The program Adobe Photoshop CS6 was used for post processing. Exact label data are cited for all specimens examined. Authors' remarks and addenda are placed in square brackets, separate label lines are indicated by a slash (/) and separate labels by a double slash (//). Measurements are mean values based on 5 specimens.

The material examined for this study is deposited in the following collections and museums:

CCBW	Collection of Cheng-Bin Wang, Chengdu, Sichuan, China
CJRZ	Collection of Jan Růžička, Prague, Czech Republic
CMNE	Collection of Masaaki Nishikawa, Ebina, Japan
CMPR	Collection of Michel Perreau, Paris, France
СҮНК	Collection of Yasuhiko Hayashi, Kawanishi, Japan
MHNG	Muséum d'Histoire Naturelle, Genève, Switzerland (G. Cuccodoro)
NSMT	National Museum of Nature and Science, Tsukuba, Japan (S. Nomura)
NTUC	National Taiwan University, Taipei, Taiwan, China
SMNS	Staatliches Museum für Naturkunde, Stuttgart, Germany (W. Schawaller)

**ZMHB** Museum für Naturkunde – Leibniz-Institut für Evolutions- und Biodiversitätsforschung an der Humboldt-Universität zu Berlin, Berlin, Germany (J. Frisch).

The following abbreviations are used for the measurements in millimetres (mm):

- **AL** (antennal length): length from the antennal base to apex.
- BTW (basitarsal width): maximum width of 1st protarsomere.
- **EBL** (extended body length): summation of HL, PL, ELL and length of exposed scutellum, preventing the error introduced by exposed or retracted head.
- ELL (elytral length): length from the tail end of scutellum to the elytral apex.
- ELW (elytral width): maximum width of two elytra combined together.
- **EW** (eye width): width of a single compound eye in dorsal view.
- **HL** (head length): axial length from the anterior apex of clypeus through the posterior margin of occipital carina.
- HW (head width): maximum width of head (usually including eyes).
- PL (pronotal length): axial length of the pronotum.
- **PW** (pronotal width): maximum width of pronotum.
- **TW** (tibial width): maximum width of protibia (excluding spines along outer margin etc.).

# Results

# Genus Ptomaphagus Hellwig, 1795

Distribution. Holarctic, north Oriental, north Neotropical.

## Subgenus Ptomaphagus s. str.

Distribution. Palaearctic, north Oriental.

# Key to species of Ptomaphagus Hellwig from Taiwan Island

1	Metathoracic wings absent; aedeagus large and strongly asymmetrical, me- dian lobe turning to right at apex (Figs (A B); spermetheca spiral shaped
	distal part discoid (Fig. 7A–C)
_	Metathoracic wings fully developed; aedeagus small and almost symmetrical,
	median lobe not turning to right at apex; spermatheca J-shaped, distal part
	simply curved2
2	Elytral apices widely rounded; aedeagus stout and wide; spermatheca not
	coiled in proximal part

## Ptomaphagus (s. str.) kuntzeni Sokolowski, 1957

Figs 1; 4

- Ptomaphagus (s. str.) kuntzeni Sokolowski 1957: 140 (Ptomaphagus; type locality: [JAPAN] Hagi (? Landschaft Jamagutshi, Honshiu); ZMHB); Szymczakowski 1964: 63 (Ptomaphagus; female description; taxonomic remarks); Nishikawa 1983: 1 (Ptomaphagus (Ptomaphagus); in check-list); Harusawa and Yamamoto 2000: 242 (Ptomaphagus; distribution); Hayashi and Nishikawa 2010: 190 (Ptomaphagus; distribution); Perreau 2000: 363 (Ptomaphagus (s. str.); in catalogue); Perreau 2004: 178 (Ptomaphagus); distribution; notes); Nishikawa et al. 2012: 274 (Ptomaphagus (Ptomaphagus); distribution; notes); Nishikawa et al. 2012: 274 (Ptomaphagus (Ptomaphagus); distribution); Perreau 2015: 249 (Ptomaphagus (Ptomaphagus); in catalogue); Wang et al. in press (Ptomaphagus (s. str.); redescription; distribution; remarks).
- Ptomaphagus (s. str.) amamianus Nakane 1963: 42 (Ptomaphagus; type locality: [JAPAN] Naze, Amami-Oshima); Hayashi 1969: 2 (Ptomaphagus; characteristic figures; distribution); Nishikawa 1983: 1 (Ptomaphagus (Ptomaphagus); in check-list); Perreau 1996: 284 (Ptomaphagus; distribution); Perreau 2000: 362 (Ptomaphagus (s. str.); in catalogue); Perreau 2004: 178 (Ptomaphagus (Ptomaphagus); in catalogue); Hayashi and Nishikawa 2010: 190 (Ptomaphagus; distribution); Perreau 2015: 249 (Ptomaphagus (Ptomaphagus); in catalogue); Wang et al. in press (Ptomaphagus (s. str.); synonymy with P. kuntzeni).

**Material examined.** 3 3, Taiwan, 25.V.1977 / Fenchihu [奮起湖, ca. 23°30'N, 120°42'E], 1400 m / Klapperich leg. (13 in CJRZ, 13 in CMPR and 13 in MHNG); 1 $\bigcirc$ , same data as previous except: 14.V.1977 (CMPR); 1 $\bigcirc$ , TAIWAN, Nantou / Hsien, Meifeng [梅峰, ca. 24°05'N, 121°10'E] / 2130 m 10–17.VII.[19]93 / yellow pan traps / A. Smetana [leg.] (T147) (CJRZ); 1 $\bigcirc$ , TAIWAN Taichung / Hsien, Anmashan [鞍馬山, ca. 24°16'N, 121°00'E] / 2230 m 30.IV.–4.V.[19]90 / A. Smetana [leg.] (T32) // PTOMAPHAGUS / sp. (SMNS).

**Remarks.** Perreau (1996) recorded the species from Taiwan Island under the name *P*. (s. str.) *amamianus*. We re-examined the specimens concerned and found that they have a partly different aedeagus from that of Japanese specimens (Fig. 4A, C, E): in specimens from Taiwan, the right apicoventral piece of median lobe is slender and



**Figure 1.** Habitus of *Ptomaphagus* (s. str.) *kuntzeni* Sokolowski, 1957 from Taiwan (dorsal view). **A**  $\stackrel{\circ}{\supset}$  (Fenchihu) **B**  $\stackrel{\circ}{\ominus}$  (Meifeng). Scale bar 1 mm.

subtriangular (Fig. 4B, D); while in specimens from Japan, it is shorter and subround (Fig. 4F). However, we consider that it is an intraspecific geographic variation because they have the basically identical shape of aedeagi and spermathecae, and no distinct differences in their external morphology.

Distribution. China (Taiwan) (Fig. 12), Japan, ?Myanmar.

## Ptomaphagus (s. str.) yasutoshii Nishikawa, 1993

Figs 2; 5–7

Ptomaphagus (s. str.) yasutoshii Nishikawa 1993: 123 (Ptomaphagus (s. str.); type locality: Taiwan, Nantou Hsien, near Tsuifeng, 2200 m; NSMT); Perreau 2000: 367 (Ptomaphagus (s. str.); in catalogue); Perreau 2004: 178 (Ptomaphagus (Ptomaphagus); in catalogue); Perreau 2015: 250 (Ptomaphagus (Ptomaphagus); in catalogue).
Ptomaphagus (s. str.) smetanai Perreau 1996: 285 (Ptomaphagus (s. str.); type locality: Taiwan, Hualien Hsien, Taroko, N. P. Duodyatunshan, 2660 m; MHNG); Perreau 2000: 364 (Ptomaphagus (s. str.); in catalogue); Perreau 2004: 178 (Ptomaphagus)



**Figure 2.** Habitus of *Ptomaphagus* (s. str.) *yasutoshii* Nishikawa, 1993 (dorsal view). **A**  $\stackrel{\wedge}{\rightarrow}$  (holotype) **B**  $\stackrel{\frown}{\rightarrow}$  (allotype) **C**  $\stackrel{\wedge}{\rightarrow}$  (holotype of *P*. (s. str.) *smetanai* Perreau, 1996, syn. n.) **D**  $\stackrel{\frown}{\rightarrow}$  (Yushan). Scale bar 1 mm.

*agus (Ptomaphagus)*; in catalogue); Perreau 2015: 249 (*Ptomaphagus (Ptomapha-gus)*; in catalogue). **Syn. n.** 

Material examined. Type material. Holotype of *P. yasutoshii*: ♂, (Near TSIFENG [翠峰, ca. 24°06'N, 121°11'E]) / Nantou - Hsien, / TAIWAN (2200 m) / Aug. 25th, 1974 / Coll. Y. Shibata // HOLOTYPE / Ptomaphagus (s. str.) / yasutoshii / M. Nishikawa, 1993 (NSMT). Allotype of *P. yasutoshii*: ♀, (Near TSIFENG [翠峰, ca. 24°06'N, 121°11'E]) / Nantou - Hsien, / TAIWAN (2200 m) / July 27th, 1974 / Coll. Y. Shibata // ALLOTYPE / Ptomaphagus (Ptomaphagus) / yasutoshii M. Nishikawa, / 1993 / Design. M. Nishikawa, 1993 / # MNIC 124929Ch2S ♀ // ♀ (CMNE). Holotype of *P. smetanai*: ♂, TAIWAN Hualien / Hsien, Taroko, N. P / [Mt.] Duodyatunshan [多加屯山, ca. 24°18'N, 121°30'E] / 2650 m, 8.–13.V.[19]90 / A. Smetana [leg.] (T57) // HOLOTYPE / PTOMAPHAGUS SMETANAI / M. Perreau det. 1994 // MHNG / ENTO / 00003352 (MHNG).

Additional material. 1, Mt. YUSHAN [ $\pm \mu$ , ca. 23°28'N, 120°57'E] / TAI-WAN / 20.V.1981 / N. ITO [leg.] // Ptomaphagus / (s. str.) yasutoshii / MS / Exs. M. NISHIKAWA, 1992 (CYHK).

**Redescription.** *Male.* EBL: 4.3 mm in holotype of *P. yasutoshii* and 4.9 mm in holotype of *P. smetanai*). Length of different body parts: HL : AL : PL : ELL = 0.78 : 1.51 : 1.08 : 2.25 mm; width: HW : EW : PW : ELW = 1.22 : 0.10 : 1.79 : 1.90 mm. Proportion of antennomeres from base to tip in µm (length × width):  $202 \times 85$ ,  $139 \times 81$ ,  $170 \times 82$ ,  $95 \times 83$ ,  $91 \times 98$ ,  $87 \times 114$ ,  $125 \times 138$ ,  $57 \times 122$ ,  $117 \times 138$ ,  $123 \times 134$ ,  $205 \times 119$ .

*Habitus* (Fig. 2A, C) elongated oval, regularly convex and sublustrous. Well pigmented: mostly dark brown; mouthparts, antennae (apical half of ultimate antennomere yellowish) and tarsi reddish brown. Dorsum continuously clothed with fine, recumbent, yellowish pubescence. Insertions of pubescence on dorsal surfaces of head, pronotum, elytra and femora aligned along transverse striolations; interspace between two striolations glabrous.

*Head* transverse, HW/HL = 1.6. Clypeofrontal suture absent. Clypeus with anterior margin almost straight. Compound eyes small, EW/HW = 0.1. Antennae (Fig. 5A) slender, AL/HW = 1.2; antennomere III much longer than II; VI with length/width = 0.8; XI pear-shaped.

*Pronotum* (Fig. 5B) much transverse, widest just before hind angles, PW/PL = 1.7. Sides regularly rounded, gradually narrowing from posterior to anterior, and slightly constricted before hind angles, which projected backwards and acute. Posterior margin widely protruding in the middle part, distinctly emarginate near hind angles.

*Elytra* oval and quite wide, widest at about basal 1/5, ELL/EW = 1.2. Sides weakly arched, gradually narrowing from widest part to apices, which obliquely truncated (Fig. 5G). Sutural striae present. Metathoracic wings absent.

*Prolegs* robust, with basal three protarsomeres (Fig. 5C) strongly expanded: TW/ BTW = 1.1. Protibiae (Fig. 5E) distinctly expanded towards apex. Profemora rather broad. Mesotibiae arcuate, mesotarsi simply linear. Metatibiae slender and straight. *Abdominal ventrite VIII* (Fig. 5I) widely and deeply emarginate at posterior edge. Genital segment (Fig. 5J) with spiculum gastrale protruding about 1/2 of its length beyond anterior edge of epipleurite IX.

*Aedeagus* (Fig. 6A, B) large, slender and strongly asymmetrical, with median lobe gradually narrowing towards lanceolate apical part which turning to right in dorsal view; opening of genital orifice situated on dorsal surface, deeply cut inwards on preapical left margin of median lobe. Ventral surface of the apical part of the median lobe (Figs 6F, G) inserted with a row of 7 ventrally-oriented setae on both sides. Parameres narrow, reaching about apical 1/5 of median lobe, each with 1 apical and 2 preapical setae, the apical one much shorter (Fig. 6E). In lateral view (Fig. 6C, D), median lobe distinctly bent ventrad and strongly tapering towards narrowly acuminate apex. Endophallus with stylus quite slender, a cheliform complex just below the base of stylus, and a circular complex in basal region.

*Female*. Similar to male in general appearance (Fig. 2B, D), including elytral apices (Fig. 5H), but distinguished by the following characteristics: protarsi (Fig. 5D) simply linear; protibiae (Fig. 5F) much narrower; abdominal ventrite VIII (Fig. 7D) strongly and widely protruded at median of posterior edge; genital segment as shown in Fig. 7A; spermatheca (Fig. 7A–C) spiral-shaped, discoidal in distal part.

**Remarks.** This species is exceptional in the genus *Ptomaphagus* in the following characters: metathoracic wings absent; aedeagus strongly asymmetrical, median lobe turning rightwards in apical part; spermatheca spiral-shaped, discoidal in distal part.

In addition, the holotypes of *Ptomaphagus yasutoshii* and *P. smetanai* have almost identical aedeagal shape (Fig. 6A–D) and no distinct differences in the external morphology, except some variations exist in the shape of aedeagal apex: the right apicoventral piece of median lobe of *P. yasutoshii* (Fig. 6H) is somewhat wider than that of *P. smetanai* (Fig. 6I). However, such differences, which fall within intraspecific variability, does not prevent us from synonymizing the two species.

Distribution. China (Taiwan) (Fig. 12).

#### Ptomaphagus (s. str.) chenggongi sp. n.

http://zoobank.org/D6994368-3822-4571-8B04-7C3AAF0BC100 Figs 3; 8; 9A, C, E, G, H; 10

**Type locality.** Central Taiwan, Nantou Hsien, Tsuifeng [翠峰, ca. 24°06'N, 121°11'E], 2,300 m.

**Type material. Holotype:** ♂, [Taiwan] Tsuifeng [翠峰, ca. 24°06'N, 121°11'E], 2,300 m / FIT: in shady Forest / Nantou Hsien // Central Taiwan / 7-14-VIII-2003 / Wataru Suzuki leg. (NSMT). **Paratypes:**  $22 \Im \Im 24 \Im \Im$ , same data as holotype ( $22 \Im \Im 22 \Im \Im$  in CMNE,  $2 \Im \Im$  in NSMT);  $2 \Im \Im$ , same data as holotype except: FIT: Forest edge (CMNE);  $10 \Im \Im 10 \Im \Im$ , same data as holotype except: 2,200 m / FIT: shady natural forest (CMNE);  $2 \Im \Im 1 \Im$ , same data as holotype except: 2,200 m (CMNE);  $1 \Im$ , TAIWAN, Nantou / Hsien, Meifeng [梅峰, ca. 24°05'N, 121°10'E] / 2130 m 10–17.VII.[19]93 / yellow pan traps / A. Smetana [leg.] (T147) (CJRZ).



**Figure 3.** Habitus of *Ptomaphagus* (s. str.) spp. (dorsal view). **A, B** *P*. (s. str.) *chenggongi* sp. n. **C–E** *P*. (s. str.) *tingtingae* sp. n. **A, C**  $\bigcirc$  (holotypes) **B, D**  $\bigcirc$  (paratypes) **E**  $\bigcirc$  (line-art drawing). Scale bar 1 mm.

**Description.** *Male.* EBL: 4.1–4.2 mm (4.2 mm in holotype). Length of different body parts: HL : AL : PL : ELL = 0.67 : 1.26 : 1.00 : 2.32 mm; width: HW : EW : PW : ELW = 1.04 : 0.09 : 1.49 : 1.64 mm. Proportion of antennomeres from base to tip in



**Figure 4.** Aedeagal apices of *Ptomaphagus* (s. str.) *kuntzeni* Sokolowski, 1957 (ventral view). **A–D** Fenchihu, Taiwan Island **E, F** Amami-Ôshima Island, Japan **B, D, F** right apicoventral piece of median lobe. Scale bars 0.1 mm.

µm (length × width): 179 × 77, 123 × 68, 105 × 74, 75 × 82, 75 × 99, 53 × 113, 104 × 135, 53 × 132, 102 × 138, 117 × 137, 217 × 116.

*Habitus* (Fig. 3A) elongated oval, regularly convex and sublustrous. Well pigmented: mostly brown; mouthparts, basal four or five antennomeres and apical half of ultimate antennomere, protarsi, and apex of meso- and metatarsi yellowish. Dorsum continuously clothed with fine, recumbent, yellowish pubescence. Insertions of pubescence on dorsal surfaces of pronotum, elytra and femora aligned along transverse striolations; interspace between two striolations glabrous.

*Head transverse*, HW/HL = 1.5. Clypeofrontal suture absent. Clypeus with anterior margin slightly rounded. Compound eyes well developed, EW/HW = 0.1. Antennae (Fig. 8A) slender, AL/HW = 1.3; antennomere III a little shorter than II; VI with length/width = 0.5; XI elongated pear-shaped.

*Pronotum* (Fig. 8B) transverse, widest just before hind angles, PW/PL = 1.5. Sides gently arched, narrowing from posterior to anterior, and slightly constricted before hind angles, which projected backwards and subacute. Posterior margin widely protruding in the middle part, distinctly emarginate near hind angles.

*Elytra* oval, widest at about basal 2/7, ELL/EW = 1.4. Sides weakly arched, gradually narrowing from widest part to apices, which narrowly rounded (Fig. 8G). Sutural striae present. Metathoracic wings fully developed.

*Prolegs* robust, with basal three protarsomeres (Fig. 8C) strongly expanded: TW/ BTW = 1.0. Protibiae (Fig. 8E) expanded towards apex. Profemora rather broad. Mesotibiae arcuate, mesotarsi simply linear. Metatibiae slender and straight.

Abdominal ventrite VIII (Fig. 8I) round at posterior edge, though an inconspicuous median notch at the median. Genital segment (Fig. 8J) with spiculum gastrale protruding about 3/8 of its length beyond anterior edge of epipleurite IX.

*Aedeagus* (Fig. 9A) long and slender, with median lobe gradually narrowing towards lanceolate apical part and terminated by round knob in dorsal view; opening of genital orifice situated on dorsal surface, deeply cut inwards on preapical left margin of median lobe. Ventral surface of the apex of the median lobe (Fig. 9G) inserted with



**Figure 5.** *Ptomaphagus* (s. str.) *yasutoshii* Nishikawa, 1993 ( $\delta$  holotype;  $\mathfrak{Q}$  allotype). **A** antenna  $\delta$  (dorsal view) **B** pronotum  $\delta$  (dorsal view) **C** protarsus  $\delta$  (dorsal view) **D** protarsus  $\mathfrak{Q}$  (dorsal view) **E** protibia and profemur  $\delta$  (ventral view) **F** protibia and profemur  $\mathfrak{Q}$  (ventral view) **G** elytral apex  $\delta$  (dorsoapical view) **H** elytral apex  $\mathfrak{Q}$  (dorsoapical view) **I** ventrite VIII  $\delta$  (ventral view) **J** genital segment  $\delta$  (ventral view). Scale bars 0.1 mm.

a row of 6 ventrally oriented setae (the bottom one is very short) on the left side and a row of 4 ventrally oriented setae on the right side. Parameres narrow, reaching about apical 1/5 of median lobe, each with 1 apical and 2 preapical setae, the apical one slightly shorter (Fig. 9E). In lateral view (Fig. 9C), median lobe regularly bent ventrad, gradually tapering apically. Endophallus with stylus quite slender, a cheliform complex just below the base of stylus, and a circular complex in basal region.

*Female*. Similar to male in general appearance (Fig. 3B), including elytral apices (Fig. 8H), but distinguished by the following characteristics: protarsi (Fig. 8D)



**Figure 6.** Aedeagi of *Ptomaphagus* (s. str.) *yasutoshii* Nishikawa, 1993. **A, C, F, H** holotype **B, D, E, G, I** holotype of *P*. (s. str.) *smetanai* Perreau, 1996, syn. n. **A, B** aedeagi (dorsal view) **C, D** aedeagi (lateral view) **E** paramere apex (lateral view) **F, G** aedeagal apices (ventral view) **H, I** right apicoventral piece of median lobe (ventral view). Scale bars 0.1 mm.

simply linear; protibiae (Fig. 8F) only slightly narrower; abdominal ventrite VIII (Fig. 9A) almost regularly rounded at posterior edge; genital segment as shown in Fig. 9B: spermatheca (Fig. 9B) curved in distal part, coiled and extended leftwards in proximal part.

**Diagnosis.** *Ptomaphagus* (s. str.) *chenggongi* sp. n. has very similar aedeagus to *P*. (s. str.) *tingtingae* sp. n., but can be distinguished from the latter by the following



**Figure 7.** *Ptomaphagus* (s. str.) *yasutoshii* Nishikawa, 1993 ( $\bigcirc$  Yushan). **A** spermatheca and genital segment (ventral view) **B** spermatheca (lateral view) **C** spermatheca (dorsal view) **D** ventrite VIII  $\bigcirc$  (ventral view). Scale bars 0.1 mm.

characters: in *P*. (s. str.) *chenggongi* sp. n., antennomere XI with length/width = 1.9, hind angles of pronotum subacute, spiculum gastrale of genital segment with ordinary width, right apicoventral piece of median lobe broad (Fig. 9H), apical seta of parameres slightly shorter than preapical setae, and spermatheca coiled and extended leftwards in proximal part; while in *P*. (s. str.) *tingtingae* sp. n., antennomere XI with length/width = 1.3, hind angles of pronotum acute, spiculum gastrale of genital segment very narrow, right apicoventral piece of median lobe rather small (Fig. 9I), apical seta of parameres very shorter than preapical setae, and spermatheca coiled but not extended leftwards in proximal part.

**Etymology.** The specific epithet is dedicated to Cheng-Gong Zheng (1624–1662), a military leader at the end of the Chinese Ming Dynasty, for his feats in 1662 when he defeated the forces of the Dutch East India Company and claimed Taiwan, bringing it under Chinese Han rule.

Distribution. China (Taiwan) (Fig. 12).



**Figure 8.** *Ptomaphagus* (s. str.) *chenggongi* sp. n. (paratypes). **A** antenna  $\mathcal{J}$  (dorsal view) **B** pronotum  $\mathcal{J}$  (dorsal view) **C** protarsus  $\mathcal{J}$  (dorsal view) **D** protarsus  $\mathcal{G}$  (dorsal view) **E** protibia and profemur  $\mathcal{J}$  (ventral view) **F** protibia and profemur  $\mathcal{G}$  (ventral view) **G** elytral apex  $\mathcal{J}$  (dorsoapical view) **H** elytral apex  $\mathcal{G}$  (dorsoapical view) **I** ventrite VIII  $\mathcal{J}$  (ventral view) **J** genital segment  $\mathcal{J}$  (ventral view). Scale bars 0.1 mm.

## Ptomaphagus (s. str.) tingtingae sp. n.

http://zoobank.org/D518FD86-9AD9-458D-972C-121655AF9A0D Figs 3C-E; 9B, D, F, I, J; 10C, D; 11

## Type locality. Taiwan, Fushan [福山, ca. 24°46'N, 121°30'E].

**Type material. Holotype:** 3, CHINA, Taiwan, Fushan [福山, ca. 24°46'N, 121°30'E], mouse carcass bait, III.2007, Wen-Bo Huang leg. (5#) (NTUC). **Para-types:** 633799, same data as holotype (1319 in CCBW, 1319 in CJRZ, 1319 in CMNE, 1319 in CMPR and 23399 in NTUC); 799, same data as holotype ex-



Figure 9. Aedeagi of *Ptomaphagus* (s. str.) spp. A, C, E, G, H *P*. (s. str.) *chenggongi* sp. n. (paratype)
B, D, F, I, J *P*. (s. str.) *tingtingae* sp. n. (paratype) A, B aedeagi (dorsal view) C, D aedeagi (lateral view)
E, F paramere apices (lateral view) G, J aedeagal apices (ventral view) H, I right apicoventral piece of median lobe (ventral view). Scale bars 0.1 mm.

cept: IV.2007, (1#) (NTUC); 2331, Taiwan: Tai Pei Co. / Noi Dong [?Neidong= 内洞, ca. 24°49'N, 121°32'E] Logging Road, / 850 m, 19.ii.2004, / Flight intercept trap. / leg. Chun Lin Li (ZMHB); 22, Taiwan: Tai Chun Co., / An Ma Shan [鞍 馬山, ca. 24°16'N, 121°00'E], 2 km, / 24.-26.vi.2003 / Flight intercept trap. / leg. Chun Lin Li (ZMHB).

**Description.** *Male.* EBL: 4.0–4.3 mm (4.1 mm in holotype). Length of different body parts: HL : AL : PL : ELL = 0.62 : 1.22 : 1.00 : 2.27 mm; width: HW : EW : PW : ELW = 1.00 : 0.11 : 1.55 : 1.68 mm. Proportion of antennomeres from base to tip in



**Figure 10. A, B** *Ptomaphagus* (s. str.) *chenggongi* sp. n. (paratype) **C, D** *P*. (s. str.) *tingtingae* sp. n. (paratype) **A, D** ventrites VIII (ventral view) **B, C** spermathecae and genital segments (ventral view). Scale bars 0.1 mm.

µm (length × width): 180 × 72, 134 × 66, 111 × 74, 73 × 79, 73 × 92, 60 × 111, 92 × 127, 47 × 125, 87 × 136, 101 × 140, 176 × 132.

*Habitus* (Fig. 3C, E) elongated oval, regularly convex and sublustrous. Well pigmented: mostly dark brown, head darker; mouthparts, basal three antennomeres and apical half of ultimate antennomere, protarsi, and apex of meso- and metatarsi somewhat yellowish. Dorsum continuously clothed with fine, recumbent, yellowish pubescence. Insertions of pubescence on dorsal surfaces of pronotum, elytra and femora aligned along transverse striolations; interspace between two striolations glabrous.



**Figure 11.** *Ptomaphagus* (s. str.) *tingtingae* sp. n. (paratypes). **A** antenna  $\Diamond$  (dorsal view) **B** pronotum  $\Diamond$  (dorsal view) **C** protarsus  $\Diamond$  (dorsal view) **D** protarsus  $\Diamond$  (dorsal view) **E** protibia and profemur  $\Diamond$  (dorsal view) **F** protibia and profemur  $\Diamond$  (dorsal view) **G** elytral apex  $\Diamond$  (dorsoapical view) **H** elytral apex  $\Diamond$  (dorsoapical view) **I** ventrite VIII  $\Diamond$  (ventral view) **J** genital segment  $\Diamond$  (ventral view). Scale bars 0.1 mm.

*Head transverse*, HW/HL = 1.6. Clypeofrontal suture absent. Clypeus with anterior margin slightly rounded. Compound eyes well developed, EW/HW = 0.1. Antennae (Fig. 11A) slender, AL/HW = 1.2; antennomere III a little shorter than II; VI with length/width = 0.5; XI pear-shaped.

*Pronotum* (Fig. 11B) transverse, widest just before hind angles, PW/PL = 1.6. Sides gently arched, gradually narrowing from posterior to anterior; hind angles projected backwards and acute. Posterior margin widely protruding in the middle part, distinctly emarginate near hind angles.



Figure 12. Distribution map of *Ptomaphagus* species from Taiwan Island.

*Elytra* oval, widest at about basal 1/3, ELL/EW = 1.4. Sides weakly arched, gradually narrowing from widest part to apices, which narrowly rounded (Fig. 11G). Sutural striae present. Metathoracic wings fully developed.

*Prolegs* robust, with basal three protarsomeres (Fig. 11C) strongly expanded: TW/ BTW = 1.2. Protibiae (Fig. 11C) distinctly expanded towards apex. Profemora rather broad. Mesotibiae arcuate, mesotarsi simply linear. Metatibiae slender and straight.

Abdominal ventrite VIII (Fig. 11I) narrowly round at posterior edge, though an inconspicuous median notch at the median. Genital segment (Fig. 8J) with very slender spiculum gastrale, protruding about 3/8 of its length beyond anterior edge of epipleurite IX.

*Aedeagus* (Fig. 9B) long and rather slender, with median lobe gradually narrowing towards narrowly lanceolate apical part and terminated by round knob in dorsal view; opening of genital orifice situated on dorsal surface, deeply cut inwards on preapical

left margin of median lobe. Ventral surface of the apex of the median lobe (Fig. 9J) inserted with a row of 6 ventrally-oriented setae on the left side and a row of 5 ventrally-oriented setae on the right side. Parameres narrow, reaching about apical 1/6 of median lobe, each with 1 apical and 2 preapical setae, the apical one very shorter (Fig. 9F). In lateral view (Fig. 9D), median lobe regularly bent ventrad, gradually tapering apically. Endophallus with stylus quite slender, a cheliform complex just below the base of stylus, and a circular complex in basal region.

*Female*. Similar to male in general appearance (Fig. 3D), including elytral apices (Fig. 11H), but distinguished by the following characteristics: protarsi (Fig. 11D) simply linear; protibiae (Fig. 11F) only slightly narrower; abdominal ventrite VIII (Fig. 10D) regularly rounded at posterior edge; genital segment as shown in Fig. 10C: spermatheca (Fig. 10C) curved in distal part and coiled in proximal part.

Diagnosis. See under P. (s. str.) chenggongi sp. n. above.

**Etymology.** The specific epithet is dedicated to Miss Ting-Ting Song, the first author's former colleague (Institute of Zoology, Chinese Academy of Sciences, Beijing, China), who did important primary work on Chinese *Leiodes* Latreille, 1796 (Leiodidae: Leiodinae).

Distribution. China (Taiwan) (Fig. 12).

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#### References

- Harusawa K, Yamamoto E (2000) Choleved [sic] beetles (Coleoptera) collected from Odamiyama, Ehime Prefecture. Nature of Odamiyama 2: 241–247.
- Hayashi Y (1969) Catopidae from Amami-Ohshima Is., Japan (Col.). Entomological Review of Japan 12(1): 1–6.
- Hayashi Y, Nishikawa M (2010) Cholevine beetles (Coleoptera: Leiodidae) occurring on Toku-no-shima Island, the Ryukyus, Southwest Japan. Entomological Review of Japan 65(1): 189–190.

- Hellwig JCL (1795) Favna etrvsca sistens Insecta qvae in provinciis Florentina et Pisana praesertim collegit Petrvs Rossivs, in Regio Pisano Aethenaeo Publ. prof. et Soc. Ital. Tomus primus. C. G. Fleckeisen, Helmstadii, 457 pp.
- Nakane T (1963) New or little-known Coleoptera from Japan and its adjacent regions. XXI. Fragmenta Coleopterologica Kyoto 10: 40–42.
- Nishikawa M (1983) Family Catopidae. Check-list of Coleoptera of Japan (23). Coleopterists' Association of Japan, Tokyo, 1–6.
- Nishikawa M (1993) Occurrence of a new apterous species of *Ptomaphagus* (Coleoptera, Cholevidae) in Taiwan. Elytra (Tokyo) 21(1): 123–128.
- Nishikawa M (2011) A new *Ptomaphagus* (Coleoptera: Leiodidae: Cholevinae) from Northwest Thailand. Special Publication of the Japanese Society of Scarabaeoidology 1: 97–102.
- Nishikawa M, Hayashi Y, Yoshida M, Fujitani Y (2012) The underground fauna of Agyrtidae and the subfamily Cholevinae of Leiodidae (Coleoptera) in eastern Shikoku, Southwest Japan, with a summary of the habitat diversity of some Japanese cholevines. Elytra, Tokyo, New Series 2(2): 267–278.
- Perreau M (1996) Contribution à la connaissance des Cholevidae du Japon et de Taiwan (Coleoptera). Revue Suisse de Zoologie 103: 283–297. doi: 10.5962/bhl.part.79946
- Perreau M (2000) Catalogue des Coléoptères Leiodidae, Cholevinae et Platypsyllinae. Mémoires de la Société entomologique de France 4: 1–460.
- Perreau M (2004) Family Leiodidae Fleming, 1821. In: Löbl I, Smetana A (Eds) Catalogue of Palaearctic Coleoptera. Volume 2: Hydrophiloidea – Histeroidea – Staphylinoidea. Apollo Books, Stenstrup, 133–203.
- Perreau M (2015) Family Leiodidae Fleming, 1821. In: Löbl I, Löbl D (Eds) Catalogue of Palaearctic Coleoptera. Volume 2/1. Hydrophiloidea – Staphylinoidea. Revised and updated edition. Brill, Leiden & Boston, 180–290.
- Sokolowski K (1957) Zwei neue japanische Catopiden (Col. Catopidae) (Catopiden-Studien 6). Deutsche entomologische Zeitschrift (N.F.) 4(3-4): 140–142.
- Szymczakowski W (1964) Analyse systématique et zoogéographique des Catopidae (Coleoptera) de la région orientale. Acta Zoologica Cracoviensia 9: 55–289.
- Wang C-B, Růžička J, Nishikawa M, Perreau M, Hayashi Y (in press) Contributions to the knowledge of the genus *Ptomaphagus* Hellwig (Coleoptera, Leiodidae, Cholevinae) from Japan. ZooKeys.

SHORT COMMUNICATION



# A new species of the genus Falsoibidion Pic (Coleoptera, Cerambycidae) from Korea

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## Abstract

A new species of the genus *Falsoibidion* Pic, 1922 (Coleoptera, Cerambycidae, Cerambycinae, Callidiopini) from Korea is described. Habitus and genitalia of male and female of the new species are illustrated.

#### Keywords

New species, Cerambycidae, taxonomy, Korea

## Introduction

*Falsoibidion* Pic, 1922 (Coleoptera, Cerambycidae, Cerambycinae, Callidiopini) is composed of six species worldwide. Until now, their distributional range was only restricted to the Oriental region: *Falsoibidion encaustum* Holzschuh, 1999 and *F. in-fidarium* Holzschuh, 1999 from Thailand, *F. fasciatum* Pic, 1922 and *F. punctuosum* Holzschuh, 2003 from Vietnam, *F. fuscipes* Hayashi, 1979 from Malaysia, and *F. trimaculatum* Pic, 1923 from Cambodia and Laos. Lifecycle of the genus has been poorly known, only *Carica papaya* Linnaeus was reported as a host plant of *F. trimaculatum* (Gressitt, 1970).

In this study, a new species of the genus *Falsoibidion* from central and southern part of Korean peninsula is described. This species was reported as *Falsoibidion* sp., without species level identification (Jang et al. 2015). The new species is the first record of this genus in the Palaearcic region. Moreover, we provide the first description of the genital structures of the genus *Falsoibidion*.

#### Materials and methods

A total of five specimens were used in this study. Two of them were deposited in the College of Agriculture and Life Sciences, Seoul National University, Seoul, Korea, and three of them in the College of Agriculture and Life Sciences, Chungnam National University, Daejeon, Korea. All specimens were preserved in dry conditions, while hind wings and leg muscles of some of them were extracted for future molecular study. Photographs were taken with a Canon digital camera EOS 70D, Canon MP-E 65 mm f/2.8 1–5x macro lens mounted, controlled by Cognisys Stackshot.

To examine the male and female genitalia, the specimens were relaxed in distilled water for two to four hours in room temperature. Then, the genitalia were separated from the last abdominal segment using hooked pins or forceps, without removing abdomen. Separated genitalia were put into 10% KOH solution in room temperature for four to six hours. For the illustration of genital structure, Microscope (DM 4000B, Leica Microsystem, Wetzlar, Germany) with USB digital camera (Infinity3, Lumenera Corporation, Ottawa, Ontario) was used.

Several layers of photographs were combined in Zerene Stacker 1.04 software (Zerene Systems 2014; http://www.zerenesystems.com/cms/stacker).

### Abbreviations

- **CN** Chungcheongnam-do;
- **GB** Gyeongsangbuk-do;
- GG Gyeonggi-do;
- **SNU** Seoul National University;
- **CNU** Chungnam National University.

## Results

*Falsoibidion bipunctatum* sp. n. http://zoobank.org/38FEEE73-373D-483A-9306-4C0B4C388C1E

**Description.** Male (Fig. 1c, d): body length: 6.32 mm, humeral width: 1.22 mm. Female (Fig. 2a, b, e): body length: 6.7 mm, humeral width: 1.27 mm.



**Figure 1.** *Falsoibidion bipunctatum* sp. n. **a** Dorsal habitus, female **b** Ventral habitus, female **c** Dorsal habitus, male **d** Ventral habitus, male **e** head, female. Scale bars: **a**–**d**: 2.5 mm, **e**: 0.5 mm.

Body reddish brown to dark brown with sparsely distributed long pale pubescence.

Head reddish brown to dark brown, mostly with minute sparse pubescence, some pale yellow pubescence present near the anterior margin of the labrum; frons distinctly punctured, moderately concave dorsally, some distinct tubercles present between antennal sockets; antennal sockets distinctly enlarged, distance between two sockets very short, only as long as the length of antennomere I.

Antennae 11-segmented, more or less longer than body (1:1.25 in male, 1:1.08 in female), brown, with fine short pale yellowish pubescence moderately distributed and comparatively long hairs sparsely present; antennomere I slightly swollen distally, ratio of each antennomere 1.00:0.26:0.92:0.77:1.47:1.47:1.47:1.18:1.26:0.88:1.00 in male; 1.00:0.30:0.82:0.67:1.36:1.32:1.31:1.08:1.01:0.93:0.85 in female.

Pronotum distinctly longer than wide (W/L=1.97 in male, 1.71 in female), almost rectangular in dorsal view; lateral margin weakly uneven, only finely granulose, without any distinct puncture; anterior fourth of prothorax curved downward in lateral view; teguments reddish to dark brown with a pair of distinct black spots on apical half of each lateral margin; intercoxal prosternal process narrowed toward the apex, not much developed, only reaching the posterior margin of the coxal cavities.

Elytra distinctly longer than wide (W/L=1:3.41 in male, 1:3.55 in female), almost parallel, rounded at apex, humeral margin slightly rounded, slightly more granulose than pronotum; teguments mainly brown with a small circular black spot on the basal fourth of each side of the lateral margin, a black band on the middle, forming an arrowtail-like pattern angulated toward the base, bright oval markings after this pattern;. Abdominal segments darker, with fine pale pubescence.

Leg brown, covered with moderately long pale golden hairs; hairs on tibia slightly denser than those on femur; distal third of femur largely inflated.

Male genitalia: Tegmen 0.84 mm long, 0.22 mm wide; lateral lobes with two distinct parts, gradually restricted to apex, here with fine soft hairs in dorsal and ventral side; two thick long hairs present on each lobe. Median lobe extraordinarily blunt at apex, much longer than tegmen in length, slightly curved in lateral view; median struts distinctly elongated, taking more than two third of the total length of median lobe.

Female genitalia: Sternite VIII twice as long as wide, almost rectangular, with five distinct long hairs at each side. Ovipositor missing.

**Differential diagnosis.** The following diagnostic characters are peculiar to this species; body slender, head short, distance between compound eyes short; antennae pubescent; prothorax cylindrical, very long; femora claviform. This new species can be easily distinguished from its congeners in the following characters: two circular spot on elytra, arrowtail-like black elytral band and legs unicolor brownish.

**Type material.** Holotype: [SNU] 1∂. Gogol-gil, Deogyang-gu, Goyang-si, GG, Korea, Light trap, 25.v.2013, D.K. Ahn.

Paratype: [SNU] 1♂. Gajang-dong, Sangju-si, GN, Korea, 9.vi.2011, street light, J.B. Choi. [CNU] 1♀. Donam-ri, Geumnam-myeon, Sejong-si, CN, Korea, 5.v.2015, J.G. Kim and H.D. Lee; 1♂, C.N.U., Gungdong-ro, Yuseong-gu, Daejeon, Korea, 9.v.2015, J.G. Kim and H.D. Lee; 1♀, same locality, 13.v.2014, Sumin Oh.



**Figure 2.** Genital structure of *Falsoibidion bipunctatum* sp. n. **a** Median lobe, dorsal **b** Median lobe, dorsal, magnified. **c**. Median lobe, lateral **d** Median lobe, lateral, magnified **e** Tegmen, dorsal **f** Tegmen, lateral **g** Tegmen, dorsal, magnified **h** sternite VIII with spiculum ventrale, dorsal **i** tergite VIII, dorsal. Scale bars: **a**, **b**, **c**, **d**, **e**, **f**, **g**, **i**: 0.1 mm, **h**: 0.25 mm.

**Etymology.** The specific epithet is named after the two black spots on pronotum and elytra.

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## References

Gressitt JL, Rondon JA (1970) Cerambycid-beetles of Laos (Disteniidae, Prioninae, Philinae, Aseminae, Lepturinae, Cerambycinae). Pacific Insects Monograph 24: 1–314.

- Hayashi M (1979) Study on Cerambycidae from West Malaysia (Col.) Part II. Bulletin of the Osaka Jonan Women's Junior College 13: 51–87.
- Holzschuh C (1999) Beschreibung von 71 neuen Bockkäfern aus Asien, vorwiegend aus China, Laos, Thailand und Indien (Coleoptera, Cerambycidae). Schriftenreihe der Forstlichen Bundesversuchanstalt (FBVA-Berichte) 110: 1–64.
- Holzschuh C (2003) Beschreibung von 72 neuen Bockkäfern aus Asien, vorwiegend aus China, Indien, Laos und Thailand (Coleoptera, Cerambycidae). Entomologica Basiliensa 25: 147–241.

Jang HK, Lee SH, Choi W (2015) Cerambycidae of Korea. Geobook, Seoul, 399 pp.

Pic M (1922) Nouveautés diverses. Mélanges Exotico-Entomologiques 36: 1-32.

Pic M (1923) Nouveautés diverses. Mélanges Exotico-Entomologiques 38: 1-32.

RESEARCH ARTICLE



# Herniosina Roháček: revised concept, two new species, new key and atlas of male and female terminalia (Diptera, Sphaeroceridae)

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#### Abstract

The taxonomic concept of *Herniosina* Roháček, 1983 (Diptera: Sphaeroceridae) is revised on the basis of five W. Palaearctic species, thus excluding the E. Nearctic *Herniosina voluminosa* Marshall, 1987 whose inclusion caused the paraphyly of the genus. Two new species, *H. erymantha* **sp. n.** (male only, Greece: Peloponnese) and *H. hamata* **sp. n.** (both sexes, Cyprus), are described and illustrated, and the other three species, *H. bequaerti* (Villeneuve, 1917), *H. horrida* (Roháček, 1978) and *H. pollex* Roháček, 1993, are diagnosed with an atlas of their male and female terminalia. The relationships of the redefined genus and of all its species are discussed, and their biology and distribution are reviewed. A new illustrated key to *Herniosina* species is given.

#### **Keywords**

Diptera, Sphaeroceridae, *Herniosina* Roháček, 2 new species, key, terminalia, taxonomy, relationships, biology, distribution, W. Palaearctic

## Introduction

The genus *Herniosina* was established by Roháček (1982, 1983) during the re-classification of the giant assemblage previously included in the genus *Limosina* Macquart, 1835 to comprise two European species of the subfamily Limosininae, viz. *Herniosina bequaerti* 

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**Figure I.** *Herniosina bequaerti* (Villeneuve), male laterally (Czech Republic: Bohemia). Body length cca 2.6 mm. S1+2 and T5 arrowed. Photograph by J. Roháček.

(Villeneuve, 1917) and *H. horrida* (Roháček, 1978). The genus was characterized by the peculiar down-curved male abdomen with protruding bulge on abdominal synsternum S1+2 (cf. Fig. 1) and distinctive male genitalia. Discussing its relationships Roháček (1982) suggested it obviously belongs together with the monotypic genera *Limosina* (redefined), *Gigalimosina* Roháček, 1983 and *Apteromyia* Vimmer, 1929 to the *Limosina* genera-group. When describing *Apteromyia newtoni* (a second species of the genus) Marshall and Roháček (1982) hypothesized *Apteromyia* as the closest relative of *Herniosina*. Marshall (1987) described another unusual species of Limosininae and placed it tentatively in *Herniosina* on the basis of (seemingly) similarly protruding male abdominal S1+2 despite his explicit recognition that it was markedly different in other characters of the male genitalia, i. e. lacking all other synapomorphies of the genus as originally delimited. The inclusion of *H. voluminosa* Marshall, 1987 made *Herniosina* a heterogeneous and apparently non-monophyletic group, as was stated already by Roháček (1993) when describing the third European species, *H. pollex* Roháček, 1993. Apart from a record of

two unidentified females from Israel (Papp and Roháček 1988: 89, as *Herniosina* sp. cf. *horrida*) no further species of *Herniosina* had been known until Roháček (2004) reported about an unnamed species found in Cyprus. However, the latter species has remained undescribed up to the present. Only the recent (2015) discovery of an additional new species in the Peloponnese peninsula initiated the present study which is not only aimed at the descriptions of these two new species but also at revision of taxonomic limits of the genus, its re-definition on the basis of the study of all known species, hypotheses of their relationships as well as at an updated synopsis of their biology and distribution.

## Material and methods

## Material

The material examined is deposited in institutional and private collections as follows:

FSBC	Faculty of Science, Masaryk University, Brno, Czech Republic;
HNHM	Hungarian Natural History Museum, Budapest, Hungary;
ISNB	Institut Royal des Sciences Naturelles de Belgique, Bruxelles, Belgium;
JRO	Collection of Dr. Jindřich Roháček, Opava, Czech Republic;
MBP	Collection of Prof. Miroslav Barták, Praha, Czech Republic;
MMBC	Moravské zemské muzeum, Brno, Czech Republic;
MNHN	Entomologie, Muséum National d'Histoire Naturelle, Paris, France;
MSNV	Museo Civico di Storia Naturale, Venezia, Italy;
MZHF	Universitetets Zoologiska Museum, Helsinki, Finland;
NMPC	Národní muzeum, Praha, Czech Republic;
PKBS	Prírodovedecká fakulta Univerzity Komenského, Bratislava, Slovakia;
SMOC	Slezské zemské muzeum, Opava, Czech Republic;
SMTD	Staatliches Museum für Tierkunde, Dresden, Germany;
UEBC	Ústav ekologie lesa, Mendelova zemědělská a lesnická univerzita, Brno,
	Czech Republic;
VKB	Collection of Dr. Vladimír Košel, Bratislava, Slovakia;
ZMHB	Museum für Naturkunde der Humboldt-Universität zu Berlin, Berlin,
	Germany.

## Methods of preparation and study of postabdominal structures

Abdomens of a number of specimens were detached, cleared by boiling several minutes in 10% solution of potassium hydroxide (KOH) in water, then neutralized in 10% solution of acetic acid (CH<sub>3</sub>COOH) in water, washed in water and subsequently transferred to glycerine. Postabdominal structures were dissected and examined in a drop of glycerine under binocular microscopes (Reichert, Olympus). Detailed examinations of genital structures were performed with a compound microscope (JENAVAL). After examination, all dissected parts were put into small plastic tubes containing glycerine, sealed with hot forceps and pinned below the respective specimens.

## Drawing techniques and photography

Legs were drawn on squared paper using a Reichert binocular microscope with an ocular screen. Details of the male and female genitalia were drawn by means of Abbe's drawing apparatus on a compound microscope (JENAVAL) at larger magnification  $(130-500\times)$ . Wings were photographed on the same microscope with an attached digital camera (Nikon COOLPIX 4500). Whole specimens were photographed by means of digital camera Canon EOS 5D Mark III with macro lens Canon MP-E 65 mm  $1-5\times$  and ring macro flash Canon MR-14EX.

## Measurements

Six main characteristics of the new species were measured: body length (measured from anterior margin of head to end of cercus, thus excluding the antenna), index  $t_2$ :  $mt_2$  (= ratio of length of mid tibia : length of mid basitarsus), wing length (from wing base to wing tip), wing width (maximum width), *C-index* ( $Cs_2$ :  $Cs_3$ ) (= ratio of length of 2nd costal sector : length of 3rd costal sector) and index  $rm \backslash dm$ -cu : dm-cu (= ratio of length of section between rm and dm-cu on discal cell : length of dm-cu). All type specimens were measured.

## Presentation of faunistic data

Label data of primary-type specimens are presented strictly verbatim including information on form and colour of all associated labels. Data from paratypes of the new species and also from formerly unpublished non-type specimens are standardized and presented in full. For data of paratypes or paralectotypes of other species and formerly published records original publications are cited. Phenological and other biological information obtained from the material examined and literature are given in the Biology paragraph; data on distributions are presented as summarized by Roháček et al. (2001) and Marshall et al. (2011).

## Morphological terminology

Morphological terminology follows that used for Sphaeroceridae by Roháček (1998) in the Manual of Palaearctic Diptera including terms of the male hypopygium. The
"hinge" hypothesis of the origin of the eremoneuran hypopygium, re-discovered and documented by Zatwarnicki (1996), has been accepted and, therefore, the following synonymous terms of the male genitalia (emanating from other hypotheses) need to be listed (terms used first): ejacapodeme = ejaculatory apodeme, epandrium = periandrium, medandrium = intraperiandrial sclerite, phallapodeme = aedeagal apodeme. Morphological terms of the male postabdomen and genitalia are depicted in Figs 2, 4–6, those of the female postabdomen in Figs 7–9. Abbreviations of morphological terms used in text and illustrations are listed below.

# Abbreviations of morphological terms used in text and/or figures

$A_{l}$	anal vein
ac	acrostichal (seta)
ads	additional (setulae) on frons
С	costa
се	cercus
$Cs_2, Cs_3$	2rd, 3th costal sector
CuA,	cubitus
dc	dorsocentral (seta)
dm	discal medial cell
dm-cu	discal medial-cubital (= posterior, tp) cross-vein
dp	distiphallus
ea	ejacapodeme
ер	epandrium
$f_1, f_2, f_3$	fore, mid, hind femur
g	genal (seta)
gs	gonostylus
hu	humeral (= postpronotal) (seta)
hy	hypandrium
ifr	interfrontal (seta)
M	media
$mt_2$	mid basitarsus
0C	ocellar (seta)
оссе	outer occipital (seta)
occi	inner occipital (seta)
ors	fronto-orbital (seta)
pg	postgonite
pha	phallapodeme
рр	phallophore
pvt	postvertical (seta)
$R_{I}$	1st branch of radius
$R_{2+3}$	2nd branch of radius

$R_{4+5}$	3rd branch of radius
r-m	radial-medial (= anterior, ta) cross-vein
<i>S1-S10</i>	abdominal sterna
SC	scutellar (seta)
stpl	sternopleural (= katepisternal) (seta)
<i>T1-T10</i>	abdominal terga
$t_{1}, t_{2}, t_{3}$	fore, mid, hind tibia
va	ventroapical seta on t <sub>2</sub>
vi	vibrissa
vte	outer vertical (seta)
vti	inner vertical (seta)

# Results

# Genus Herniosina Roháček, 1983

Herniosina Roháček, 1983: 18 (feminine). – Roháček 1983: 18-21 [diagnosis, key, revision of European species, illustr]; Roháček 1993: 186 [taxonomy, key, illustr.]; Roháček 1998: 487 [diagnosis in key, illustr.]; Roháček et al. 2001: 148 [catalog].
Herniosina Roháček, 1982: 221 [nomen nudum, phylogeny].
Type species. Leptocera (Limosina) Bequaerti Villeneuve, 1917, original designation.

**Diagnosis.** put absent; 3–5 ifr; 2–5 minute ads inside and below ors; g small; 2 hu, the internal reduced to microseta; 2 postsutural dc, the anterior short; ac setulae in 6–10 rows on suture, the medial prescutellar *ac* pair more or less enlarged; 2 *stpl*, the anterior very small, hair-like or absent; scutellum large, rounded triangular to trapezoidal;  $t_{a}$ chaetotaxy as in Figs 16, 18, 57, 61, in male ventrally with a row of short spine-like setae and with reduced va, in female with anteroapical and va setae long (Fig. 18); male  $f_2$  ventrally with a row of more or less thickened setae (Figs 18, 54) in basal half; C not extended beyond apex of  $R_{4+5}$ ;  $R_{4+5}$  sinuate but apically almost straight; dm cell long and its posterior outer corner often rounded; alula relatively small and narrow; female postabdomen relatively (compared to preabdomen) narrow and telescopically retractile; male abdomen terminally strongly down-curved in consequence of enlarged T5 and S8 (Figs 1, 2, 15); male SI+2 protruding in a slightly (Figs 47, 51) to strongly convex bulge (Figs 1, 15); male S3 and S4 with anterior corners lobe-shaped (= sclerites anteromedially more or less deeply emarginate, Figs 17, 41); male S5 reduced, very transverse and band-shaped but posteromedially with a pair of projections (Figs 36, 65) which can be basally fused (Fig. 19) and/or prolonged (Fig. 11); epandrium with a row of robust long lateral setae at ventral margin and (usually) 1 longer dorsolateral seta (Figs 4, 28); male cerci modified to long, slender (usually doubled) processes (Figs 5, 21, 38, 50) below anal opening; gonostylus with a small (Fig. 5) to distinctive internal process (see Figs 22, 50); phallophore relatively long, anteriorly movably attached to dorsal side

of distiphallus and projecting (epiphallus-like) posteroventrally (25, 26); distiphallus apically funnel-shaped and ventromedially projecting posteriorly in an unpaired process (Figs 26, 52); postgonite relatively robust, with small setulae only; ejacapodeme absent or strongly reduced (Fig. 53); female *T8* dorsomedially compact, paler pigmented or divided; female *T10* triangular, with a pair of long setae and some micropubescence; female *S8* reduced to a small sclerite with a few setulae (Figs 8, 33, 62); female *S10* short, strip-like, horseshoe- or V-shaped (Figs 33, 62, or medially divided into 2 sclerites (Fig. 8); female genital chamber membranous, lacking internal sclerites; spermathecae (2+1) pyriform (Fig. 10) to bulbous (Figs 59, 60); female cerci dark, long and slender, each with 2 long (apical and dorsopreapical) sinuous setae and a few shorter hairs.

**Discussion.** The genus *Herniosina* can be identified by the key to European (Roháček 1983) and/or Palaearctic Limosininae (Roháček 1998). It seems to be best recognized by combination of apomorphic characters in the male abdomen and terminalia (postabdomen strongly down-curved, *S1+2* bulging, *S5* strongly reduced, cerci modified to peculiar projections, both distiphallus and phallophore projecting posteroventrally) and the plesiomorphic formation of the female postabdomen (relatively narrow and telescopic, no internal sclerites) having reduced *S8*. Although the diagnosis of the genus has to be somewhat modified (see above) with respect to the inclusion of the two new species described below, the genus remains to be a very compact monophyletic group if only Palaearctic species (reviewed here) are included.

However, Marshall (1987) described a very peculiar Limosinine species from USA (New Hampshire) and placed it as a tentative member of Herniosina on the basis of its bulging male S1+2 although this Herniosina voluminosa Marshall, 1987 differs very markedly from all other Herniosina species in many characters, lacking all other synapomorphies of the genus as originally delimited, including the modified male preabdominal sterna, reduced male S5, enlarged T5, projecting male cerci, form of phallophore, general shape of spermathecae etc. I have examined male and female paratypes of H. voluminosa kindly donated by S. A. Marshall to SMOC (USA: New Hampshire: Coos Co., 3 mi. NE East Inlet Dam, Norton Pool, flight interception trap, 12.-24.vi.1986, 1&, 25.vi.-9.vii.1986, 1Q, D. S. Chandler leg.) and found that the male S1+2 of H. voluminosa is differently (posteromedially) protruding and somewhat bilobed (see also Marshall 1987: Fig. 1) suggesting that this modification of S1+2 evolved independently and hence cannot be a synapomorphy of this Nearctic species and Herniosina s. str. species. Also its extremely enlarged aedeagal complex (with enormous distiphallus, phallophore and postgonite being several times larger than epandrium) and quite differently formed female terminalia (with S8 large and transverse, internal spectacles-shaped sclerite developed, spermathecae elongate and transversely wrinkled and T10 fused with base of cerci) clearly demonstrate that these taxa cannot be congeneric. Inasmuch as it seems that both known Apteromyia species (cf. Marshall and Roháček 1982) are apparently more closely allied to the Palaearctic species of Herniosina than is H. voluminosa (see below) the latter species is excluded from *Herniosina* here to render the genus monophyletic. It is therefore suggested to establish a new genus for the removed H. voluminosa in the near future.

When describing the genus, Roháček (1982: 221, 1983: 18) placed *Herniosina* in the *Limosina* genera-group and discussed its affinity as being either a sister-group of the genus *Apteromyia* Vimmer, 1929 or sister-group of a clade comprising besides the latter genus also two other members of the *Limosina* genera-group, viz. *Limosina* Macquart, 1835 and *Gigalimosina* Roháček, 1983. Subsequently, Marshall & Roháček (1982) considered the former hypothesis to be more probable pointing out similarly modified (projecting) male cercus and setosity of epandrium in the Nearctic species *Apteromyia newtoni* Marshall & Roháček, 1982 and *Herniosina* species. Based on the present study the relationships of *Herniosina* and *Apteromyia* is supported by four supposedly synapomorphic characters (all in the male genitalia): epandrium with a series of robust ventral lateral setae; male cerci modified to compact processes below anal fissure, distiphallus with unpaired ventromedial lobe projecting posteriorly; phallophore anteriorly slender and elongately projecting, movably attached to dorsal side of distiphallus.

**Species included.** *Herniosina bequaerti* (Villeneuve, 1917), *H. erymantha* sp. n. (described here), *H. horrida* (Roháček, 1978), *H. pollex* Roháček, 1993 and *H. hamata* sp. n. (described here). Hitherto, *Herniosina* species are only known from the W. Palaearctic area, including that recorded as *Herniosina* sp. cf. *horrida* from Israel by Papp and Roháček (1988). The latter record, based on two females only, may belong to *H. horrida* or, more probably, to an additional unnamed species but its description is pending further study of (hitherto unknown) males.

## Herniosina bequaerti (Villeneuve, 1917)

Figs 1-11

- *Leptocera (Limosina) Bequaerti* Villeneuve, 1917: 143 [both sexes]. Type locality: The Netherlands, Maestricht, St. Pietersberg.
- Leptocera (Scotophilella) Bequaerti. Duda 1925: 154 [subgeneric combination].
- Limosina (Limosina) Bequaerti. Duda 1938: 110 [generic combination, illustr.].
- Leptocera bequaerti. Goddard 1938: 240-241 [puparium, illustr.].
- *Limosina bequaerti.* Roháček 1978: 55 [redescription, genitalia, illustr.]; Papp 1984: 96 [Palaearctic catalog].
- Herniosina bequaerti. Roháček 1982: 260–263 [illustr.]; Roháček 1983: 19 [generic combination, redescription, phylogenetic notes]; Roháček 1993: 191 [key]; Skidmore 1993: 8, 16 [puparium, illustr.]; Roháček et al. 2001: 148 [catalog]; Marshall et al. 2011: 243 [catalog].
- Limosina (Scotophilella) herniata Duda, 1918: 108 [both sexes, illustr.]. Type locality: Austria, "Styriae Alpes". Duda 1924: 194 [synonymy].

**Type material.** *Leptocera (Limosina) Bequaerti* Villeneuve: Lectotype & (designated by Roháček 2001: 471), labelled: "Maestricht, S'Pietersberg, 5-IX-12" (obverse), "grot" (reverse), "Limosina sp. III, bu L. nana Rdi." (handritten by ?), "Limosina Bequaerti

Villen." (Villeneuve's handwriting) and "Leptocera (Limosina) Bequaerti Villen., J. Roháček des. 2000,  $\stackrel{<}{\bigcirc}$  Lectotypus" (red label). Paralectotype  $\stackrel{\bigcirc}{\bigcirc}$  labelled as lectotype but lacking the label "Limosina sp. III …". Lectotype with genit. prep., paralectotype intact, both deposited in MNHN.

*Limosina* (*Scotophilella*) *herniata* Duda: Lectotype  $\Im$  (designated by Roháček, 1983: 19), labelled: "Styriae Alpes Strobl", "L. rufilabris Stenh.  $\Im$  23/9", "52 138", "nova spec. Herniata mihi det Duda" (pink label), deposited in ZMHB. Paralectotypes:  $2\Im$ , labelled: "No. 200 Wypustek" and "herniata  $\Im$  det Duda", deposited in MMBC).

**Other material examined.**  $90\sqrt[3]{78}$  – BELGIUM:  $5\sqrt[3]{5}$  (ISNB), for localities see Roháček (1978). CZECH REPUBLIC:  $80\sqrt[3]{67}$  (JRO, MMBC, NMPC, SMOC), for localities see Roháček (1978, 1980, 1983, 1984); additional data: SE Bohemia: Palupín nr. Strmilov (distr. Jindřichův Hradec), in cellar, 19.viii.1991,  $55\sqrt[3]{39}$ , J. Roháček leg. (JRO); N Moravia: Vidnava env. (distr. Šumperk), nest of *Talpa europaea*, 28.iii.1985, 1 $\bigcirc$ , J. Roháček leg. (SMOC). FINLAND:  $1\bigcirc$  (MZHF), for locality see Roháček (1983). ITALY:  $1\sqrt[3]{}$  (MSNV), for locality see Roháček (1983). SLOVAKIA:  $4\sqrt[3]{59}$  (SMOC), for localities see Roháček (1983, 1986, 1994, 2009); addtional data: NE Slovakia: Regetovka env. (distr. Bardejov), sifting decayed grass in runs of *Microtus agrestis*, 10.x.1985,  $1\sqrt[3]{}$ , J. Roháček leg. (SMOC).

**Diagnosis.** Largest Palaearctic species on the average (body length: male 2.26–2.85 mm, female 2.22–3.05 mm), with lightest head (ochreous to reddish brown anteriorly). Male: abdomen with large and long *T5* and *S8* (Fig. 2); *S1+2* strongly bulging (Figs 1, 2); *S5* with longest (in lateral view sinuate) medial, apically forked, process (Figs 2, 11); epandrium with a long dorsolateral seta (Fig. 4); cerci relatively shortly but acutely double-projecting (Fig. 5); gonostylus rather simple (Fig. 3), ventrally somewhat emarginate, with small and short internal subdorsal projection (cf. Fig. 5); hypandrial rod long and slender (Fig. 4); phallapodeme long, with large dorsal keel (Fig. 4); postgonite short and robust; distiphallus with short lateral and ventral lobes and robust funnel-shaped apex (Fig. 6). Female: postabdomen slender, with relatively narrow sclerites of 6th–8th segment (Figs 7, 8); *T8* complete and entirely pigmented (Fig. 7); *S8* small, subtrapezoidal, with a small anterior structure (Fig. 8); spermathecae pyriform with conical base (Fig. 10); *S10* medially divided (Fig. 8); cerci long and slender (Figs 7–9).

**Biology.** *Herniosina bequaerti* is closely associated with subterranean habitats, such as caves (Czižek 1916; Duda 1918, 1938; Papp & Plachter 1976), cellars (Pax & Maschke 1935; Roháček 1978) and burrows, runs and nests of small mammals, including those of rabbits (*Oryctolagus cuniculus*), rats (*Rattus norvegicus*), hedgehogs (*Erinaceus europaeus*), moles (*Talpa europaea*), shrews (*Sorex araneus*), mice (*Mus musculus*) and voles (*Microtus agrestis, Microtus sp., Arvicola terrestris*) (Duda 1918; Richards 1930; Goddard 1938; Roháček 1978, 1983; Rotheray 1991). Adults can be also caught by means of soil traps (Roháček 1980); only very scarcely (migrated specimens) they can be collected outside subterranean habitats (e.g. Grundmann 1991).

Because of being adapted to cold and the complete darkness in aphotic parts of caves and having the ability to develop under these conditions, Papp and Plachter (1976) classified *H. bequaerti* as a troglophilous species. They found larvae consuming various



**Figures 2–6.** *Herniosina bequaerti* (Villeneuve), male (Czech Republic: Bohemia). **2** Abdomen, laterally **3** Gonostylus, laterally **4** Genitalia, laterally **5** External genitalia, caudally **6** Aedeagal complex (phallapodeme partly omitted), laterally. Scales: 0.5 mm (**2**), 0.1 mm (**3,6**), 0.2 mm (**4,5**). For abbreviations see pp. 73–74. Adapted from Roháček (1978).



**Figures 7–11.** *Herniosina bequaerti* (Villeneuve), female, male (Czech Republic: Bohemia). **7** Female postabdomen, dorsally **8** Ditto, ventrally **9** Ditto, laterally **10** Spermathecae **11** Male *S5*, ventrally. Scales: 0.2 mm (**7–9**), 0.1 mm (**10, 11**). For abbreviations see pp. 73–74. Adapted from Roháček (1978, 1983).

decaying media, viz. dead animals, rotten vegetation including wood and/or mycelia of fungi and determined the length of its life-history (from egg to imago) within caves as 70–90 days and the life as an adult being 38 days on the average. The sometimes abundant occurrence of the species in cellars (see Roháček 1978 and material examined), caused by convenient conditions and a rich supply of larval food, can be considered a special case of synanthropy (Roháček 1983). In burrows of mammals the larvae develop in their droppings and other nest debris (Rotheray 1991) but obviously much more rapidly due to higher temperature. Adults can occur throughout the whole year. Puparia of *H. bequaerti* were described by Goddard (1938) and Skidmore (1993) based on specimens found in mouse-runs and on subfossil specimens excavated in an archaeological site in Iceland respectively.

**Distribution.** Widespread in Europe (Austria, Belgium, Czech Republic, Finland, Germany, Great Britain, Hungary, Iceland, Ireland, Italy, Latvia, Netherlands, Poland, Slovakia, Spain, Sweden, Switzerland) but surprisingly hitherto unrecorded from its SE part (Balkan peninisula).

#### Herniosina erymantha sp. n.

http://zoobank.org/174E0AE5-52C3-417A-9AAF-3120652AAC8B Figs 14–26

**Type material.** Holotype ♂ labelled: "GREECE: NW Peloponnese: Alepochori 0.5 km SE 37°58'57"N, 21°48'10"E", "590 m, 27.5.2015, sifting leaves under *Platanus*, J. Roháček leg.", "Holotypus ♂ Herniosina erymantha sp. n., J. Roháček det. 2016" (red label). The specimen is dry-mounted on pinned triangular card, with left wing and abdomen detached, genitalia dissected and all removed parts preserved in glycerine in coalesced plastic tube pinned below the specimen (SMOC).

**Etymology.** The name of the new species is an adjective derived from the Erimanthos (= Lat. Erymanthos) Mts inasmuch as its type locality is situated in the western part of this montane range.

**Description. Male.** Total body length 1.79 mm; general colour blackish brown with relatively sparse dark greyish brown microtomentum. Head blackish brown to brown. Frons largely blackish brown, brownish only at anterior margin, rather sparsely microtomentose. Occiput blackish brown and dark greyish brown microtomentose. Orbits, interfrontalia (poorly delimited) and ocellar triangle also greyish brown (not densely) microtomentose and duller than rest of frons; frontal triangle comparatively wide and shining. Cephalic chaetotaxy: *pvt* absent, only minute adpressed postocellar setulae behind ocellar triangle; *occe* and *occi* subequal and less than half length of *vte*; *vti* longest among frontal setae, *vte* and *oc* slightly shorter than *vti*; 2 strongly exclinate *ors*, both distinctly shorter than *oc*; only 3 relatively short *ifr*, the middle pair longest; 3–4 very minute *ads* inside and below *ors*; *g* weak, not longer than anterior peristomal setula; *vi* about as long as *vti*. Frontal lunule short, wide, similarly brown as anterior margin of frons. Face with cavities below antennae dark brown, rather shining; me-

dial carina slightly elevated but distinct. Gena high, reddish only anteriorly, otherwise blackish brown, sparsely greyish microtomentose. Eye relatively small; its longest diameter about 2.2 times as long as smallest genal height. Antenna blackish brown, relatively long; its 3rd segment distinctly tapered apically both in dorsal and lateral view. Arista long, about 3.8 times as long as antenna, relatively long ciliate.

*Thorax* dark brown to blackish, mesonotum subshining due sparser microtomentum, pleuron lighter and dull. Suturae between pleural sclerites paler brown. Scutellum relatively large and long, rounded triangular. Thoracic chaetotaxy: 2 *hu* but internal reduced to microseta; 2 postsutural *dc*, anterior short and weak (only twice longer than ac microsetae), posterior strong but slightly shorter than basal *sc*; 8–10 rows of *ac* microsetae on suture; medial prescutellar *ac* pair somewhat prolonged; 2 strong *sc*, basal slightly longer than scutellum, apical about 1.6 times as long as basal; 2 *stpl* but anterior reduced to minute hair-like setula.

*Legs* dark brown, coxae, trochanters, knees and tarsi pale brown to ochreous.  $f_1$  with relatively sparse setae in posterodorsal and posteroventral rows.  $f_2$  with a row of curved but relatively short ventral setae in basal half (Fig. 18);  $t_2$  ventrally with a long row of small dense spines and reduced *va* seta (shorter than anteroapical seta), see Fig. 18; dorsal chaetotaxy of  $t_2$  as in congeners but posterodorsal seta in apical fourth somewhat shorter (Fig. 16).  $t_2 : mt_2 = 1.84$ .

*Wing* (Fig. 14) with pale brownish membrane and ochreous to dark brown veins. *C* hardly produced beyond apex of  $R_{4+5}$ .  $R_{2+3}$  slightly sinuate but apically distinctly upcurved to *C*;  $R_{4+5}$  sinuate and its apical half almost straight. Discal cell (*dm*) relatively short and distally less tapered than in most relatives, with small process of *M* beyond *dm-cu*; posterior outer corner of dm not rounded but obtuse-angled.  $A_1$  sinuate; anal lobe well developed; alula narrow but not acute. Wing measurements: length 1.87 mm, width 0.77 mm, *C-index* = 0.95, *rm*\*dm-cu* : *dm-cu* = 2.62. Haltere with ochreous stem and dark brown knob.

Abdomen blackish brown, with some sclerites brown. Preabdominal terga large, shining blackish brown, with only scarce greyish microtomentum, sparsely and shortly setulose. T4 longer than T3; T5 enlarged but less than that of H. bequaerti, postabdomen strongly down-curved (Fig. 15). Preabdominal sterna as in Figs 15, 17: S1+2strongly bulging (Fig. 15) and anteromedially narrowly desclerotized (Fig. 17); S3 and S4 deeply anteriorly emarginate due to large lateral lobes (Fig. 17), with distinctive pigmentation; S1+2, S3 and S4 with sparse setae at posterior margins, with only medial (in S4 submedial) pair longer. S5 (Fig. 19) reduced and transversely strip-shaped, with setose lateral parts as in relatives but with distinctive dark medial part provided with a flattened (in lateral view knob-like, Fig. 15) and distally forked process having 2 setulae on each lobe of its digitiform terminal part (Fig. 19). S6 and S7 fused to form a complex sclerite on left side of postabdomen, narrow ventrally and dorsally but dilated laterally (Fig. 15) as in congeners. S8 shorter and more tapered, with a slit left laterally and a few setae.

*Genitalia*. Epandrium (Figs 20, 21) of medium length but comparatively wide and more angular dorsolaterally (see Fig. 21) than those of relatives, and with a group of



**Figures 12–14.** *Herniosina erymantha* sp. n., male holotype and its habitat (Greece: Peloponnese). **12** Valley above Alepochori in Erimanthos Mts, habitat in the type locality **13** Microhabitat (arrow) from where the holotype was sifted **14** Right wing (length 1.87 mm). Photographs by J. Roháček.

longer and stronger setae laterally and lateroventrally (posterior seta longest and most robust) but dorsolaterally without longer seta. Anal fissure slightly wider than high (Fig. 21), subcircular. Cerci fused with epandrium, posteroventrally projecting in 2 processes, one (more anterior) robust, long (about as long as gonostylus) and distally somewhat thickened and bearing 1 long seta in addition to a number of setulae, the other (more medial) small, elongately conical and simple (Figs 20, 21). Medandrium



Figures 15–19. *Herniosina erymantha* sp. n., male holotype (Greece: Peloponnese). 15 Abdomen, laterally 16 Mid tibia, dorsally 17 Preabdominal sterna, ventrally 18 Mid femur and tibia, laterally 19 *S5*, ventrally. Scales: 0.2 mm (15–18), 0.1 mm (19).

small (low), reduced but connected by long internal arms with gonostyli (Fig. 21), posteromedially fused with cerci. Hypandrium with very long and slender anteromedial rod-like apodeme (Fig. 20). Gonostylus (Figs 20–23) most resembling that of *H. bequaerti* but ventrally simple (not emarginate in lateral view), with longer anteroventral seta, and with long, very slender, curved and apically lancet-shape dorsal internal process (cf. Fig. 22). Aedeagal complex (Figs 24–26) with long phallapodeme (as in *H.* 



**Figures 20–26.** *Herniosina erymantha* sp. n., male holotype (Greece: Peloponnese). **20** Genitalia, laterally **21** External genitalia, caudally **22** Dorsal half of gonostylus, caudally **23** Gonostylus, laterally **24** Phallapodeme and postgonite, laterally **25** Aedeagus, dorsally **26** Ditto, laterally. Scales: 0.1 mm (**20, 21, 24–26**), 0.05 mm (**22, 23**). For abbreviations see pp. 73–74.

*bequaerti*) but having distinctly lower dorsal keel. Aedeagus also somewhat similar to that of *H. bequaerti* but with funnel-shaped apex of distiphallus more robust, its lateral lobes and unpaired ventral process markedly longer and its postgonite more slender, with curved, slender and terminally blunt apex. Phallophore closely resembling that that of *H. bequaerti*, anteriorly rod-like but dorsoventrally flattened, posteriorly projecting ventrally and hence epiphallus-like. Ejaculatory apodeme not observed.

Female unknown.

**Discussion.** *Herniosina erymantha* sp. n. is only known from the male holotype and, consequently, for the evaluation of its relationships the female characters cannot be used. However, based on the male terminalia the species is a distinctive member of *Herniosina* unmistakeably recognizable from any other known congener. It differs from all relatives by the flattened, distinctively forked medial process of *S5* (Fig. 19), broad epandrium with strikingly rectangular dorsolateral corners without dorsolateral long seta and with broad (wider than high) anal fissure (Fig. 21), relatively simple sub-oblong gonostylus (Fig. 23) with very slender and long internal process (Fig. 22), distinctive cercus with long and robust, distally somewhat dilated but laterally flattened lateral process combined with short medial ones (Figs 20, 21) and characteristic postgonite (Fig. 24).

Judging from the construction of the male abdomen and male genitalia, *H. ery*mantha seems to be related to *H. bequaerti* and *H. horrida* sharing with them the following synapomorphies: strongly bulging *S1+2*; very slender and dorsally situated internal process of gonostylus. Its closest relative obviously is *H. bequaerti* having similarly (albeit much more) prolonged and basally fused medial processes of *S5*, a small medial apically pointed process of cercus and more robust funnel-shaped apex of distiphallus.

**Biology.** The holotype of *H. erymantha* sp. n. was sifted towards the end of May from dead leaves under *Platanus* trees (see Fig. 13, arrow) in a valley of a montane brook in the western ridge of the Erimanthos Mts (Fig. 12). The microhabitat (layers of decaying leaves of broad-leaved trees) is similar to that known for *H. horrida* and *H. pollex* in Central Europe (see under these species).

Distribution. Hitherto only known from Greece: NW Peloponnese.

## Herniosina horrida (Roháček, 1978)

Figs 27-30

*Limosina horrida* Roháček, 1978: 51 [both sexes, illustr.]. Type locality: Slovakia, Veľká Fatra Mts., Suchá dolina (valley). – Papp 1984: 99 [Palaearctic catalog].

Herniosina horrida. – Roháček 1982: 265-266 [illustr.]; 1983: 20 [generic combination; redescription, phylogenetic notes]; 1993: 191 [key]; Roháček et al. 2001: 149 [catalog].



Figures 27–30. *Herniosina horrida* (Roháček), male paratype (Slovakia). 27 Aedeagal complex, laterally.
28 Genitalia, laterally 29 Gonostylus, laterally 30 External genitalia, caudally. All scales: 0.1 mm. Adapted from Roháček (1978).

**Type material.** Holotype  $\Im$  labelled: "Slovakia centr. 27.6.1975, V. Fatra, Suchá dolina, J. Roháček leg., decayed hay" (handwritten) and "Limosina horrida sp.n., J. Roháček det., holotypus  $\Im$ " (framed handwriting), deposited in JRO ((intact, in ethanol). Allotype  $\Im$  (JRO) and  $7\Im$ 11 $\Im$  paratypes (all in ethanol, some with genit. prep.), with the

same data, deposited in JRO and HNHM. For data of other paratypes (7∂18♀, JRO, SMOC) from the Czech Republic and Slovakia see Roháček (1978, 1983).

**Other material examined.**  $18\sqrt[3]{32}$  – AUSTRIA:  $1\sqrt[3]{2}$  (NHMW), for localities see Roháček (1993). CZECH REPUBLIC:  $2\sqrt[3]{17}$  (JRO, MBP, SMOC, UEBC), for localities see Roháček (1980, 1983, 1984, 1993, 1996); additional data: N Moravia: Vidnava env. (distr. Šumperk), sweeping undergrowth of deciduous forest, 10.vii.1984, 1 $\stackrel{\circ}{2}$ ; Hrubý Jeseník Mts, Velká kotlina valley, on excrement of red deer, 20.vi.1990, 1 $\stackrel{\circ}{3}$ ; Dlouhá Stráň env. (distr. Bruntál), mouth of muskrat (*Ondatra*) burrow, 6.v.1987, 1 $\stackrel{\circ}{2}$ ; Karlova Pláň-Karlovec (distr. Bruntál), sweeping undergrowth of alder forest, 20.vii.1987, 1 $\stackrel{\circ}{2}$ ; Karlova Pláň-Volárenský potok (distr. Bruntál), sweeping undergrowth of alder forest, 20.vii.1987, 1 $\stackrel{\circ}{2}$ , all J. Roháček leg. (SMOC). SLOVA-KIA:  $15\sqrt[3]{13}$  (JRO, SMOC, UKB), for localities see Roháček (1983, 1986, 1993, 1995, 2009, 2011).

**Diagnosis.** Body length: male 2.06–2.46 mm, female 2.20–2.90 mm. Male: abdomen with *T5* and *S8* somewhat shorter than in *H. bequaerti*; *S1+2* strongly bulging; *S5* with a pair of small, shortly digitiform processes (Fig. 36); epandrium with a long dorsolateral seta (Fig. 28); cerci long, with 2 projections (Figs 28, 30), medial blunt and half-length of lateral, lateral tapered distally, with sinuate outer margin (Fig. 30) and long curved seta; gonostylus with roundly lobate posteroventral part and with slender elongate subdorsal internal projection (Fig. 29); hypandrial rod relatively short and slender (Fig. 28); phallapodeme also short, without dorsal keel (Fig. 27); postgonite relatively long, sinuate, with apex bent medially; distiphallus with longer lateral and ventral lobes and slender funnel-shaped apex (Fig. 27). Female: postabdomen slender, with relatively narrow sclerites of 6th–8th segment (Figs 32–34); *T8* complete but medially narrowly paler-pigmented (Fig. 32); *S8* relatively large, simple, transversely suboval (Fig. 33); spermathecae pyriform with conical base (Figs 31, 35); *S10* undivided, horseshoe-shaped (Fig. 33); cerci long and slender (Figs 32–34).

**Biology.** The species is associated with decayed herbaceous vegetation, most of known specimens having been collected from decayed leaves, hay, grass (Roháček 1978, 1983) in forests or their margins, in cold montane valleys also in open, unforested habitats; they can be also captured by soil traps in these habitats (Roháček 1980). Grundmann (1991) collected a series by Barber traps. Only occasionally it can be found in forests on excrement, rotting fungi (Roháček 1993), in runs of voles (Roháček 2009) and recently was also found in entrances of caves (Roháček 2011). Despite the latter record, the statement by Roháček (1983) that it has never been collected in caves together with *H. bequaerti* remains to be correct. However, *H. horrida* could possibly co-occur with *H. pollex* in mouths of caves or in ravines but hitherto I cannot confirm this presupposition by records. Adults were recorded in March to August.

**Distribution.** Only known from Central Europe (Austria, Czech Republic, Germany, Slovakia). The record from Germany (Grundmann 1991; cf. also Roháček 1993) was erroneously attributed to *H. pollex* in the World catalog of Sphaeroceridae (Roháček et. al 2001).



Figures 31–36. *Herniosina horrida* (Roháček), female and male paratypes (Slovakia). 31 Spermathecae 32 Female postabdomen, dorsally 33 Ditto, ventrally 34 Ditto, laterally 35 Spermatheca 36 Male *S5*, ventrally. Scales: 0.1 mm (31, 35, 36), 0.2 mm (32–34). Adapted from Roháček (1978).

#### Herniosina pollex Roháček, 1993

Figs 37-46

Herniosina pollex Roháček, 1993: 186 [both sexes, phylogenetic notes, illustr.]. Type locality: Slovakia, Slovenský kras, Stará brzotínska jaskyňa (cave); Roháček et al., 2001: 149 [catalog].

**Type material.** Holotype 3 labelled: "CS: Slovakia or., Slovenský kras, Stará brzotínská jask., V. Košel leg." (obverse of the label, handwritten), "16/87, 9.6.1987, 2-5 m" (reverse of the label, handwritten), "Holotypus (red printed), Herniosina pollex sp. n. 3, J. Roháček det. 1991 (handwritten)" (label with red margin), deposited in JRO (intact). Allotype 9 (JRO) and 113209 paratypes with the same data, deposited in JRO, PKBS, SMTD (several with genit. prep.). For data of other paratypes (203639, deposited in JRO, PKBS, SMOC) from the Czech Republic and Slovakia see Roháček (1993).

**Other material examined.**  $6^{\circ}_{\circ}4^{\circ}_{\circ}$  – CZECH REPUBLIC:  $3^{\circ}_{\circ}2^{\circ}_{\circ}$  (FSBC, MBP), for localities see Roháček (1996, 1999), Roháček & Barták (2001). RUSSIA: C. Caucasus, Kabardino-Balkariya, Nalchik env., canyon of upper course of Nalchik River, Omega-12 Cave, soil traps, 30.vii.1998–25.vi.1999, 2 $^{\circ}_{\circ}$ , A. G. Koval leg. (SMOC). SLOVAKIA:  $1^{\circ}_{\circ}1^{\circ}_{\circ}$  (SMOC), for localities see Roháček (2009).

Diagnosis. Smaller species, body length: male 1.90-2.18 mm, female 2.10-2.86 mm. Male: abdomen with T5 and S8 distinctly shorter than in H. bequaerti; S1+2 protruding but with bulge reduced (Fig. 41); S5 with a pair of small, shortly digitiform processes (Fig. 42); epandrium with dorsolateral seta distinct (Fig. 37); male cerci large, each with 2 divergent projections (Figs 37, 38), medial robust, long, digitiform and projecting posteroventrally, lateral also long but terminally slender, having 1 extremely long curved seta inserted in short lateral process (Fig. 37); gonostylus with similarly (although shortly) lobate posteroventral part as that of *H. horrida* but with subdorsal internal projection keel-like and anteroventral seta much shorter (Fig. 39); hypandrial rod very long and (particularly basally) slender (Fig. 37); phallapodeme very long and with dorsal keel (Fig. 40); postgonite relatively long, straighter than in other species and with apex simply pointed (Fig. 40); distiphallus with longer lateral and ventral lobes and slender funnel-shaped apex (Fig. 40). Female: postabdomen slender, with relatively narrow sclerites of 7th-8th segment (Figs 43, 46), with T6 relatively broad; T8 complete but medially narrowly paler-pigmented (Fig. 43); S8 relatively large, simple, more trapezoidal (Fig. 46) than that of *H. horrida*; spermathecae shortly pyriform with conical base (Fig. 44); S10 undivided, horseshoe-shaped (Fig. 46); cerci long and slender (Figs 43, 45, 46).

**Biology.** Although the majority of known specimens originate from caves in Slovakia the species is not troglophilous because it occurs on decayed vegetation only in the entrance zone of caves (Roháček 1993, 2011); it can also be found on rotten wet leaves in other cold and shaded places such as ravines or narrow valleys of torrents.



Figures 37–39. *Herniosina pollex* Roháček, male paratype (Slovakia). 37 Genitalia, laterally 38 External genitalia, caudally 39 Gonostylus, laterally. Scales: 0.1 mm (37, 38), 0.05 mm (39). For abbreviations see pp. 73–74. Adapted from Roháček (1993).

Hitherto, it has not been recorded from runs or burrows of mammals. In Central Europe adults were collected in March, June–August.

**Distribution.** Known only from Central Europe (Czech Republic, Slovakia) and northern part of Central Caucasus Mts (Russia: Kabardino-Balkariya). Roháček et al. (2001) incorrectly also listed Germany but this record belongs in fact to *H. horrida* (see above).



**Figures 40–42.** *Herniosina pollex* Roháček, male paratype (Slovakia). **40** Aedeagal complex, laterally **41** Abdomen, ventrally (genitalia removed) **42** Male *S5*, ventrally. Scales: 0.1 mm (**40, 42**), 0.2 mm (**41**). For abbreviations see pp. 73–74. Adapted from Roháček (1993).

# Herniosina hamata sp. n.

http://zoobank.org/90E15ED5-1D90-4B01-B49C-1356186E9E61 Figs 47–65

**Type material.** Holotype ♂ labelled: "C CYPRUS: Troodos Mts., Pedoulas env., J. Roháček leg.", "sweeping over ruderal vegetation, 12.4.2002", "Holotypus ♂ Herniosina hamata sp. n., J. Roháček det. 2016" (red label). The specimen (see Fig. 47) is intact except for the left wing being detached for photography (Fig. 48) and preserved in glycerine in a coalesced plastic tube pinned below the specimen (SMOC). Paratypes: C



**Figures 43–46.** *Herniosina pollex* Roháček, female paratype (Slovakia). **43** Postabdomen, dorsally **44** Spermathecae **45** End of postabdomen, laterally **46** Postabdomen, ventrally. All scales: 0.1 mm. For abbreviations see pp. 73–74. Adapted from Roháček (1993).



**Figures 47–48.** *Herniosina hamata* sp. n., male holotype (Cyprus). **47** Male, laterally, S1+2 arrowed **48** Right wing (length 2.24 mm). Photographs by J. Roháček.

CYPRUS: Troodos Mts, Troodos 2 km NE, 1700 m, sweeping vegetation along small creek, 11.iv.2002,  $1 \stackrel{\circ}{\supset} 8 \stackrel{\circ}{\ominus} (1 \stackrel{\circ}{\supset} 1 \stackrel{\circ}{\ominus}$  genit. prep.); Troodos Mts, Troodos env., 1800 m, sweeping vegetation along spring, 11.iv.2002,  $1 \stackrel{\circ}{\ominus}$  (genit. prep.); Troodos Mts, Kakopetria 2 km SW, sweeping vegetation along brook, 11.iv.2002,  $1 \stackrel{\circ}{\ominus}$  (genit. prep.); Pano Platres env., Caledonia Falls, on decayed leaves by stream, 12.iv.2002,  $1 \stackrel{\circ}{\supset}$  (genit. prep.); W CYPRUS: Troodos Mts, Kykko Monastery 4 km E, sweeping undergrowth of pine forest, 12.iv.2002,  $1 \stackrel{\circ}{\ominus}$ , all J. Roháček leg. (SMOC). Paratypes labelled "Paratypus  $\stackrel{\circ}{\supset}$  or  $\stackrel{\circ}{\ominus}$ , Herniosina hamata sp. n., J. Roháček det. 2016" (yellow label) in addittion to their locality labels.

**Etymology.** The new species is named by the adjective "hamata" to reflect its hook-like posteromedial (internal) process of the gonostylus (hamatus = Lat. provided with hooks).

Description. Male (Fig. 47). Total body length 1.94–2.38 mm; general colour blackish brown with relatively sparse dark greyish brown microtomentum, subshining (thorax) to shining (abdomen). Head blackish brown to brown, much higher than long (Fig. 47). Frons brown anteriorly, dark brown to blackish posteriorly, sparsely microtomentose. Occiput blackish brown with microtomentum denser. Orbits, interfrontalia and ocellar triangle sparsely greyish brown microtomentose; frontal triangle poorly delimited, relatively wide, anteriorly acute and more shining than rest of frons. Cephalic chaetotaxy: pvt absent, only minute divergent postocellar setulae behind ocellar triangle; occe and occi subequal (or occi slightly longer) and about half length of vti; *vti* robust and longest of frontal bristles; *vte* and *oc* slightly to distinctly shorter than *vti*; 2 ors, posterior longer than anterior but distinctly shorter than oc; 3-4 relatively short *ifr*, all subequal or foremost shorter, if 4 *ifr* present, the foremost reduced to small setula; 3-6 very minute ads inside and below ors; g weak, hardly longer than anterior peristomal setula; vi as long as or longer than vte but thinner. Frontal lunule short and wide, brown and greyish brown microtomentose. Facial cavities below antennae dark brown, relatively shining; medial carina poorly developed but distinct. Gena brown (lightest on virbrissal angle), posteriorly dark brown, greyish brown microtomentose. Eye relatively small; its longest diameter about 2.2 times as long as smallest genal height. Antenna dark brown, relatively long; its 3rd segment distinctly tapered apically, both in lateral and dorsal view. Arista long, about 4 times as long as antenna, relatively long and densely ciliate.

*Thorax* blackish brown and dark greyish brown microtomentose, mesonotum subshining, pleuron with denser microtomentum and dull. Suturae between pleural sclerites pale brown. Scutellum large, relatively long and flat, rounded trapezoidal. Thoracic chaetotaxy: 2 *hu*, internal reduced to microseta; 2 postsutural *dc*, anterior short (only 2–3 times as long as *dc* microsetae), posterior as long as or slightly longer than basal sc; 10 dense rows of *ac* microsetae on suture; medial prescutellar ac pair prolonged, about as long as anterior dc but finer; 2 long *sc*, basal about as long as or slightly longer than scutellum, apical about 1.7 times as long as basal; 1–2 *stpl*, anterior (if present) reduced to very minute pale setula. *Legs* brown, coxae, trochanters, knees and tarsi paler brown to ochreous.  $f_2$  with a doubled row of curved but relatively short ventral setae in basal half (Fig. 54);  $t_2$  ventrally with a long row of small dense spines, very reduced *va* seta and 1 distinct anteroapical seta (Fig. 54); dorsal chaetotaxy of  $t_2$  as in Fig. 57, with posterodorsal seta in apical fourth long.  $t_2 : mt_2 = 1.85 - 1.89$ .

Wing (Fig. 48) with pale brown membrane and yellowish brown to dark brown veins. C ending at or very slightly produced beyond apex of  $R_{4+5}$ .  $R_{2+3}$  very slightly sinuate and also apically slightly upcurved to C;  $R_{4+5}$  distinctly sinuate but its apical half nearly straight. Discal cell (dm) rather long, distally tapered, with small process of M beyond dm-cu; posterior outer corner of dm cell varies from angular with a remnant of  $CuA_1$  to rounded and lacking the latter.  $A_1$  slightly sinuate; anal lobe large, well developed; alula narrow, apically rounded. Wing measurements: length 2.06–2.24 mm, width 0.85–0-91 mm, C-index = 0.97–1.03, rm\dm-cu : dm-cu = 3.64–4.50. Haltere with yellowish brown to ochreous yellow stem and dark brown knob.

Abdomen blackish brown dorsally, brown ventrally. Preabdominal terga large, glabrous and shining because of reduced and sparse greyish microtomentum (restricted to T1+2 and bases of T3-T5), sparsely setose but with more setae on disc than those of relatives. T5 enlarged but not so prolonged as in *H. bequaerti*. Preabdominal sterna S1+2-S4 (Fig. 51) also shining but distinctly more setose than in all congeners. S1+2 with ventral bulge reduced (Fig. 47, arrow) but somewhat protruding in the middle; S3 and S4 (Fig. 51) anteromedially emarginate and with characteristic lateral dark pigmentation. S5 (Fig. 65) very shortened, reduced to a transverse strip-like and largely weakly sclerotized and pale-pigmented sclerite with only partly darker and setose lateral parts (with 5–6 setae on each side) and posteromedially provided with a pair of small digitiform processes arising from a common base. S6+7 and S8 asymmetrical on left side of down-curved postabdomen, most similar to those of *H. pollex*, thus the latter relatively short.

*Genitalia*. Epandrium (Figs 49, 50) of medium length but comparatively broad (wider than high), with a series of longer and stronger setae mainly lateroventrally (posterior longest); also laterodorsally with 1 longer seta. Anal fissure relatively small, suboval, slightly wider than in *H. pollex*. Cerci fused with epandrium, each projecting ventrally in single (medial process absent) long, digitiform, terminally somewhat dilated process with blunt apex, basally carrying 1 long seta (Figs 49, 50). Medandrium fused with cerci medially and connected by long internal arms with gonostyli (Fig. 50). Hypandrium with long anteromedial rod-like apodeme, more robust than that of *H. pollex*. Gonostylus (Figs 49, 50, 56) dissimilar to those of all congeners, with pointed anteroventral corner and long anterior seta as in most relatives but ventrally externally with rounded and setose lobe and posteroventrally with distinctive, robust, dark, hook-like internal process. Aedeagal complex (Figs 52, 53, 55). Phallapodeme large and long, laterally flattened due to very large (high) dorsal and ventral keel. Aedeagus with peculiar distiphallus, most different from those of relatives because of small lateral lobes (Fig. 53), long ventromedial, posteriorly far projecting lobe (Fig. 52) and relatively



**Figures 49–56.** *Herniosina hamata* sp. n., male paratype (Cyprus). **49** Genitalia, laterally **50** External genitalia, caudally **51** Preabdominal sterna, ventrally **52** Phallapodeme and aedeagus, laterally **53** Aedeagus, dorsally **54**  $f_2$  and  $t_2$  anteriorly **55** postgonite, laterally **56** Gonostylus, laterally. Scales: 0.1 mm (**49, 50, 52, 53, 55, 56**), 0.2 mm (**51, 54**). For abbreviations see pp. 73–74.

short but broad funnel-shaped apex (Fig. 53); also phallophore distinctive, with short and more robust anterior part and small, slender, pointed posterior epiphallus-like projection (Fig. 52); postgonite relatively short and robust (Fig. 55), with expanded posterior lobe proximally and distinctly bent and pointed apex distally. Ejacapodeme reduced to very minute sclerite (see Fig. 53) hidden in posterior fissure of phallophore.

**Female.** Similar to male unless mentioned otherwise below. Total body length 1.90–2.54 mm. Gena sometimes paler, reddish brown anteriorly and brown posteriorly.  $f_2$  ventrally without curved setae, simply setulose;  $t_2$  ventrally only finely setulose and with 1 long *va* seta; also anteroapical seta somewhat longer (Fig. 61).  $t_2 : mt_2 = 1.65-1.85$ . Wing measurements: length 1.79–2.28 mm, width 0.73–0.95 mm, *C-index* = 0.92–1.13, *rm\dm-cu* : *dm-cu* = 3.41–4.40. Preabdominal terga shorter, more transverse and becoming narrower posteriorly, similarly setose as in male. Preabdominal sterna unmodified, simple, sparsely and shortly setose. *S1+2* smallest and dark pigmented only posteriorly (one fourth to half); *S3–S5* becoming wider posteriorly, *S3* and *S4* trapezoidal (wider posteriorly); *S5* transversely sub-oblong, wider but distinctly shorter than *S4*; all these sclerites dark brown and shining.

Postabdomen (Figs 58, 62, 63) telescopically retractible but broader than in relatives, particularly as regards 7th and 8th segments. T6 wide and short, transversely oblong, paler brown than T7 (Fig. 58); T7 hardly narrower than T6 but reaching farther onto lateral side (Fig. 63), sparsely setose only at posterior margin. T8 medially not only depigmented but distinctly divided in two dark sclerites (Fig. 58). T10 subtriangular, distinctly wider than long (shorter than that of *H. pollex*), pale-pigmented only in anterior half and dorsally with a pair of longer setae arising far each from other (Fig. 58). S6 slightly wider, paler and more densely setulose than S7, shorter and more transverse (Fig. 62) than in all relatives. S7 dark-pigmented except for small anteromedial area (Fig. 62) and with 4 longer and several short setae at posterior margin. S8 (Figs 62, 64) narrow, of highly distinctive, posteriorly widened shape, having large subcircular to ovoid membranous (sometimes posteriorly open) window in posterior half and only 4-8 fine setulae at posterior margin. S10 reduced to short, broadly V-shaped microtomentose and setose sclerite (Fig. 62). Spermathecae 2+1 (Figs 59, 60) blackish brown, bulbous (onion-shaped), without robust basal conical parts; terminal parts of ducts very slender and pale-pigmented. Cerci (Fig. 58, 63) distinctly wider and shorter than in all relatives (including *H. pollex*), with 1 dorsal preapical and 1 apical seta long sinuate as in congeners but the latter inserted somewhat subapically (see Fig. 63).

**Discussion.** Herniosina hamata sp. n. is a distinctive species, markedly different from all other species of the genus in the structures of the male and female terminalia. It is characterized by an interesting combination of plesiomorphic (e.g. reduced bulge on male S1+2; more setose male preabdominal sclerites; male S5 with a pair small medial projections; male cercus projecting in single process; gonostylus without dorsal internal projection; ejacapodeme minute but present; spermathecae simple, bulbous, without conical basal part) and distinctly derived autapomorphic features (gonostylus with hook-like posteroventral internal process; phallapodeme dorsoventrally dilated by both dorsal and ventral keel; distiphallus with long posteriorly projecting medial lobe;



**Figures 57–65.** *Herniosina hamata* sp. n., female and male paratypes (Cyprus). **57** Female t<sub>2</sub>, dorsally **58** Female postabdomen, dorsally **59, 60** Spermathecae **61** Female t<sub>2</sub>, anteriorly **62** Female postabdomen, ventrally **63** ditto, laterally **64** female S8, ventrally **65** male S5, ventrally. Scales: 0.2 mm (**57, 61**), 0.1 mm (**58, 62–65**), 0.05 mm (**59, 60**).



**Figures 66–67.** Habitats of *Herniosina hamata* sp. n. (Cyprus). **66** Shores of a small creek with decayed remnants of vegetation and shooting plants (Troodos 2 km NE, 1700 m) **67** Decayed leaves (arrow) in valley of a montane torrent below Caledonia Falls (nr. Pano Platres). Photographs by J. Roháček.

female postabdominal segments widened; female *T8* dorsomedially divided; female *S8* with "window"; cercus robust and with subapically inserted apical seta). *H. hamata* sp. n. most resembles *H. pollex* but the shared characters proved to be all plesiomorphic (male S1+2 with bulge reduced; male S5 with a pair of small medial projections; shorter male *T5* and *S8*) and do not demonstrate their sister-species relationships. Indeed, the set of plesiomorphies of *H. hamata* sp. n. indicate that it could represent a sister-taxon to its four remaining congeners (see discussion of intrageneric relationships below).

**Biology.** Almost all type specimens were swept from low (and sparse) vegetation growing on layers of wet rotten plant debris. This is also true for the holotype being netted from "ruderal" vegetation on a pile of decayed leaves in a shaded ditch by a road. The longest series (9 specimens) was taken by netting over shooting plants on the wet shores of a small creek covered with decayed remnants of vegetation shortly after the snow melted (Fig. 66); also the habitat with decayed leaves close to a montane stream (Fig. 67) near the Caledonia Falls can be considered typical for the species. The altitudes of localities (all in Troodos Mts) range from about 900 m (Kakopetria env) to 1800 m (Troodos, close to Olympos Mt.) and all specimens were collected on 11–12 April.

**Distribution.** Hitherto only known from Cyprus (Troodos Mts); first recorded as unnamed species of *Herniosina* by Roháček (2004).

#### Key to identification of the species of Herniosina

1	Male
_	Female (that of <i>H. erymantha</i> unknown)6
2(1)	<i>S1+2</i> with a strong protruding bulge (Figs 1, 2, 15, 17) <b>3</b>
_	<i>S1+2</i> only slightly protruding (Figs 41, 47, 51) <b>5</b>
3(2)	S5 with a single long medial process that is apically forked (Figs 2, 11, 15,
	19); gonostylus in lateral view sub-oblong (Fig. 23), at most ventrally emar-
	ginate (Fig. 3); phallapodeme and hypandrial rod very long (Figs 4, 20); me-
	dial process of cercus small, with apex more acute (Figs 5, 21); funnel-shaped
	apex of distiphallus more robust and postgonite with apex simple (Figs 6, 24,
	26)
_	S5 with 2 small digitiform medial processes (Fig. 36); gonostylus in lateral
	view with large posteroventral lobe (Figs 28, 29); both phallapodeme and hy-
	pandrial rod short (Fig. 28); medial process of cercus robust, with apex bluntly
	rounded (Figs 28, 30); funnel-shaped apex of distiphallus slender and postgo-
	nite with apex curved medially (Fig. 27) H. horrida (Roháček, 1978)
4(3)	S5 with medial process longer, in lateral view sinuous (Fig. 2), elongately
	conical and apically shortly forked (Fig. 11); 75 and S8 longer (Fig. 2); gono-
	stylus ventrally emarginate (Fig. 3); epandrium with 1 long dorsolateral seta
	in addition to ventrolateral robust setae (Figs 4, 5); cercus with both processes

relatively short and apically pointed (Figs 4, 5); distiphallus with ventral and lateral lobes short, also postgonite short and robust (Fig. 6).....

S5 with medial process shorter, in lateral view pestle-shaped (Fig. 15), flattened and apically deeply forked (Fig. 19); T5 and S8 shorter (Fig. 15); gonostylus ventrally rounded (Fig. 23); epandrium without longer dorsolateral seta (Fig. 21); cercus with only medial process short and somewhat pointed; its lateral process very long and robust, apically dilated in lateral view (Figs 20, 21); distiphallus with ventral and lateral lobes long (Fig. 26) and postgonite 5(2)Preabdominal sterna sparsely setose (Fig. 41); cercus with medial process very long, robust, digitiform and projecting posteroventrally; its lateral process distally slender and laterally provided with a robust long seta arising on small lobe (Figs 37, 38); gonostylus with lobe-like posteroventral part and internally with a small keel-like process (Fig. 39); phallophore anteriorly slender, ventromedial lobe of distiphallus simple (unmodified) and postgonite rather Preabdominal sterna more densely setose (Fig. 51); cercus without medial process and its lateral process long, slender, apically somewhat dilated, with long seta arising more basally (Figs 49, 50); gonostylus with a robust posterior internal hook-like process directed ventrally and is posteroventral lobe smaller, knob-like (Figs 49, 50, 56); phallophore anteriorly thicker, ventromedial lobe of distiphallus projecting far posteriorly and of unusual shape (Fig. 52) and postgonite proximally dilated and with curved apex (Fig. 55)... 6(1)T6, T7, S6 and S7 shorter and more transverse (Figs 58, 62); T8 dorsomedially interrupted into 2 lateral sclerites (Figs 58, 63); S8 with membranous window in posterior half (Figs 62, 64); spermathecae bulbous, without separate basal conical part (Figs 59, 60); cercus shorter and more robust (Fig. 58), with terminal seta inserted rather supapically (Fig. 63)......H. hamata sp. n. T6, T7, S6 and S7 longer, narrower, less transverse (Figs 7, 8, 43, 46); T8 dorsomedially complete (Fig. 7), at most with narrow, pale-pigmented, stripe (Figs 32, 43); S8 entirely sclerotized and pigmented (Figs 8, 33, 46); spermathecae pyriform, with distinct basal conical part (Figs 10, 31, 44); cercus longer and slender (Figs 7, 32, 43), with terminal seta inserted on apex (Figs 9, 34, 45)......7 7(6) T6 narrow, about as wide as T7 (Fig. 7); S10 divided into 2 small lateral sclerites (Figs 8, 9); S8 small and usually with a small sclerotization in front of it in posteromedial emargination of S7 (Fig. 8) ........... H. bequaerti (Villeneuve, 1917) T6 broad, distinctly wider than T7 (Figs 32, 43); S10 undivided, horseshoeshaped (Figs 33, 46); S8 larger, simple, without additional sclerotization (Figs **3**3, 46).....**8** 

8(7) *T10* longer, elongately triangular (Fig. 32); *S8* transversely suboval, with only 1 pair of setae (Fig. 33); cercus longer (Fig. 34).....*H. horrida* (Roháček, 1978) *T10* shorter, transversely triangular (Fig. 43); *S8* more trapezoidal and with 1 pair of longer plus 1–2 pairs of short setae (Fig. 46); cercus shorter (Fig. 45).... *H. pollex* Roháček, 1993

# General discussion

**Relationships.** The genus *Herniosina*, as redefined here (i. e. without the Nearctic species *H. voluminosa* Marshall, 1987), is a compact group of habitually very similar species differing mainly by the structures of the male and female terminalia. It is affiliated to the *Limosina* group of genera (Roháček 1982) and *Apteromyia* Vimmer, 1929 is considered its most closely allied genus (see also Marshall and Roháček 1982) based on the following synapomorphic characters: epandrium with a series of robust ventral lateral setae; distiphallus with unpaired ventromedial lobe projecting posteriorly; phallophore anteriorly slender and elongately projecting, movably attached to dorsal side of distiphallus; male cerci modified to compact processes below anal fissure.

The relationships of species within the genus Herniosina can be hypothetized as follows. The set of plesiomorphies of *H. hamata* sp. n. (see in discussion under that species) indicate that it could represent a sister-taxon to the four remaining congeners which seem to form a monophyletic group supported by 5 synapomorphies: male preabdominal sclerites with setosity reduced; male cercus modified to 2 (lateral and medial) processes; gonostylus with dorsal internal projection; ejacapodeme absent; spermathecae pyriform, with distinct conical basal part. Herniosina pollex, having the male S1+2 with bulge reduced (a plesiomorphy shared with *H. hamata*) is obviously the sister-group to a cluster formed by *H. horrida*, *H. erymantha* sp. n. and *H. bequaerti* which possess the male S1+2 strongly protruding (bulging); moreover, this group also shares the very slender (in *H. bequaerti* secondarily shortened) dorsal internal projection of the gonostylus. Both these characters can be considered synapomorphies supporting relationships of these three species. Finally, H. horrida, with male S5 bearing a pair small posteromedial projections (a plesiomorphy shared with H. hamata sp. n. and *H. pollex*) can be postulated as sister-group to the remaining pair, *H. erymantha* sp. n. and *H. bequaerti*. Relationship of these sister-species is based on 3 synapomorphies: male S5 with posteromedial projections fused and prolonged to form a single, distally forked, process; medial apically pointed process of cercus small; funnel-shaped apex of distiphallus short and robust.

**Habitat.** *Herniosina* species seem to be originally terricolous phytosaprophagous flies associated with layers of decaying vegetation (leaf litter of broad-leaved trees in particular) in humid woodland habitats, as now known for *H. hamata* sp. n., *H. horrida, H. erymantha*, and partly also *H. pollex*. The latter species preferably lives on plant remnants in caves (but only close to their entrances) while *H. bequaerti* became entirely adapted to cavernicolous habitats developing in various rotting matter of plant and

animal origin in caves (e.g. Czižek 1916; Duda 1918, 1938) including their aphotic parts (Papp and Plachter 1976), cellars or mine galleries (see Roháček 1978, 1983) and burrows, runs and nests of various small mammals (Duda 1918; Richards 1930; Roháček 1978, 1983; Rotheray 1991). Consequently, *H. pollex*, living in caves only temporarily as a component of the parietal fauna due to convenient conditions, can be classified only as a hemitroglophilous species while *H. bequaerti*, having the ability to develop deep in caves in complete darkness for generations (see Papp and Plachter 1976), is considered troglophilous despite the fact it can also develop in small subterranean habitats (burrows of mammals) or in cellars (Roháček 2014). The living habits of *Herniosina* species have partly reflected on their morphology, e.g. the somewhat reduced eyes, elongate arista, relatively strong sclerotization of body. They also are poor flyers, moving usually only by running and skipping on the substrate; hence they can be caught by sweeping with difficulty and only from very low vegetation or by netting over accumulated decayed plant remnants on the ground.

Biogeography. Two new species described above essentially contributed to the knowledge of the distribution of Herniosina. Particularly, its presence in the Eastern Mediterranean was confirmed; previously there were a few records of unidentified Herniosina spp. from Israel (Papp and Roháček 1988: Mt. Hermon) and from Cyprus (Roháček 2004: Troodos Mts), but those of the latter are now attributed to H. hamata sp. n. Based on available data the distribution of the genus Herniosina ranges from Spain in the west to Russia (Kabardino-Balkariya) in the east and from Iceland and Fennoscandia in the north to Spain, Cyprus and Israel in the south (Roháček et al. 2001; Marshall et al. 2011). The most widespread species seems to be H. bequaerti being recorded from most of Europe (including Iceland) except for its southeastern parts (the absence of this species in caves of Balkan peninsula, cf. Séguy 1963, is particularly peculiar) and, surprisingly, H. pollex found besides Central Europe (Czech Republic, Slovakia) unexpectedly also in the Russian Caucasus (Kabardino-Balkariya). Other species may have a more restricted distribution, viz. H. horrida (Central Europe), H. erymantha (Greece: Pelopponese), H. hamata (Cyprus), Herniosina sp.cf. horrida (Israel). However, also these species can be more widely distributed considering the fact that the southern areas of W. Palaearctic are underinvestigated and that the terricolous or cavernicolous Hernisiona species are difficult to collect.

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# References

- Czižek K (1916) Beiträge zur rezenten Fauna der mährischen Höhlen. 1. Teil. Zeitschrift des mährischen Landesmuseums, Brünn 15: 13–58.
- Duda O (1918) Revision der europäischen Arten der Gattung *Limosina* Macquart (Dipteren). Abhandlungen der k.k. zoologisch-botanischen Gesellschaft in Wien 10(1): 1–240.
- Duda O (1924) Berichtigungen zur Revision der europäischen Arten der Gattung *Limosina* Macq. (Dipteren), nebst Beschreibung von sechs neuen Arten. Verhandlungen der zoologisch-botanischen Gesellschaft in Wien 73(1923): 163–180.
- Duda O (1925) Die außereuropäischen Arten der Gattung Leptocera Olivier Limosina Macquart (Dipteren) mit Berücksichtigung der europäischen Arten. Archiv für Naturgeschichte, Berlin, Abteilung A, 90(11)(1924): 5–215.
- Duda O (1938) 57. Sphaeroceridae (Cypselidae). In: Lindner E (Ed.) Die Fliegen der palaearktischen Region. Vol.6, E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 182 pp.
- Goddard WH (1938) The description of the puparia of fourteen British species of Sphaeroceridae (Borboridae, Diptera). Transactions of the Society for British Entomology 5: 235–258.
- Grundmann B (1991) Die Dungfliegen (Sphaeroceridae) des Sauerlandes. Beitrag zur Kenntnis der Dipterenfauna Westfalens. Mitteilungen der Arbeitsgemeinschaft Ostwestfälischlippischer Entomologen 7(1): 31–48.
- Marshall SA (1987) Herniosina voluminosa: a new sphaerocerid of isolated position described from northeastern North America (Diptera: Sphaeroceridae). Proceedings of the Entomological Society of Washington 89: 711–714.
- Marshall SA, Roháček J (1982) Two new species and a new Nearctic record in genera Apteromyia and Nearcticorpus (Diptera: Sphaeroceridae). Annals of the Entomological Society of America 75: 642–648. doi: 10.1093/aesa/75.6.642
- Marshall SA, Roháček J, Dong H, Buck M (2011) The state of Sphaeroceridae (Diptera: Acalyptratae): a world catalog update covering the years 2000–2010, with new generic synonymy, new combinations, and new distributions. Acta Entomologica Musei Nationalis Pragae 51(1): 217–298.
- Papp L (1984) Family Sphaeroceridae (Borboridae). In: Soós Á, Papp L (Eds) Catalogue of Palaearctic Diptera. Vol.10., Akadémiai Kiadó, Budapest, 68–107.
- Papp L, Plachter H (1976) On cave-dwelling Sphaeroceridae from Hungary and Germany (Diptera). Annales Historico-Naturales Musei Nationalis Hungarici 68: 195–207.
- Papp L, Roháček J (1988) The Sphaeroceridae (Diptera) of Israel. Israel Journal of Entomology 21(1987): 77–109.
- Richards OW (1930) The British species of Sphaeroceridae (Borboridae, Diptera). Proceedings of the Zoological Society of London 1930: 261–345.

- Roháček J (1978) Limosina horrida sp.n., a new species from Czechoslovakia related to Limosina bequaerti (Vill.) (Diptera, Sphaeroceridae). Časopis Slezského Muzea, Opava (A) 27: 49–60.
- Roháček J (1980) Sphaeroceridae (Diptera) collected by the soil trap method in submountaine areas of North Moravia (Czechoslovakia). Časopis Slezského Muzea, Opava (A) 29: 145–160.
- Roháček J (1982) A monograph and re-classification of the previous genus *Limosina* Macquart (Diptera, Sphaeroceridae) of Europe. Part I. Beiträge zur Entomologie, Berlin 32: 195–282.
- Roháček J (1983) A monograph and re-classification of the previous genus *Limosina* Macquart (Diptera, Sphaeroceridae) of Europe. Part II. Beiträge zur Entomologie, Berlin 33: 3–195.
- Roháček J (1984) Acalypterate Diptera of peat-bogs in North Moravia (Czechoslovakia). Part 6. Sphaeroceridae. Časopis Slezského Muzea, Opava (A) 33: 97–131.
- Roháček J (1986) Čeľaď: Sphaeroceridae. In: Čepelák J (Ed.) Diptera Slovenska II, Veda, Bratislava, 149–164, 375–378. [In Slovak]
- Roháček J (1993) Herniosina Roháček and Minilimosina Roháček of Europe: two new species, new records and taxonomic notes (Insecta, Diptera: Sphaeroceridae). Entomologische Abhandlungen, Staatliches Museum für Tierkunde in Dresden 55: 185–203.
- Roháček J (1998) 3.43. Family Sphaeroceridae. In: Papp L, Darvas B (Eds) Contributions to a Manual of Palaearctic Diptera. Vol. 3., Higher Brachycera. Science Herald, Budapest, 463–496.
- Roháček J (1994) Sphaeroceridae (Diptera) of Slovakia: corrections and additions to faunal list. Entomological Problems 25(1): 83–91.
- Roháček J (1995) Sphaeroceridae. In Roháček J, Starý J, Martinovský J, Vála M (Eds) Diptera Bukovských vrchov [Diptera of the Bukovské hills]. SAŽP - Správa CHKO a BR Východné Karpaty, Humenné, 163–171. [In Slovak, with English abstract & summary]
- Roháček J (1996) Sphaeroceridae (Diptera) of the Czech Republic: corrections and additions to the faunal list, with taxonomical notes. Časopis Slezského zemského Muzea, Opava (A) 44(1995): 219–240.
- Roháček J (1999) Sphaeroceridae. In: Rozkošný R, Vaňhara J (Eds) Diptera of the Pálava Biosphere Reserve of UNESCO, II. Folia Facultatis Scientiarum Naturalium Universitatis Masarykianae Brunensis, Biologia 100: 347–357.
- Roháček J (2001) The type material of Sphaeroceridae described by J. Villeneuve with lectotype designations and nomenclatural and taxonomic notes (Diptera). Bulletin de la Société entomologique de France 105(5)(2000): 467–478.
- Roháček J (2004) New records of Clusiidae, Anthomyzidae and Sphaeroceridae (Diptera) from Cyprus, with distributional and taxonomic notes. In: Kubík Š, Barták M (Eds) Dipterologica bohemoslovaca 11. Folia Facultatis Scientiarum Naturalium Universitatis Masarykianae Brunensis, Biologia 109: 247–264.
- Roháček J (2009) Sphaeroceridae. In: Roháček J, Ševčík J (Eds) Diptera of the Poľana Protected Landscape Area - Biosphere Reserve (Central Slovakia). SNC SR, Administration of the PLA – BR Poľana, Zvolen, 260–271.
- Roháček J (2011) The fauna of Sphaeroceridae (Diptera) in the Gemer area (Central Slovakia). Časopis Slezského zemského Muzea, Opava (A) 60: 25–40. doi: 10.2478/v10210-011-0004-9

- Roháček J (2014) First cavernicolous population of *Crumomyia parentela* (Séguy, 1963) and a review of cave-dvelling fauna of Sphaeroceridae (Diptera) in the Czech Republic. Acta Musei Silesiae Scientiae Naturales 63: 97–109. doi: 10.2478/cszma-2014-0011
- Roháček J, Barták M (2001) Sphaeroceridae. In: Barták M, Vaňhara J (Eds) Diptera in an industrially affected region (north-western Bohemia, Bílina and Duchcov environs), II. Folia Facultatis Scientiarum Naturalium Universitatis Masarykianae Brunensis, Biologia 105: 415–423.
- Roháček J, Marshall SA, Norrbom AL, Buck M, Quiros DI, Smith I (2001) World catalog of Sphaeroceridae (Diptera), Slezské zemské muzeum, Opava, 414 pp.
- Rotheray GE (1991) E B Basden's collection of Diptera from bird and mammal nests and mammal runs, burrow and droppings. National Museum of Scotland Information Series 3: 1–46.
- Séguy E (1963) Diptères hypogés recueillis par M. Paul A. Remy en Yugoslavie. Mémoires du Muséum National d'Histoire Naturelle, Paris (n.s.), (A), 18: 187–229.
- Skidmore P (1993) Notes on the taxonomy of the puparia of British Sphaeroceridae. Dipterist's Digest 13: 6–22.
- Villeneuve J (1917) Description d'espèces nouvelles de la famille des Cypselidae (Borboridae) (Dipt.). Bulletin de la Société Entomologique de France, Paris 1917: 139–144.

RESEARCH ARTICLE



# Molecular phylogeny of the forensically important genus Cochliomyia (Diptera: Calliphoridae)

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#### Abstract

*Cochliomyia* Townsend includes several abundant and one of the most broadly distributed, blow flies in the Americas, and is of significant economic and forensic importance. For decades, *Cochliomyia hominivorax* (Coquerel) and *C. macellaria* (Fabricius) have received attention as livestock parasites and primary indicator species in forensic entomology. However, *C. minima* Shannon and *C. aldrichi* Del Ponte have only been subject to basic taxonomy and faunistic studies. Here we present the first complete phylogeny of *Cochliomyia* including numerous specimens per species, collected from 13 localities in the Caribbean. Four genes, the mitochondrial COI and the nuclear EF-1 $\alpha$ , 28S rRNA, and ITS2, were analyzed. While we found some differences among gene trees, a concatenated gene matrix recovered a robustly supported monophyletic *Cochliomyia* with *Compsomyiops* Townsend as its sister group and recovered the monophyly of *C. hominivorax*, *C. macellaria* and *C. aldrichi* containing *C. minima*, indicating recent speciation, or issues with the taxonomy of the group. We provide basic information on habitat preference, distribution and feeding habits of *C. minima* and *C. aldrichi* that will be useful for future forensic studies in the Caribbean.

#### **Keywords**

Forensic entomology, Caribbean region, habitat preferences, *Cochliomyia minima*, *Cochliomyia aldrichi*, *Cochliomyia macellaria*, *Cochliomyia hominivorax* 

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# Introduction

*Cochliomyia* Townsend is endemic to the Americas and includes only four species: *Cochliomyia minima* Shannon, *C. aldrichi* Del Ponte, *C. macellaria* (Fabricius) and *C. hominivorax* (Coquerel). All of them are flesh eaters during their larval stage and are locally abundant. In particular, *Cochliomyia macellaria* is one of the most broadly distributed blow flies in the New World (Whitworth 2010). These species vary in habitat preference, feeding habits, dispersal abilities, and morphology among the species (Hall 1948, Whitworth 2010). For instance, *C. aldrichi, C. minima* and *C. macellaria* are primarily carrion feeders, while, *C. hominivorax* is an obligate parasite of mammals (Hall 1948, Stevens and Wallman 2006, McDonagh et al. 2009, McDonagh and Stevens 2011).

Cochliomyia hominivorax and C. macellaria have been intensely studied due to their commercial and forensic importance. Cochliomyia macellaria is one of the most forensically important species commonly found on decomposing remains. This species is considered important for post mortem interval estimations (Smith 1986, Byrd and Castner 2010) being among the first species to colonize corpses. In contrast, Cochlio*myia hominivorax* is an obligate parasite with its larvae producing myiasis and feeding on living tissue (Hall 1948, Guimaraes et al. 1983). This species is one of the most important insect pests of livestock in the Neotropics causing economic losses of billions of dollars every year (Vargas-Terán et al. 2005). Both species are common throughout the year in tropical, warm and humid areas (Hall 1948). Cochliomyia macellaria can be found in temperate climates from Canada to Argentina during the summer months (Whitworth 2010). Cochliomyia hominivorax initially ranged from southern United States to northern Argentina (Guimaraes et al. 1983) but has been eradicated from North America, Central America, Puerto Rico and the Virgin Islands (Vargas-Terán et al. 2005). It is worth noting that in 1988 this species was introduced in Libya and it was successfully eradicated in 1992 based on the sterile insect technique (SIT). This was the major international effort and avoid a major disaster for the livestock industry of Africa and Southern Europe (Lindquist et al. 1992). Despite those successfully eradications C. hominivorax continues to be an economically important pest in South America and parts of the Caribbean (Vargas-Terán et al. 2005).

The other two congeners, *C. minima* and *C. aldrichi*, are poorly known and research has been limited to descriptive morphology and faunistics (Hall 1948, Dear 1985, Whitworth 2010). These two species are restricted to the West Indies and *C. aldrichi* has been reported in the Florida Keys (Whitworth 2010). Dear (1985) listed *C. minima* for the Florida Keys, however Whitworth (2010) concluded that Dear mistakenly identified one *C. aldrichi* specimen as *C. minima*. Forensically important insects in the Caribbean are generally understudied and these two species have not played an important role in forensic entomology. Yet, due to their abundance and broad distribution in this region, including Cuba, Dominican Republic, Jamaica, Puerto Rico, Virgin Islands, Bahamas and Cayman Islands (Hall 1948, Dear 1985, Whitworth 2010) they have an enormous forensic potential. For example, recent studies conducted in
Puerto Rico showed that *C. minima* is abundant and widely distributed on the island, and that adults are attracted to, and feed on, carrion (Yusseff-Vanegas 2014).

Although the adult morphology of the four species is well known (Hall 1948, Dear 1985, Whitworth 2010), studies on the relationship among Cochliomyia species have not been conducted yet. Morphological studies have provided synapomorphies of *Cochliomyia* that clearly diagnose it from all other Calliphoridae (Hall 1948; Dear 1985; Whitworth 2010). These include short and filiform palpus and phallus with extremely elongated paraphallus and a complex distiphallus (Dear 1985, Figs 37–44). Prior studies on the relationships among Calliphoridae (Stevens 2003, Harvey et al. 2008, McDonagh and Stevens 2011) and the subfamily Chrysomyinae (Singh and Wells 2011), including C. macellaria and C. hominivorax, supported Cochliomyia monophyly, and placed it as sister to Compsomyiops Townsend. However, the monophyly of the genus has not been formally tested with thorough sampling of all species, and the relationships among its species remain unknown. Furthermore, DNA-based methods can provide reliable identification of specimens by non-experts and will be particularly important for the identification of larval stages of C. minina and C. aldrichi that remain poorly known. For example, only the third instar of C. minima has been described (Yusseff-Vanegas 2014).

Here we provide a robust phylogenetic hypothesis of *Cochliomyia* based on four genes sequenced from 38 individuals collected throughout the Caribbean, including for the first time molecular data about *C. minima* and *C. aldrichi*. Our main goals are to test the monophyly of this genus and the validity of, and relationships among, its species.

# Methods

#### Specimens and DNA extraction

A total of 44 specimens were included in this study, 38 representing the ingroup plus six outgroup species [*Chrysomya megacephala* (Fabricius), *C. rufifacies* (Macquart), *Hemilucilia sp., Lucilia cuprina* (Wiedemann), *Compsomyiops fulvicrura* (Robineau-Desvoidy) and *Compsomyiops callipes* (Bigot)]. All sequences used here are new except for *Compsomyiops fulviclura* and *C. callipes* (Table 1). The specimens were collected in the Caribbean (Jamaica, Cuba, Dominican Republic, Puerto Rico, Saint Barts Martinique and Dominica) from 2011 to 2013 and in the following countries, Colombia (2014), Florida (2013) and Mexico (2010 and 2012) (Table 1). All specimens were killed and preserved in 95% ethanol and stored at -20 °C. The adults were examined with a Leica MZ16 stereomicroscope and identified using the Whitworth (2010) keys. The DNA was isolated from thoracic muscle or two legs of each individual with the QIAGEN DNeasy Tissue Kit (Qiagen, Inc., Valencia, CA). Voucher specimens were deposited at the UVM Natural History Museum (in the Zadock Thompson Zoological Collections) and sequences were submitted to GenBank.

Species name –Voucher Number	Location	CO1	EF-1a	ITS2	28S rRNA
Cochliomyia macellaria CO002	Colombia, El refugio Dry Forest	KX529522	KX529616	KX529574	KX529487
Cochliomyia macellaria CO010	Colombia, Choco, Jardín botánico del Pacífico	KX529545	KX529617	KX529575	KX529488
Cochliomyia macellaria CO017	Colombia, Santander, Chipatá, Finca el Castillo	KX529543	KX529618	KX529576	KX529489
Cochliomyia macellaria ME015*	Mexico, Torreon, Coahuila	KX529546	KX529629	KX529588	KX529492
Cochliomyia macellaria FL006	USA, Florida, Everglades National Park, North- east	KX529535	KX529623	KX529581	KX529503
Cochliomyia macellaria JA002	Jamaica, Marshall's Pen House	KX529538	KX529624	KX529582	KX529502
Cochliomyia macellaria CU018	Cuba, Pinar del Rio, Viñales Nacional Park	KX529526	KX529620	KX529578	KX529499
Cochliomyia macellaria CU014	Cuba, Pinar del Rio, Viñales Nacional Park	KX529541	KX529619	KX529577	KX529497
Cochliomyia macellaria DR134	Dominican Republic, Puerto Plata	KX529527	KX529622	KX529580	KX529504
Cochliomyia macellaria DR010	Dominican Republic, El Morro, Monte Cristi	KX529536	KX529621	KX529579	KX529496
Cochliomyia macellaria PR129	Puerto Rico, Vieques, Monte Pirata	KX529542	-	KX529591	KX529501
Cochliomyia macellaria PR128	Puerto Rico, Vieques, Monte Pirata	KX529540	-	KX529590	KX529494
Cochliomyia macellaria PR121	Puerto Rico, Trujillo Alto, Ciudad Universitaria	KX529544	KX529630	KX529589	KX529500
Cochliomyia macellaria M112	Puerto Rico, Isla de Mona, Los Caobos	KX529528	-	KX529587	KX529493
Cochliomyia macellaria M081	Puerto Rico, Isla de Mona, Los Caobos	KX529537	KX529628	KX529586	KX529498
Cochliomyia macellaria M077	Puerto Rico, Isla de Mona, Bajuras - Cerezos	KX529539	KX529627	KX529585	KX529495
Cochliomyia macellaria LA142	Saint Barts, Colombier Deciduos Dry Forest	KX529523	KX529631	KX529592	-
Cochliomyia macellaria LA096	Martinique, Cap de Macré Coastal Forest	KX529524	KX529626	KX529584	KX529491
Cochliomyia macellaria LA071	Dominica, Middleham Falls Trail	KX529525	KX529625	KX529583	KX529490
Cochliomyia aldrichi M080	Puerto Rico, Isla de Mona, Near Cueva Por- tugues	KX529529	KX529605	KX529563	KX529513
Cochliomyia aldrichi M085	Puerto Rico, Isla de Mona, Los Caobos	KX529530	KX529606	KX529564	KX529515
Cochliomyia aldrichi M086	Puerto Rico, Isla de Mona, Camino del Indio	KX529531	KX529607	KX529565	KX529514
Cochliomyia aldrichi M103	Puerto Rico, Isla de Mona, Los Caobos	KX529532	KX529608	KX529566	KX529516
Cochliomyia aldrichi M105	Puerto Rico, Isla de Mona, Near Cueva Por- tugues	KX529533	KX529609	KX529567	KX529518
Cochliomyia aldrichi M107	Puerto Rico, Isla de Mona, Near Cueva Por- tugues	KX529534	KX529610	KX529568	KX529517
Cochliomyia minima CU046	Cuba, Guantanamo, Alejandro de Humboldt National Park	KX529547	KX529633	KX529595	KX529510
Cochliomyia minima CU022	Cuba, Pinar del Rio, Viñales National Park	KX529549	KX529632	KX529593	KX529511
Cochliomyia minima CU023	Cuba, Pinar del Rio, Viñales National Park	KX529550	-	KX529594	KX529508
Cochliomyia minima DR136	Dominican Republic, Puerto Plata	KX529548	KX529635	KX529597	KX529509
Cochliomyia minima DR055	Dominican Republic, Haitises National Park	KX529552	KX529634	KX529596	KX529507
Cochliomyia minima PR141	Puerto Rico, Loiza, Mangrove area	KX529551	-	KX529600	KX529512
Cochliomyia minima PR132	Puerto Rico, Loiza, Mangrove area	KX529553	KX529636	KX529598	-
Cochliomyia minima PR133	Puerto Rico, Vieques, Monte Pirata	KX529554	KX529637	KX529599	KX529506
Cochliomyia hominivorax CO001	Colombia, El refugio Dry Forest	-	KX529611	KX529569	KX529482
Cochliomyia hominivorax CU020	Cuba, Pinar del Rio, Viñales Nacional Park	-	KX529612	KX529570	KX529483

 Table 1. Specimen details, collection information and GenBank accession numbers.

Species name –Voucher Number	becies name –Voucher Number Location		EF-1a	ITS2	28S rRNA
Cochliomyia hominivorax CU033	Cuba, Pinar del Rio, Viñales Nacional Park	KX529556	KX529613	KX529571	KX529484
Cochliomyia hominivorax DR042	Dominican Republic, Rabo de Gato	KX529557	KX529614	KX529572	KX529485
Cochliomyia hominivorax DR105	Dominican Republic, East National Park, Yuma	KX529558	KX529615	KX529573	KX529486
Chrysomya megacephala FL003	USA, Florida, Everglades National Park, North- east	KX529521	KX529603	KX529561	KX529480
Chrysomya rufifacies CU004	Cuba, Granma: Turquino National Park	KX529555	KX529604	KX529562	KX529481
Hemilucilia sp. CO018	Colombia, Santander, Chipatá, Finca el Castillo	KX529560	KX529638	KX529601	KX529519
Lucilia cuprina PR073	Puerto Rico, Trujillo Alto, Ciudad Universitaria	KX529559	KX529639	KX529602	KX529520
Compsomyiops fulvicrura	As Published (Kutty et al. 2008)	FJ025607	FJ025667	-	FJ025504
Compsomyiops callipes	As Published (Wells and Sperling 2001)	AF295549	-	-	-

\*The sample from Mexico was collected by Fabián García Espinoza from Universidad Antonio Narro Unidad Laguna.

# PCR amplification and sequencing

We amplified regions of three nuclear loci: the protein coding elongation factor-1 alpha (EF-1 $\alpha$ ), the ribosomal 28S, and internal transcribed spacer 2 (ITS2), plus the mitochondrial protein coding cytochrome oxidase I (COI). The primer sequences are listed in Table 2. Protocols for COI reactions included an initial denaturation step of 95 °C for 2 min, followed by 35 cycles of 95 °C for 30 s, 44 °C for 45 s and 72 °C for 45 s, and a final elongation step of 72 °C for 10 min (Agnarsson et al. 2007). For ITS2 an initial denaturation step of 94 °C for 2 min was followed by 38 cycles of 94 °C for 30 s, 44 °C for 35 s and 72 °C for 30 s, and a final elongation step of 72 °C for 3 min (Agnarsson 2010). For EF-1 $\alpha$  an initial denaturation of 95 °C for 5 min was followed by 35 cycles of 94 °C for 30 s, 55 °C for 35 s and 72 °C for 1 min, and a final elongation step of 72 °C for 10 min (McDonagh et al. 2009). For 28S rRNA initial denaturation of 94 °C for 5 min was

Gene	Primer name	Sequence (5' to 3')	Source
COI	LCO1490	GGTCAACAAATCATAAAGATATTGG	Folmer et al. (1994)
	CI-N-2776	GGATAATCAGAATATCGTCGAGG	Hedin and Maddison (2001)
EF-1α	B1	CCCATYTCCGGHTGGCACGG	McDonagh et al. (2009)
	C1	CTCTCATGTCACGDACRGCG	McDonagh et al. (2009)
28S	D1.F	CCCCCTGAATTTAAGCATAT	Friedrich and Tautz (1997)
	D35.486.R	TCGGAAGGAACCAGCTACTA	Friedrich and Tautz (1997)
ITS	ITS4	TCCTCCGCTTATTGATATGC	White et al. (1990)
	ITS5.8	GGGACGATGAAGAACGCAGC	Agnarsson (2010)

Table 2. PCR primers use in this study.

followed by 35 cycles of 93 °C for 1 min, 60 °C for 1 min and 72 °C for 2 min, and a final elongation step of 72 °C for 3 min (Friedrich and Tautz 1997). Amplified fragments were sequenced in both directions by University of Arizona Genetics Core. Sequences were interpreted from chromatograms using Phred (Green and Ewing 2002) and Phrap (Green 1999, Green and Ewing 2002) using the Chromaseq module (Maddison and Maddison 2010a) in the evolutionary analysis program Mesquite 3.03 (Maddison and Maddison 2010b) with default parameters. The sequences were then proofread by examining chromatograms by eye. Alignments were done using MAFFT (Katoh et al. 2002) through the online portal EMBL-EBI. The gene matrices were then concatenated in Mesquite 3.03 (Maddison and Maddison 2010b) and the full aligned data set is 3368 bp.

#### Phylogenetic analysis

We partitioned each gene and codon position for a total of eight partitions that were exported from Mesquite for model choice and the appropriate models were chosen using jModeltest v2.1.4 (Posada and Crandall 1998), and the AIC criterion (Posada and Buckley 2004). The corresponding model of evolution was used for the Bayesian analysis: GTR +  $\Gamma$  + I for 28S, ITS2 and COI3rd, GTR +  $\Gamma$  for COI1st, COI2nd, EF-1 $\alpha$ 3rd, HKY +  $\Gamma$  for EF-1 $\alpha$ 2nd and F81 for EF-1 $\alpha$ 1st. We ran the MC<sup>3</sup> (Metropolis Coupled Markov Chain Monte Carlo) chain in MrBayes v3.2.3 (Huelsenbeck and Ronquist 2001) through the online portal Cipres Science Gateway v3.3 (Miller et al. 2010). The analysis was run for 30.000.000 generations, sampling every 1000 generations. Chain stationary, ESS, and appropriate burnin was verified using Tracer 1.6 (Rambaut and Drummond 2009). Maximum likelihood (ML) analysis of the concatenated matrix was done in Garli (Zwickl 2006) using the same partitioning scheme and models.

#### Results

The phylogenetic analyses of the concatenated matrix, either using Bayesian or maximum likelihood approaches, recovered a generally well supported monophyletic *Cochliomyia* (Fig. 1). *Cochliomyia macellaria*, *C. hominivorax* and *C. minima* were recovered as monophyletic, while *C. aldrichi* was recovered as paraphyletic.

Independent analyses of 28S and ITS2 supported the monophyly of *Cochliomyia*, while COI and EF-1 $\alpha$  recovered it as a paraphyletic group (Suppl. material 1). At the species level, EF-1 $\alpha$  and 28S had limited signal and did not distinguish between *C. minima* and *C. aldrichi*. COI recovered the monophyly of *C. minima*, but did not resolve relationships among *C. aldrichi* and *C. macellaria*. ITS2 fully resolved the relationships within *Cochliomyia*, and is the only gene that recovered the monophyly of *C. aldrichi*. Despite of the incongruence detected among the four gene trees, they all recovered monophyletic *C. hominivorax* and three of the four genes (COI, 28S and ITS2) strongly supported a monophyletic *C. hominivorax* as sister to the other three species.



**Figure 1.** Phylogenetic relationship within *Cochliomyia* (ingroup) based on partitioned Bayesian analysis of the combined gene (COI, EF-1α, 28S rRNA and ITS2) data set. Branch support values: normal fond, Bayesian posterior probability; bold-italic font, maximum likelihood percentage bootstrap. Each color represents different species.

The concatenated dataset yielded a topology supporting a close relationship between *C. minima* and *C. aldrichi* which is congruent with the current taxonomy and indicates *C. macellaria* as the sister lineage of these two.

# Discussion

We present the first species complete phylogeny of the genus *Cochliomyia* including samples collected throughout the Caribbean from 13 different localities (Table 1). The concatenated matrix recovered a monophyletic *Cochliomyia*, partially resolved relationships among its species and recovered *Compsomyiops* as its sister group (Fig. 1), in congruence with prior studies (McDonagh and Stevens 2011, Singh and Wells 2011).

Independent gene trees did not yield fully congruent relationships among species, unsurprising as genes have independent histories. Two nuclear genes, 28S and ITS2 (adjacent loci), strongly supported the monophyly of *Cochliomyia* while the other two genes, COI and EF-1 $\alpha$  did not. These results differ from McDonagh (2009), where EF-1 $\alpha$  and COI strongly supported the monophyly of *Cochliomyia*, while 28S recovered *Cochliomyia* as paraphyletic. However, McDonagh (2009) included only two of the species of *Cochliomyia* represented by one specimen each. The differences between the studies could be due to a variety of taxon sampling issues, where our sampling was designed specifically to test monophyly and relationships among *Cochliomyia* species.

The monophyly of C. hominivorax is supported in all analyses, however, independent gene trees were not congruent with regards to other species. The relatively slowly evolving nuclear genes EF-1a and 28S supported C. macellaria but failed to distinguish between C. minima and C. aldrichi. The relatively rapidly evolving COI "DNA barcode" was found suitable for species identification and delineation (Hebert et al. 2003). COI was the only gene that recovered the monophyly of C. minima, however, COI did not resolve relationships among specimens of C. aldrichi and C. macellaria. This is surprising as these species are clearly identifiable based on morphological characteristics (Hall 1948, Whitworth 2010). Other studies also reported similar results where COI failed to distinguish among some closely related calliphorids (Wallman and Donnellan 2001, Nelson et al. 2007, Whitworth et al. 2007, Harvey et al. 2008, DeBry et al. 2013, Whitworth 2014), a result that has been attributed to incomplete lineage sorting. Results from COI, EF-1a, and 28S combined suggested C. aldrichi as sister to C. macellaria, instead of to C. minima as we would expect based on morphological characteristics. Based on these results we opted to add the rapidly evolving nuclear marker, ITS2 to help resolve species level relationships (Nelson et al. 2007, Agnarsson 2010). ITS2 was the only gene that recovered *C. aldrichi* as a monophyletic group and supported C. minima as its sister lineage.

Despite the incongruence detected between the four genes, a concatenate matrix recovered the monophyly of *C. hominivorax, C. macellaria* and *C. minima*, and supported the monophyly of *C. minima* plus *C. aldrichi*, mostly congruent with the current taxonomy. However, we found that *C. minima* is nested within *C. aldrichi*. That one species is paraphyletic with respect to another is not unexpected and does not necessarily refute their species status. The non-monophyly of *C. aldrichi* is surprising in that all specimens included in this study were collected from the tiny Mona Island (22 square miles). This indicates incomplete lineage sorting, or possibly recent speciation, rather than other processes like gene flow among species (given Mona's isolation, expectation of panmixia among *C. aldrichi* on the tiny island, and absence of *C. aldrichi* from other islands (Table 1) and the populations in different islands do not show any geographic structure (Fig. 1), indicating a constant gene flow among populations through migration.

The variability in feeding habits, habitat preference and morphology within *Cochliomyia* is considerable (Fig. 2). In feeding habits, *C. aldrichi*, *C. minima* and *C. macellaria* share similar behaviors. They are primarily carrion feeders, commonly found on



Figure 2. Variability in feeding habits, habitat preference and morphology within *Cochliomyia*.

\*C. aldrichi has been reported in the Florida Keys Islands.

\*\*We refer to temperatures around 10–15 °C.

● Carrion feeder; ▲ primary facultative parasite; ■ secondary facultative parasite; ★ obligate parasite.

decomposing cadavers. However, they are also capable of producing myiasis in open wounds as secondary facultative parasites under certain conditions or as primary facultative parasites as in the case of *C. minima*, (Hall 1948, Dear 1985). In contrast, *C. hominivorax* is an obligate parasite of mammals never found in decaying meats (Hall 1948, Stevens and Wallman 2006, McDonagh et al. 2009, McDonagh and Stevens 2011, but see Brody and Knipling 1943). Several authors have studied the evolution of parasitism within Calliphoridae and have concluded that the parasitic behavior in this family evolved independently several times (Stevens and Wallman 2006, McDonagh and Stevens 2011, Singh and Wells 2011). Within *Cochliomyia*, we conclude that parasitism evolved once in *C. hominivorax*, since the congeners are carrion feeders, as are members of the sister group, *Compsomyiops* (Fig. 2).

The habitat preferences of *C. hominivorax* and *C. macellaria* are largely known (Hall 1948, Greenberg 1971, Smith 1986, Wells and Greenberg 1992, Byrd and Butler 1996, Byrd and Castner 2010, Koller et al. 2011), however, little is known about *C. minima* and *C. aldrichi*. In recent studies of *C. minima* in Puerto Rico, Yusseff-Vanegas (2014) reported that *C. minima* prefer highly humid areas and can tolerate relatively cool conditions at altitudes >800m, while this species is absent from extremely dry and hot areas. Similar results were found in Dominican Republic and Cuba where *C. minima* was found abundantly in tropical and subtropical rain/moist forest even at altitudes >1300m, but absent from dry forest (unpublished data). These results supported the assumption that *C. minima* prefer humid cool areas, however, more studies are needed to understand its habitat preferences. In contrast, *C. aldrichi* seems to prefer hot dry areas, different from what we expected given the apparent recent divergence between *C. minima* and *C. aldrichi*. This is the case of recently divergent species like *Lucilia sericata* (Meigen) and *L. cuprina* Wiedemann, and *L. coeruleiviridis* Macquart and *L. mexicana* Macquart that have similar habitat preferences (Stevens and Wall 1996, 1997, Whitworth 2006, Byrd and Castner 2010, Whitworth 2010, 2014). However, *C. aldrichi* was found only on Mona Island, a subtropical dry forest with an average annual temperature of 27 °C (National Oceanic and Atmospheric Administration - NOAA) and low humidity through the year, strikingly different from *C. minima*. Yet, similar results have been reported before for closely related species like *C. megacephala* and *C. pacifica* (Singh et al. 2011) which are characterized by very different habitat preferences (Kurahashi 1981, 1991). Despite we have extensively collected in Florida (Everglades and the Keys), Cuba, Puerto Rico and the Bahamas, where *C. aldrichi* was previously reported (Whitworth 2010), we did not find this species. This could be explained by sampling bias as we only collected during the summer when precipitation and relative humidity are very high in the Caribbean. It is possible, for example, that *C. aldrichi* may be seasonal, being present during the winter when conditions are generally drier and cooler in the Caribbean. Alternatively, our sampling might indicate the recent extinction of this species from areas outside Mona, nevertheless, further studies are necessary to test these alternative hypotheses.

Two of the four species, *C. minima* and *C. aldrichi* are Caribbean endemics while the other two are widespread (Figs. 1–2). It is difficult to assess the biogeographical history of widespread species, however, we can conclude from our data that divergence between *C. minima* and *C. aldrichi* probably occurred in the Caribbean after the area was colonized. Island colonization is sometimes accompanied by a reduction in dispersal abilities and such processes may have led to reduced gene flow among islands, and promoted the formation of the Caribbean endemics. Further phylogeographic/ phylogenomic studies including more taxa from the Caribbean and the continents are necessary to assess the colonization history of the genus and the possible secondary loss of dispersal ability in this group.

# Conclusions

We provide the first complete phylogeny of *Cochliomyia*, supporting its monophyly and placement within the subfamily Chrysomyinae. Given incongruence among gene trees and low level of information at the species level for slowly evolving genes, the resolution of the outstanding questions in *Cochliomyia* phylogeny will require more data rich approaches, such as those offered by NGS methods. Nevertheless, we advance knowledge on the phylogeny, distribution, and life history of these species that should prove useful in future research and in realizing the potential of these species as forensic insects.

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#### References

- Agnarsson I (2010) The utility of ITS2 in spider phylogenetics: notes on prior work and an example from *Anelosimus*. Journal of Arachnology 38: 377–382. doi: 10.1636/B10-01.1
- Agnarsson I, Maddison WP, Aviles L (2007) The phylogeny of the social *Anelosimus spiders* (Araneae : Theridiidae) inferred from six molecular loci and morphology. Molecular Phylogenetics and Evolution 43: 833–851. doi: 10.1016/j.ympev.2006.09.011
- Brody AL, Knipling EF (1943) Can Larvae of *Cochliomyia americana* C. & P. Mature in Carcasses? Journal of Parasitology 29: 59–60. doi: 10.2307/3272748
- Byrd JH, Butler JF (1996) Effects of temperature on *Cochliomyia macellaria* (Diptera: Calliphoridae) development. Journal of Medical Entomology 33: 901–905. doi: 10.1093/jmedent/33.6.901
- Byrd JH, Castner JL (2010) Forensic Entomology: The Utility of Arthropods in Legal Investigations. CRC Press, 705 pp.
- Dear JP (1985) A revision of the New World Chrysomyini (Diptera: Calliphoridae). Revista Brasileira de Zoologia 3: 109–169. doi: 10.1590/S0101-81751985000300001
- DeBry RW, Timm A, Wong ES, Stamper T, Cookman C, Dahlem GA (2013) DNA-Based Identification of Forensically Important *Lucilia* (Diptera: Calliphoridae) in the Con-

tinental United States. Journal of Forensic Sciences 58: 73–78. doi: 10.1111/j.1556-4029.2012.02176.x

- Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R (1994) DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology 3: 294–299.
- Friedrich M, Tautz D (1997) An episodic change of rDNA nucleotide substitution rate has occurred during the emergence of the insect order Diptera. Molecular Biology and Evolution 14: 644–653. doi: 10.1093/oxfordjournals.molbev.a025804
- Green P (1999) Phrap, version 1.090518. http://phrap.org
- Green P, Ewing B (2002) Phred, version 0.020425c. http://phrap.org
- Greenberg B (1971) Flies and Disease, Vol. 2: Biology and Disease Transmission. Princeton University Press, Princeton, 460 pp.
- Guimaraes JH, Papavero N, Prado AP (1983) As miiases na regiao neotropical (identificacao, biologia, bibliografia); familia Calliphoridae (Genero *Cochliomyia*). Revista Brasileira de Zoologia 1: 270–335.
- Hall DG (1948) The blowflies of North America. The Thomas Say Foundation, 477 pp.
- Harvey ML, Gaudieri S, Villet MH, Dadour IR (2008) A global study of forensically significant calliphorids: Implications for identification. Forensic Science International 177: 66–76. doi: 10.1016/j.forsciint.2007.10.009
- Hebert PDN, Cywinska A, Ball SL, DeWaard JR (2003) Biological identifications through DNA barcodes. Proceedings of the Royal Society B-Biological Sciences 270: 313–321. doi: 10.1098/rspb.2002.2218
- Hebert PDN, Stoeckle MY, Zemlak TS, Francis CM (2004) Identification of birds through DNA barcodes. Plos Biology 2: 1657–1663. doi: 10.1371/journal.pbio.0020312
- Hedin MC, Maddison WP (2001) A combined molecular approach to phylogeny of the lumping spider subfamily Dendryphantinae (Araneae : Salticidae). Molecular Phylogenetics and Evolution 18: 386–403. doi: 10.1006/mpev.2000.0883
- Huelsenbeck JP, Ronquist F (2001) MRBAYES: Bayesian inference of phylogenetic trees. Bioinformatics 17: 754–755. doi: 10.1093/bioinformatics/17.8.754
- Katoh K, Misawa K, Kuma K, Miyata T (2002) MAFFT: a novel method for rapid multiple sequence alignment based on fast Fourier transform. Nucleic Acids Research 30: 3059– 3066. doi: 10.1093/nar/gkf436
- Koller WW, de Barros ATM, Correa EC (2011) Abundance and seasonality of *Cochliomyia ma-cellaria* (Diptera: Calliphoridae) in Southern Pantanal, Brazil. Revista Brasileira De Parasitologia Veterinaria 20: 27–30. doi: 10.1590/S1984-29612011000100006
- Kutty SN, Pape T, Pont A, Wiegmann BM, Meier R (2008) The Muscoidea (Diptera: Calyptratae) are paraphyletic: Evidence from four mitochondrial and four nuclear genes. Molecular Phylogenetics and Evolution 49: 639–652. doi: 10.1016/j.ympev.2008.08.012
- Lindquist DA, Abusowa M, Hall MJR (1992) The New-World screwworm fly in Libya A review of its introduction and eradication. Medical and Veterinary Entomology 6: 2–8. doi: 10.1111/j.1365-2915.1992.tb00027.x
- Maddison DR, Maddison WP (2010a) Chromaseq: a Mesquite package for analyzing sequence chromatograms. Version 1.0. http://mesquiteproject.org/packages/chromaseq

- Maddison WP, Maddison DR (2010b) Mesquite: a modular system for evolutionary analysis. Version 2.75. http://mesquiteproject.org
- McDonagh L, Garcia R, Stevens JR (2009) Phylogenetic analysis of New World screwworm fly, *Cochliomyia hominivorax*, suggests genetic isolation of some Caribbean island populations following colonization from South America. Medical and Veterinary Entomology 23: 14–22. doi: 10.1111/j.1365-2915.2008.00777.x
- McDonagh LM (2009) Assessing patterns of genetic and antigenic diversity in Calliphoridae (blowflies). PhD Thesis, University of Exeter, Exeter. http://hdl.handle.net/10036/98597
- McDonagh LM, Stevens JR (2011) The molecular systematics of blowflies and screwworm flies (Diptera: Calliphoridae) using 28S rRNA, COX1 and EF-1 alpha: insights into the evolution of dipteran parasitism. Parasitology 138: 1760–1777. doi: 10.1017/ S0031182011001089
- Miller MA, Pfeiffer W, Schwartz T (2010) Creating the CIPRES Science Gateway for inference of large phylogenetic trees. Gateway Computing Environments Workshop (GCE), 2010.
- Nelson LA, Wallman JF, Dowton M (2007) Using COI barcodes to identify forensically and medically important blowflies. Medical and Veterinary Entomology 21: 44–52. doi: 10.1111/j.1365-2915.2007.00664.x
- Posada D, Crandall KA (1998) MODELTEST: testing the model of DNA substitution. Bioinformatics 14: 817–818. doi: 10.1093/bioinformatics/14.9.817
- Posada D, Buckley TR (2004) Model selection and model averaging in phylogenetics: Advantages of akaike information criterion and Bayesian approaches over likelihood ratio tests. Systematic Biology 53: 793–808. doi: 10.1080/10635150490522304
- Rambaut A, Drummond A (2009) Tracer v1.5. Available from http://beast.bio.ed.ac.uk/Tracer [accessed February 2010]
- Singh B, Wells JD (2011) Chrysomyinae (Diptera: Calliphoridae) is monophyletic: a molecular systematic analysis. Systematic Entomology 36: 415–420. doi: 10.1111/j.1365-3113.2011.00568.x
- Smith KGV (1986) A manual of forensic entomology. University Printing House, London, 205 pp.
- Stevens J, Wall R (1996) Species, sub-species and hybrid populations of the blowflies *Lucilia cuprina* and *Lucilia sericata* (Diptera: Calliphoridae). Proceedings of the Royal Society B-Biological Sciences 263: 1335–1341. doi: 10.1098/rspb.1996.0196
- Stevens J, Wall R (1997) Genetic variation in populations of the blowflies *Lucilia cuprina* and Lucilia sericata (Diptera: Calliphoridae). Random amplified polymorphic DNA analysis and mitochondrial DNA sequences. Biochemical Systematics and Ecology 25: 81–97. doi: 10.1016/S0305-1978(96)00038-5
- Stevens JR (2003) The evolution of myiasis in blowflies (Calliphoridae). International Journal for Parasitology 33: 1105–1113. doi: 10.1016/S0020-7519(03)00136-X
- Stevens JR, Wallman JF (2006) The evolution of myiasis in humans and other animals in the Old and New Worlds (part I): phylogenetic analyses. Trends in Parasitology 22: 129–136. doi: 10.1016/j.pt.2006.01.008
- Vargas-Terán M, Hofmann HC, Tweddle NE (2005) Impact of screwworm eradication programmes using the sterile insect technique. In: Dyck VA, Hendrichs J, Robinson AS (Eds) Sterile Insect Technique. Springer, Dordrecht, 629–650. doi: 10.1007/1-4020-4051-2\_24

- Wallman JF, Donnellan SC (2001) The utility of mitochondrial DNA sequences for the identification of forensically important blowflies (Diptera : Calliphoridae) in southeastern Australia. Forensic Science International 120: 60–67. doi: 10.1016/S0379-0738(01)00426-1
- Wells JD, Greenberg B (1992) Interaction between *Chrysomya rufifacies* and *Cochliomyia macellaria* (diptera, calliphoridae) the possible consequences of an invasion. Bulletin of Entomological Research 82: 133–137. doi: 10.1017/S0007485300051543
- Wells JD, Sperling FAH (2001) DNA-based identification of forensically important Chrysomyinae (Diptera: Calliphoridae). Forensic Science International 120: 110–115. doi: 10.1016/S0379-0738(01)00414-5
- White TJ, Bruns T, Lee S, Taylor JW (1990) Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: Innis MA, Gelfand DH, Sninsky JJ, White TJ (Eds) PCR Protocols: A Guide to Methods and Applications. Academic Press, Inc., New York, 315–322. doi: 10.1016/b978-0-12-372180-8.50042-1
- Whitworth T (2006) Keys to the genera and species of blow flies (Diptera : Calliphoridae) of America North of Mexico. Proceedings of the Entomological Society of Washington 108: 689–725.
- Whitworth T (2010) Keys to the genera and species of blow flies (Diptera: Calliphoridae) of the West Indies and description of a new species of Lucilia Robineau-Desvoidy. Zootaxa 2663: 1–35.
- Whitworth T (2014) A revision of the Neotropical species of *Lucilia* Robineau-Desvoidy (Diptera: Calliphoridae). Zootaxa 3810: 1–76. doi: 10.11646/zootaxa.3810.1.1
- Whitworth TL, Dawson RD, Magalon H, Baudry E (2007) DNA barcoding cannot reliably identify species of the blowfly genus *Protocalliphora* (Diptera : Calliphoridae). Proceedings of the Royal Society B-Biological Sciences 274: 1731–1739. doi: 10.1098/rspb.2007.0062
- Yusseff-Vanegas SZ (2014) Description of Third Instars of *Cochliomyia minima* (Diptera: Calliphoridae) From West Indies, and Updated Identification Key. Journal of Medical Entomology 51: 1051–1056. doi: 10.1603/ME13088
- Zwickl DJ (2006) Genetic algorithm approaches for the phylogenetic analysis of large biological sequence datasets under the maximum likelihood criterion. PhD Thesis, The University of Texas at Austin.

# Supplementary material I

# Phylogenetic relationship within *Cochliomyia* (ingroup) based on a Bayesian analysis of nucleotide data from (a) 28S, (b) COI, (c) EF-1 $\alpha$ and (d) ITS2

Authors: Yusseff-Vanegas S, Agnarsson I

Data type: molecular data

Explanation note: Numbers indicate posterior probability support values.

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RESEARCH ARTICLE



# Taxonomic notes on the genus Orthobrachia Warren, with description of a new species from China and Thailand (Lepidoptera, Geometridae)

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# Abstract

All seven members of the genus Orthobrachia Warren, 1895 are recorded, with description of a new species from Sichuan Province, China and N. Thailand, including O. latifasciata (Moore, 1888) and O. flavidior (Hampson, 1898) from northern India, Nepal and China, O. tenebrosa Yazaki, 1992 from Nepal and India, O. owadai Yazaki, 1992 from India, O. simpliciata Yazaki, 2002 from China, and O. maoershanensis Huang, Xin & Wang, 2003 from South China. A key to the Orthobrachia species is provided, along with a distributional map of all nominal species. The type specimens of the new species are deposited in Hunan Agricultural University (China), South China Agricultural University (China) and Zoological Research Museum Alexander Koenig (Germany).

#### Keywords

Ennominae, Orthobrachia hirowatarii sp. n., Sichuan province, taxonomy

# Introduction

The genus Orthobrachia, belonging to the subfamily Ennominae (Geometroidea: Geometridae), was established by Warren in 1895 with Stegania latifasciata Moore, 1888 as its type species. The genus remained monotypic until the same author one year later described O. particolor Warren, 1896 from the Khasi Hills, India. However, this species later was transferred to Crypsicometa Warren, 1894 by Prout (1915), without any further comments —neither on the genus Orthobrachia nor its type-species latifasciata Moore — in this work. Wehrli (1939) treated Orthobrachia as a subgenus of Lomographa Hübner, [1825] sensu auct. (= Stegania Guenée, [1845]), and Inoue (1987) placed its type-species latifasciata into Heterostegane Hampson, 1893, thus synonymizing Orthobrachia with Heterostegane. Yazaki (1992) finally revived Orthobrachia as a valid genus (and described two new species), but based this treatment on comparison with the genera Stegania and Heterostegane (which belong to the tribe Cassymini) and not to more closely related genera like Crypsicometa Warren, 1894 or Heterostegania Warren, 1893 (which belong - like Orthobrachia, to our opinion - to the tribe Baptini). Crypsicometa was later synonymized with Platycerota Hampson, 1893 by Stüning 2000. Scoble (1999) also treated Orthobrachia as a valid genus and included four species. Subsequently, Yazaki (2002) and Huang et al. (2003) named further two new Orthobrachia species from Taiwan and Guangxi, respectively. To date, six species are reported worldwide (Scoble 1999; Yazaki 1992, 2002; Huang et al. 2003): Orthobrachia latifasciata (Moore, 1888) (type locality Darjeeling, India) and O. flavidior (Hampson, 1898) (type locality Khasi Hills, India) from N. India, Nepal, Thailand, Vietnam and China, O. tenebrosa Yazaki, 1992 (type locality Gandaki Parbat District, C. Nepal) from Nepal and India, O. owadai Yazaki, 1992 (type locality West Sikkim) from India, O. simpliciata Yazaki, 2002 (type locality Taiwan) from China, and O. maoershanensis Huang, Xin & Wang, 2003 (type locality Guangxi) also from China.

Recently, some geometrid moths were collected at Longcanggou Town, Yingjing County, Sichuan Province, among them one species of the genus *Orthobrachia* which was confirmed as new to science and will be described herein. Surprisingly, one additional specimen of this species was discovered among material from N. Thailand in the ZFMK collection.

In the present paper, seven species from the Oriental Region are treated, and the adults and the genitalia are illustrated. Diagnostic generic characters of adults are proposed, and a key to all species is provided, based on external features. A distributional map of all *Orthobrachia* species is presented.

#### Material and methods

Adults of the new species were collected by light trap. The types of previously described species, deposited in the Natural History Museum, London, UK (BMNH) and in the National Science Museum, Tokyo, Japan (NSMT), were examined. Other specimens

examined in this study are deposited in South China Agricultural University (SCAU), Hunan Agricultural University (HUNAU), China and Zoological Research Museum Alexander Koenig, Bonn, Germany (ZFMK).

The methods for examining the genitalia and taking the photographs are as described in Wang et al. (2015). Morphological terminology in descriptions follows Kristensen (2003). Type specimens of the new species described here are deposited in HUNAU, SCAU and ZFMK.

# Taxonomy

# Orthobrachia Warren, 1895

Orthobrachia Warren, 1895. Novit. zool. 2: 121. Type species: Stegania latifasciata Moore, 1888 by original designation. In: Hewitson & Moore, Descr. new Ind. lep. Insects Colln late Mr. Atkinson: 260. [Type specimen: Lectotype, male, Darjeeling in India (BMNH, London), designation by Yazaki in Haruta, 1992]

**Description and diagnosis.** Head. Male antennae shortly and stiffly bipectinate to three-fourths or four-fifth, rami unscaled on dorsal side, flattened and distally slightly clubbed, arising ventrally from about the middle or the proximal one third of the flagellomers. Female antennae filiform. Frons narrow, flat, smooth-scaled. Palps delicate, slightly curved upward, reaching just beyond frons. Basal segment rough-scaled, second segment smooth-scaled, terminal segment very small. Haustellum well developed. Thorax. Hind leg tibia not dilated, without scent-brush. Index of spurs 0-2-4. Forewings without fovea; common stalk of veins  $R_2$ - $R_5$  arising at large distance from the upper corner of the cell (= origin of  $M_1$ ) in forewing, very close to the origin of vein  $R_1$ which anastomoses with Sc. In hindwing vein Rs also at large distance from  $M_1$ . Abdomen with tergites and sternites weak, membranous, only tergites 1 and 2 and sternites 1+2 may be slightly sclerotized. Sternite 3 without setal comb. Tympanal organs rather large, globular, without laciniae.

Characters indicating *Orthobrachia* to be a distinct genus are found in the male genitalia: Elongated, spined or densely setose lobes arising from dorsal margin of sacculus near its base are present in all species of *Orthobrachia*, but are not found in other genera of Baptini. The valves are elongated, more or less parallel-sided, with rounded apex, curved upward in all species except *O. simpliciata*, with a broad, immaculate zone with one or two processes of different shape; valve lamina with an elongated field of setae; gnathos weak, only lateral arms present; juxta a broad, oval, somewhat elongate plate, ventrally angled and with v-shaped incision distally; aedeagus with bulbous caudal end, curved or straight, with one or two large cornuti on vesica, in two species with a bunch of external cornuti or a long row of small cornuti.

The female genitalia also indicate the distinctness of *Orthobrachia*, though their characters separate two species-groups: 1) the *latifasciata*-group, also containing *fla*-



Figure 1. Distributional map of Orthobrachia species.

*vidior, tenebrosa* and *owadai*: their genitalia are characterized by a well sclerotized antrum with distal and/or lateral processes, continued into a long, sclerotized band that reaches deeply into the bursa copulatrix. Signum a large, ring-like structure without dentation; 2) the *simpliciata*-group with semicircular lamellae antevaginales, without long sclerotized bands and with a stellate signum. *O. simpliciata* exhibits the most plesiomorphic characters in the female, but also in the male genitalia.

#### Host-plant. Unknown.

**Distribution.** Oriental Region. The distributional map of all the known species is provided in Figure 1.

# Key to the species of the genus Orthobrachia (based on wing pattern and colouration)

1	Hindwing pale yellow with incomplete postmedial line only, or with a large
	pale greyish-brown medial area2
_	Hind wing orange-yellow or pale yellow, with a white or greyish-white me-
	dial band3
2	Hind wing with incomplete postmedial line only
_	Hind wing with a large, pale grey or grey-brown medial area

3	Medial band of hind wing white or greyish-white, postmedial area consisting
	of a greyish-brown apical part and a large, oval, orange-yellow or pale yellow
	posterior part. Transverse lines of forewings waved
_	Medial band of hindwing clear white, postmedial area almost entirely orange-
	yellow or pale yellow
4	Transverse lines of forewing waved
_	Postmedial line almost straight from costa to vein CuA <sub>1</sub>
5	Transverse lines of forewing waved, tornal and medial area greyish-brown,
	except for an oval, pale yellow patch near costa O. tenebrosa
_	Transverse lines of forewing straight or nearly straight, medial area predomi-
	nantly pale yellow, only partly dark brown6
6	Postmedial line slightly curved inward near costa, tornal dark brown patch
	reaching rather shortly into the medial area; dark grey postmedial line of hind
	wing evenly curved, reaching costa basally from apexO. maoershanensis
_	Postmedial line straight, tornal dark brown patch narrow, but almost reach-
	ing antemedial line; dark grey postmedial line of the hindwing straight or
	almost straight between apex and tornus O. birowatarii

# Orthobrachia latifasciata (Moore, 1888)

Figures 2A-B, 4A, 5A

Stegania latifasciata Moore, 1888, in Hewitson & Moore, Descr. new Indian lepid. Insects Colln late Mr Atkinson: 260. Type locality: Darjeeling, India. Orthobrachia latifasciata: Yazaki 1992: 21.

**Diagnosis.** This species can be recognized and distinguished from the other *Orthobrachia* species based on external features. Main diagnostic characters are the strongly waved antemedial and postmedial lines in forewing, the white or slightly greyish-white medial bands and the large, dark brown apical patch with concave posterior border in hind wing (see also key to species). In addition the genitalia of both sexes exhibit distinctive characters: valva with a large, dorsal saccular lobe, formed like a heterocercal fish-tail in a lateral view, broadly oval in dorsal view. Compared to *flavidior*, the uncus is more slender, and the shorter and broader valva of the latter has a large basal lobe instead of the hook-like costal process just beyond the middle of the valva. The aedeagus of *latifasciata* is long and slender, with one stout cornutus, that of *flavidior* is shorter and rather stout, with two cornuti. The female genitalia are distinctive, with three long spines distally on the antrum, while *flavidior* has two short distal and two long proximal spines laterally on antrum. A second similar species is *owadai*, also having a white median band in hind wing (diagnosis given under *owadai*).

**Material examined.** INDIA: 1♂, Lectotype of *Stegania latifasciata* Moore, designated by Yazaki (1992), labeled "Type/ *Stegania latifasciata* Moore, Type/1621 Darjeeling/ Moore Coll. 94-106/ Geometridae genitalia slide No. 7925 ♂", BMNH;



**Figure 2.** Adults of *Orthobrachia* species. **A–B** *O. latifasciata* (Moore, 1888) **A** male from Darjeeling in India, lectotype **B** female from Nepal **C–F** *O. flavidior* (Hampson, 1898) **C** male from India **D** female from India, Lectotype **E** male from Guangxi province in China **F** female from Guangxi province in China.

 $1^{\circ}_{\circ}2^{\circ}_{\circ}$ , W. Bengal, Tiger Hill, 2573 m, 30.IX-5.X.1986, F. Aulombard & J. Plante leg., BMNH.  $1^{\circ}_{\circ}1^{\circ}_{\circ}$ , "Khasias", L. B. Prout Coll., B.M. 1939-643 (ZFMK, by exchange from BMNH, 1964); NEPAL:  $1^{\circ}_{\circ}$ , Godavari, 28.VI.1990, preserved in BMNH; Gandaki Parbat District,  $1^{\circ}_{\circ}$ , Ghorapani, Deolari, 2800 m, 15.X.1981, M. Owada leg., NSMT;  $1^{\circ}_{\circ}$ , Ulleri, 2070 m, 14.X.1981, M. Owada leg., preserved in NSMT;  $3^{\circ}_{\circ}^{\circ}_{\circ}$ , Banthanti, 2620 m, 16.X.1981, M. Owada leg., NSMT;  $1^{\circ}_{\circ}2^{\circ}_{\circ}_{\circ}$ , nr Kathmandu, Siwapuri 2650 m, 7.X.1981, M. Owada leg., NSMT.  $1^{\circ}_{\circ}_{\circ}$ , Indien, Jammu & Kashmir, Ladakh, 15 km E Drass, 3000 m, 1.VIII.1986, leg. W. Thomas, Gen. prep. no. 2306-DS, ZFMK; CHINA:  $1^{\circ}_{\circ}2^{\circ}_{\circ}_{\circ}_{\circ}$ , Tieshanting, Mao'ershan Na-

tional Nature Reserve, 1950 m, 11.IX.2015, M. Wang leg., SCAU; 1 $\bigcirc$ , "Frontière orientale du Thibet, Chasseurs indigènes du P. Déjean 1906"/*Lomographa*, Orthobrachia Warr., *latifasciata* Moore  $\bigcirc$ , abgebildet Seitz IV. Suppl. fig. 22g, ex coll. Ch. Oberthür. ZFMK.

Biology. The adults are flying in summer and autumn.

Distribution. N. India, Nepal and China.

**Remarks.** This species is distributed in the high mountains, usually above 2000 m and up to 3000 m in altitude.

# Orthobrachia flavidior (Hampson, 1898)

Figures 2C–F, 4B, 5B

*Orthobrachia latifasciata* ab. *flavidior* Warren, 1896, Novit. zool. 3: 128. Unavailable, infrasubspecific.

*Stegania latifasciata* var. *flavidior* Hampson, 1898, J. Bombay nat. Hist. Soc. 11: 714. Type locality: Khasi Hills, India.

Lomographa latifasciata flavidior Warren [sic]: Wehrli 1939: 296. Incorrect authorship. Orthobrachia flavidior: Yazaki 1992: 22.

**Diagnosis.** This species is very similar to *O. latifasciata*, but is generally smaller and can be distinguished by external features and characters of the genitalia: the postmedial line of forewing is almost straight or just slightly curved inward from costa to tornus, the clear white medial bands of hind wing are narrowly bordered dark grey outside, but a large, dark apical patch is absent; the uncus is broader and a little shorter than in *latifasciata*; the valva is shorter and broader and has a large, roundish, sclerotized lobe at base of the costa and lacks a median, hook-like costal process found in *latifasciata*. The basal saccular process is much larger and longer and arises more distally. A second saccular lobe is missing. The aedeagus is rather stout, with a round apex, which is bluntly pointed in *latifasciata*. The cornuti, consisting of a pair of stout spines situated on a diverticulum of the vesica, are somewhat longer than in *latifasciata*. In the female genitalia, the antrum is well sclerotized, nearly quadrate, with two pairs of processes, longer at caudal and shorter at distal margin, while in *latifasciata* it bears three longer distal spines.

**Material examined.** INDIA: 1 $\bigcirc$ , Lectotype of *Orthobrachia latifasciata* ab. *flavidior* Warren, designated by Yazaki (1992), labeled "Type/ *Orthobrachia latifasciata* Moore ab. *flavidior* Warr. Type  $\heartsuit$ / Khasis Nat. Coll. /Rothschild Bequest B. M. 1939-1/ Geometridae genitalia slide No. 15658  $\heartsuit$ ", BMNH; 1 $\heartsuit$ , Paralectotype of *Orthobrachia latifasciata* ab. *flavidior* Warren, "Khasis, May 1896, Nat. Coll."/ Collectio H. J. Elwes/ ZFMK, by exchange from BMNH, 1964; 1 $\circlearrowright$ , Khasia Hills, Assam, Nissary; Joicey Bequest. Brit. Mus. 1934-120/ ZFMK, by exchange from BMNH, 1964; 1 $\circlearrowright$ , India, W. Bengal, 2400 m, Darjeeling, Tigerhill, 10-12.VII.1986, leg. W. Thomas. ZFMK; 1 $\heartsuit$ , same locality & collector, 29-31.VIII.1986, ZFMK. NEPAL: 1 $\circlearrowright$ , Godavari, 2.V.1990, preserved in BMNH; l♂, Mt. Phulchouki 21.VII.1990, BMNH. l♂, Pokhara, 2 km S Kharey, 1785 m, 21–25.II.2009, leg. T. Ihle & S. Löffler. ZFMK; l♂, Gandaki Kaski District, Naudanda, 1470 m, 12.X.1981, M. Owada leg., NSMT. CHINA: 1♀, Tieshanting, Mao'ershan National Nature Reserve, 1950 m, 11.IX.2015, M. Wang leg., SCAU. l♂, West-Tien-Mu-Shan, 1600 m, Pz. Chekiang, 18.VII.1932, H. Höne. "/ Lomographa latifasciata [sic] Moore ♂, abgebildet Seitz IV. Suppl. Fig. 22g, ZFMK; 1♀, "Chasseurs Indigènes des Missionaires de Ta-tsien-Lou, 1906", ex coll. Ch. Oberthür. ZFMK. THAILAND: l♂, Changwat Chiang Mai, Doi Phahompok, 18km NW of Fang, 2100 m, 7.II.2000, leg. Hreblay & Szabó, ZFMK; VIETNAM: l♂, N. Vietnam, Mt. Fan-si-pan, 2250 m, 1-6.XI.1995, leg. V. Sinjaev & E. Afonin; l♂1♀, N. Vietnam, Mt. Fan-si-pan, 1500-1800 m, 10.VI-6.VII.1994, leg. V. Sinjaev & local collectors (ZFMK).

Biology. The adults are flying from February to November.

Distribution. N. India, Nepal, Thailand, Vietnam and China.

**Remarks.** This species was firstly described by Warren (1896) as *latifasciata* ab. *flavidior*, which is nomenclaturally unavailable. Hampson (1898) raised the name to a species-group rank, stating, "The Khasi form has the dark markings of forewing reduced, and the white band of hindwing broader." — The "*latifasciata*"-male from Zhejiang figured in Seitz 4, Suppl. on plate 22, line g, is misidentified and in fact a male of *flavidior*. It is preserved in coll. ZFMK and could be checked by D.S.

#### Orthobrachia owadai Yazaki, 1992

Figs 3B, 4D, 5D

**Diagnosis.** This species can be distinguished from other *Orthobrachia* species, especially from the very similar female of *latifasciata*, based predominantly on the following characters: In the forewing, the postmedial line is situated more distally and less deeply waved. In the hindwing, the postmedial line is shaded distally with brown, more broadly than in *flavidior*, but much less than in *latifasciata*. In the latter the whole apical one-third is dark brown, with a rounded posterior border. In the male genitalia, the valva has a large triangular, distally rounded costal process just before the middle, a second, smaller one at the base of the valva and the saccular lobes are shorter and broader, roundish, curved basad. The aedeagus is slender with a bunch of short spines externally near apex, the vesica bears two cornuti situated one after another on a large diverticulum (looking like one large cornutus in our Fig. 4D). In the female genitalia, a large lamella postvaginalis is absent and the antrum bears only two spines distally, pointing laterally. Longitudinal sclerotized band and round, ring-like signum are uniting *owadai* with the three species mentioned before.

*Orthobrachia owadai* Yazaki, 1992, Tinea, 13 (Suppl. 2): 23. Type locality: West Sikkim, India.



**Figure 3.** Adults of *Orthobrachia* species. **A** *O. tenebrosa* Yazaki, 1992, male from Nepal, paratype **B** *O. owadai* Yazaki, 1992, female from Nepal, paratype **C–D** *O. simpliciata* Yazaki, 2002 **C** male from China, paratype **D** female from China, paratype **E–F** *O. maoershanensis* Huang, Xin & Wang, 2003 **E** male from Guangxi Province in China, holotype **F** female from Guangxi Province in China, paratype **G–H** *O. hirowatarii* Huang, Su & Stüning, sp. n. **G** male from Sichuan Province in China, holotype **H** female from Sichuan Province in China, paratype.



Figure 4. Male genitalia of Orthobrachia species. A O. latifasciata (Moore, 1888), Lectotype B O. flavidior (Hampson, 1898) C O. tenebrosa Yazaki, 1992, paratype D O. owadai Yazaki, 1992, holotype E O. simpliciata Yazaki, 2002, paratype F O. maoershanensis Huang, Xin & Wang, 2003, holotype G O. hirowatarii Huang, Su & Stüning, sp. n., holotype.

Material examined. INDIA, 1<sup>3</sup>, Holotype, West Sikkim, Choka, 3050 m, 23-24.IX.1983, M. Owada leg., NSMT. 1<sup>3</sup>, Indien, W. Bengal, 2400 m, Darjeeling, Tigerhill, 10-12.VII.1986, leg. W. Thomas. Gen. prep. no. 2305-DS. ZFMK.

**Biology.** The two adults known were flying in Juli and September, at elevations between 2400 and 3050 m.

Distribution. N.E. India, Sikkim.

**Remarks.** This species has so far been observed near the type locality only.

#### Orthobrachia tenebrosa Yazaki, 1992

Figures 3A, 4C, 5C

*Orthobrachia tenebrosa* Yazaki, 1992, Tinea, 13 (Suppl. 2): 23. Type locality: Gandaki Parbat District, Nepal.

**Diagnosis.** This species is similar to *O. latifasciata*, *O. flavidior* and *O. owadai*, especially similar to *latifasciata*, which has very similar transverse lines and also a large, dark brown apical patch in the hindwing, but can be distinguished easily from all three species by the dark brown medial area of the hindwing which are white or greyish-white in the other three. Moreover, the postmedian line is situated more distally. In the forewing, the broader median area is more strongly suffused with greyish-brown (see also key to species). In the male genitalia, length and width of the uncus are intermediate between *latifasciata* and *flavidior*. The valva bears a small triangular, apically rounded costal process arising from beyond the middle, and the saccular lobe is longer, extending more dorsally beyond dorsal margin of the valva, compared to *flavidior*. The aedeagus is more slenderly built and shorter, two cornuti are present on vesica, but smaller in size. There is no external bunch of spines like in *owadai*. The female genitalia are very similar to those of *latifasciata*, but the antrum is smaller, with the lateral pair of spines of equal length of the central one. In *latifasciata*, the lateral spines are longer.

Material examined. NEPAL: 1♂, Holotype, Gandaki Parbat District, Ghorapani, Deolari, 2800 m, 15.X.1981, M. Owada leg., NSMT; Paratypes, 5♂♂, Same data as holotype. INDIA: 1♀, Western Bengal, Tiger Hill, 2573 m, 30.IX-5.X.1986, F. Aulombard & J. Plante leg., BMNH.

**Biology.** The adults are flying in September and October in high elevations between 2500 and 2800 m.

# Distribution. Nepal, NE. India

**Remarks.** The female from Sikkim, designated as paratype by Yazaki (1992), is the only female known so far. We figure its genitalia here, provided by Mr. K. Yazaki.

#### Orthobrachia simpliciata Yazaki, 2002

Figures 3C–D, 4E, 5E

Orthobrachia simpliciata Yazaki, 2002, Tinea, 17 (1): 32. Type locality: Taiwan, China.

**Diagnosis.** This species is characterized in appearance by rather long antennal rami in the male, less yellowish (rather creamy white) wings, especially in the distal third of the hindwing, somewhat ill-defined transverse fasciae, and in the hindwing-pattern consisting of an incomplete postmedial line only. In the male genitalia the valva is simple, almost not curved dorsad at apex and any costal ornamentation, such as



Figure 5. Female genitalia of Orthobrachia species. A O. latifasciata (Moore, 1888) B O. flavidior (Hampson, 1898) C O. tenebrosa Yazaki, 1992, paratype D O. owadai Yazaki, 1992, paratype E O. simpliciata Yazaki, 2002, paratype F O. maoershanensis Huang, Xin & Wang, 2003, paratype (bursa copulatrix ripped on left side) G O. hirowatarii Huang, Su & Stüning, sp. n., paratype (bursa thinly membranous, margins only faintly visible).

small processes, present in *latifasciata* and *tenebrosa*, or the large dorsal expansions in *flavidior* and *owadai*, are absent. The saccular process is small and situated close to the base of valva. The aedeagus is unique in having a large row of small cornuti on vesica, together with a terminal, stronger and straight cornutus. Female genitalia are very different compared to *latifasciata*, *flavidior*, *tenebrosa* and *owadai* ("*latifasciata*-group"). The distinctive differences unite *simpliciata* with *maoershanensis* and *hirowatarii* 

(the *simpliciata*-group): with an arcuate, narrow lamella antevaginalis instead of a spined antrum, without long sclerotized bands and with an asymmetric, stellate signum. *O. simpliciata* exhibits the most plesiomorphic characters in the female, but also in the male genitalia.

**Material examined.** TAIWAN: 1, Holotype, Taichung, Mt. Anmashan, 2350 m altitude, 1.IV.1996, H.R. Tzuoo leg., NMNS; Paratypes 1, same data as holotype, 1 same locality as holotype except for 9.III.1996, Fu leg., NSMT.

Biology. The species was flying in spring at the type-locality.

Distribution. China (Taiwan).

Remarks. This species is endemic to Taiwan.

#### Orthobrachia maoershanensis Huang, Xin & Wang, 2003

Figures 3E-F, 4F, 5F

Orthobrachia maoershanensis Huang, Xin & Wang, 2003, Tinea, 17 (5): 229. Type locality: Guangxi, China.

**Diagnosis.** The species is externally very similar to the new species described below, to *O. simpliciata* and also to *O. tenebrosa*, but can be distinguished from all by the following characters: The antemedial and postmedial lines of the forewing are distinctly waved in *tenebrosa*, in *maoershanensis* almost straight, only the postmedial is slightly curved inward near costa of forewing, straight in the new species. From *O. simpliciata*, it can easily be separated mainly by the differences in the hind wing pattern described above. Further distinguishing features see next species. The male genitalia of all three species have clear specific characters, the female genitalia as well, the latter uniting *simpliciata*, *maoershanensis* and *hirowatarii* sp. n. by a number of characters shared.

**Material examined.** CHINA: 1 $\checkmark$ , Holotype, Mao'ershan National Nature Reserve, 2000 m altitude, 25°54'N, 110°30'E, Primary forest, Xin'an County, Guangxi Province, China, 28.VI.2003, G.H. Huang leg., Gen. prep. no. HGH-SCAU\_0011, SCAU; Paratypes  $2 \checkmark \checkmark 7 \diamondsuit \diamondsuit$ , same locality as in the holotype, 1600-2000 m, 28.VI-4.VII.2003, M. Wang and G.H. Huang leg., Gen. prep. no. HGH-SCAU\_0013 (female), SCAU ( $1 \checkmark 1 \circlearrowright$  donated to Institute of Zoology, Chinese Academy of Sciences, Beijing (IZCAS));  $1 \textdegree$ , Huilongsi, Mao'ershan National Nature Reserve, 1489 m, 10.IX.2015, M. Wang leg., HUNAU.  $1 \circlearrowright$ , N. Vietnam, Cha-pa, Mt. Fan-si-pan, 22°15'N 103°46'E, 1500-1800 m, 10.VI-6.VII.1994, lux, leg.V. Sinjaev & local coll., ZFMK.

**Biology.** The species was collected in June-July and again in September in a primary forest near the top of a mountain, at elevations between 1500 and 2000 m.

Distribution. China (Guangxi), Vietnam.

# *Orthobrachia hirowatarii* Huang, Su & Stüning, sp. n. http://zoobank.org/EB40BAE2-48B5-408D-94ED-E45F7D8AA338 Figures 3G–H, 4G, 5G

Diagnosis. This new species is externally very similar to O. maoershanensis but can be distinguished by the dark-brown ante- and postmedial lines, which are stronger and straight in *hirowatarii*, more delicate and the postmedial line curved inwards near costa in maoershanensis. The tornal dark brown patch is broader and shorter in the latter, reaching up to the middle of the medial band; the narrower patch of *hirowatarii* is longer and reaches almost back to the antemedial line. In the hind wing, the narrow, almost black postmedial line is almost straight between apex and tornus in hirowatarii, while it is evenly curved between anterior and posterior margin distinctly basad of apex and tornus in maoershanensis. The valve in the male genitalia is longer and narrower with two processes near the base in *hirowatarii*, a multi-dentate costal process and an arm-shaped, angled, apically densely setose saccular process. The costal process in maoershanensis is short and apically rounded, the saccular process thumblike, with shorter setae at tip. In addition, the latter has a broad, basal costal process, similar to that found in *flavidior*. The aedeagus is short, stout, with two cornuti in maoershanensis, while hirowatarii has a longer, narrow aedeagus with a bunch of external spines at the border between shaft and vesica. The female genitalia are also clearly separable, though both (and *simpliciata*, too) have a similar, asymmetric, stellate signum (very small in *simpliciata*). *Hirowatarii* has a large, rather quadrate, strongly sclerotized antrum, with a transverse, semicircular, broad lamella antevaginalis distally, decorated with a pair of lateral spines. In *maoershanensis*, the quadrate part is absent, the semicircular part more delicate and the spines smaller. Moreover, maoershanensis has a much longer, fluted ductus bursae and the bursa is smaller (in our Fig. 5G with a damage on the left side).

**Description.**  $\circlearrowleft$  Expanse 27–30 mm, length of forewing 13–15 mm.

Head. Antenna bipectinate to three-fourths, rami arising from the proximal one third of flagellomers, apical 15–16 segments not pectinated. Frons narrow, smooth-scaled, lower half with yellow, upper half with greyish-brown scales. Vertex with larger, creamy white scales. Palps narrow, short, scaled light greyish-brown. Thorax. Patagia greyish-brown, tegulae creamy white, thorax subdorsally with two longitudinal, dark brown lines (which are continued on the abdomen). Forewing ground colour creamy white, with transverse striation of dark brown and orange, scales of the same colours also accompany the veins. There is a dark brown patch at tornus, extended along posterior margin, reaching almost the antemedial line. The latter line strong, dark brown, straight, shortly curved basad and broadening near costa; postmedial line straight from tornus to 1/4 of costal margin; there is a small, semicircular loop between veins  $R_5$  and  $M_1$  at termen (also present in *maoershanensis* and *simpliciata*); cilia dark brown at posterior half of termen, creamy white between the dark end of the veins in anterior half. Hindwing rounded; ground colour similar to forewing, with broad, greyish-brown medial area. Thin blackish-brown postmedial line straight between tornus and apex,

discal cell with a small black spot. Cilia brown, apart from those in the spaces  $M_1$ - $M_3$ ,  $M_3$ -CuA<sub>1</sub> and CuA<sub>1</sub>- CuA<sub>2</sub> which are creamy white.

 $\bigcirc$  Expanse 30–34 mm, length of forewing 14–16 mm, antenna filiform. The ground colour of the wings and the pattern elements are very similar to the male.

Male genitalia: Uncus rather broad and short, beak-shaped. Gnathos consisting of weak, flattened lateral arms only, not fused in the middle. Valva long and narrow, with the distal end of costa projecting above the valve surface. Costa with a large, multidentate process just basally of the middle, and saccular process with a narrow basal arm and a broader, globular, apically densely setose distal parts. Juxta a large, broad, somewhat elongated plate. Saccus broad and rounded, flattened at base. Aedeagus slender with a bunch of well-developed cornuti, arising externally at the border between shaft and vesical, the latter without cornuti.

Female genitalia: Papillae anales elongate, apophyses long; a. anteriores about 3/5 the length of a. posteriores; lamella antevaginalis well sclerotized, semicircular, with a pair of spines bilaterally, united with a large, nearly quadrate, well sclerotized antrum; bursa copulatrix thinly membranous, pear-shaped (not clearly visible in our figure), distal part sclerotized, fluted, containing a wrinkled band; ductus bursae very short; signum rounded, margins and internal surface covered with spines.

**Holotype.** ∂, China: Sichuan, Yingjing County, Longcanggou Town, 1420 m, 10.VIII.2015, light trap, G.H. Huang leg., Gen. prep. no. HGH-HUNAU\_0165 deposited in HUNAU.

**Paratypes.**  $5\sqrt[3]{8}$ , same locality as holotype, but 09-11.VIII.2015, G.H. Huang, T. Hirowatari, T.T. Yu and M. Wang leg., Gen. prep. no. HGH-HU-NAU\_0168 (female), deposited in HUNAU and SCAU.  $1\sqrt[3]{}$ , N.Thailand, Changwat Chiang Mai, 23 km NW Sop Kha, 1 km E Kop Dong, 1650 m, 29.I.2000, leg. Márton Hreblay. Gen. prep. no. 2304-DS, ZFMK

**Etymology.** The specific epithet is in honour of Prof. Toshiya Hirowatari, who was the supervisor of the first author for Ph.D. Course in Osaka Prefecture University.

**Biology.** The adults fly in August in Sichuan, in January in Thailand, at elevations between 1400 and 1700 m. The host of larvae is unknown.

Distribution. China (Sichuan), Thailand.

**Remarks.** This new species was collected at a small village in the forest, with a light-trap inside a house, with artificial vegetation around it. Therefore the habitat seems to be quite different from that of other *Orthobrachia* species. E. g., *O. maoershanensis* originates from environment with natural vegetation in the core zone of the Nature Reserve.

# **Conclusions and discussion**

The systematic relationship of the genus *Orthobrachia* has been questioned for a long time, as explained in the introduction chapter. We are convinced that it is a member of the tribe Baptini (sensu Holloway (1994)) indicated by the following characters:

1) vein  $R_2$  in the forewing arising from a common stalk with  $R_3$ - $R_5$ ; 2) fovea in forewing absent; 3) transverse comb of setae on sternite 3 absent; 4) valves elongate, more or less parallel-sided, rounded at apex, with a broad, immaculate costal zone, often with a marginal process or angle, an elongate field of setae, often with peg-like, short, broad setae (the latter not present in *Orthobrachia*, but also not present in a number of other genera of Baptini, sensu Holloway (1994)); 5) gnathos weak or absent (in *Orthobrachia* separated lateral arms present only). All or most of these characters are present in the genus *Orthobrachia*. Related genera in the Baptini are *Platycerota* Hampson, 1893 (= *Crypsicometa* Warren, 1894) and *Heterostegania* Warren, 1893.

Orthobrachia species are distributed from NW India (Kashmir) to Zhejiang and Taiwan (E. China), S. China, N. Vietnam and N. Thailand (the China-Himalayan animal area, as considered by Huang et al. 2010). O. latifasciata and O. flavidior are the most widespread species, latifasciata occurring from Kashmir to Western Central China, *flavidior* from C. Nepal to E. China (Zhejiang), the latter also being the most abundant of all species. Most other species seem to be rare or are at least rarely collected. O. tenebrosa is only known from a few specimens from C. Nepal and Sikkim, NE. India, O. owadai from the latter region only. Species of the simpliciata-group are only distributed in E. and SE. China, including the more northern Sichuan region. O. simpliciata is endemic to Taiwan, and also the recently described O. maoershanensis and O. hirowatarii, described herein, were considered to be very local species firstly, but the discovery of both species in N. Vietnam and N. Thailand, respectively, proved them to be more widespread. More collecting at appropriate places (i.e. natural forests at elevations between 1500 and 3000 m a.s.l.) will probably reveal even more localities where these rare species occur. Considering the fact, that no Orthobrachia species are known at all to us from N. Myanmar and N. Laos, we also believe that the discovery of further new species is possible.

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#### References

Hampson GF (1898) The moths of India: supplementary paper to the volumes in "The Fauna of British India", Part III. Journal of the Bombay Natural History Society 11: 698–724.

- Holloway JD (1993) [1994] The Moths of Borneo, part 11: Geometridae, Ennominae. Malayan Nature Journal 47: 1–309. [19 pls]
- Huang GH, Wang M, Xin DY (2003) A new species of the genus *Orthobrachia* Warren, 1895 (Lepidoptera, Geometridae) from China. Tinea 17(5): 229–231.
- Huang GH, Hirowatari T, Wang M (2010) A review of the China-Himalayan members of the subfamily Euplocaminae (Insecta: Lepidoptera: Tineidae). Zootaxa 2511: 1–21.
- Inoue H (1987) Geometridae of Eastern Nepal based on the collection of the Lepidopterological research expedition to Nepal Himalaya by the Lepidopterological Society of Japan in 1963. Part III. Bulletin Faculty of Domestic Science of Otsuma Women's University 23: 215–270.
- Kristensen NP (Ed.) (2003) Lepidoptera, Moths and Butterflies. 2. Morphology, Physiology, and Development. Handbook of Zoology, 4. Arthropoda: Insecta (36). Walter de Gruyter Inc., Berlin & New York, 564 pp.
- Moore F (1888) Heterocera continued (Pyralidae, Crambidae, Geometridae, Tortricidae, Tineidae). In: Hewitson WC, Moore F (Eds) Descriptions of New Indian Lepidopterous Insects from the Collection of the Late Mr. WS Atkinson. MA, FLS & c. Part 3, 199–299.
- Prout LB (1912–1916) Die Gross-Schmetterlinge der Erde: Band 4. Palaearktische Geometridae (Macrolepidoptera of the World 4). Stuttgart, Germany, 479 pp. [25 pls]
- Scoble MJ (Ed.) (1999) Geometrid moths of the world: a catalogue (Lepidoptera, Geometridae). 2 vols. CSIRO Publishing, Canberra, Australia, 676 pp.
- Stüning D (2000) Additional notes on the Ennominae of Nepal, with descriptions of eight new species (Geometridae). In: Haruta T (Ed.) The Moths of Nepal, part 6. Tinea 16 (Suppl. 1): 94–152. [pl. 170–172]
- Wang X, Wang M, Zolotuhin VV, Hirowatari T, Wu S, Huang GH (2015) The fauna of the family Bombycidae sensu lato (Insecta, Lepidoptera, Bombycoidea) from Mainland China, Taiwan and Hainan Islands. Zootaxa 3989: 1–138.
- Warren W (1895) New species and genera of Geometridae in the Tring Museum. Novitates Zoologicae 2: 82–159.
- Wehrli E (1939–1954) In Seitz, Macrolepidoptera of the World 4. Suppl. 4. Palearctic Geometridae: 254-766. Stuttgart, Germany, 768 pp.
- Yazaki K (1992) Geometridae from Nepal. In: Haruta T (Ed.) Moths of Nepal (Part 1). Tinea 13 (Suppl. 2): 5–46.
- Yazaki K (2002) Three new Geometridae (Lepidoptera) from Taiwan. Tinea 17: 29-32.

CORRIGENDA



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It came to our attention after our manuscript was published that the Institution name was missing. The full and correct institution name and address is provided here in order to acknowledge the deserved credits.

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